# WATERSHED ASSESSMENT
# FINAL REPORT

# TURKEY RIDGE CREEK
# TURNER COUNTY, SOUTH DAKOTA

**South Dakota Water Resource Assistance Program**
**Division of Financial and Technical Assistance**
**South Dakota Department of Environment and Natural Resources**
**Steven M. Pirner, Secretary**

**July 2005**

**SECTION 319 NONPOINT SOURCE POLLUTION CONTROL PROGRAM**

**WATERSHED ASSESSMENT**
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**Prepared By**

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**State of South Dakota**
**M. Michael Rounds, Governor**

**July, 2005**

**SECTION 319 NONPOINT SOURCE POLLUTION CONTROL PROGRAM**

## EXECUTIVE SUMMARY

Project Title: Turkey Ridge Creek Watershed Assessment

Project Start Date: November 10, 2001    Project Completion Date: December 31, 2003

### Funding

Total Budget: $98,550

Total EPA Grant (604b): $85,000 (FY2001)

Total Expenditures of EPA Funds: $98,260.35

Total Match Accrued: $13,400

Budget Revisions (604b): $20,000 amendment (FY2002)

Total Expenditures: $111,660.35

### Summary Accomplishments:

The 1998 and 2002 South Dakota § 303(d) Waterbody List (33 U.S.C. §§1251-1387 of the Clean Water Act), only identified Turkey Ridge Creek as it relates to Swan Lake as a priority for the development of accumulated sediment and nutrient TMDLs. During 1995-1999 Swan Lake was involved with a Section 319 project designed to remove approximately 330,000 $yds^3$ of accumulated sediment in the lake, install shoreline protection, and reduce sediment-laden waters from Turkey Ridge Creek.

During 1999, TMDLs for total phosphorus and accumulated sediment were approved for Swan Lake. The watershed for Turkey Ridge Creek was not included as part of these TMDLs because the drainage ditch constructed in 1914 was closed. The drainage ditch was originally used to divert spring flows from Turkey Ridge Creek to Swan Lake to maintain the lake water level for recreational purposes. However, because of the accumulated sediment in Swan Lake the diversion was closed.

After completion of the implementation project in 2001, the Swan Lake Improvement Association approached the South Dakota Department of Environment and Natural Resources (SDDENR) with a design plan to upgrade the closed structure used to divert water prior to the implementation project. One of the stipulations of the plan agreed upon by SDDENR, the Swan Lake Improvement Association, the US Army Corps of Engineers, and the US Fish and Wildlife Service was the watershed be assessed to determine sources of excessive sediment and nutrient loadings

In late 2001 an assessment project was initiated to determine the sources of impairments to Turkey Ridge Creek. Sampling began in October of 2001 and continued through to fall of 2003. Physical, chemical, and biological data were collected to determine impairments and their sources. Stream gaging equipment was installed at nine monitoring locations within the watershed (Figure i).

Only a 26.1-mile segment of the 47.5-mile length of Turkey Ridge Creek is classified for warmwater marginal fish life propagation and limited contact recreation. Water quality criteria established for these designated uses were used to determine impairments and possible TMDL development for individual chemical and biological parameters. The analysis of the chemical water quality samples collected from this segment exhibited violation rates of less than 10%, which is the current threshold for TMDL development. In fact, total suspended solids concentrations violated the allowable daily maximum concentration of 263 mg/L only 6.6% of the time. In contrast, the biological parameter, fecal coliform bacteria, which is one of the parameters used to assess use support of the limited contact recreation beneficial use, exhibited a violation rate of 24.7%. This was the only parameter for Turkey Ridge Creek requiring a TMDL.

The water quality data indicated a downstream longitudinal gradient where increased concentrations occurred with each successive downstream site. This was also exhibited with the physical habitat assessment and the benthic macroinvertebrate populations. The Index of Physical Integrity or IPI used a combination of eight physical parameters to determine possible physical impairments. The habitat values were lower in the center of the watershed whereas the three upstream sites and three downstream sites were significantly less impaired. Three central monitoring sites (n=9) were classified as poor whereas the bottom three monitoring sites were classified as exhibited fair classification and the upstream sites were ranked as good. Some of the physical impairments were related to channel instability, lack of physical complexity, and overgrazing.

Physical impairments seemed to be effecting the benthic macroinvertebrate populations as well. Several macroinvertebrate metrics indicated significant downstream impacts for EPT Abundance, Species Richness, Trichopteran Richness, Filterer Richness, Margalef's Richness, and Clinger Richness ($r^2>0.55$, df=8, $p<0.025$).

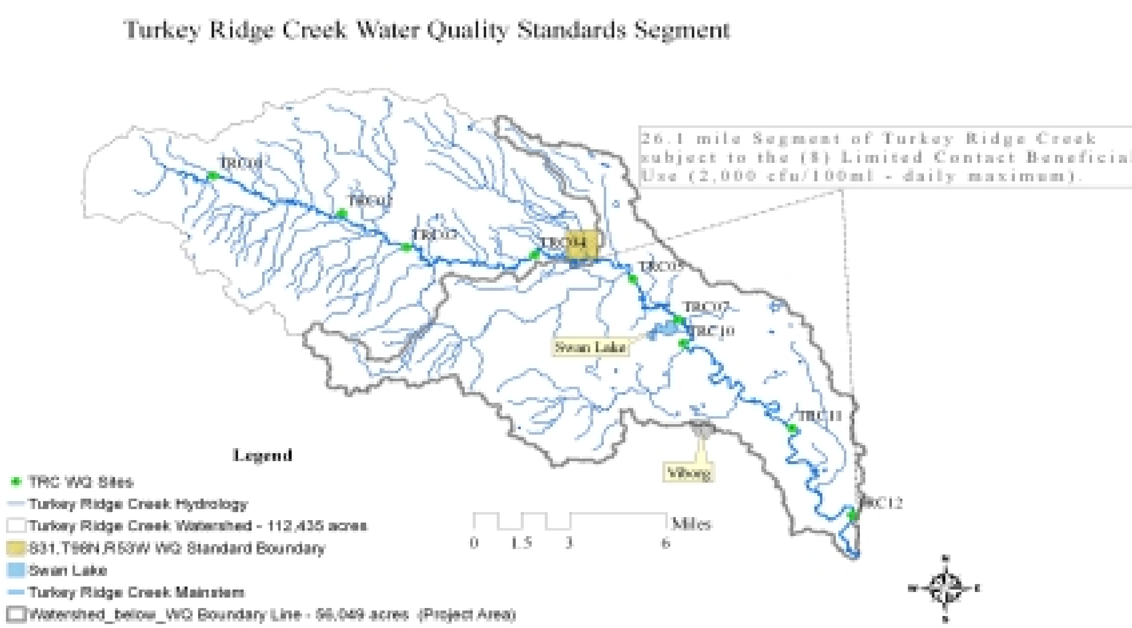


**Figure i.**

AGNPS stand-alone feedlot model was used to assess 129 animal feeding operations (AFOs) within the watershed for pollution potential on a scale of 0 (no effect) to 100 (severe). Forty-five of the 129 AFOs exhibited a rating of 50 or higher and should be targeted as part of an implementation project.

Although a sediment TMDL was not required sediment and nutrient loadings were still calculated by using the US Army Corps of Engineers computer model FLUX. The results were reported on a per acre basis (export coefficients) for each of the nine monitoring locations. Data from these calculation methods revealed extremely high sediment export coefficients (lbs/acre) from lower watershed areas. These were significantly greater than the export coefficients calculated from the upstream areas.

Load duration curves were used to analyze the fecal coliform and total suspended solids data and identify the hydrologic zones where most of the water quality violations occur. In the case of fecal coliform bacteria, reductions required for full support of the limited contact beneficial use were calculated. The load duration curves indicated that 87% of the fecal coliform violations occurred at the extreme high flows where the flow has a 0-10% probability of being exceeded. The remaining 13% of the violations occurred within the midrange or base flow hydrologic conditions 40-100% of the flows being exceeded. To bring Turkey Ridge Creek into compliance with currently water quality standards a 95% reduction in fecal coliform concentrations during high flows would be required.

In order to achieve these reductions allocations of possible sources within the watershed were determined by using the USEPA Bacterial Source Indicator Tool. This tool indicated that during the months when the fecal coliform standard applies (May 1 through September 30) the largest contributors of bacteria were:

| Pollutant Type | Source | May | June | July | August | September |
|---|---|---|---|---|---|---|
| Diffuse | Cropland | 30.3% | 8.8% | 8.7% | 10.6% | 28.7% |
| | Pastureland | 17.7% | 22.3% | 22.3% | 22.1% | 18.6% |
| Direct | Cattle in Streams | 9.4% | 15.0% | 15.0% | 14.6% | 11.4% |
| | Feedlots rated > 60 | 42.5% | 53.9% | 54.0% | 52.7% | 41.2% |
| | Total | 100% | 100% | 100% | 100% | 100% |

Best management practices targeting animal feeding operations, grazing management for pastureland, and manure management and filter strips along cropland should achieve the necessary 95% reductions needed during high flow conditions.

Because a sediment TMDL was not required Annualized AGNPS modeling was not completed for this watershed. However, the Turkey Ridge Creek watershed will be analyzed using the computer-model as part of the Vermillion River Basin Assessment that is currently being conducted. Turkey Ridge Creek will be compared to all other tributaries within the Vermillion River Basin and will be ranked as to its importance in sediment and nutrient contribution to the impaired segments of the Vermillion River.

**AKNOWLEDGEMENTS**

The cooperation of the following organizations and individuals is gratefully appreciated. The assessment of Turkey Ridge Creek and its watershed could not have been completed without their assistance.

US EPA Non-Point Source Program
Turner Conservation District
Swan Lake Improvement Association
Vermillion Basin Water Development District
Cory Medill
Derrol Pasco
Gary Olson
Minnehaha Conservation District
Natural Resources Conservation Service – Turner County
City of Viborg
SD Department of Game, Fish, and Parks
SD Department of Environment and Natural Resources – Surface Water Quality Program
SD Department of Environment and Natural Resources – Water Rights Program
SD Department of Environment and Natural Resources – Water Resources Assistance Program

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## 1.0 INTRODUCTION

The purpose of this assessment was to determine the sources of impairment and develop restoration alternatives for the Turkey Ridge Creek Watershed located within southern Turner County. Direct runoff primarily related to seasonal snowmelt or rainfall events contribute loadings of sediment, nutrients, and fecal coliform bacteria to the stream. A TMDL(s) will be developed for each documented impairment by quantifying all sources to Turkey Ridge Creek.

In the 1998 South Dakota 303(d) Waterbody List, Swan Lake and Turkey Ridge Creek were listed together for accumulated sediment and nutrients (Table 1). During 1995-1999 Swan Lake was involved with a Section 319 project designed to remove approximately 330,000 $yds^3$ of accumulated sediment in the lake, install shoreline protection, and reduce sediment-laden waters from Turkey Ridge Creek.

A diversion created in 1914 to divert spring runoff water from Turkey Ridge Creek into Swan Lake substantially increased the drainage area, resulting in excessive sediment and nutrient loading into the lake (Stueven, 1991). During the ensuing implementation project, the diversion was closed, eliminating the spring flows into Swan Lake. This loss of water resulted in considerable seasonal fluctuations in the lake levels due to evaporation and loss to groundwater. After completion of the implementation project in 2001 the Swan Lake Improvement Association approached the South Dakota Department of Environment and Natural Resources (SDDENR) with a design plan to upgrade the closed structure used to divert water prior to the implementation project. One of the stipulations of the plan, agreed upon by SDENR, the Swan Lake Improvement Association, the US Army Corps of Engineers, and the US Fish and Wildlife Service was: 1) the watershed be assessed to determine sources of excessive sediment and nutrient loadings; 2) a determination for the period of time when Turkey Ridge Creek exhibits the highest quality of water; and 3) a sediment retention basin be constructed to improve the quality of water diverted into Swan Lake. The project required a Section 404 certification from the Corps and consultation with USFWS regarding the impact on the federally endangered species: Topeka Shiner, *Notropis topeka*.

In late 2001 an assessment project was initiated to address the first two objectives listed above. The purpose of this Pre-Implementation Assessment is to determine the sources of impairments to Turkey Ridge Creek in Turner County and the small tributaries in the watershed. This watershed ultimately drains to the Vermillion River (Figure 1). The creeks and small tributaries are intermittent streams with loadings of sediment and nutrients related to snowmelt or rainfall events.

Turkey Ridge Creek was listed on the State § 303(d) list as a 319 Project-related TMDL Water for sediment and nutrients. This perennial stream was part of the Section 319 Implementation Project for Swan Lake which is located near the center of the watershed (Figure 2). The streams in the watershed drain predominantly agricultural lands with both cropland (85%) and grazing acres (13%). Feedlots and winter feeding areas for livestock are present in the watershed. The stream carries pathogens, sediment, and nutrient loads, which degrade water quality in Swan Lake and cause increased eutrophication when allowed to flow into the lake.

The drainage ditch constructed in 1914 involved the installation of a small corrugated steel dam on Turkey Ridge Creek which elevated the water levels and increased the amount of water that could be diverted into Swan Lake. The main objective of the ditch was to maintain water levels in Swan Lake (quantity vs. quality). Initially, the structure had a functional control wheel, however it was not maintained and wood stoplogs were used with the structure in the 1980s. It remained uncontrolled until the late 1990's when USEPA required the ditch be closed before dredging was initiated. The current engineering plan involves a control structure with sediment retention basins. The operational period will only occur during winter months when higher water quality is available.

Total suspended solids (TSS) was the parameter of concern for Turkey Ridge Creek because of the diversion to Swan Lake. However, this was not listed in any of the section 303(d) listings. The 1998 and 2002 South Dakota 303(d) waterbody list only identified Turkey Ridge Creek as it relates to Swan Lake as a priority for the development of Total Maximum Daily Loads (TMDLs) (Table 1). In 1999, TMDLs for total phosphorus and accumulated sediment were approved for Swan Lake. The watershed for the Turkey Ridge Creek was not included as part of these TMDLs because the drainage ditch was no longer connected the creek to the lake.

**Table 1. 1998 and 2002 SDDENR Section 303(d) Waterbody Listing for Turkey Ridge Creek and Swan Lake.**

**Excerpt from 1998 List (pg 34 of the 303(d) waterbody list)**

| Basin | Waterbody | Location | Project, Permittee, or other description | Permit Number | Exp. Date | Parameter | Priority | Note |
|---|---|---|---|---|---|---|---|---|
| Vermillion | Swan Lake/Turkey Ridge Creek | Turner County | Swan Lake Restoration | N/A | N/A | Accumulated Sediment, Nutrients | 1 | 319 Project |

**Excerpt from 2002 List (Table 11 – Delisted Waters, pg 39 of the 303(d) waterbody list).**

| Basin | Waterbody | Location | Parameter | Information to Support Delisting | EPA Approved |
|---|---|---|---|---|---|
| Vermillion | Swan Lake | Turner County | TSI, Trend | EPA Approved TMDL | 4/12/1999 |

The surface watershed area for Turkey Ridge Creek is approximately 112,430 acres in size (Figure 2). Viborg is the only municipality in the watershed. Table 2 and Figure 2 show Turkey Ridge and how it is listed in the water quality standards for the State of South Dakota (ARSD, 74:51:03). Only the lower 26.1 miles of Turkey Ridge Creek (47.5 total miles) is subject to more stringent water quality standards the parameters such as suspended solids and fecal coliform bacteria.

Turkey Ridge Creek Watershed in the Vermillion River Basin

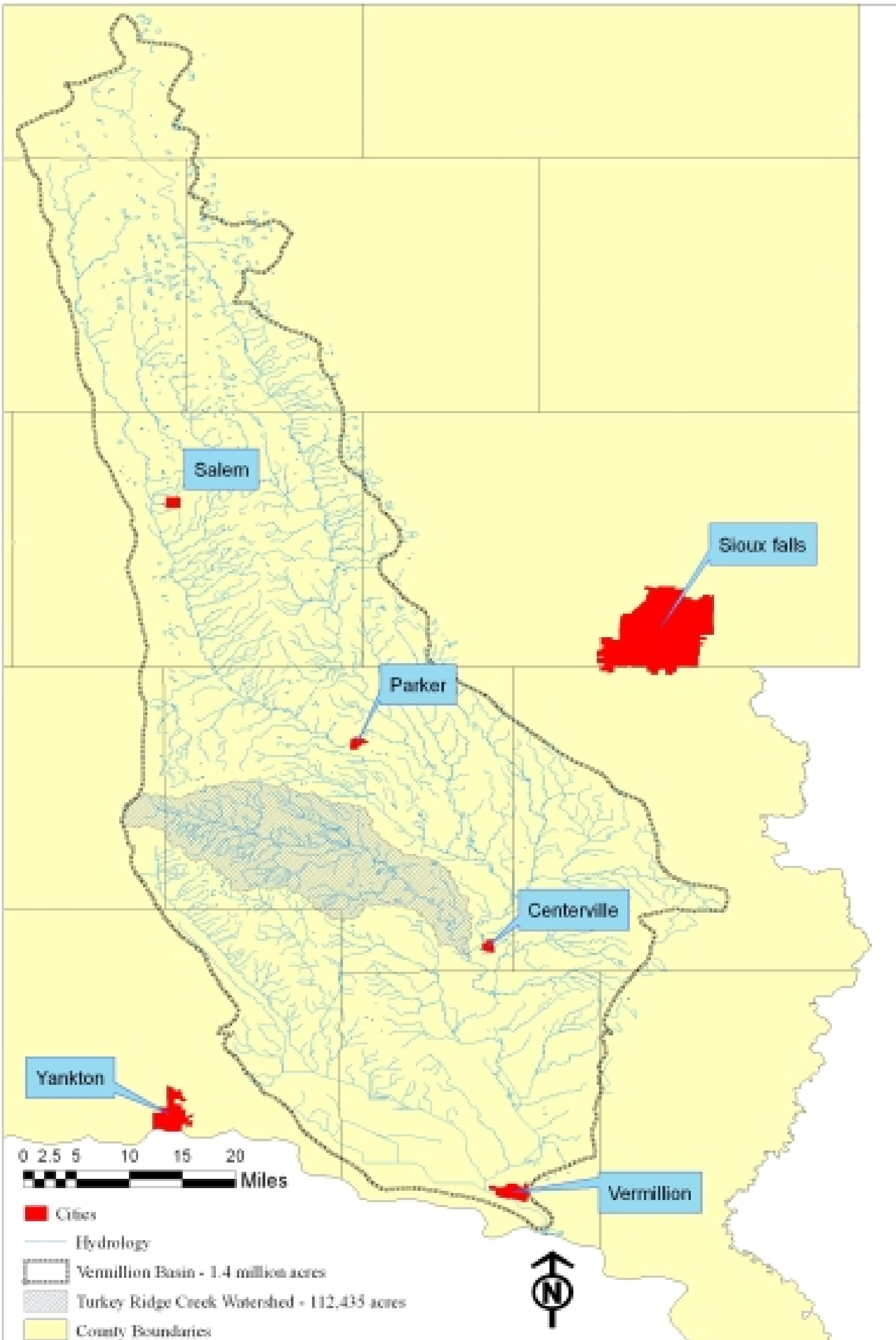



**Figure 1. Location of Turkey Ridge Creek Watershed.**

**Table 2. Turkey Ridge Creek Water Quality Criteria (ARSD: 74:51:03)**

**74:51:03:25. Vermillion River and certain tributaries' uses.** Stream segments of the Vermillion River and certain tributaries covered by § 74:51:03:02 include the following:

| Water Body | From | To | Beneficial Uses | County |
|---|---|---|---|---|
| Vermillion River | Missouri River | confluence of its east and west forks | 5,8 | Turner |
| West Fork Vermillion River | Vermillion River | McCook-Miner County Line | 6,8 | McCook\ Miner |
| Silver Lake Creek | West Fork Vermillion River | Silver Lake outlet | 6,8 | Turner |
| East Fork Vermillion River | Vermillion River | McCook-Lake County Line | 6,8 | McCook\ Lake |
| Saddle Creek | Long Creek | S17, T97N, R50W | 6,8 | Lincoln |
| Haram Creek | Saddle Creek | S23, T97N, R51W | 6,8 | Lincoln |
| Clay Creek | Clay County ditch | S.D. Highway 46 | 6,8 | Yankton |
| Turkey Creek | Clay County ditch | S.D. Highway 46 | 6,8 | Yankton |
| **Turkey Ridge Creek** | **Vermillion River** | **S31, T98N, R53W of the fifth principal meridian** | **6,8** | **Turner** |
| Camp Creek | Vermillion River | S6, T99N, R52W | 6,8 | Turner |

**Source:** SL 1975, ch 16, § 1; 4 SDR 32, effective December 4, 1977; transferred from § 34:04:04:24, effective July 1, 1979; 10 SDR 145, effective July 4, 1984; 13 SDR 129, 13 SDR 141, effective July 1, 1987; transferred from § 74:03:04:24, July 1, 1996, 24 SDR 10, effective July 20, 1997; 31 SDR 29, effective September 13, 2004.

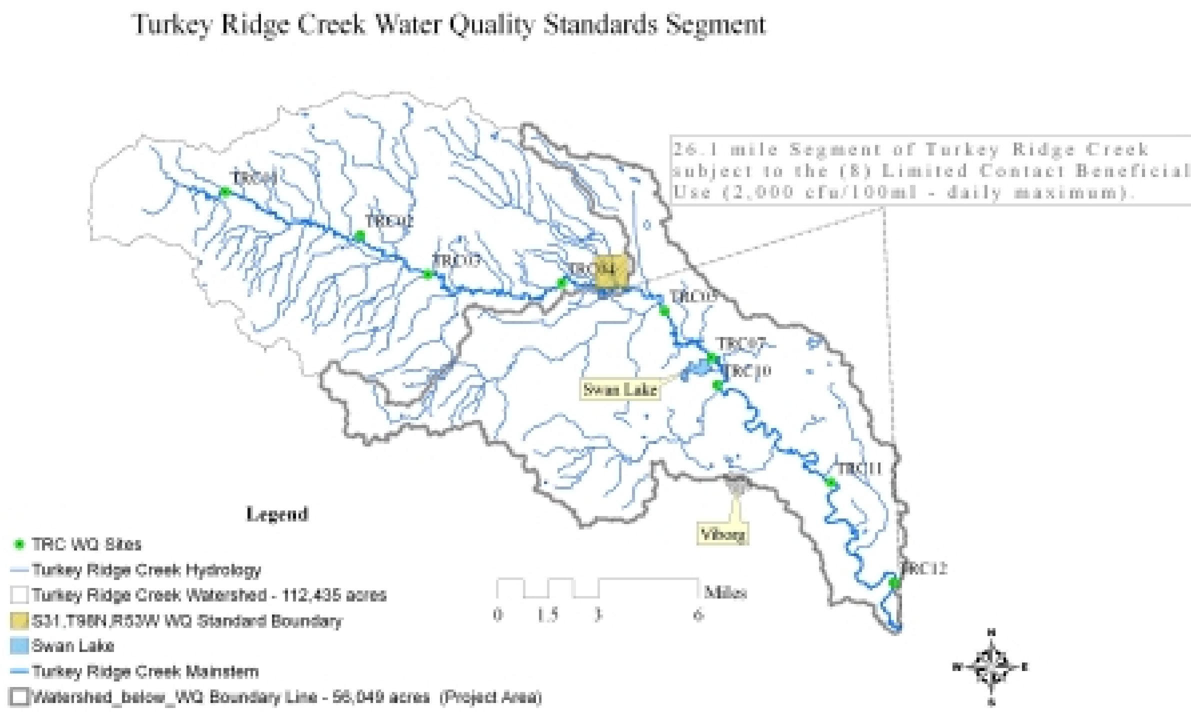



**Figure 2. Segment of Turkey Ridge Creek Subject to Warmwater Marginal and Limited Contact Beneficial Uses.**

### 1.1. General Watershed Description

The Turkey Ridge Creek watershed is approximately 112,435 acres (45,502 hectares) in size and lies within the Vermillion River Basin (Figure 1). Turkey Ridge Creek is a perennial, natural stream that flows northwest to southeast along the southern portion of Turner County. The creek drains into the Vermillion River near Centerville. There are also numerous intermittent tributaries which only carry water during spring snowmelt or rainfall events.

***Geology and Soils***

Based on the relative age of the landscape, the surficial character of the watershed can be divided into two parts. The Turkey Ridge Creek watershed is located in southern Turner County with the western and southern portions of the watershed lying in the James River Highlands division of the Central Lowlands physiographic province (Figure 3).

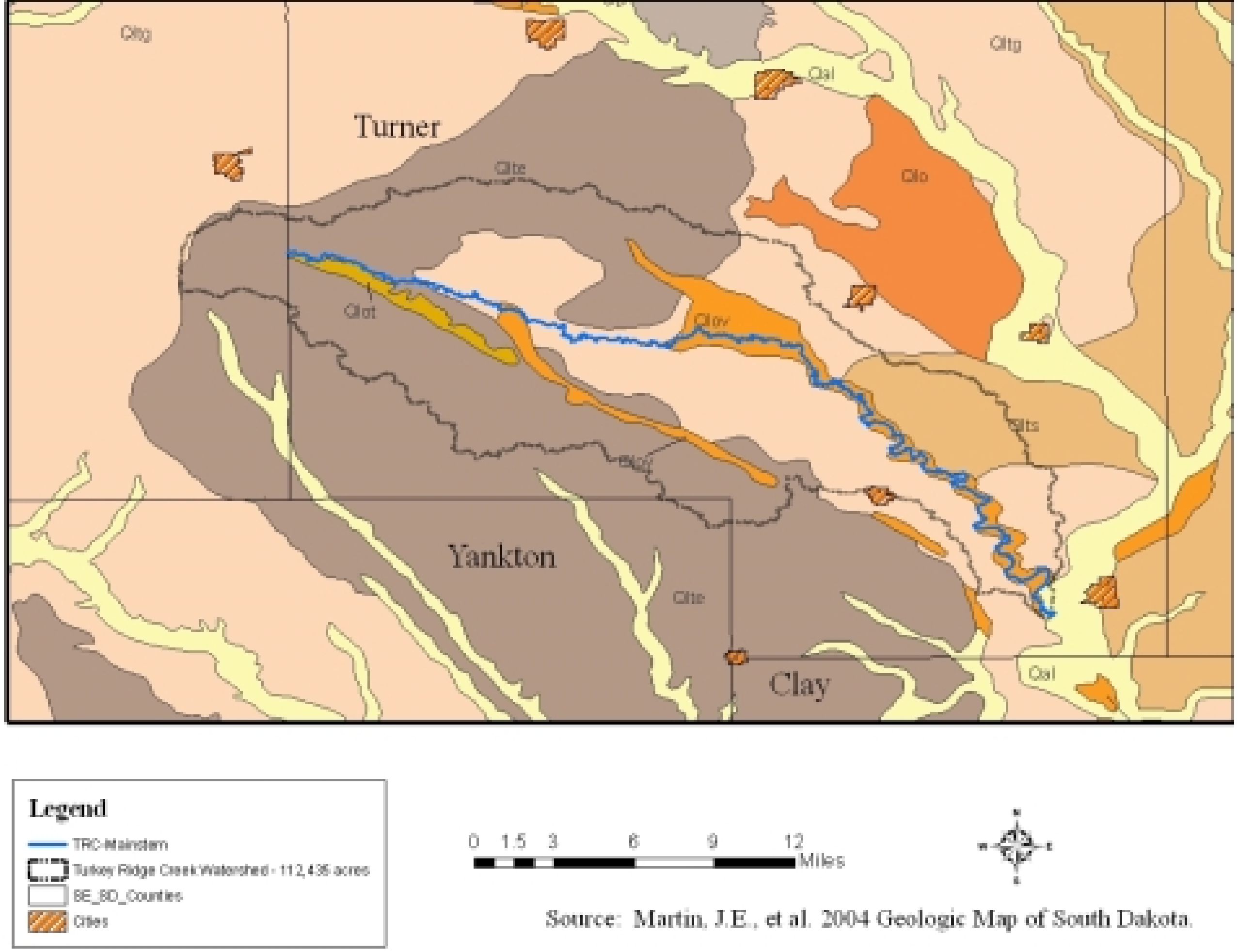



**Figure 3. 2004 Geologic Map of South Dakota.**

- Qal — **Alluvium** (Quaternary) - Clay- to boulder-sized clasts with locally abundant organic material. Thickness up to 75 ft (23 m).
- Qlov — **Outwash, valley train** (Upper Wisconsin) - Heterogeneous silt to gravel. Confined to valleys of glaciofluvial origin. Thickness up to 60 ft (18 m).
- Qlte — **Till, end moraine** (Upper Wisconsin) - Compact, silty, clay-rich matrix with sand- to boulder-sized clasts of glacial origin. A geomorphic feature characterized by elevated linear ridges with hummocky terrain locally at former ice sheet margins. Composite thickness of all Upper Wisconsin till may be up to 300 ft (91 m).
- Qlot — **Outwash, terrace** (Upper Wisconsin) - Heterogeneous clay to gravel of glaciofluvial origin. Thickness up to 60 ft (18 m).
- Qltg — **Till, ground moraine** (Upper Wisconsin) - Compact, silty, clay-rich matrix with sand- to boulder-sized clasts of glacial orgin. A geomorphic feature characterized by smooth, rolling terrain. Composite thickness of all Upper Wisconsin till may be up to 300 ft (91 m).
- Qlts — **Till, stagnation moraine** (Upper Wisconsin) - Compact, silty, clay-rich matrix with sand- to boulder-sized clasts of glacial orgin. A geomorphic feature characterized by hummocky terrain with abundant sloughs resulting from stagnation of ice sheets. Composite thickness of all Upper Wisconsin till may be up to 300 ft (91 m).

The central and eastern part of the watershed is located within the James Basin division of the Central Lowlands Province. The surficial sediments consist of Pleistocene glacial deposits of the Late Wisconsin ages (Figure 3). The landscape is an undulating, gently rolling glacial plane composed of glacial sediments (Christensen, et al., 1967). The two principal drainage areas in the southern portion of Turner County are Turkey Ridge Creek and Clay Creek (Turner County Soil Survey, 1980).

The relief in the area is moderate. Land elevation ranges greatly. The elevation is nearly 1,700 feet above mean sea level (msl) in the southwestern part of the study area where drainage flows to the northeast coming off “Turkey Ridge” which is part of the James River Highland. This is in contrast to the 1,200 feet msl where Turkey Ridge Creek merges with the Vermillion River near Centerville in the southeastern part of the watershed, part of the James River Lowland.

Recent alluvial deposits of clay, silt, sand, and gravel occur along both sides of Turkey Ridge Creek, all of which were primarily deposited during the late Wisconsin age. Major soil associations found in the watersheds include Clarno-Bonilla, Clamo-Lamo, Egan-Trent, Wentworth-Chandler-Wakonda, Egan-Ethan, and Roxbury-Davis-Chaska.

### *Ecoregion Description*

This 112,435-acre watershed lies within one level III ecoregion (Level III): Northern Glaciated Plains (NGP). Within the NGP, two of 15 level IV ecoregions are represented in the assessment area: Prairie Coteau and James River Lowland (Figure 4). Descriptions of the Level IV ecoregions are provided in Table 3.

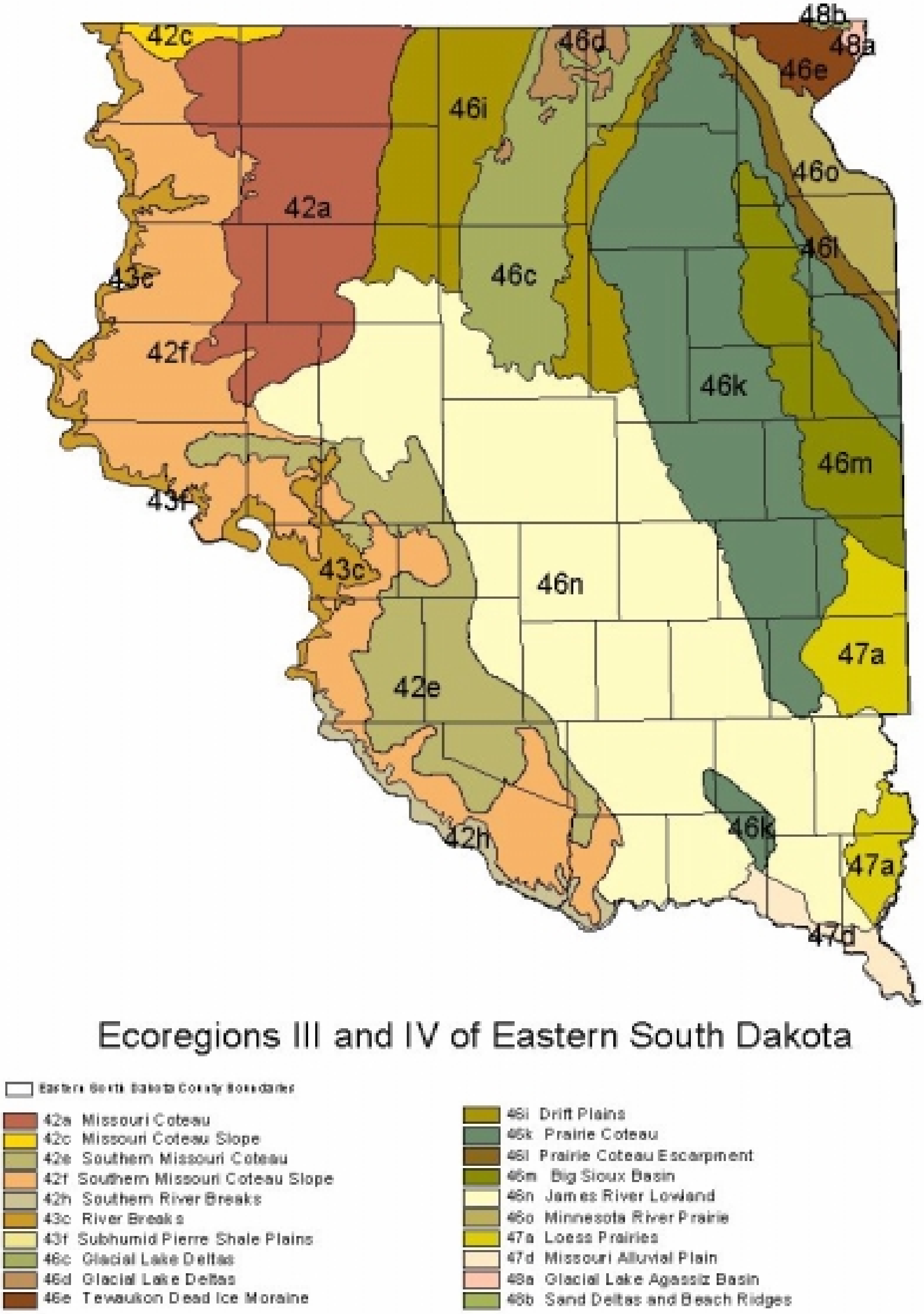



**Figure 4. Ecoregions III and IV of Eastern South Dakota**

**Table 3 . Ecoregions for the Turkey Ridge Creek Watershed.**

| *Level III Ecoregion 46. Northern Glaciated Plains* | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **Soil** | | | **Climate** | | | | |
| **Level IV Ecoregion** | **Physiography and Geology** | **Order (Great Groups)** | **Common Soil Series** | **Temperature / Moisture Regimes** | **Precipitation** (Mean Annual Inches) | **Frost Free** Mean Annual (days) | **Mean Temperature** Jan min/max; July min/max (°F) | **Potential Natural Vegetation** | ***Land Use and Land Cover*** |
| **46k. Prairie Coteau** (Area: 5,229 sq. miles) (Elevation/local Relief: 1500-2010 / 50-150) | Surficial geology of glacial till over Cretaceous shales. Hummocky, rolling landscape with high concentration of lakes and wetlands and poorly defined stream network. | Mollisols (Argiborolls, Haploborolls, Argiaquolls) | Forman, Aastad, Buse, Poinsett, Waubay, Parnell | Frigid/Udic | 20-22 | 110-140 | 1/21; 60/85 | Big bluestem, little bluestem, switchgrass, indiangrass, and blue gramma. | Rolling portions of landscape primarily in pastureland. Flatter portions of landscape in row crop, primarily of corn and soybeans. Some small grain and alfalfa. |
| **46n. James River Lowland** (Area: 9,227 sq. miles) (Elevation/local Relief: 1200-1850 / 10-150) | Surficial geology of glacial till over Cretaceous Pierre Shale and sandstone of Niobrara Formation. Rolling landscape with defined stream network and few wetlands. | Mollisols (Arglustolls, Haplustolls, Natrustolls) | Beadle, Dudley, Hand, Bonilla, Houdek, Prosper | Mesic | 18-20 | 115-120 | 1/22; 60/87 | Western wheatgrass, green needlegrass, big bluestem, blue grama. | Extensively tilled fro spring wheat, sunflower, corn, and soybeans. |

Source: Bryce, S.A., Omernik, J.M., Pater, D.A., Ulmer, M., Schaar, J., Freeouf, J., Johnson, R., Kuck, P., and Azevedo, S.H., 1996, Ecoregions of North Dakota and South Dakota, (color poster with map, descriptive text, summary tables, and photographs): Reston, Virginia, U.S. Geological Survey (map scale 1:1,500,000).

*Climate*

The average annual precipitation in for Turner County is 24.08 inches, of which 74 percent typically falls during the growing season of April through September (See Figures 4 and 5). Tornadoes and severe thunderstorms strike occasionally. These storms are often of only local extent and duration, and occasionally produce heavy rainfall events. The average seasonal snowfall for Turner County is 38 inches per year.

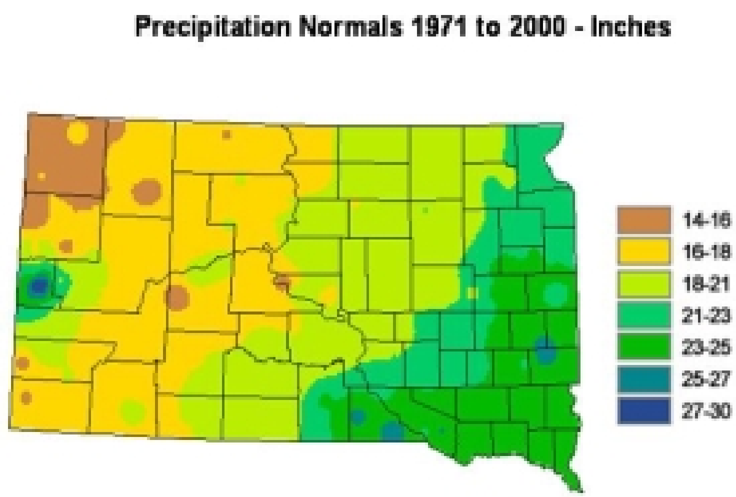



**Figure 5. South Dakota Precipitation Normals in Inches from 1971 to 2000**

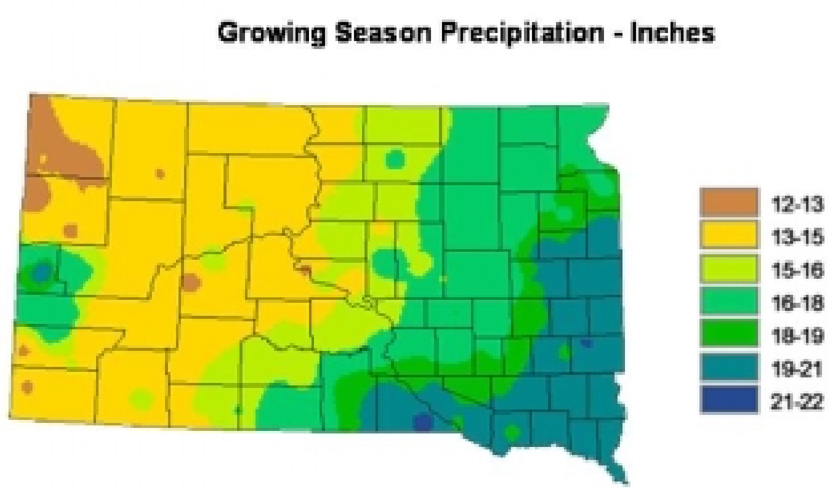



**Figure 6. South Dakota Growing Season Precipitation in Inches from 1971 to 2000**

### *Land Use*

The landuse within the watershed is predominately agricultural. Approximately 13% of the watershed is used for pasture and 85% consists of cropland (Figure 7-8). The over-grazed pastures are primarily located along the creek and livestock have direct access to the stream. According to the National Agricultural Statistics Service (NASS) in 2002 Turner County had approximately 139,000 livestock animals reported in the county (Table 4). During the assessment 129 animal feeding operation (AFOs) were identified in the watershed. The AFOs were modeled using the Agricultural Nonpoint Source (AGNPS) stand-alone feedlot model. The only National Pollution Discharge Elimination System (NPDES) permitted facilities within the watershed are the city of Viborg (pop. 832) and four confined animal feeding operations (CAFOs).

**Table 4. National Agricultural Statistics Service (NASS) Data for Turner County, SD, 2002 and Livestock determined through the AGNPS Feedlot Inventory for Turkey Ridge Creek Watershed .**

**LIVESTOCK INVENTORY**

| *Species* | *Number* |
|---|---|
| **All Cattle** 1/ | **55,000** |
| **Beef Cows** 1/ | **14,000** |
| **Milk Cows** 1/ | **5,900** |
| **Hogs & Pigs** 2/ | **48,108** |
| **All Sheep** 2/ | **16,495** |

**1/ Reference Date: January 1, 2003**

**2/ Reference Date: December 31, 2002; Source: 2002 Ag Census**

**CROP PRODUCTION - 2002** 1/

| *Commodity* | *Hvstd Acres* | *Yield* | *Production* | *Unit* |
|---|---|---|---|---|
| **Corn** | **138,500** | **105** | **14,561,000** | *bu* |
| **Soybeans** | **129,200** | **34** | **4,418,000** | *bu* |
| **All Wheat** | **1,000** | **43** | **43,000** | *bu* |
| **Winter Wheat** | **600** | **52** | **31,000** | *bu* |
| **Spring Wheat** | **--** | **--** | **--** | *bu* |
| **Oats** | **1,800** | **58** | **105,000** | *bushels* |
| **Alfalfa Hay** | **23,000** | **2.81** | **64,600** | *tons* |
| **Other Hay** | **7,000** | **1.40** | **9,800** | *tons* |
| **Sunflower** | **--** | **--** | **--** | *pounds* |

**5,602 acres were in the2002 Conservation Reserve Program**

**1/ Dashes indicate valid zeros or not published due to disclosure rules.**

**Livestock numbers from the AGNPS Feedlot Inventory, 2002**

| *Animal Type* | *Number* |
|---|---|
| **Beef Cow (Slaughter Steer)** | **4,040** |
| **Beef Cow (Young beef)** | **5,352** |
| **Dairy Cattle (Mature)** | **445** |
| **Dairy Cattle (Young)** | **315** |
| **Horse** | **3** |
| **Pig** | **490** |
| **Pig (Feeder)** | **690** |
| **Sheep/Goat** | **3,991** |
| **Total** | **15,326** |


**Figure 7. Turkey Ridge Creek Watershed landuse.**

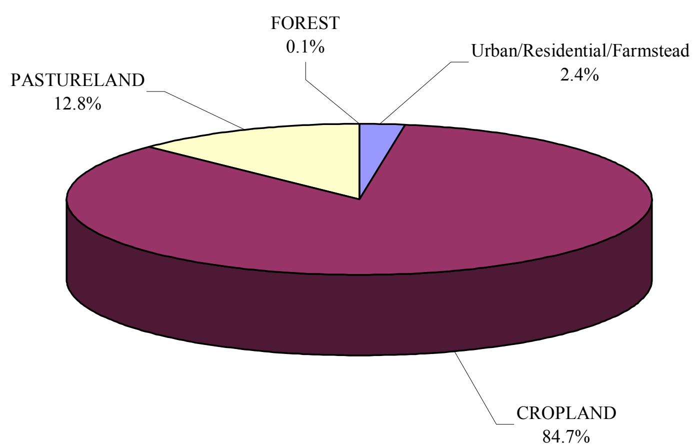



**Figure 8. Turkey Ridge Creek Watershed Landuse.**

### *Beneficial Uses*

The State of South Dakota has assigned all of the water bodies within its borders two or more of the possible 11 beneficial uses (ARSD 74:51:03:02). "Beneficial Use" can be defined as the purpose or benefit to be derived from a water body. Under state and federal law (ARSD 74:51:01:34), "The existing beneficial uses of surface waters of the state and the level of water quality that is assigned by designated beneficial uses shall be maintained and protected"; therefore, the beneficial use of a waterbody is to be protected from degradation. Two of the eleven beneficial uses are assigned to all streams: (9) fish and wildlife propagation, recreation and stock watering and (10) irrigation (ARSD 74:51:03:01). A set of water quality standards associated with each beneficial use are used to determine if the waterbody such as Turkey Ridge Creek is meeting or maintaining all of its assigned beneficial uses.

Turkey Ridge Creek is not part of the statewide monitoring network which contains 137 ambient monitoring sites. Turkey Ridge was listed in the 1998 303(d) impaired waterbody list with Swan Lake for total phosphorus and accumulated sediment. However, these two parameters were associated with the water quality impairments for Swan Lake and not necessarily for Turkey Ridge Creek specifically. It became the goal of the watershed assessment to determine if Turkey Ridge Creek was meeting all of its specific beneficial uses. The questions was "Is the limited contact beneficial use impaired by fecal coliform bacteria, sediment, or some other parameter listed in Table 5?". If so, what are the probable sources, i.e. irrigated cropland, overgrazed pastureland, and animal holding/management areas? Turkey Ridge Creek or segments of Turkey Ridge Creek have been assigned four (4) of 11 beneficial uses:

6) Warmwater marginal fish life propagation
8) Limited contact recreation
9) Fish & wildlife propagation, recreation & stock watering
10) Irrigation

Table 5 shows the numeric criteria assigned to the beneficial uses for Turkey Ridge Creek. Note that only a 26.1-mile segment of the entire 47.5-mile length of Turkey Ridge Creek has been assigned the Warmwater Marginal Fish Life and Limited Contact Recreational Uses (Figure 2, pg 5). Established narrative and numeric criteria are used to determine if the water quality of the stream is achieving full support of its assigned beneficial use.

Use support for limited contact recreation is determined by monitoring the levels of the various parameters outlined in Table 5. The fecal coliform standard is only applicable from May 1 through September 30 (Table 5). During 2002 and 2003, event-based and baseflow water quality samples were collected using SDDENR-Water Resources Assistance Program (WRAP) standard operating procedures (SOP). Exceedence of any parameter over the established concentration level were documented and a violation rate (percent) was calculated. Any violation rate exceeding a threshold of 10% (10% of 20 or more samples) would require the development of a TMDL for that parameter including fecal coliform. All parameters identified in ARSD 74:51 as part of the water quality criteria for (6) warmwater marginal fish life propagation and/or (8) limited contact recreation uses were assessed in this manner.

**Table 5. Numeric Criteria Assigned to Beneficial Uses of Surface Waters for Turkey Ridge Creek (ARSD 74:51:01).**

| Parameters (mg/L) except where noted | **6** Warmwater marginal fish life propagation | **8** Limited contact recreation | **9** Fish & wildlife propagation, recreation & stock watering | **10** Irrigation |
|---|---|---|---|---|
| Fecal Coliform (cfu[3] per 100 mL) May 1 - Sept. 30 | | ≤ 1,000 (mean) ≤ 2,000 (single sample) | | |
| Conductivity (µmhos/cm @ 25° C) | | | ≤ 4,000[1]/ 7,000[2] | ≤ 2,500[1]/ 4,375[2] |
| Total Ammonia Nitrogen as N, (Equations 1-4 in ARSD Chap. 74:51:01 | Equal to or less than the result from Equation 3 in Appendix A (5/1-10/31)[1]<br>Equal to or less than the result from Equation 4 in Appendix A (11/1-4/30)[1]<br>Equal to or less than the result from Equation 2 in Appendix A [2] | | | |
| Nitrogen, Nitrates as N | | | ≤ 50[1]/ 88[2] | |
| Dissolved oxygen | ≥ 4.0 | ≥ 5.0 | | |
| pH (standard units) | ≥ 6.0 - ≤ 9.0 | | ≥ 6.0 - ≤ 9.5 | |
| Suspended solids | ≤ 150[1]/ 263[2] | | | |
| Total dissolved solids | | | ≤ 2,500[1]/ 4,375[2] | |
| Temperature (°F) | ≤ 90 | | | |

Note: [1] 30-day average; [2] daily maximum; [3] colony forming units

## 1.2. Threatened and Endangered Species

Information from South Dakota Game, Fish and Parks, USGS, and the USFWS were used to construct the following table (Table 6) of the threatened and endangered species that may be found within the Turkey Ridge Creek watershed study area. Species status, within the study area is identified as endangered, threatened, rare, or candidate. The county in which each may be found is given, along with the occurrence of each. The Topeka Shiner (*Notropis topeka*) have been found in tributaries located in Turner County. The Bald Eagle and the Western Prairie Fringed Orchid, are listed by the USFWS as species that have historically been found to occur in the Vermillion River Basin where Turkey Ridge Creek is located and could possibly still be in the area. However, none of these species were encountered during the study.

**Table 6. Endangered, Threatened, and Candidate Species of the Turkey Ridge Creek Watershed Area**

U.S. Fish & Wildlife Service

*Mountain-Prairie Region*

South Dakota Ecological Services Field Office

## ENDANGERED SPECIES BY COUNTY LIST

(updated 15 August 2005)

## STATE: SOUTH DAKOTA

T - Threatened

E - Endangered

XN - Proposed/Experimental Population

CH - Critical Habitat

PCH - Proposed Critical Habitat

| COUNTY | GROUP | SPECIES | CERTAINTY OF OCCURRENCE | STATUS |
|---|---|---|---|---|
| TURNER | BIRD | EAGLE, BALD | KNOWN | T |
| | FISH | SHINER, TOPEKA | KNOWN | E |
| | PLANT | ORCHID, WESTERN PRAIRIE FRINGED[1] | POSSIBLE | T |

[1] The counties indicated for the Western Prairie Fringed Orchid are counties with potential habitat. Currently, there are no known populations of this species in South Dakota. Status surveys have been completed for the orchid in South Dakota. However, because of the ecology of this species, there is a possibility that plants may be overlooked.

Any corrections or additions to this list should be submitted to Charlene Bessken, U.S. Fish and Wildlife Service, South Dakota Field Office, Ecological Services, 420 South Garfield Avenue, Pierre, SD; Telephone (605)224-8693, ext. 31.

## 1.3. Project Goals, Objectives, and Milestones

***Goals***

This projects goal is to produce a TMDL for bacteria, nutrients, and sediment to improve the water quality by reducing nutrient and sediment loading of the streams. The project will produce information needed for planning an effective implementation project. Reducing nonpoint pollutants in the watershed will improve the water quality for the creek, improve habitat for upland and aquatic species and will improve the aesthetic value of Turkey Ridge Creek.

The goals of this assessment project are to:

1) Determine and document sources of impairments to Turkey Ridge Creek located in southern Turner County.
2) Determine timeframe during the course of the sampling year as to when the creek carries the lowest possible sediment load for the Swan Lake Diversion.
3) Identify feasible restoration alternatives to support watershed implementation projects to improve water quality impairments.
4) Develop a TMDL based on identified pollutants.

Impairments cited in the 1998 and the 2000 305(b) Water Quality Assessment Report and the 1998 South Dakota 303(d) Waterbody List for Swan Lake and Turkey Ridge Creek were accumulated sediment and nutrients.

Goals were accomplished through the collection of stream monitoring data and aided by the completion of the FLUX, EPA Bacterial Indicator Tool (developed by Tetra Tech, Inc.), and the Agricultural Non-Point Source (AGNPS) watershed modeling tools. Through data analysis and modeling, the identification of impairment sources occurred. The identification of these impairment sources will aid the implementation phase by allowing strategic targeting of funds to portions of the watershed that will provide the greatest benefit per expenditure.

***Objectives***

**Objective 1. Estimate the sediment and nutrient loadings from the individual tributaries in Turkey Ridge Creek Watershed Assessment through hydrologic, chemical and biological monitoring. The information will be used to locate critical areas in the watershed to be targeted for implementation.**

Water sampling and equipment installation began in October 2001. Only suspended sediment data was collected in the fall of 2001 near the proposed water diversion and Swan Lake (upstream and downstream of the proposed diversion site). In the spring of 2002 water quality and landuse data collection began on a watershed wide basis. This continued through September, 2003 (Table 7).

Detailed level and flow data were entered into a database that was used to assess the nutrient and solids loadings. Stevens Type F Stage Recorders, ISCO Automatic Samplers, as well as Nimbus

Bubble Sensor (OTT Hydrometry) were installed at the pre-selected monitoring sites along the mainstem of Turkey Ridge Creek.

**Objective 2. Ensure that all water quality samples are accurate and defendable through the use of approved Quality Assurance/Quality Control procedures.**

Duplicate and blank samples consisted of ten percent of all samples and were collected during the course of the project to provide defendable proof that sample data were collected in a scientific and reproducible manner. QA/QC data collection began with sample collection in October 2001 and continued throughout the project ending in October 2003.

**Objective 3. Evaluation of agricultural impacts to the water quality of the watershed through the use of the Annualized Agricultural Nonpoint Source (AnnAGNPS) model.**

The FLUX model was used to calculate loadings and concentrations in monthly, yearly, and daily increments. Reductions for TSS were acquired with the help of the FLUX model. After determining that a sediment TMDL was not required for Turkey Ridge Creek an Annualized AGNPS modeling run was not completed for Turkey Ridge Creek. This part of the project will be completed with the Vermillion River Basin Watershed Assessment which is currently underway. The sediment analysis for Turkey Ridge Creek will be completed in the context of the entire river basin to determine its impact relative to all other tributaries within the Vermillion River Basin. The AGNPS Stand-Alone Feedlot Model was used to characterize all animal feeding operations (AFO) with regard nutrient and solids runoff loads. Each AFO was given a pollutant severity rating which identify areas of concern in the watershed. Load duration intervals and hydrologic conditions were used to calculate fecal coliform loads and predict reductions to meet water quality standards.

**Objective 4. Public participation and involvement will be provided for and encouraged.**

The Turner Conservation and the Vermillion Basin Water Development District had several board meetings during the course of the project where project updates were given. One field trip was organized where knowledge about the project was provided as well as demonstrations about field operations. Assessments of the conditions of animal feeding operations located within the project area were conducted by contacting landowners individually. Press releases were also provided to local papers at various points throughout the project (see following page).

## Guest Editorial

### Medill explains water quality assessment project

My name is Cory Medill and I will be working for Turner Conservation District as the coordinator for the Turkey Ridge Creek water quality assessment project. I graduated from Northern State University in May with a degree in Environmental Science. After graduation I worked for South Brown Conservation District in Aberdeen where I gained experience with a similar project on Moccasin Creek.

The Turner Conservation District has elected to be the sponsor of the Turkey Ridge Creek assessment, which is one of many projects across the state. The purpose of this project is to determine the current status of water quality within the creek and to develop a list of recommendations to improve its water quality in the future. A post assessment project will potentially take place in the near future to implement as many conservation practices as possible to resolve the water quality issue. As areas with excess sediment and nutrients in runoff become evident, options for participation of conservation practices will be considered.

The water quality assessment study is a process that includes three basic steps. The first step is to determine the amount of water a stream carries. Once the volume of water is established, the maximum capacity for sediment and nutrients for that body of water can be determined. The next step is to collect a number of water samples from the stream to determine the amount of sediment and nutrients the stream currently carries via runoff from snow melt and/or rain events. The results from the first two steps will indicate the amount reduction in sediment and nutrients needed to obtain a healthy stream. The third step involves a computer model that simulates rain events and runoff to help determine where and how to lower the level of sediment and nutrients entering the stream.

One benefit as a result of this study is the funding that becomes available to Ag producers in the form of cost share to assist in the installation of conservation practices where they are needed. With the much-needed cooperation of the producers, the installation of the conservation practices will result in less sediment and pollutants entering the creek. Other benefits gained are the improvement of habitat for wildlife in the surrounding area, as well as the refined aesthetic value of Turkey Ridge Creek.

Funding for the project was supplied by U.S. Environmental Protection Agency Grant, South Dakota Department of Environment and Natural Resources funding, Vermillion Basin Water Development District funding, and Turner Conservation District funding. Other agencies that are assisting in the project are the Natural Resources Conservation Service and the Farm Service Agency.

The FSA office will be handing out questionnaires in regards to the project. Landowners and operators will receive this form when they certify with the FSA office. These completed questionnaires will supply information that is needed to make the project results as accurate as possible. The Cooperation of the landowners and operators is greatly needed and appreciated.

**Press Release circa March 2002**

**Objective 5. Development of watershed restoration recommendations.**

A waterbody listed on the state's 303(d) list must result in a TMDL for the pollutant of concern at levels that will allow the waterbody to meet water quality standards for the designated beneficial uses, shown in Table 5. A TMDL is a water quality target based on linkages between water quality conditions and point and non-points sources of pollution. Allowable levels of pollution are allocated to various point and nonpoint sources so that water quality standards are attainable. Areas exceeding allowable levels (or loadings) must be addressed in an implementation plan that identifies management actions that reduce loadings (1998 and 2002 SD 303(d) Waterbody List). An implementation plan can also call for protection of areas that are below allowable levels. Identifying the cause of the water quality impairment continues the circular process that placed the waterbody on the 303(d) list.

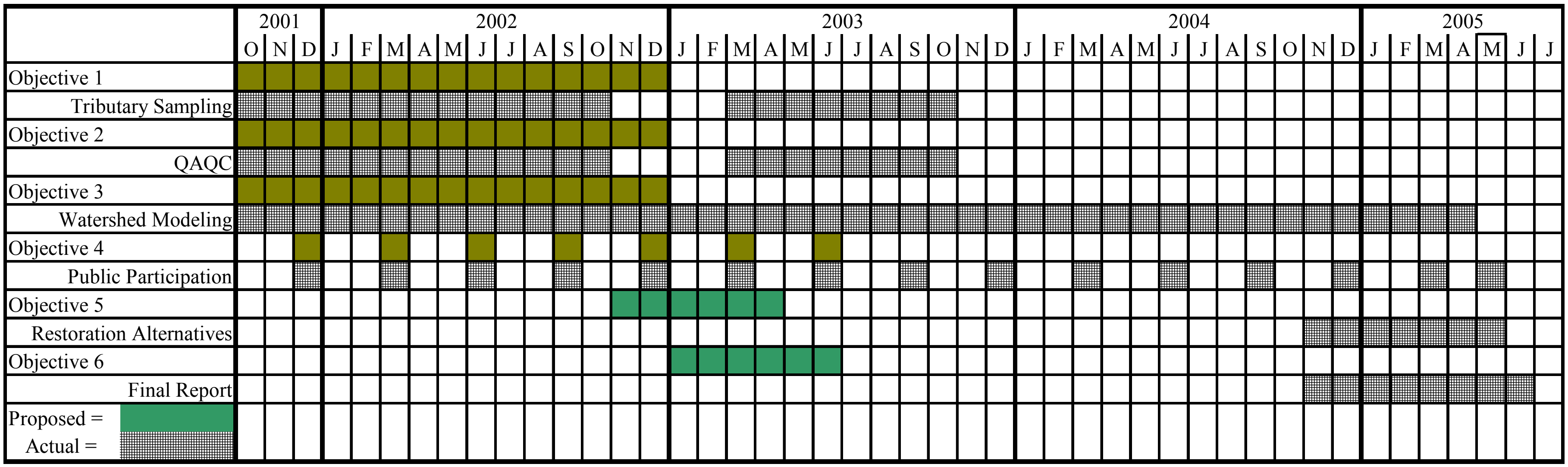
**Objective 6. Produce and publish a final report containing water quality results and restoration recommendations.**

***Milestones***

The Turkey Ridge Creek Watershed Assessment Project was started in October 2001 and proposed to be completed in December of 2002. However, due to a minimum number of storm events during 2002 the project was extended through October 2003. As a result of this extension all objectives fell behind schedule. The following table shows the proposed completion dates versus the actual completion dates of the project goals, objectives, and activities.

**Table 7. Milestones - Proposed and Actual Objective Completion Dates**

Turkey Ridge Creek Watershed Assessment
Turner Conservation District
Milestone Chart



## 2.0 METHODS

### 2.1. Water Quality Monitoring

Water samples were collected from nine sites located along the mainstem of Turkey Ridge Creek (Table 8 and Figure 9). The samples were scheduled for collection to coincide with spring runoff and storm events, and at base flow conditions. A total of 246 samples were collected over a two year period from October 2001 through October 2003. This included 19 samples where TSS was the only parameter collected, 13 blank samples, and 10 duplicate samples.

Field measurements included dissolved oxygen, pH, turbidity, air temperature, water temperature, conductivity, salinity, stage, and general climatic information. A YSI 600XL multiparameter probe meter was used to measure pH, dissolved oxygen (DO), water temperature, and conductivity.

The SD Department of Health Laboratory in Pierre performed analysis on all chemical and bacteria samples. A standard suite of chemical parameters included total solids, total suspended solids (TSS), ammonia, nitrate-N, total Kjeldahl nitrogen, organic nitrogen, total phosphorus, and total dissolved phosphorous, fecal coliform, and Escherichia Coli (E. Coli). Appendix B contains all grab sample data for each monitoring site.

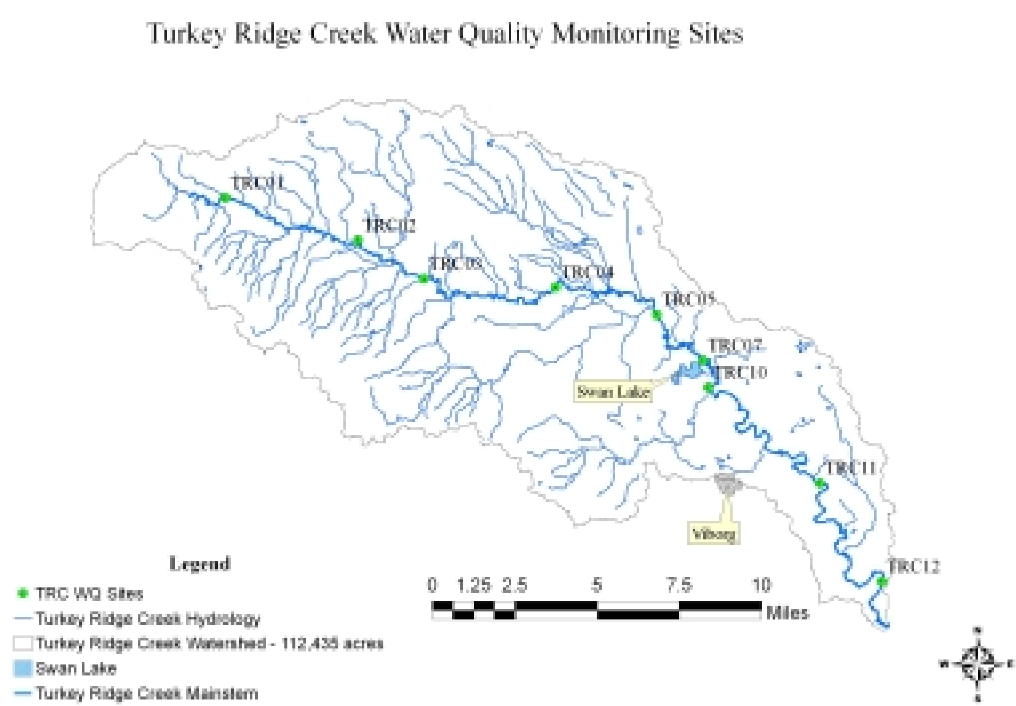



**Figure 9. Location of Turkey Ridge Creek Water Quality Monitoring Sites.**

**Table 8. Project Monitoring Locations and Equipment**

| SITE | LATITUDE | LONGITUDE | EQUIPMENT |
|---|---|---|---|
| TRC01 | 43.301707 | -97.378568 | Nimbus |
| TRC02 | 43.282062 | -97.29941 | Stevens |
| TRC03 | 43.264471 | -97.259648 | Nimbus |
| TRC04 | 43.259505 | -97.181013 | ISCO |
| TRC05 | 43.246571 | -97.12014 | Stevens |
| TRC07 | 43.226057 | -97.09139 | Stevens |
| TRC10 | 43.213845 | -97.090121 | Nimbus |
| TRC11 | 43.170494 | -97.02518 | Isco Bubbler |
| TRC12 | 43.126579 | -96.988255 | Nimbus |

### *Description of Parameters*

Water quality was sampled according to the SD protocols (Stueven et al. 2000). Water quality analyses provided concentrations for a standard suite of parameters (Table 9). The detection limits are set by the State Health lab based on equipment sensitivity.

**Table 9. Water Quality Parameters Analyzed and Laboratory Detect Limits**

| Parameter | Units | Lower Detect Limit |
|---|---|---|
| Total suspended solids | mg/L | N/A |
| Total solids | mg/L | N/A |
| Nitrate+Nitrite | mg/L | 0.002 |
| Ammonia-nitrogen | mg/L | 0.02 |
| Organic nitrogen | mg/L | 0.10 |
| TKN | mg/L | 0.10 |
| Total phosphorus | mg/L | 0.002 |
| Total dissolved phosphorus | mg/L | 0.002 |
| Fecal Coliform | cfu/100 mL | <1, <10, <100 |
| E. coli | Cfu/100 ml | <1, <10, <100 |

*Fecal Coliform Bacteria*

Fecal coliform are environmental bacteria which are indicators of possible sewage contamination, as they are commonly found in human and animal feces. They indicate the possible presence of pathogenic bacteria, viruses, and protozoans that also live in human and animal digestive systems. These bacteria can enter the river and tributaries by runoff from feedlots, pastures, sewage treatment plants, and seepage from septic tanks. Major sources in the Turkey Ridge Creek drainage are most likely livestock and possibly failing individual septic systems.

*Escherichia Coli (E.coli) Bacteria*

E. coli is a type of fecal coliform bacteria commonly found in the intestines of animals and humans. The presence of ***E. coli*** in water is a strong indication of recent sewage or animal waste contamination. Sewage may contain many types of disease-causing organisms. Fecal coliforms are bacteria that are associated with human or animal wastes. They usually live in human or animal intestinal tracts, and their presence in drinking water is a strong indication of recent sewage or animal waste contamination. During rainfalls, snowmelts, or other types of precipitation, ***E. coli*** may be discharged into creeks, rivers, streams, lakes, or groundwater. When these waters are used as sources of drinking water and inadequately treated, ***E. coli*** may appear in drinking water. ***E. coli*** O157:H7 is one of hundreds of strains of the bacterium ***E. coli***. Although most strains are harmless and live in the intestines of healthy humans and animals, this particular strain produces a powerful toxin and can cause severe illness. Infection often causes severe bloody diarrhea and abdominal cramps; sometimes the infection causes non-bloody diarrhea. Frequently, no fever is present. It should be noted that these symptoms are common to a variety of diseases, however, and may be caused by sources other than contaminated drinking water (Standard Methods, 18$^{th}$ ed., 1992).

*Total Solids*

Total Solids are materials, suspended or dissolved, present in natural water from both inorganic and organic sources. Total solids are derived from many different areas including industrial discharges, sewage, fertilizers, road runoff, and soil erosion, aquatic and terrestrial plant. “Total solids is the material residue left after evaporation of a water sample and its subsequent drying in an oven at a defined temperature” (Standard Methods, 18$^{th}$ ed., 1992).

*Total Suspended Solids*

TSS is the portion of total solids that are suspended and still in solution, whereas dissolved solids make up the remaining total. Suspended solids include silt and clay particles, plankton, algae, fine organic debris, and other particulate matter. Higher TSS can increase surface water temperature and decrease water clarity. Suspended solids are the materials that are too large to pass through a filter, e.g. sediment and algae.

*Volatile Suspended Solids*

Volatile suspended solids are that portion of suspended solids termed organic (organic matter that burns in a 500$^{o}$ C muffle furnace). Volatile solids have considerable error when used as an estimate of organic matter. More accurate assessments of organic matter versus inorganic can be made through total organic carbon, biological oxygen demand, and chemical oxygen demand (Standard Methods, 18$^{th}$ ed., 1992).

*Total Dissolved Solids*

Subtracting suspended solids from total solids was used to derive an estimate of total dissolved solids concentrations.

*Ammonia*

Ammonia is the nitrogen product of bacterial decomposition of organic matter and is the form of nitrogen most readily available to plants for uptake and growth. Sources of ammonia in the watershed may come from animal feeding areas, decaying organic matter, bacterial conversion of other nitrogen compounds, or industrial and municipal surface water discharges.

*Nitrate-Nitrite*

Nitrate and nitrite are inorganic forms of nitrogen easily assimilated by algae and other macrophytes. Sources of nitrate-nitrite can be from agricultural practices and direct input from septic tanks, precipitation, groundwater, and from decaying organic matter. Nitrate-nitrite can also be converted from ammonia through denitrification by bacteria. The process increases with increasing temperature and decreasing pH.

*Total Kjeldahl Nitrogen*

Total Kjeldahl Nitrogen (TKN) is used to calculate organic nitrogen. TKN minus ammonia derives organic nitrogen. Sources of organic nitrogen can include release from dead or decaying organic matter, septic systems or agricultural waste. Organic nitrogen is broken down to more usable ammonia and other forms of inorganic nitrogen by bacteria.

*Total Nitrogen*

Total nitrogen is the sum of nitrate-nitrite and TKN concentrations. Total nitrogen is used mostly in determining the limiting nutrient, either nitrogen or phosphorus. Nitrogen was analyzed in four forms: nitrate/ nitrite, ammonia, and Total Kjeldahl Nitrogen (TKN). From these four forms, total, organic, and inorganic nitrogen may be calculated. Nitrate and nitrite levels are usually caused from fertilizer application runoff. High ammonia concentrations are directly related to sewage and fecal runoff. Nitrogen is difficult to manage because it is highly soluble and very mobile in water.

*Total Phosphorus*

Phosphorus differs from nitrogen in that is not as water-soluble and will attach to fine sediments and other substrates. Once attached, it is less available for uptake and utilization. Phosphorus can be natural from geology and soil, from decaying organic matter, waste from septic tanks or agricultural runoff. Nutrients such as phosphorus and nitrogen tend to accumulate during low flows because they are associated with fine particles whose transport is dependent upon discharge (Allan 1995). These nutrients are also retained and released on stream banks and floodplains within the watershed. Phosphorus will remain in the sediments unless released by increased stage, discharge, or current.

*Total Dissolved Phosphorus*

Total dissolved phosphorus is the fraction of total phosphorus that is readily available for use by algae. Dissolved phosphorus will attach to suspended materials if they are present in the water column and if they are not already saturated with phosphorus. Dissolved phosphorus is readily available to algae for uptake and growth.

*Dissolved Oxygen*

Dissolved oxygen is important for the growth and reproduction of fish and other aquatic life. Solubility of oxygen generally increases as temperature decreases, and decreases with lowing atmospheric pressure. Stream morphology, turbulence, and flow can also have an affect on oxygen concentrations. Dissolved oxygen concentrations are not uniform within or between stream reaches. A stream with running water will contain more dissolved oxygen than still water. Cold water holds more oxygen than warm water. Dissolved oxygen levels of at least 4-5 mg/L are needed to support a wide variety of aquatic life. Very few species can exist at levels below 3 mg/L.

*pH*
pH is based on a scale from 0 to 14. On this scale, 0 is the most acidic value, 14 is the most alkaline value, and 7 represents neutral. A change of 1 pH unit represents a 10-fold change in acidity or alkalinity. The range of freshwater is 2-12. pH is a measure of hydrogen ion activity, the more free hydrogen ions (more acidic), the lower the pH in water. Values outside the standard (pH 6.0 – 9.5) do not meet water quality standards.

*Water Temperature*
Water temperature affects aquatic productivity and water chemistry, including the levels of DO and un-ionized ammonia. Temperature extremes are especially important in determining productivity of aquatic life from algae to fish.

*Conductivity*
Conductivity is the measurement of the conductive material in the sample without regard to temperature. In streams and rivers, conductivity is affected primarily by the geology of the area through which the water flows. Streams that run through areas with granite bedrock tend to have lower conductivity, and areas with clay soils tend to have higher conductivity. Discharges into streams can also change the conductivity. In general, a higher conductivity indicates that more material is dissolved material.

*Specific Conductivity*
Specific Conductivity is also known as temperature compensated conductivity where the reading is automatically adjusted to a standardized temperature of $25^{o}$ C. The ability of water to conduct an electrical current is the measure of the quantity of ions in the water, i.e. it is greatly effected by the presence of inorganic dissolved solids, such as salts. Specific conductivity can generally be related to the concentration of total dissolved solids (TDS) and salinity.

### *Sampling*

Samples were collected between Fall 2001 and Fall 2003 during base flows and storm events. Samples were collected using the SDENR-WRAP standard operating procedures for field sampling (SDDENR, 2003). Water samples were then filtered, preserved (if needed), and packed in ice for delivery to the State Health Laboratory. The chemical, physical, and biological parameters analyzed in each sample were shown in Table 9. Stream, climatic, and weather conditions were also recorded at the time of sampling.

### *Flow and Discharge Gaging*

Nine tributary monitoring sites were selected along the Turkey Ridge Creek and continuous stream flow records were collected using stage recorders. The sites were selected to determine which portions of the watershed were contributing the greatest amount of nutrient and sediment load to the creek. Three of the sites were equipped with Stevens Type F stage recorders, two of the sites had ISCO Automatic Samplers with 4230 flow meters, and the remaining sites had Nimbus bubbler surface water level hydrometers. Stream stages were monitored and recorded to the nearest $1/100^{th}$ of a foot for each of the sites. A USGS top setting wading rod with Marsh-McBirney current meter was used to determine flows at various stages.

Recorded stages and flows were used to create stage-discharge tables and curves for each site (Gordon et al. 1992). Stage to discharge tables, curves, and regression equations can be found in Appendix C.

### *Biological Monitoring*

The Turkey Ridge Creek watershed used the methods outlined in the approved SDDENR-WRAP SOP methods. At this time SDDENR does not have an established biological assessment and biotic index development framework. Biological monitoring was completed once for each of the nine monitoring sites during the Summer 2002 following SDDENR-WRAP biological monitoring protocols. With nine data points (one from each site) and without a biological reference network SDDENR was unable to develop a functional biotic index that incorporated various benthic macroinvertebrate metrics, which distinguished between impaired and least impaired habitat conditions. The Turkey Ridge Creek information with biological data collected during the Vermillion River Basin watershed assessment will result in a basin-wide biotic index used to identify impaired and unimpaired stream reaches.

### *Macroinvertebrate Sampling*

Sampling of macroinvertebrates with D-net kicknets (SDWRAP-SOP) occurred on nine monitoring sites from July 2002 to mid August 2002. Sorting, identification, and enumeration of macroinvertebrates occurred at the lowest practical taxonomic level. Econalysts, Inc. of Moscow, Idaho, was contracted to complete all laboratory work for the macroinvertebrates. Ecoanalysts were required to follow SDDENR-WRAP standardized laboratory procedures for the identification of benthic macroinvertebrates. Using the biological information in conjunction with water quality and visual habitat data sites (stream reaches) were ranked from least impaired to most impaired.

**Table 10. Macroinvertebrate Metrics Calculated for Turkey Ridge Creek and their response to perturbation.**

| Category | # | Metric | Response to Disturbance |
|---|---|---|---|
| **Abundance Measures** | 1 | Corrected Abundance | Variable |
| | 2 | EPT Abundance | Decrease |
| **Dominance Measures** | 3 | 1st Dominant Abundance | Increase |
| | 4 | 2nd Dominant Abundance | Increase |
| | 5 | 3rd Dominant Abundance | Increase |
| | 6 | % 1 Dominant Taxon | Increase |
| | 7 | % 2 Dominant Taxa | Increase |
| | 8 | % 3 Dominant Taxa | Increase |
| **Richness Measures** | 9 | Species Richness | Decrease |
| | 10 | EPT Richness | Decrease |
| | 11 | Ephemeroptera Richness | Decrease |
| | 12 | Plecoptera Richness | Decrease |
| | 13 | Trichoptera Richness | Decrease |
| | 14 | Chironomidae Richness | Decrease |
| | 15 | Oligochaeta Richness | Decrease |
| | 16 | Non-Chiro. Non-Olig. Richness | Decrease |
| | 17 | Rhyacophila Richness | Decrease |
| **Community Composition** | 18 | % Ephemeroptera | Decrease |
| | 19 | % Plecoptera | Decrease |
| | 20 | % Trichoptera | Decrease |
| | 21 | % EPT | Decrease |
| | 22 | % Coleoptera | Decrease |
| | 23 | % Diptera | Increase |
| | 24 | % Oligochaeta | Variable |
| | 25 | % Baetidae | Increase |
| | 26 | % Brachycentridae | Increase |
| | 27 | % Chironomidae | Increase |
| | 28 | % Hydropsychidae | Increase |
| | 29 | % Odonata | Decrease |
| | 30 | % Perlidae | Decrease |
| | 31 | % Pteronarcyidae | Decrease |
| | 32 | % Simuliidae | Increase |
| **Functional Group Composition** | 33 | % Filterers | Increase |
| | 34 | % Gatherers | Decrease |
| | 35 | % Predators | Variable |
| | 36 | % Scrapers | Decrease |
| | 37 | % Shredders | Decrease |
| | 38 | % Piercer-Herbivores | Decrease |
| | 39 | Filterer Richness | Decrease |
| | 40 | Gatherer Richness | Decrease |
| | 41 | Predator Richness | Decrease |
| | 42 | Scraper Richness | Decrease |
| | 43 | Shredder Richness | Decrease |
| | 44 | Piercer-Herbivore Richness | Decrease |
| **Diversity/Evenness Measures** | 45 | Shannon-Weaver H' (log 10) | Decrease |
| | 46 | Shannon-Weaver H' (log 2) | Decrease |
| | 47 | Shannon-Weaver H' (log e) | Decrease |
| | 48 | Margalef's Richness | Decrease |
| | 49 | Pielou's J' | Decrease |
| | 50 | Simpson's Heterogeneity | Decrease |
| **Biotic Indices** | 51 | Hilsenhoff Biotic Index | Increase |
| | 52 | Fine Sediment Biotic Index | Decrease |
| | 53 | FSBI - average | Decrease |
| | 54 | FSBI - weighted average | Decrease |
| | 55 | Temp. Pref. Metric - average | Decrease |
| | 56 | TPM - weighted average | Decrease |
| | 57 | DEQ MBI | Decrease |
| **Karr BIBI Metrics** | 58 | Long-Lived Taxa Richness | Decrease |
| | 59 | Clinger Richness | Decrease |
| | 60 | % Clingers | Decrease |
| | 61 | Intolerant Taxa Richness | Decrease |
| | 62 | % Tolerant taxa | Increase |

## 2.2. Physical Habitat

The following procedures for field measurements of the physical characteristics of wadeable streams were a synthesis of many sources, but the basic framework was adopted from Simonson et al. (1994) and Platts et al. (1983). The data are compatible with available physical assessments (Barbour et al. 1999; Stueven et al. 2000) and are now the approved methods for the SDDENR WRAP (SDDENR-WRAP, 2005). A list of terms and definitions are provided in Appendix H to aid use of the following procedures.

Near each monitoring site, a reach was selected with one type and intensity of riparian landuse, and where bridges and dams appeared to have minimal impact. Data collection consisted of five components: physical, discharge, water surface slope, water quality, and reach classification.

***Habitat Assessment***

Field measurements of physical characteristics using a transect method were adapted from Simonson et al. (1994) and Platts et al. (1983). Data collected is also provided in Appendix H. Reaches were selected within one type of riparian land use in most cases, and where bridges and dams appeared to have minimal impact. Once a reach was selected, a preliminary mean stream width (PMSW) was obtained and used to determine transect spacing (Simonson et al. 1994). When low flows restricted stream width to a small portion of the streambed, streambed width was used to determine transect spacing. Transects were marked with flags, then data collection was conducted from upstream to downstream.

Transect data collection were divided into three practical components based on tools used. The first suite of data was collected according to visual estimates and counts. On either end of a transect the riparian land use, dominant vegetation type, animal vegetation use, dominant bank substrate, and bank slumping (presence/absence) were recorded. Where a transect crossed the stream, dominant macrohabitat type was designated as pool, riffle, or run. Bed substrate data was collected using the Wolman "pebble count" by visually dividing the transect into eight "cells." Within each cell, substrate size was measured and the class size recorded. This method objectively classified substrates in clear streams and was a necessity in turbid streams where visual estimates were not possible (Wolman 1954).

A second suite of data focused on stream bank and riparian features and was measured with a graduated pole and angle finder. After identifying the break point between the channel bank and channel bottom, measurements related to stream bank length, bank angle, and bank height were taken (Figure 10). Along the stream bank length, the length of bank that was vegetated, eroded, and depositional was measured. Vegetated portions were that length of bank where root structure contributed to bank stability, eroded portions were that length with no root structure support, and depositional portions were that length where recent deposition dominated the bank surface. Riparian-related cover types were measured at the end of each transect as the horizontal length of overhanging vegetation (OHV) and undercut bank (UCB) extending over the streambed.

A third suite of data focused on horizontal and vertical point measurements which were used to calculate stream width, depth and velocity; channel bottom and top width; and bankfull width, depth, and width:depth ratio. At most sites, point data were obtained by staking a tape measure from left top bank to the right top bank. In some cases, the tape measure was staked at left bankfull and right bankfull. Moving from left to right, key channel features (i.e., location codes) were identified and the distance from the left stake was recorded. Vertical measurements were bankfull depth, water depth, and water velocity. Bankfull depths were measured at the water edge and at three points within the stream. Water depth and velocity were measured at the three points within the stream (1/4, 1/2, and 3/4 of the distance across the stream surface).

At each site, data were also collected on large woody debris (LWD), discharge, water surface slope, and water quality. The number of LWD was tallied for the entire reach. Length, diameter, and angle to streambank measurements of all LWD were measured and used to calculate the volume of LWD within the reach. Discharge data were collected at a single transect or other stream cross-sections where flow was uniform. The velocity-area method described in Gordon et al. (1992) was used. Water surface slope (%) was calculated by dividing the drop in water surface from transect one to transect 13 by the longitudinal stream distance using a surveying level.

Water quality data measured included water temperature, air temperature, turbidity, pH, dissolved oxygen, and conductivity. These measurements were taken once at each reach.

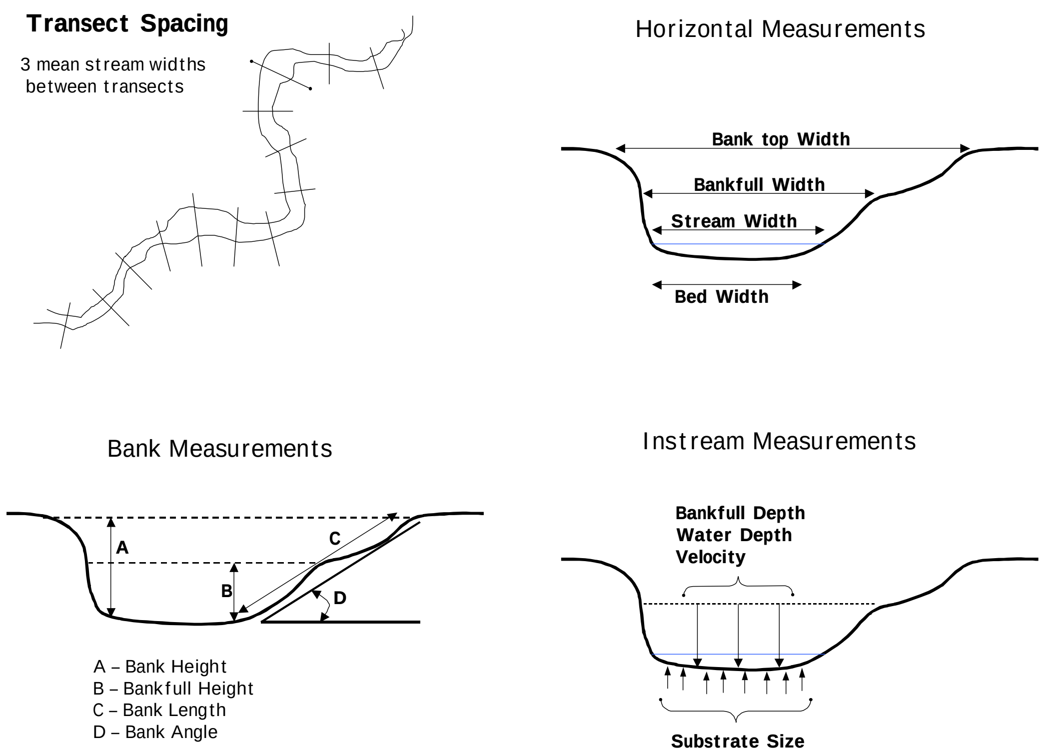



**Figure 10. Diagrams of Transect Spacing, Horizontal, Bank, and Instream Measurements**

### *Index of Physical Integrity (IPI)*

The physical habitat index for Turkey Ridge Creek used the same methods and parameters as outlined in the Central Big Sioux Watershed Assessment final report (EDWDD, In Press). The IPI was developed using EPA's Rapid Bioassessment of substrate, channel morphology, bank structure, and riparian vegetation (Barbour et al. 1999). Parameters and scoring of each site was modified to suit this project. Table 12 outlines the parameters and the score assigned to each rating. The information collected on the field data sheets from each monitoring site was used to rate the site individually using the eight parameters.

Scores ranged from 0 to 100. After each site was scored, a standardized metric score that was based on 'best value' was calculated and served as the final index value for that site as shown (Table 13).

From the sample listed below, the Centerville site scored a 65.5. This was repeated for each site that had a physical habitat assessment field data sheet. Since there were no reference sites on which to base the information, the 95$^{th}$ percentile score of each metric based on all monitoring sites was made the standard upon which to base each metric score. The following calculation was used to find the metric score for each of the eight physical habitat parameters shown in Table 12.

**Table 11. Sample Score Sheet for Physical Habitat**

| | **SiteID:** Example | **Site Name:** Centerville |
|---|---|---|
| | **Parameter** | **Score** |
| 1 | Channel Flow Status (10) | 10 |
| 2 | Hydrologic Complexity (10) | 10 |
| 3 | CV of Velocity (10) | 5 |
| 4 | Bed Composition (20) | 8 |
| 5 | Channel Incision (10) | 10 |
| 6 | Bank Stability (20) | 15 |
| 7 | Overhanging Vegetation (10) | 0 |
| 8 | Animal Vegetation Use (10) | 7.5 |
| | **Total =** | **65.5** |

### *Table 12. Parameters and Scores Used to Rate the Physical Habitat Measurements*

| Physical Parameter | Rating | | | | |
|---|---|---|---|---|---|
| | **Very Good** | **Good** | **Fair** | **Poor** | **Very Poor** |
| **1. Channel Flow Status** | Perennial streamflow. Water surface reaches base of both lower banks, and minimal amount of channel substrate is exposed. | Perennial streamflows. Water surface covers <100% but >75% of the available channel bottom. | Perennial streamflows. Water surface covers 50-75% of the available channel bottom. | Perennial streamflows. Water surface covers >50% of the available channel bottom. | Average Stream Width about 1/3 channel bottom width. Intermittent. |
| **SCORE** | **20** | **15** | **10** | **5** | **0** |
| **2. Physical Complexity** | high | high/moderate | moderate | moderate/low | low |
| | ≥8 hydrologic units, usually at least 3 riffles present | 6 to 7 hydrologic units, usually 2 to 4 riffles present | 4 to 5 hydrologic units, usually 1 to 3 riffles present | 2 to 3 hydrologic units, usually 0 to 1 riffles present | 1 hydrologic units, no riffles present |
| **SCORE** | **10** | **7.5** | **5** | **2.5** | **0** |
| **3. Coefficient of Variation of Velocity** | ≥1.2 | 0.9 to 1.2 | 0.6 to 0.9 | 0.3 to 0.6 | <0.3 |
| **SCORE** | **10** | **7.5** | **5** | **2.5** | **0** |
| **4. Bed Composition** | ≥ 75% gravel and larger | ≥ 75% gravel and sand (at least 50% gravel) | ≥ 75% coarse gravel, sand, and silt | ≥ 75% sand and silt (at least 50% sand) | > 75% silt or smaller |
| **SCORE *** | **16** | **12** | **8** | **4** | **0** |
| * Add 4 points if cobble size and larger comprise 10% of substrate | | | | | |
| **5. Measure of Incision** | Mean Bank Full Height is ≥70% of mean Bank Height. | Mean Bank Full Height is ≥60 to 69% of mean Bank Height. | Mean Bank Full Height is ≥50 to 59% of mean Bank Height. | Mean Bank Full Height is ≥40 to 49% of mean Bank Height. | Mean Bank Full Height is <40% of mean Bank Height. |
| **SCORE** | **10** | **7.5** | **5** | **2.5** | **0** |
| **6. Bank Stability** | >80% bank vegetated; the remaining erosional or depositional. | ≥60 to 80% bank vegetated; the remaining erosional or depositional. | ≥40 to 60% bank vegetated; the remaining erosional or depositional. | ≥20 to 40% bank vegetated; the remaining erosional or depositional. | <20% bank vegetated; the remaining erosional or depositional. |
| **SCORE** | **20** | **15** | **10** | **5** | **0** |
| **7. Overhanging Vegetation** | Average amount ≥0.5 m | ≥0.3 - 0.49 m | ≥0.2 - 0.29 m | ≥0.1 - 0.19 m | <0.1 m |
| **SCORE** | **10** | **7.5** | **5** | **2.5** | **0** |
| **8. Animal Vegetation Use** | No Use: All the potential plant biomass is present. | Light Use: Almost all of the potential plant biomass is present. | Moderate Use: About 1/2 of plant biomass is present. Plant stubble about half potential height. | High Use: Less than 1/2 of plant biomass is present. Plant stubble greater than 2 inches. | Very High Use: Nearly all plant biomass removed. Plant stubble less than 2 inches. |
| **SCORE** | **10** | **7.5** | **5** | **2.5** | **0** |

(measured metric value) ÷ (standard best value) × 100 = standardized metric score

The final index value was found by averaging the eight standardized metric scores. The values range from 0 (very poor) to 100 (excellent). Standardized data for each site can be found in Appendix H.

**Table 13**. Sample Final Score Sheet for Physical Habitat

| **Site Example** | | | | |
|---|---|---|---|---|
| **Metric** | **Percentile for "best" value** | **Standard (best value)** | **Measured metric value** | **Standardized Metric score** |
| Channel Flow Status | 95th | 10 | 10 | 100 |
| Physical Complexity | 95th | 10 | 10 | 100 |
| CV of Velocity | 95th | 10 | 5 | 50 |
| Bed Composition | 95th | 18 | 8 | 44 |
| Measure of Incision | 95th | 10 | 10 | 100 |
| Bank Stability | 95th | 20 | 15 | 75 |
| Overhanging Vegetation | 95th | 7.5 | 0 | 0 |
| Animal Vegetation Use | 95th | 10 | 7.5 | 75 |
| | | Final index value for this site: | | **68** |

## 2.3. Quality Assurance and Data Management

Quality Assurance/Quality Control (QA/QC) samples were collected for at least 10% of the samples taken. A total of 246 water samples were collected from nine monitoring sites. Total QA/QC samples were 23, with 10 being duplicates and 13 blanks.

QA/QC results were entered into a computer database and screened for errors. Significant differences between the original samples and the duplicates can be explained by the variation within stream and downstream transport mechanisms, especially fecal coliform counts.

A consistent problem was identified with blank samples between the field and laboratory for dissolved phosphorus. The deionized-distilled water source is the probable culprit. A new water source has been found and is in compliance with SDDENR-WRAP QAQC requirements. Quality assurance/Quality Control data can be found in Appendix D.

## 2.4. Modeling

The modeling methods shown in Table 14 were all used as part of the Turkey Ridge Creek Watershed Assessment.

**Table 14. Modeling and Assessment Techniques and Outputs Used for the TRC Assessment.**

| Modeling Technique | Outputs |
|---|---|
| Bacterial Indicator Tool | used here to estimate potential daily accumulation rates from diffuse nonpoint sources and daily loading rates from direct nonpoint sources for fecal coliform bacteria |
| FLUX Model | Loadings for WQ Parameters |
| | Concentrations for WQ Parameters |
| Flow Duration Interval Zones | Hydrologic Condition Targets and Loads<br>% reduction for fecal coliform bacteria |
| AGNPS - Feedlot Rating Model | Total P & N, chemical oxygen demand (COD), and a feedlot rating |
| **Assessment Technique** | **Outputs** |
| Physical Assessment | Index of Physical Integrity (IPI) |
| Biological Assessment | Macroinvertebrate Metrics |

### *Bacterial Indicator Tool*

***Point Sources - Wastewater Treatment Facilities (NPDES)***

Data for the only permitted NPDES facility (Viborg ~pop.832) was obtained from DENR (Surface Water Quality Program) in Pierre. The data was reviewed and calculation of their contributions was made and added to all other possible sources of bacteria.

The NPDES facilities taken into consideration within this watershed include four concentrated animal feeding operations (CAFOs) and one municipal wastewater treatment facility. The City of Viborg discharged from the wastewater lagoons during the study period, but this occurred outside the applicable period for the fecal coliform standard (May 1 – September 30) (Surface Water Quality, 2005). The contribution from the City of Viborg wastewater treatment facility (WWTF) should they have to discharge during May 1 to September 30 was considered as part of the potential sources in the Turkey Ridge Creek Watershed. The 2,000 cfu daily maximum (1,000 geometric mean from 5 samples collected over five 24-hour periods) would have to be maintained during the discharge period. The CAFOs do not discharge at any time and constitute 0% of the direct total fecal loadings to Turkey Ridge Creek.

To estimate the possible percent contribution for the City of Viborg should a discharge event occur during May 1 – September 30 a daily fecal coliform loading rate was calculated by using: 1) the total storage capacity of the sewage lagoons from the city of Viborg, and 2) using the 2,000 cfu/day daily maximum allowable as the maximum possible concentration for fecal coliform.

***Nonpoint Sources – Direct and Diffuse Sources***

The Bacterial Indictor Tool was used to allocate all possible sources for fecal coliform bacteria in the Turkey Ridge Creek Watershed with the exception of the point sources (NPDES). This spreadsheet tool estimates contributions from a variety of sources and was used to potential daily bacterial loadings from these sources (EPA, 2002). The output from the Bacterial Indicator Tool is primarily used as input file for the WinHSPF and the Hydrological Simulation Program Fortran (HSPF) water quality model within BASINS. This tool is used here to estimate potential daily accumulation rates from diffuse nonpoint sources and daily loading rates from direct nonpoint sources for fecal coliform bacteria in the Turkey Ridge Creek Watershed

Bacterial contributions from four landuse types were estimated using this tool. Cropland, built-up (urban or suburban), forest and pastureland areas (acres) were estimated by using GIS coverages assembled by the Farm Services Agency (USDA-FSA). Using this GIS coverage, acreages were calculated for each of the different landuse types within the 112,435-acre Turkey Ridge Creek Watershed.

Maximum storage of fecal coliform bacteria on land uses and their percent contribution by month for the period May 1 to September 30 were calculated using accumulation and dieoff bacterial equations developed by Horsely & Whitten (1986). The Bacterial Indicator User Manual is located in Appendix E.

A potential daily loading rate (cfu/day) was also determined from direct and diffuse nonpoint sources and added to the point sources. The percent contribution for each source was calculated from the total daily fecal loading rate for the period (May 1 – September 30).

### *FLUX Model*

Total nutrient and sediment loads were calculated with the use of the Army Corps of Engineers Eutrophication Model known as FLUX (Walker, 1999). FLUX uses six calculation methods to calculating loadings. The FLUX model uses individual sample data combined with daily discharges for each calculation method. Loadings of total suspended solids, as well as other water quality parameters, were calculated with the model for each monitoring location. The data inputs result in a coefficient of variation (CV) statistic for each of the six calculation methods as well as the loadings and concentrations. It is important to stratify the data by flow or date so that there is a convergence of the CV values. This reduces the potential error/bias in the calculation giving a higher degree of accuracy in the loading result. The results from each method used for each parameter for each monitoring site are located in Appendix F.

Water quality analyses provided concentrations for a standard suite of parameters previously mentioned. Continuous streamflow records for tributary sites were derived using stage records and stage-discharge curves with regression analysis (Appendix C).

### *Load Duration Curves*

Load duration curves were constructed for all the Turkey Ridge Creek monitoring sites to use as a tool for differentiating pollutant problems over an entire flow regime. These curves represent the percentage of time during which a permissible load, which is based on water quality standards, is equaled, or exceeded.

Load duration curves are developed using an average daily, long-term record of stream flow. Typically longterm discharge from the USGS is required to develop a load duration curve. Although Turkey Ride Creek is not monitored by the USGS the two years of gauging data collected from the nine monitoring stations did provide enough data and variation within the data to calculate individual load duration curves for each station. The method recommended in Dr. Cleland's 2004 load duration training workshop and used for the Willamette River Basin Bacteria TMDL in Oregon (comparison of historic flow data sets) was used to compare the 2-years of discharge from Turkey Ridge Creek to the nearest USGS gauging station with a drainage area of similar size. However, using the USGS data as a surrogate for long-term data was unsuccessful. As a result only the two years of data collected during the project was used, but flows fluctuated dramatically between 2002 and 2003 as shown in Figure 11.

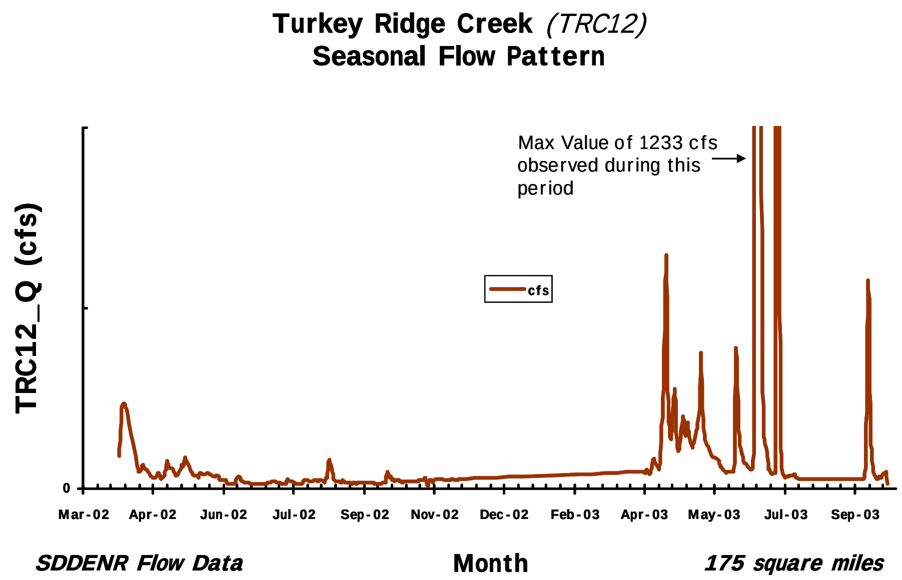



**Figure 11. 2002-2003 Flow Comparison for Turkey Ridge Creek.**

Daily average flows over the 2-year period were ranked from highest to lowest. The percent of days each flow was exceeded was calculated by dividing each rank by the number of flow data points.

rank ÷ number of data points = percent of days the flow was exceeded

Next, the load was calculated. This was done by multiplying each average daily flow by the water quality standard for the parameter and multiplying by the conversion factor.

flow (cfs) × standard (mg/L) × conversion factor = load

The conversion factor for converting the mg/L to pounds per day for TSS is 5.396, as shown by the following formula:

$$\frac{\text{mg}}{\text{L}} \times \frac{1\ \text{L}}{.0353146667\ \text{ft}^3} \times \frac{86400\ \text{sec}}{1\ \text{day}} \times \frac{\text{ft}^3}{\text{sec}} \times \frac{1\ \text{lb}}{453592.37\ \text{mg}} = \text{lbs/day}$$

The conversion factor for converting cfu/100mL to colonies per day for fecal coliform bacteria is 24,468,480 as shown by the following formula:

$$\frac{\text{col}}{\text{day}} \times \frac{28320\ \text{mL}}{1\ \text{ft}^3} \times \frac{86400\ \text{sec}}{1\ \text{day}} \times \frac{\text{ft}^3}{\text{sec}} = \text{col/day}$$

The actual load duration curve is formed by plotting the load against the percent days flow exceeded (NDEP, 2003). To plot the grab sample data, a daily load for each sample is calculated. The stream flow for each day is found and the value for percent of days that load exceeded from the previous data (Figure 12). The loads and percent days exceeded are plotted.

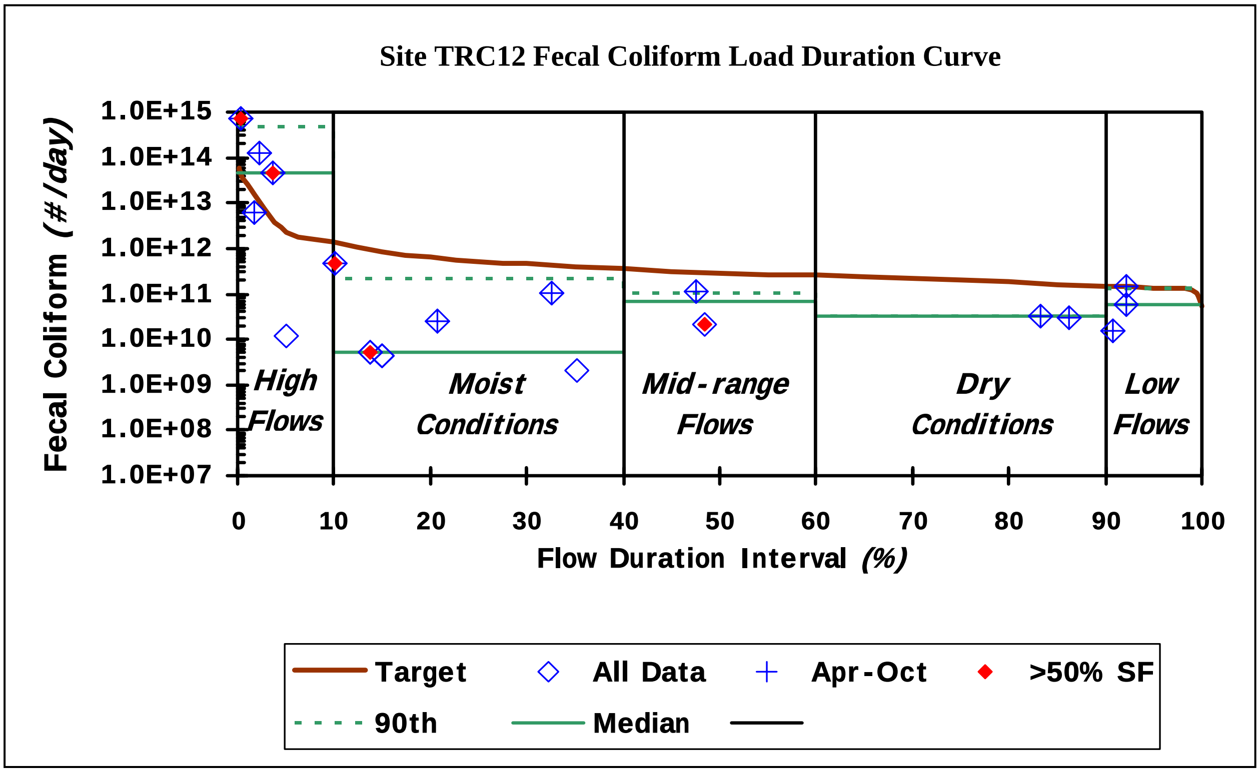



**Figure 12. Example of a Load Duration Curve.**

Flow duration intervals using flow duration curve zones in conjunction with fecal coliform or E. coli bacteria concentrations were used to set TMDL water quality goals for Turkey Ridge Creek. This method calculates fecal coliform bacteria "load" by multiplying (concentration) x (flow) within zones based on hydrologic conditions and the medians of the fecal coliform bacteria grab sample data. By defining hydrologic conditions, specific restoration efforts were targeted for that zone (Cleland, 2003). The five hydrologic conditions are (1) High Flows (0-10%), (2) Moist Conditions (10-40%), (3) Mid-Range Flows (40-60%), (4) Dry Conditions (60-90%), and (5) Low Flows (90-100%) (Figure 12). For example, if several samples exceeded the target load during dry conditions, restoration efforts may be targeted at instream livestock, riparian areas, or discharges from industries as they ae a more probable source during base flows. This is further defined and explained in the Summary and Conclusion Section.

Two major accumulations of data were used to calculate reductions: (1) discharge data, and (2) water quality samples. Appendix I contains fecal coliform data and flow frequency spreadsheets. Figure 12 – see previous graph is an example of a flow duration interval, separated into zones, with seasonal fecal grab samples plotted. Seasonal months include May, June, July, August, and September.

The target line was graphed along 21 points using percentiles of the target load at matching flows. Similarly, grab samples were plotted using the instantaneous flow at the time the sample was taken. Medians, 90th percentiles, and whether or not the sample was collected at or above 50% of the stormflow, were calculated, per zone, for grab sample data.

To find the percent reduction per hydrologic condition, the median of the allowable load within a hydrologic zone (target) was divided by the median of the sampled load at that particular hydrologic condition (site value) and then subtracted from 1.

1 – [(Target) ÷ (Site Value)] = % reduction

Table 15 shows an example of these calculations. Reduction calculation tables for all the monitoring sites can be found in Appendix G. When considering management options for fecal coliform bacteria reductions, these tables will be useful in targeting those hydrologic conditions exceeding their allowable loads.

**Table 15. Sample of Fecal Coliform Bacteria Reduction Calculation Results**

| Station ID: | TRC12 | | | | |
|---|---|---|---|---|---|
| Station name: | Turkey Ridge Creek near Centerville, SD | | | | |
| 174.5 | = Drainage Area (square miles) | | | | |
| Flow Zone → | High | Moist | Mid | Dry | Low |
| Median Flow (cfs) | 46.33 | 10.75 | 5.64 | 4.05 | 2.68 |
| Median Runoff (mm/day) | 0.251 | 0.058 | 0.031 | 0.022 | 0.015 |
| Target Load (cfu/day) | 2.27E+12 | 5.26E+11 | 2.76E+11 | 1.98E+11 | 1.31E+11 |
| Actual Load (cfu/day) | 4.64E+13 | 5.11E+09 | 6.80E+10 | 3.15E+10 | 6.01E+10 |
| Reduction | 95.1% | -10197.6% | -306.0% | -528.5% | -118.5% |

### *AGNPS Feedlot Model*

The Agricultural Non-Point Source (AGNPS) Stand-Alone feedlot model is a water quality model that predicts non-point source pollutant loadings from feedlots and produces a rating based on those loadings. A feedlot with a rating of zero has zero pollution potential whereas a feedlot with a rating of 100 had a very severe rating relative to pollution potential. Watersheds dominated by agricultural land uses, pasturing cattle in stream drainages, runoff from manure application, and runoff from concentrated animal feeding operations can influence fecal coliform bacteria concentrations. The AGNPS feedlot assessment assumed the probable sources of fecal coliform bacteria loadings were related to agricultural land use (upland and riparian), use of streams for stock watering, and animal feeding operations.

## 3.0 RESULTS

### 3.1. Water Quality Monitoring

The data was evaluated based on the specific criteria that DENR developed for listing water bodies in the 1998 and 2002 South Dakota 303(d) Waterbody List. Use support was based on the frequency of exceedences of water quality standards (if applicable) for the following chemical and field parameters. A stream segment with only a slight exceedence (10% or less violations for each parameter) is considered to meet water quality criteria for that parameter. The EPA established the following general criteria in the 1992 305(b) Report Guidelines (SDDENR 2000) suitable for determining use support of monitored streams.

| | |
|---|---|
| Fully supporting | ≤ 10 % of samples violate standards |
| Not supporting | > 10 % of samples violate standards |

This general criteria is based on having 20 or more samples for a monitoring location. Many of the monitoring sites were sampled less than 20 times. For those monitoring sites with less than 20 samples, the following criteria will apply:

| | |
|---|---|
| Fully supporting | ≤ 25 % samples violate standards |
| Not supporting | > 25 % of samples violate standards |

To determine use support for the fish life propagation beneficial use primarily involved monitoring levels of the following major parameters: dissolved oxygen, unionized ammonia, water temperature, pH, and suspended solids. For the limited contact recreation beneficial use involved monitoring the levels of fecal coliform bacteria (May 1 – September 30) and dissolved oxygen. If more than one beneficial use is assigned for the same parameter (i.e. fecal coliform bacteria) at a particular monitoring site, the more stringent water quality criteria will apply. The use support for each monitoring sites is discussed in subsequent sections. The results for all parameters, nutrient and solids loadings, and biological data are summarized in the following sections for all of the Turkey Ridge Creek monitoring sites.

***Chemical Parameters***

***Fecal Coliform Bacteria***

Fecal coliform ranged from a minimum of <10 cfu/100ml found at least once at every site to a maximum of 1,060,000 cfu/100ml (Site TRC03) (Table 16). Only a 26.1 mile segment of Turkey Ridge Creek is subject to the beneficial use (8) Limited contact recreation (Figure 2 pg 5). This segment includes only monitoring Sites TRC05-TRC12. However, there is a significant number of elevated coliform concentrations that occurred upstream of Site TRC05. Improper application of manure as fertilizer or various animal feeding operations located in this part of the watershed that may be part of the problem. Although there were some violations during base flow conditions, the vast majority of the water quality violations occurred during storm events. Because of the transport mechanisms from the upper to the lower part of the watershed, bacterial loadings during high flow storm events are very difficult to manage. Natural buildup of bacteria occurs across the landscape from wildlife and other sources. The daily maximum concentration (2,000 cfu/100ml) was used to determine the number of violations as there were not enough samples collected to determine a geometric mean which requires a minimum of five samples collected during separate 24 hour periods (1,000 cfu/100ml).

Site TRC03 exhibited significantly higher mean and median concentration (1,000 cfu/100ml) as well as the largest concentration collected during the project period. The median, which is middle value when the data is ranked highest to lowest, is used as a measure of the central tendency of the data and are used to compare between sets of data. Although Site TRC03 exhibited higher concentrations a Kruskal-Wallis nonparametric analysis indicated no significant differences between sites $H(8, N=170, P>0.05)$. There were higher concentrations observed at all of the monitoring sites indicating that coliform sources are a watershed wide problem.

**Table 16. Summary Statistics for Fecal Coliform, Turkey Ridge Creek.**

| Site | N | Mean | St Dev | Variance | Min | Max | Median | N>2,000 cfu/100ml | Violation Rate |
|---|---|---|---|---|---|---|---|---|---|
| TRC01 | 20 | 4194.05 | 11682.8 | 1.36E+08 | 10 | 50000 | 425 | 3 | 15.0% |
| TRC02 | 18 | 27771.11 | 90127.6 | 8.12E+09 | 10 | 380000 | 635 | 6 | 33.3% |
| TRC03 | 19 | 69033.16 | 241562.7 | 5.83E+10 | 10 | 1060000 | 1000 | 8 | 42.1% |
| TRC04 | 20 | 4145.50 | 11425.9 | 1.30E+08 | 10 | 50000 | 800 | 5 | 25.0% |
| TRC05 | 19 | 7922.63 | 29604.2 | 8.76E+08 | 10 | 130000 | 430 | 5 | 26.3% |
| TRC07 | 20 | 4540.00 | 9089.6 | 8.26E+07 | 10 | 31000 | 200 | 4 | 20.0% |
| TRC10 | 14 | 4438.57 | 7856.1 | 6.17E+07 | 10 | 24000 | 795 | 5 | 35.7% |
| TRC11 | 18 | 1745.00 | 2684.6 | 7.20E+06 | 10 | 9000 | 460 | 5 | 27.8% |
| TRC12 | 22 | 5082.73 | 12209.3 | 1.49E+08 | 10 | 44000 | 440 | 4 | 18.2% |
| Samples collected within 26.1 mile stream segment where limited contact recreation beneficial use (8) water quality criteria applies (Sites TRC05-TRC12) | | | | | | | | 23 | 24.7% |

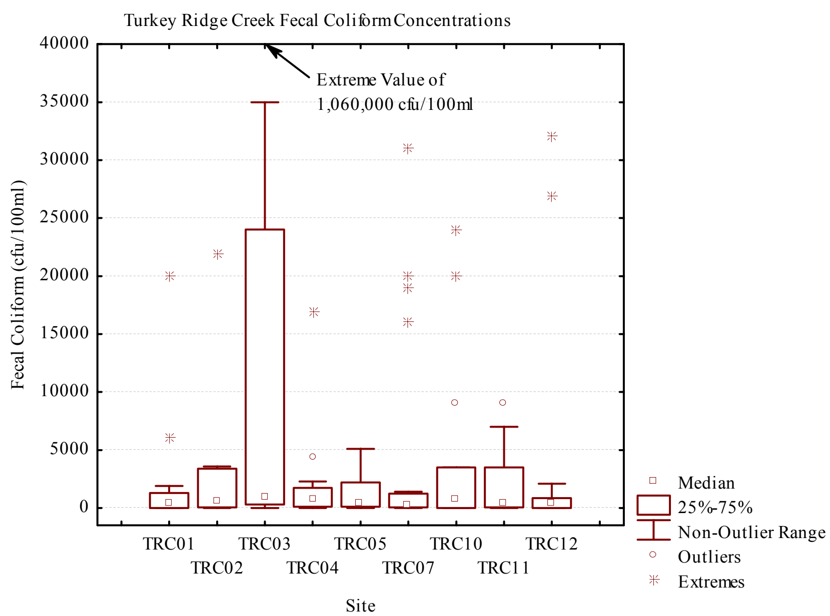



**Figure 13. Site vs. Fecal Coliform Boxplots.**

### *Total Solids*

Total solids ranged from a minimum of 667 mg/L (Site TRC12) to a maximum of 5,536 mg/L (Site TRC04) (Figure 14 and Table 17). The lowest mean and median were calculated from data collected from TRC10 located just downstream from the Swan Lake outlet.

Kruskal-Wallis Analysis indicated no significant differences between sites (d.f.=8,n=163, P>0.05).

There is no standard or assigned beneficial use for this parameter.

**Table 17. Summary Statistics for Total Solids, Turkey Ridge Creek.**

| Site | N | Mean | St Dev | Variance | Minimum | Maximum | Median |
|---|---|---|---|---|---|---|---|
| TRC01 | 19 | 1626 | 362.5 | 131396.1 | 794 | 2093 | 1717 |
| TRC02 | 19 | 1605 | 333.0 | 110911.8 | 941 | 2012 | 1689 |
| TRC03 | 18 | 1655 | 362.6 | 131486.5 | 916 | 2110 | 1728 |
| TRC04 | 19 | 1929 | 924.9 | 855519.1 | 1024 | 5536 | 1716 |
| TRC05 | 18 | 1719 | 444.8 | 197831.8 | 811 | 2466 | 1742 |
| TRC07 | 19 | 1674 | 469.4 | 220378.8 | 944 | 2502 | 1772 |
| TRC10 | 13 | 1535 | 464.1 | 215365.0 | 903 | 2340 | 1550 |
| TRC11 | 17 | 1788 | 484.7 | 234943.1 | 926 | 2535 | 1844 |
| TRC12 | 21 | 1592 | 518.1 | 268476.3 | 667 | 2444 | 1701 |

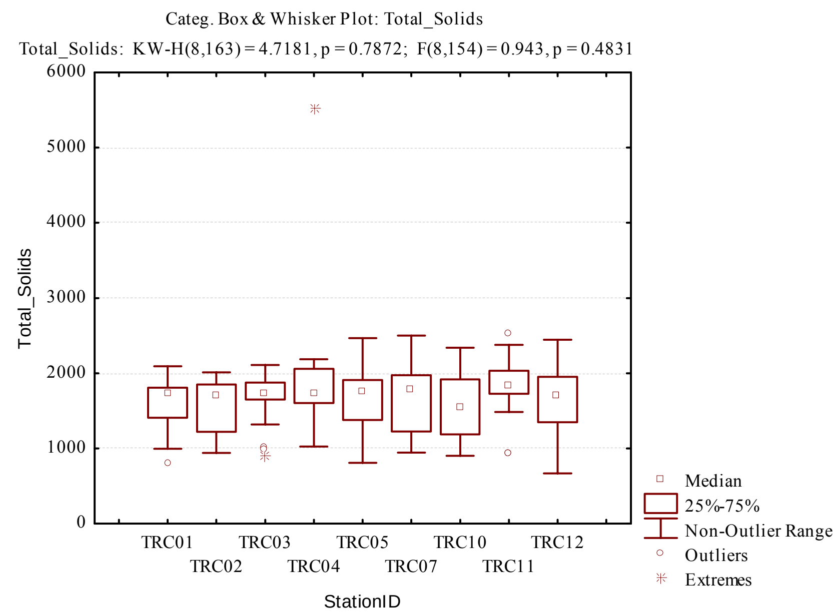



**Figure 14. Site vs. Total Solids Boxplots.**

### *Total Suspended Solids*

Total suspended solids ranged from a minimum of 2 mg/L (Site TRC01 and TRC07) to a maximum of 552 mg/L which was observed from Site TRC11(Table 18 and Figure 15). The lowest mean and median were both observed from Site TRC01, and were 24 and 18 mg/L, respectively (Table 18). Site TRC11 exhibited the highest mean and median, 114 and 78 mg/L, respectively (Table 18).

The 263 mg/L daily maximum TSS concentration observed in a single grab sample was used to determine the percent violations and assess for the beneficial use support of (6) Warm Water Marginal Fish Life Propagation for the lower 26.1 miles of Turkey Ridge Creek. This includes Site TRC05-TRC12. Based on the data collected in the segment of Turkey Ridge Creek subject to the TSS water quality standard is fully supporting of this parameter and beneficial use. This tributary is part of the Vermillion River Watershed Assessment. The Vermillion River is currently not supporting the criteria involved with the beneficial use (5) Warmwater Semipermanent Fish Life Propagation. Although Turkey Ridge Creek is meeting its assigned beneficial it may be impacting the Vermillion River. The Vermillion River Watershed Assessment will determine if Turkey Ridge Creek will require sediment reductions in order for the Vermillion River to fully support its beneficial uses.

A Kruskal-Wallis Nonparametric Statistical analysis indicated a significant difference between the following sites at the $p<0.05$ level: TRC01 was significantly different TRC05, TRC11, TRC12 and TRC05 was significantly different from TRC10 (d.f.=8,n=197, p=0.004) (Figure 15).

Concentrations from Sites TRC05, TRC06, TRC07, and TRC10 were pooled together and analyzed for seasonal trends. The seasonal information indicated the best times of the year to divert water from Turkey Ridge Creek into Swan Lake (Figure 16). Starting in the fall (late-September) total suspended solids significantly decrease and then increase in the spring (March).

**Table 18. Summary Statistics for Total Suspended Solids, Turkey Ridge Creek.**

| Site | N | Mean | Median | Std.Dev. | Variance | Min | Max | N>263 mg/L | Violation Rate |
|---|---|---|---|---|---|---|---|---|---|
| TRC01 | 19 | 24 | 18 | 25.7 | 658.5 | 2 | 114 | 0 | 0.0% |
| TRC02 | 19 | 44 | 27 | 48.4 | 2344.0 | 5 | 176 | 0 | 0.0% |
| TRC03 | 18 | 73 | 34 | 97.8 | 9573.7 | 7 | 400 | 1 | 5.6% |
| TRC04 | 19 | 82 | 35 | 118.2 | 13975.8 | 7 | 504 | 1 | 5.3% |
| TRC05 | 18 | 93 | 64 | 74.7 | 5580.9 | 19 | 244 | 0 | 0.0% |
| TRC07 | 36 | 65 | 26 | 94.7 | 8964.7 | 2 | 360 | 2 | 5.6% |
| TRC10 | 30 | 66 | 19 | 106.1 | 11247.1 | 3 | 364 | 3 | 10.0% |
| TRC11 | 17 | 114 | 78 | 135.3 | 18317.6 | 8 | 552 | 2 | 11.8% |
| TRC12 | 21 | 88 | 50 | 90.6 | 8201.9 | 14 | 356 | 1 | 4.8% |
| Samples collected within 26.1 mile stream segment where Warmwater Marginal Fishery beneficial use (8) water quality criteria applies (Sites TRC05-TRC12) | | | | | | | | 8 | 6.6% |

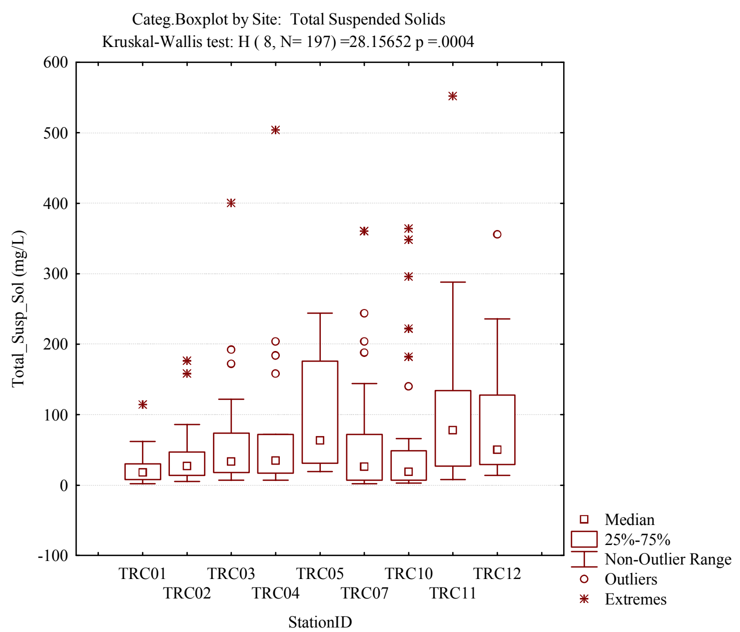



**Figure 15. Site vs. Total Suspended Solids Boxplots.**

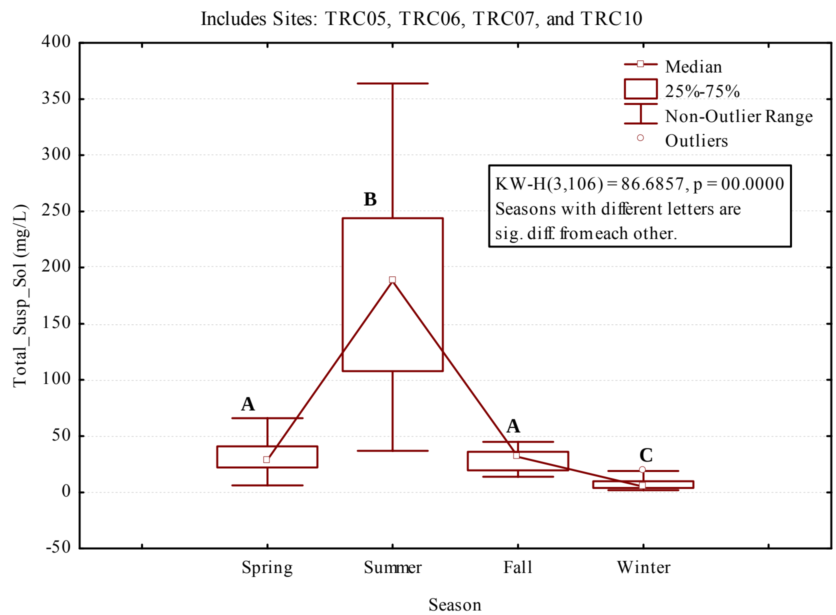



**Figure 16. Seasonal Boxplots for Total Suspended Solids.**

### *Total Dissolved Solids*

TDS ranged from a minimum of 311 mg/L (TRC12) to a maximum of 5,513 mg/L (TRC04), which can be classified as an extreme observation (Figure 17). The lowest mean was1,399 mg/L (TRC10) and the highest mean was 1,847 mg/L (TRC04). The lowest median of 1,202 mg/L was also calculated from Site TRC10 whereas the highest median of 1,741 mg/L was calculated from Site TRC11 (Table 19).

A single grab sample daily maximum of 4,375 mg/L was used to determine the percent violations and assess for the beneficial use support of (9) Fish and Wildlife, Propagation, Recreation and Stock Watering for all nine sites. The maximum value of 5,513 mg/L, which was collected during baseflow, was the only violation documented during the study. The concentration of 5,513 could be an indication of an influence of groundwater in the Turkey Ridge Creek hydrologic system.

A nonparameteric Kruskal-Wallis analysis on total dissolved solids concentrations indicated no significant differences between monitoring locations (d.f.=8, n=163, p>0.05).

**Table 19. Summary Statistics for Total Dissolved Solids, Turkey Ridge Creek.**

| StationID | N | Means | Median | Std.Dev. | Variance | Minimum | Maximum | Standard >4,375mg/L* |
|---|---|---|---|---|---|---|---|---|
| TRC01 | 19 | 1601 | 1702 | 366 | 134279.9 | 789 | 2073 | 0 |
| TRC02 | 19 | 1561 | 1663 | 356 | 126994.8 | 783 | 1995 | 0 |
| TRC03 | 18 | 1582 | 1706 | 419 | 175276.9 | 516 | 2099 | 0 |
| TRC04 | 19 | 1847 | 1709 | 958 | 917787.6 | 950 | 5513 | 1 |
| TRC05 | 18 | 1626 | 1666 | 489 | 239468.1 | 615 | 2447 | 0 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| TRC07 | 19 | 1563 | 1570 | 517 | 266786.2 | 584 | 2480 | 0 |
| TRC10 | 13 | 1399 | 1202 | 540 | 291476.6 | 539 | 2274 | 0 |
| TRC11 | 17 | 1674 | 1741 | 562 | 316077.1 | 389 | 2510 | 0 |
| TRC12 | 21 | 1504 | 1642 | 555 | 307937.2 | 311 | 2391 | 0 |
| * Beneficial Use (9) Fish an Wildlife Propagation, Recreation, and Stock Watering | | | | | | | | |

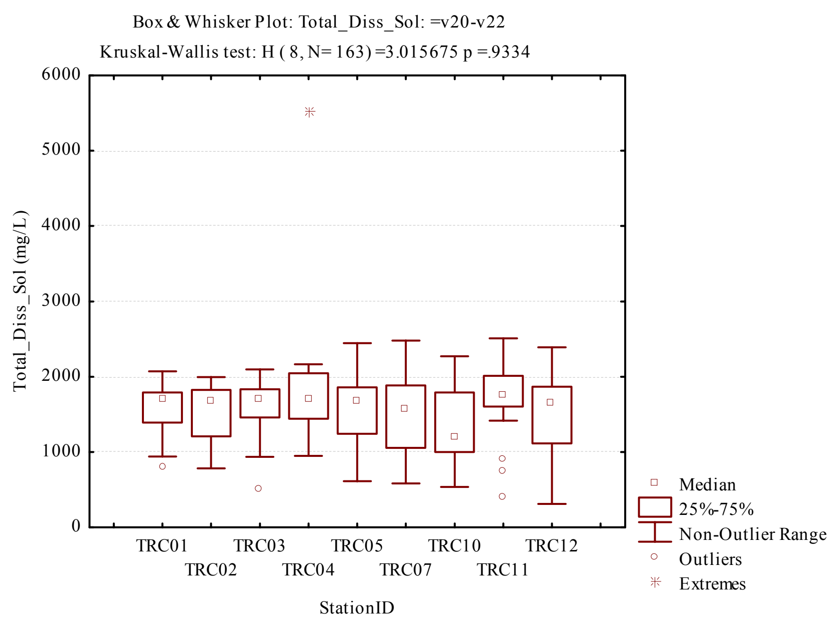



**Figure 17. Site vs. Total Dissolved Solids Boxplots.**

***Total Volatile Suspended Solids***

Volatile suspended solids estimates the amount of organic matter present in the solid fraction. There is no water quality standard associated with this parameter. The minimum concentration was observed at several sites whereas the maximum concentration of 108 mg/L was collected from Site TRC04. As is indicated on Table 20, the mean and median concentrations were higher in the downstream sites. The longitudinal changes/inputs that occur along the creek result in more organic matter in downstream areas because of transport from the upper reaches (headwaters) as well that derived from within the stream (autochothonous sources). This is part of the river continuum concept which describes the changes in a stream/river that occur over a longitudinal gradient (Vannote, et. al, 1980). There is also a strong seasonal difference with volatile suspended solids. Figure 19 shows that during the productive summer period VTSS concentrations are significantly higher when compared to the other two seasons where data was collected (df=2,n=170, $p<0.05$).

No significant differences were detected using a Kruskal-Wallis nonparametric analysis (n=8, d.f.=7, $p>0.05$).

**Table 20. Summary Statistics for Volatile Suspended Solids, Turkey Ridge Creek.**

| StationID | N | Means | Median | Std.Dev. | Variance | Minimum | Maximum |
|---|---|---|---|---|---|---|---|
| TRC01 | 19 | 11.7 | 5.0 | 22.5 | 507.0 | 1.00 | 102 |
| TRC02 | 19 | 10.0 | 6.0 | 10.7 | 113.4 | 1.00 | 40 |
| TRC03 | 18 | 15.8 | 7.5 | 22.4 | 502.3 | 1.00 | 96 |
| TRC04 | 19 | 16.2 | 9.0 | 23.6 | 556.8 | 2.00 | 108 |
| TRC05 | 18 | 18.3 | 9.0 | 17.4 | 304.5 | 4.00 | 60 |
| TRC07 | 19 | 24.1 | 14.0 | 22.3 | 496.9 | 1.00 | 72 |
| TRC10 | 13 | 27.8 | 14.0 | 28.8 | 827.0 | 2.00 | 84 |
| TRC11 | 17 | 27.7 | 18.0 | 27.4 | 750.0 | 3.00 | 104 |
| TRC12 | 21 | 19.7 | 12.0 | 18.9 | 357.5 | 4.00 | 84 |

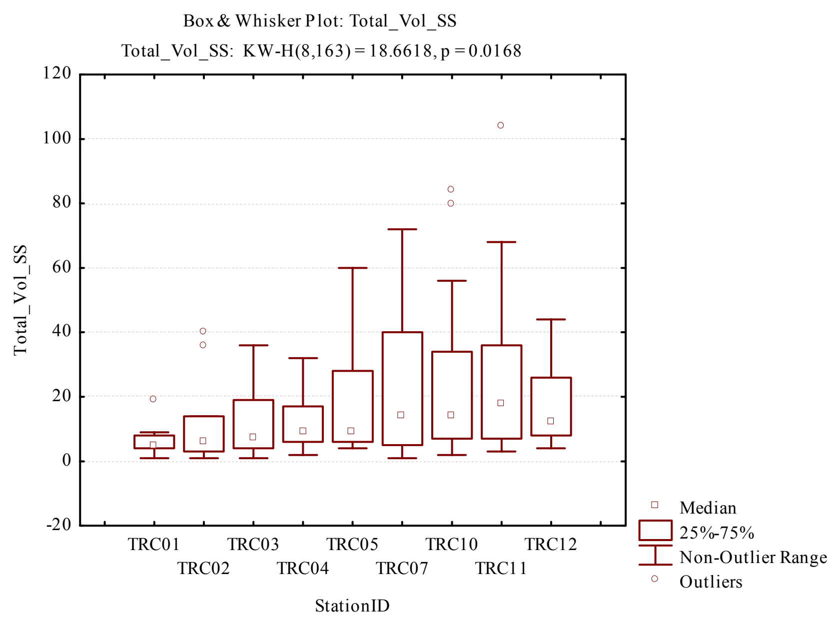



**Figure 18. Site vs. Total Volatile Suspended Solids Boxplots.**

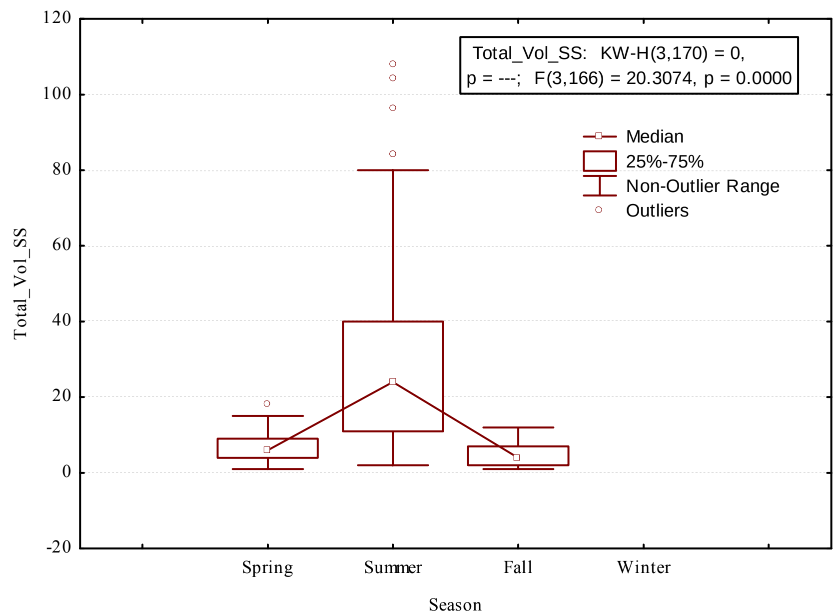



**Figure 19. Seasonal Boxplots for Total Volatile Suspended Solids.**

### *Ammonia*

Ammonia ranged from a non-detect collected from multiple locations to a maximum of 0.92 mg/L (TRC12) (Table 21 and Figure 20). The lowest mean of 0.06 mg/L (TRC01) and the highest mean was 0.18 mg/L (TRC12). The lowest median of 0.02 mg/L was documented at several locations and the highest median of 0.10 mg/L was calculated from Site TRC03. No significant differences were documented for this parameter using the Kruskal-Wallis analysis procedure (d.f.=8,n=161,p>0.05). Equation 2 in Appendix A to Chapter ARSD 74:51:01 was used to calculate the daily maximum concentration allowable for waters where salmonid fish are not present. Based on the results from Equation 2 there were no ammonia related violations documented for Turkey Ridge Creek.

**Table 21. Summary Statistics for Ammonia, Turkey Ridge Creek.**

| StationID | N | Means | Median | Std.Dev. | Variance | Minimum | Maximum |
|---|---|---|---|---|---|---|---|
| TRC01 | 18 | 0.06 | 0.02 | 0.10 | 0.01 | 0.02 | 0.43 |
| TRC02 | 19 | 0.10 | 0.08 | 0.10 | 0.01 | 0.02 | 0.35 |
| TRC03 | 18 | 0.16 | 0.10 | 0.17 | 0.03 | 0.02 | 0.61 |
| TRC04 | 19 | 0.13 | 0.09 | 0.13 | 0.02 | 0.02 | 0.42 |
| TRC05 | 17 | 0.09 | 0.04 | 0.11 | 0.01 | 0.02 | 0.37 |
| TRC07 | 19 | 0.10 | 0.03 | 0.12 | 0.01 | 0.02 | 0.38 |
| TRC10 | 13 | 0.21 | 0.04 | 0.29 | 0.08 | 0.02 | 0.90 |
| TRC11 | 17 | 0.09 | 0.02 | 0.13 | 0.02 | 0.02 | 0.47 |
| TRC12 | 21 | 0.18 | 0.02 | 0.28 | 0.08 | 0.02 | 0.92 |
| All Grps | 161 | 0.12 | 0.04 | 0.17 | 0.03 | 0.02 | 0.92 |

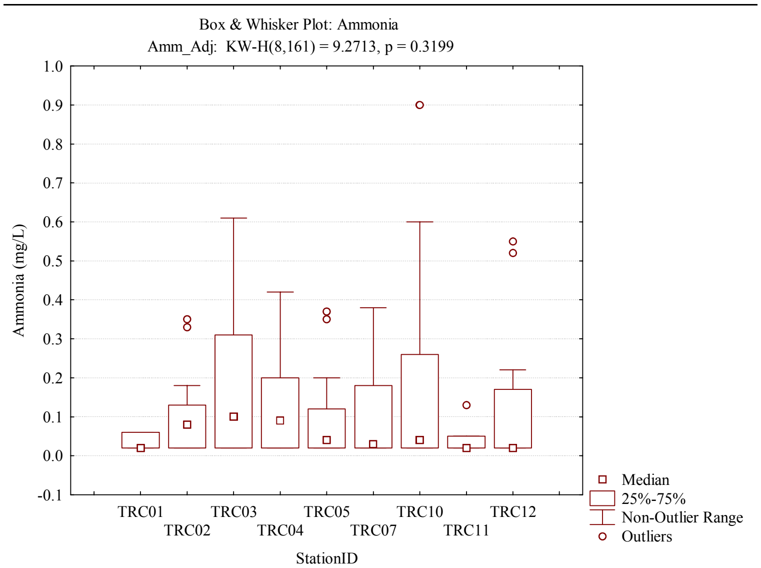



**Figure 20. Site vs. Ammonia as N Boxplots.**

### *Nitrate-Nitrite*

Nitrate-nitrite ranged from a minimum of 0.01 mg/L, which was observed from Sites TRC04-TRC12 whereas the maximum of 4.10 mg/L was collected from Site TRC03 (Table 22). The lowest mean was 0.38 mg/L (TRC11) and the highest mean was 0.97 mg/L (TRC03). The lowest median of 0.10 mg/L at TRC07, TRC11, and TRC12 whereas the highest median of 0.65 mg/L was taken from the Site TRC03 data.

A single grab sample daily maximum of 88 mg/L was used to determine the percent violations and assess for the beneficial use support of (9) Fish and Wildlife Propagation, Recreation and Stock Watering for all monitoring sites. Using this criterion, Turkey Ridge Creek is in full support of this parameter.

As a whole the group analysis indicated a significant difference but when individual comparisons were made differences were not detected at the 0.05 level. The most significant differences occurred between TRC01 and TRC12, and TRC03 and Sites TRC11 and TRC12.

**Table 22. Summary Statistics for Nitrate, Turkey Ridge Creek.**

| StationID | N | Means | Median | Std.Dev. | Variance | Minimum | Maximum |
|---|---|---|---|---|---|---|---|
| TRC01 | 19 | 0.85 | 0.50 | 0.79 | 0.63 | 0.30 | 3.20 |
| TRC02 | 19 | 0.69 | 0.50 | 0.41 | 0.17 | 0.20 | 1.60 |
| TRC03 | 18 | 0.97 | 0.65 | 1.03 | 1.07 | 0.30 | 4.10 |
| TRC04 | 19 | 0.71 | 0.40 | 0.80 | 0.63 | 0.10 | 3.50 |
| TRC05 | 18 | 0.61 | 0.40 | 0.64 | 0.41 | 0.10 | 2.30 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| TRC07 | 19 | 0.52 | 0.10 | 0.64 | 0.41 | 0.10 | 2.40 |
| TRC10 | 13 | 0.62 | 0.50 | 0.62 | 0.38 | 0.10 | 2.10 |
| TRC11 | 17 | 0.38 | 0.10 | 0.48 | 0.23 | 0.10 | 1.40 |
| TRC12 | 21 | 0.51 | 0.10 | 0.90 | 0.81 | 0.10 | 3.70 |
| All Grps | 163 | 0.65 | 0.40 | 0.73 | 0.54 | 0.10 | 4.10 |

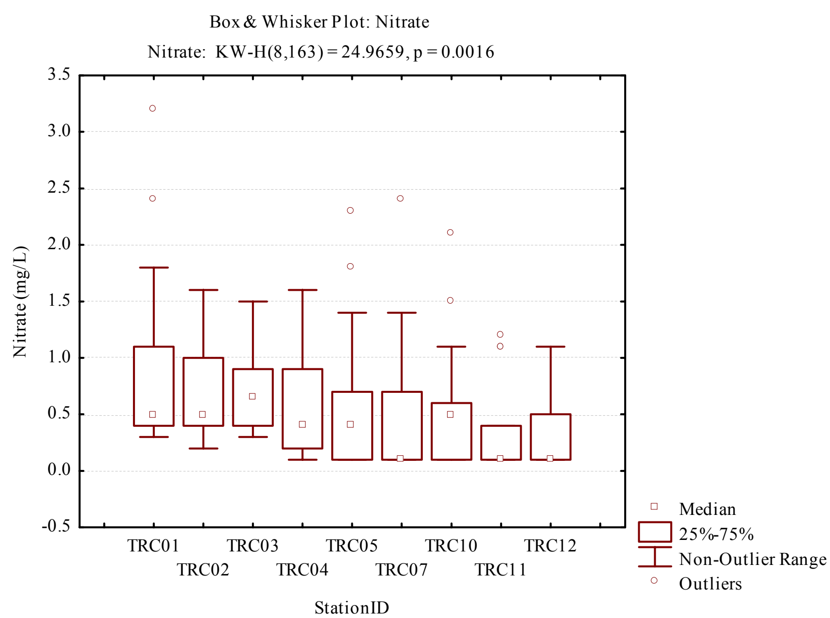



**Figure 21. Site vs. Nitrate Boxplots.**

### *Total Kjeldahl Nitrogen*

TKN ranged from a minimum of 0.32 mg/L (Sites TRC01, TRC02, and TRC04) to a maximum of 2.85 mg/L (TRC11) (Table 23 and Figure 22). The lowest mean was 0.84 mg/L (TRC04) whereas the highest mean was 1.50 mg/L (TRC11). The lowest median of 0.77 mg/L was at Site TRC04 and the highest median of 1.45 mg/L was calculated from Site TRC12.

There is no standard or assigned beneficial use for this parameter. There was a slight increasing trend for the TKN parameter where downstream sites were significantly higher than upstream concentrations. Site TRC04 was significantly lower than Sites TRC11 and TRC12 (d.f.=8,n=163,$p<0.05$).

**Table 23. Summary Statistics for TKN, Turkey Ridge Creek.**

| StationID | N | Means | Median | Std.Dev. | Variance | Minimum | Maximum |
|---|---|---|---|---|---|---|---|
| TRC01 | 19 | 0.96 | 0.84 | 0.52 | 0.27 | 0.32 | 2.57 |
| TRC02 | 19 | 0.97 | 0.79 | 0.67 | 0.45 | 0.32 | 2.78 |
| TRC03 | 18 | 1.08 | 0.93 | 0.68 | 0.46 | 0.34 | 2.83 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| TRC04 | 19 | 0.84 | 0.77 | 0.48 | 0.23 | 0.32 | 2.00 |
| TRC05 | 18 | 0.95 | 0.97 | 0.35 | 0.12 | 0.41 | 1.75 |
| TRC07 | 19 | 1.22 | 1.08 | 0.58 | 0.34 | 0.35 | 2.45 |
| TRC10 | 13 | 1.29 | 1.10 | 0.62 | 0.39 | 0.40 | 2.38 |
| TRC11 | 17 | 1.50 | 1.28 | 0.71 | 0.50 | 0.37 | 2.85 |
| TRC12 | 21 | 1.47 | 1.45 | 0.58 | 0.34 | 0.59 | 2.38 |

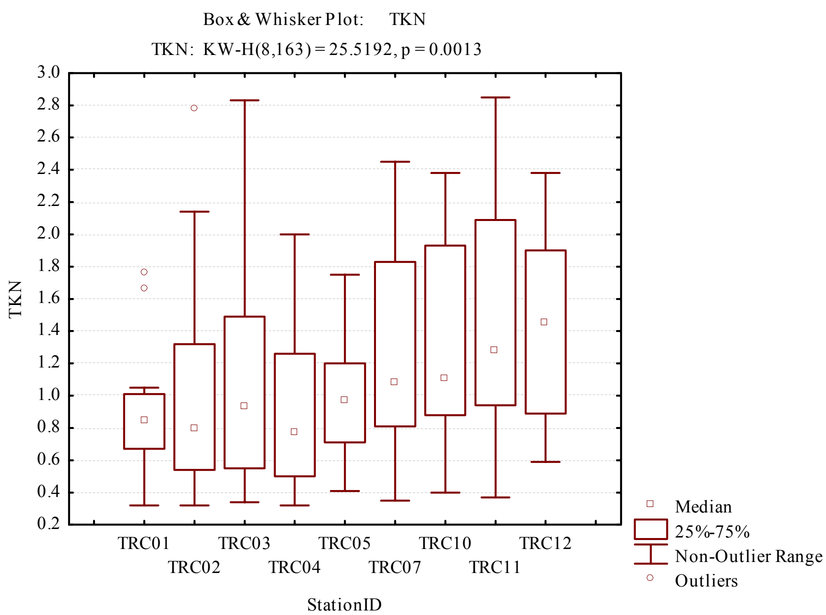



**Figure 22. Site vs. Total Kjeldahl Nitrogen Boxplots.**

***Organic Nitrogen***

Organic nitrogen ranged from a minimum of 0.250 mg/L (TRC02) to a maximum of 2.68 mg/L (TRC02) (Figure 23). The lowest mean was 0.86 mg/L (TRC01) and the highest mean of 1.42 mg/L was observed from Site TRC11 mg/L (T10). The lowest median of 0.60 mg/L was calculated from Site TRC04 data and the highest median of 1.24 mg/L was observed from Site TRC12.

Using a Kruskal-Wallis nonparametric analysis for multiple independent groups, Site TRC04 was significantly lower from Sites TRC11 and TRC12 (d.f.=8,n-161,p=0.0003).

**Table 24. Summary Statistics for Organic Nitrogen, Turkey Ridge Creek.**

| Site | **N** | **Means** | **Median** | **Std.Dev.** | **Variance** | **Minimum** | **Maximum** |
|---|---|---|---|---|---|---|---|
| TRC01 | 18 | 0.86 | 0.74 | 0.48 | 0.23 | 0.30 | 2.38 |
| TRC02 | 19 | 0.87 | 0.61 | 0.64 | 0.41 | 0.25 | 2.68 |
| TRC03 | 18 | 0.92 | 0.75 | 0.57 | 0.32 | 0.32 | 2.52 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| TRC04 | 19 | 0.71 | 0.60 | 0.39 | 0.16 | 0.28 | 1.78 |
| TRC05 | 17 | 0.87 | 0.93 | 0.33 | 0.11 | 0.32 | 1.71 |
| TRC07 | 19 | 1.12 | 0.92 | 0.57 | 0.33 | 0.33 | 2.42 |
| TRC10 | 13 | 1.08 | 1.06 | 0.44 | 0.19 | 0.38 | 2.03 |
| TRC11 | 17 | 1.42 | 1.12 | 0.71 | 0.51 | 0.35 | 2.83 |
| TRC12 | 21 | 1.29 | 1.24 | 0.51 | 0.26 | 0.57 | 2.36 |
| AllGrps | 161 | 1.01 | 0.88 | 0.56 | 0.32 | 0.25 | 2.83 |

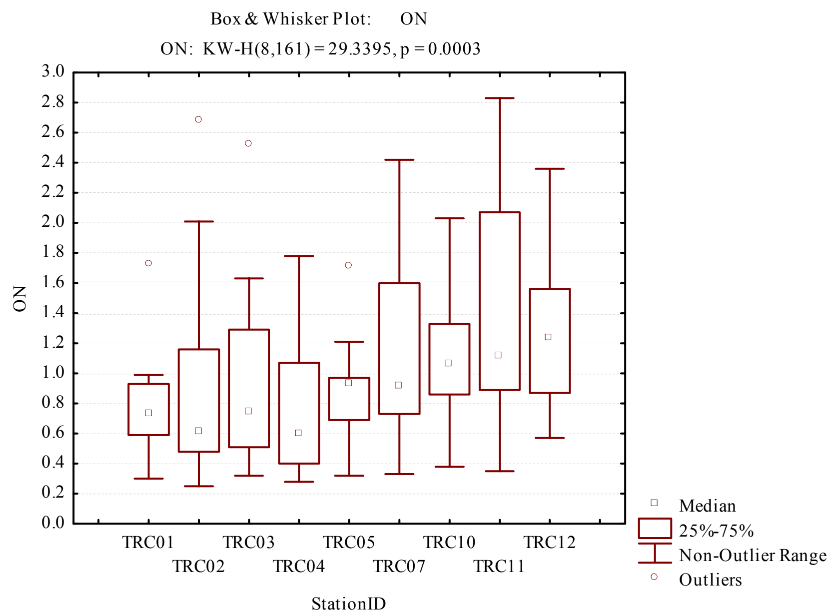



**Figure 23. Site vs. Organic Nitrogen Boxplots.**

### *Total Nitrogen*

Total nitrogen concentrations ranged from a minimum of 0.45 mg/L (TRC07) to a maximum of 6.34 mg/L (TRC03). The highest mean was calculated from Site TRC03 whereas the highest median was observed from Site TRC11.

No significant differences were detected between stations using Kruskal-Wallis analysis (n=8,d.f.=7,p>0.05).

**Table 25. Summary Statistics for Total Nitrogen, Turkey Ridge Creek.**

| StationID | N | Means | Median | Std.Dev. | Variance | Minimum | Maximum |
|---|---|---|---|---|---|---|---|
| TRC01 | 19 | 1.81 | 1.39 | 1.05 | 1.09 | 1.01 | 4.96 |
| TRC02 | 19 | 1.66 | 1.36 | 0.92 | 0.85 | 0.77 | 3.88 |
| TRC03 | 18 | 2.06 | 1.61 | 1.59 | 2.54 | 0.83 | 6.34 |
| TRC04 | 19 | 1.55 | 1.42 | 1.16 | 1.34 | 0.54 | 5.50 |
| TRC05 | 18 | 1.55 | 1.32 | 0.80 | 0.64 | 0.51 | 3.25 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| TRC07 | 19 | 1.74 | 1.78 | 0.85 | 0.73 | 0.45 | 3.53 |
| TRC10 | 13 | 1.91 | 1.70 | 1.02 | 1.04 | 0.50 | 4.03 |
| TRC11 | 17 | 1.88 | 2.14 | 0.81 | 0.66 | 0.47 | 3.15 |
| TRC12 | 21 | 1.99 | 1.88 | 1.09 | 1.18 | 0.69 | 5.15 |

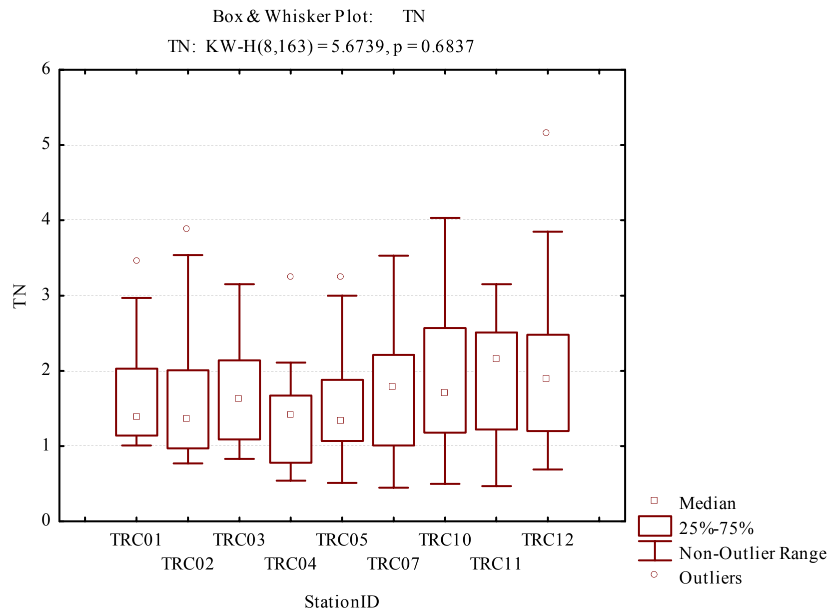



**Figure 24. Site vs. Total Nitrogen Boxplots.**

***Total Phosphorus***

Total phosphorus ranged from a minimum of 0.031 mg/L (TRC01) to a maximum of 2.030 mg/L (TRC10) (Table 26). The lowest mean was 0.236 mg/L (TRC01) and the highest mean was 0.508 mg/L (TRC10). The lowest median of 0.164 mg/L was at Site TRC04 whereas the highest median of 0.414 mg/L was observed from Site TRC10.

No standard or assigned beneficial use exists for this parameter. However, phosphorous is an essential plant nutrient and is applied in the form of commercial fertilizer or animal waste to various crops throughout the watershed. Excessive amounts of phosphorus from these sources can result in excessive growth phytoplankton and periphytic algae. Various ambient total phosphorus concentrations have been documented in the literature to which Turkey Ridge total phosphorus concentrations can be compared. Ecoregional mean phosphorus concentrations derived from data collected in southwestern Minnesota was compared to the Turkey Ridge Creek concentrations (Fandrei et al. 1988). This report used a reference mean of 0.25 mg/L for summer total phosphorus concentrations for the Northern Glaciated Plains level III ecoregion. In comparison, Turkey Ridge Creek, which falls within the same ecoregion, exhibited significantly higher summer concentrations (0.537 mg/L) for Sites TRC05, TRC06, and TRC10.

Kruskal-Wallis Analysis indicated no significant differences (d.f.=8,n=163,p>0.05). Although a significant increasing trend with downstream sites was not detected, slightly higher concentrations were observed with the downstream sites (Table 26).

Seasonally, concentrations were significantly higher during the summer (>0.500 mg/L) when compared to spring and fall (<0.100 mg/L) concentrations (d.f.=3,n=54,p<0.05) (Figure 26). This was also taken into consideration when diverting water from Turkey Ridge Creek into Swan Lake. Sediment is the primary concern but nutrient trends in Turkey Ridge Creek were considered when developing the operating plan for the USACE approved diversion.

**Table 26. Summary Statistics for Total Phosphorus, Turkey Ridge Creek.**

| StationID | N | Means | Median | Std.Dev. | Variance | Minimum | Maximum |
|---|---|---|---|---|---|---|---|
| TRC01 | 19 | 0.236 | 0.188 | 0.153 | 0.023 | 0.031 | 0.660 |
| TRC02 | 19 | 0.305 | 0.218 | 0.316 | 0.100 | 0.043 | 1.200 |
| TRC03 | 18 | 0.375 | 0.238 | 0.377 | 0.142 | 0.063 | 1.340 |
| TRC04 | 19 | 0.274 | 0.164 | 0.282 | 0.080 | 0.058 | 1.140 |
| TRC05 | 18 | 0.294 | 0.226 | 0.199 | 0.039 | 0.074 | 0.651 |
| TRC07 | 19 | 0.313 | 0.225 | 0.222 | 0.049 | 0.041 | 0.791 |
| TRC10 | 13 | 0.508 | 0.414 | 0.521 | 0.271 | 0.050 | 2.030 |
| TRC11 | 17 | 0.436 | 0.374 | 0.298 | 0.089 | 0.048 | 1.150 |
| TRC12 | 21 | 0.396 | 0.361 | 0.219 | 0.048 | 0.103 | 0.896 |

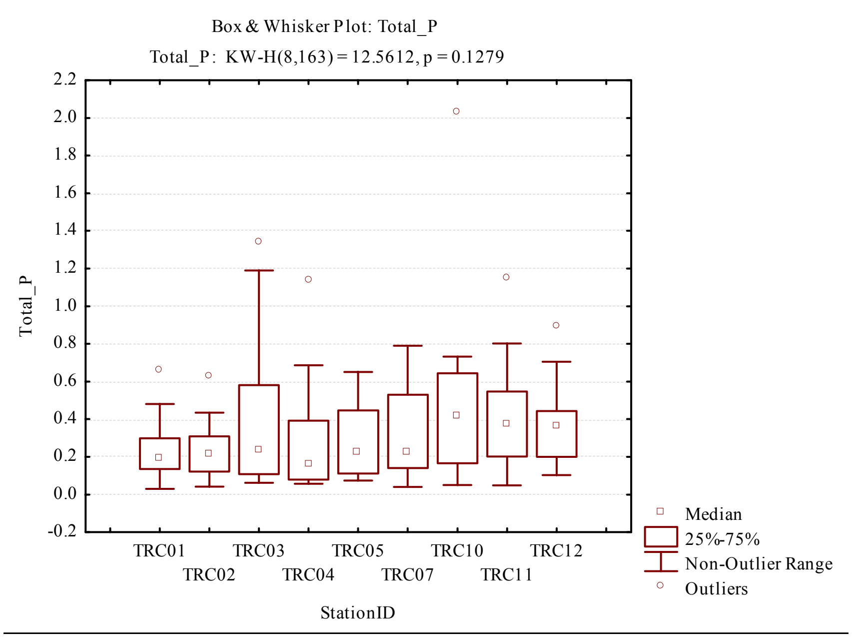



**Figure 25. Site vs. Total Phosphorus.**

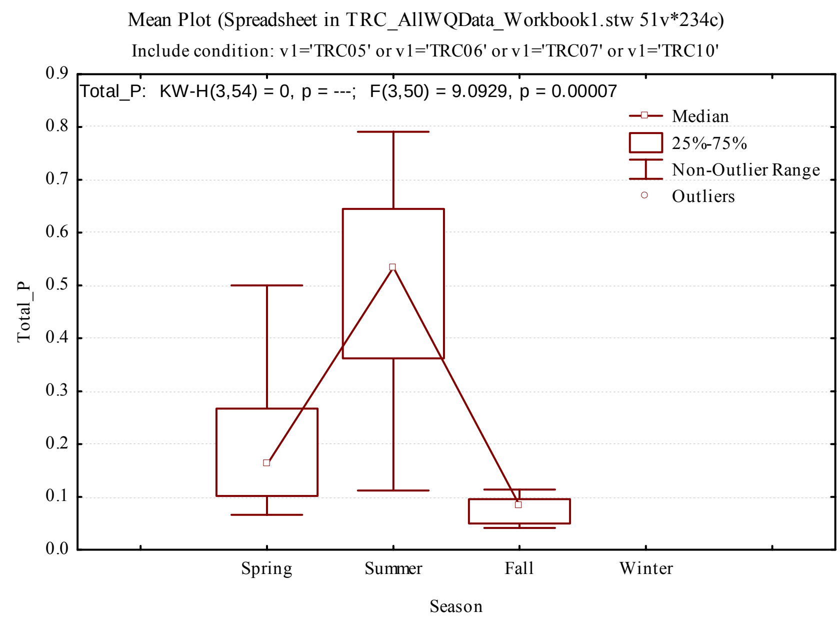



**Figure 26. Seasonal Boxplots for Total Phosphorus.**

### *Total Dissolved Phosphorus*

Total dissolved phosphorus ranged from a minimum of 0.010 mg/L (TRC11) to a maximum of 0.675 mg/L (TRC03) (Table 27). The lowest mean was 0.110 mg/L (TRC11) and the highest mean was 0.190 mg/L (TRC02). The lowest median of 0.034 mg/L was observed from Site TRC07 whereas the highest median of 0.124 mg/L was at Site TRC02.

There is no standard or assigned beneficial use for this parameter.

Kruskal Wallis indicated no significant differences between sites (p>0.05) and an increasing or decreasing trend versus longitudinal position of monitoring sites was not detected (p>0.05). However, a significant difference does exist between all seasons of total dissolved phosphorus concentrations (Figure 27). Fall concentrations are significantly less than the other two seasons where data was collected.

**Table 27. Summary Statistics for Total Dissolved Phosphorus, Turkey Ridge Creek.**

| StationID | N | Means | Median | Std.Dev. | Variance | Minimum | Maximum |
|---|---|---|---|---|---|---|---|
| TRC01 | 17 | 0.154 | 0.121 | 0.101 | 0.010 | 0.030 | 0.362 |
| TRC02 | 18 | 0.190 | 0.124 | 0.191 | 0.037 | 0.032 | 0.648 |
| TRC03 | 18 | 0.187 | 0.115 | 0.170 | 0.029 | 0.032 | 0.675 |
| TRC04 | 19 | 0.124 | 0.060 | 0.151 | 0.023 | 0.030 | 0.638 |
| TRC05 | 18 | 0.127 | 0.059 | 0.125 | 0.016 | 0.025 | 0.385 |
| TRC07 | 19 | 0.093 | 0.034 | 0.091 | 0.008 | 0.018 | 0.261 |
| TRC10 | 13 | 0.146 | 0.092 | 0.135 | 0.018 | 0.019 | 0.400 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| TRC11 | 17 | 0.110 | 0.063 | 0.140 | 0.019 | 0.010 | 0.610 |
| TRC12 | 21 | 0.131 | 0.080 | 0.102 | 0.010 | 0.034 | 0.382 |

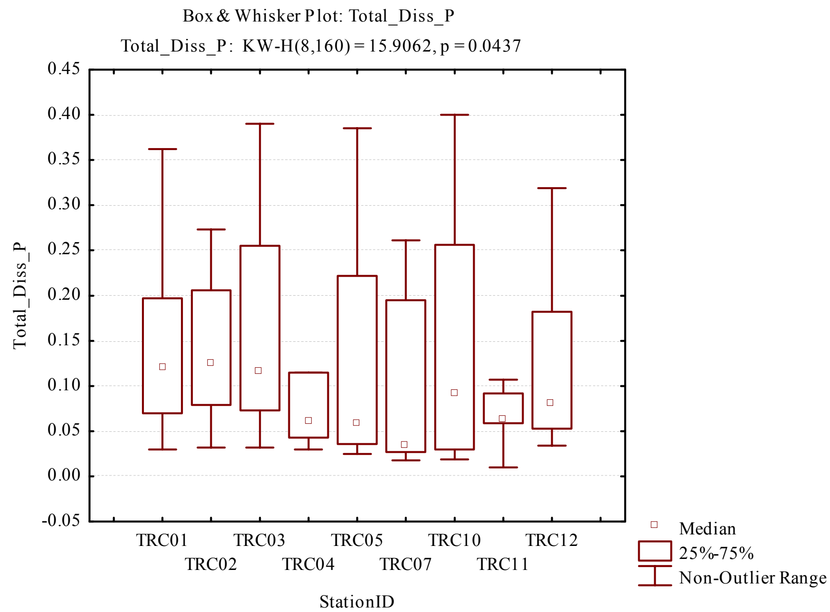



**Figure 27. Site vs. Total Dissolved Phosphorous Boxplots.**

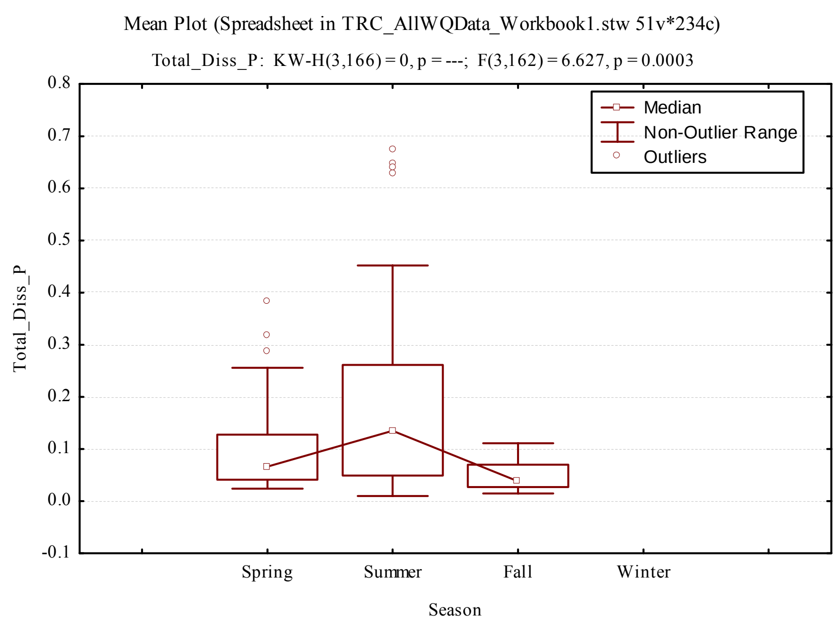



**Figure 28. Seasonal Boxplots for Total Dissolved Phosphorus.**

## Field Parameters

### *Dissolved Oxygen*

Dissolved oxygen ranged from a minimum of 3.820 mg/L (TRC01) to a maximum of 17.01 mg/L (TRC11) (Table 28). The lowest mean was 7.26 mg/L (TRC01) and the highest mean was 12.39 mg/L (TRC12). The lowest median of 7.50 mg/L at TRC01, and the highest median of 13.09 mg/L was observed from Site TRC12 (Table 28).

A single grab sample daily maximum of $\geq$ 4.0 mg/L (most stringent) was used to determine the percent violations and assess the support status of the 26.1 mile segment of Turkey Ridge Creek (warmwater marginal fish life propagation beneficial use). No violations of this were recorded for this dissolved oxygen criteria.

Kruskal-Wallis analysis indicated that Site TRC01 was significantly different from Site TRC12 (d.f.=8,n=143, p<0.0012). No significant longitudinal trend was detected for dissolved oxygen concentrations (p>0.05). However, the difference between Site TRC01 and Site TRC12 oxygen concentrations can be attributed to the time of day. All samples collected from Site TRC01 were collected in the morning (AM) whereas Site TRC12 were collected in the mid to late afternoon (PM). The stream, because of periphyton and aquatic plant photosynthesis, would have had more time to increase the average concentration of oxygen during the late afternoon period. A seasonal difference was also detected (d.f.=2,n=149,p<0.000)(Figure 30).

**Table 28. Summary Statistics for Dissolved Oxygen, Turkey Ridge Creek.**

| StationID | N | Means | Median | Std.Dev. | Variance | Minimum | Maximum |
|---|---|---|---|---|---|---|---|
| TRC01 | 17 | 7.26 | 7.50 | 2.912 | 8.48 | 3.820* | 13.06 |
| TRC02 | 17 | 9.44 | 8.37 | 3.047 | 9.29 | 5.780* | 16.34 |
| TRC03 | 16 | 8.80 | 7.84 | 3.415 | 11.66 | 3.500* | 15.28 |
| TRC04 | 16 | 10.40 | 9.76 | 3.392 | 11.50 | 4.830* | 18.07 |
| TRC05 | 16 | 10.61 | 10.13 | 3.149 | 9.92 | 5.580 | 17.04 |
| TRC07 | 17 | 10.00 | 9.85 | 2.738 | 7.50 | 5.930 | 16.63 |
| TRC10 | 10 | 11.73 | 12.10 | 3.432 | 11.78 | 5.960 | 16.80 |
| TRC11 | 17 | 10.74 | 11.06 | 3.073 | 9.44 | 5.480 | 17.01 |
| TRC12 | 17 | 12.39 | 13.09 | 3.113 | 9.69 | 6.410 | 16.91 |
| * Only Sites TRC05-TRC12 are subject to Beneficial Use (6) Warmwater Marginal Fish Life Propagation Waters Criteria for Dissolved Oxygen > 4.0 mg/L. | | | | | | | |

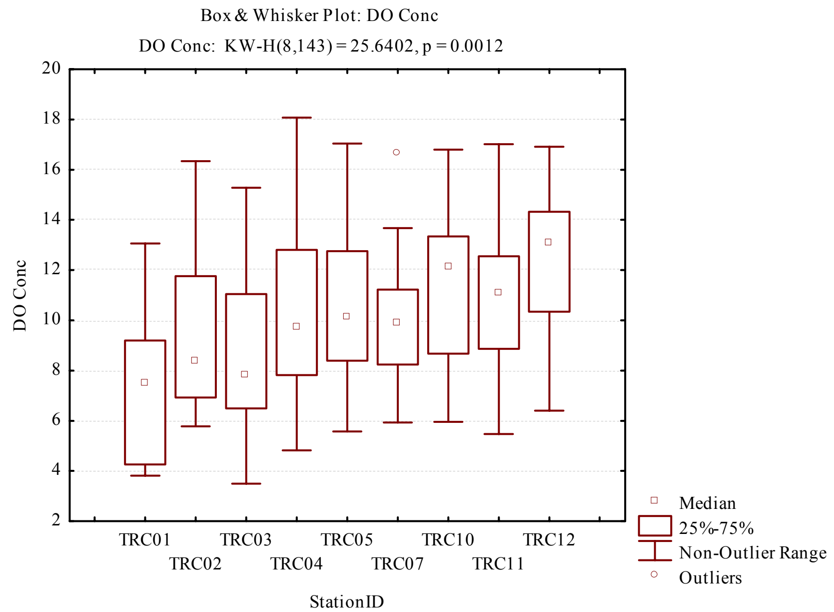



**Figure 29. Site vs. Dissolved Oxygen Boxplots.**

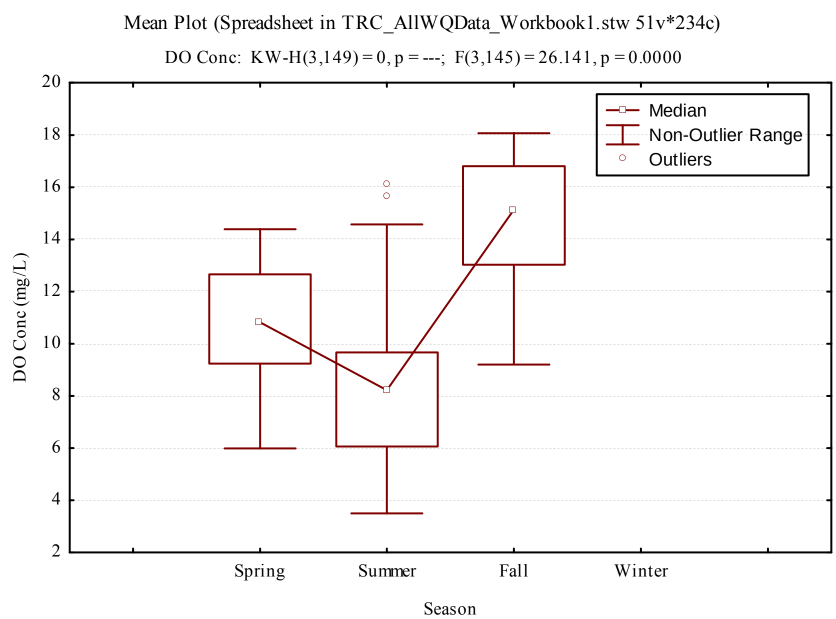



**Figure 30. Seasonal Boxplots for Dissolved Oxygen.**

### *pH*

pH ranged from a minimum of 7.28 (TRC01) to a maximum of 9.06 (TRC10) (Table 29). The lowest mean and median were 7.79 and 7.64, respectively (TRC01); and the highest mean and median were 7.64 and 8.29 and 8.27, respectively (TRC12).

A single grab sample daily maximum of the most restrictive standard of 6.0-9.0 was used to determine the violation rate and assess support of the warmwater marginal fish life beneficial use (6). Only one violation was observed (9.06 – Site TRC10) (Table 29). Using this criterion, Turkey Ridge Creek is in full support for this parameter.

A Kruskal-Wallis analysis indicated that Site TRC01 differs significantly from Site TRC02 and TRC12 (d.f.=8,n=169,p=0.0005) (Figure 31). No seasonal differences were detected using a Kruskal-Wallis analysis (d.f.=2,n=169,p>0.05) (Figure 32).

**Table 29. Summary Statistics for pH, Turkey Ridge Creek.**

| StationID | N | Means | Median | Std.Dev. | Variance | Minimum | Maximum |
|---|---|---|---|---|---|---|---|
| TRC01 | 19 | 7.79 | 7.64 | 0.34 | 0.11 | 7.28 | 8.58 |
| TRC02 | 19 | 8.13 | 8.12 | 0.18 | 0.03 | 7.95 | 8.57 |
| TRC03 | 18 | 8.05 | 8.01 | 0.18 | 0.03 | 7.86 | 8.54 |
| TRC04 | 18 | 8.04 | 8.04 | 0.12 | 0.01 | 7.89 | 8.34 |
| TRC05 | 18 | 8.08 | 8.08 | 0.16 | 0.03 | 7.80 | 8.41 |
| TRC07 | 19 | 8.11 | 8.08 | 0.23 | 0.05 | 7.74 | 8.56 |
| TRC10 | 12 | 8.18 | 8.04 | 0.37 | 0.14 | 7.69 | 9.06* |
| TRC11 | 19 | 8.11 | 8.10 | 0.21 | 0.04 | 7.68 | 8.52 |
| TRC12 | 19 | 8.29 | 8.27 | 0.30 | 0.09 | 7.69 | 8.75 |
| * - only one violation occurred for the water quality criteria (pH<9.00) for the Beneficial Use (6) Warmwater marginal fish life propagation waters. | | | | | | | |

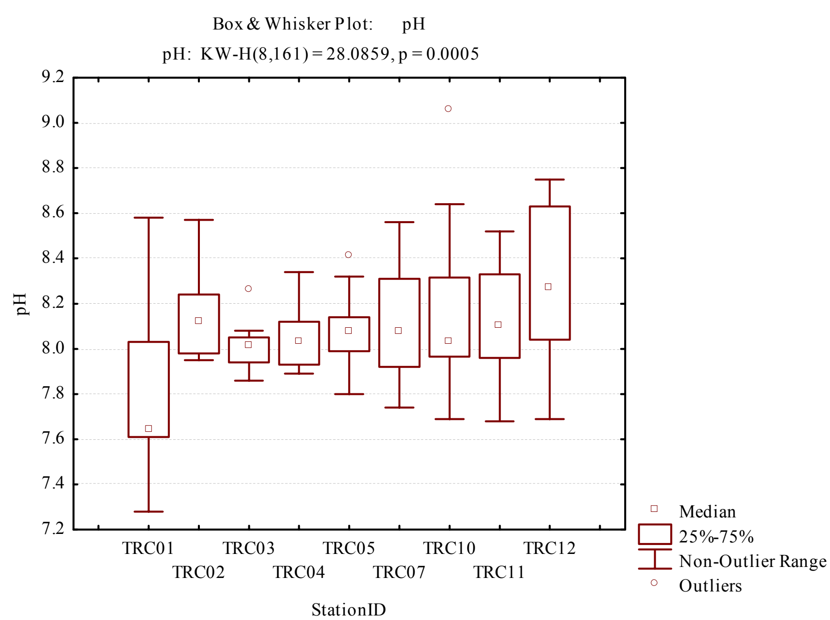



**Figure 31. Site vs. pH Boxplots.**

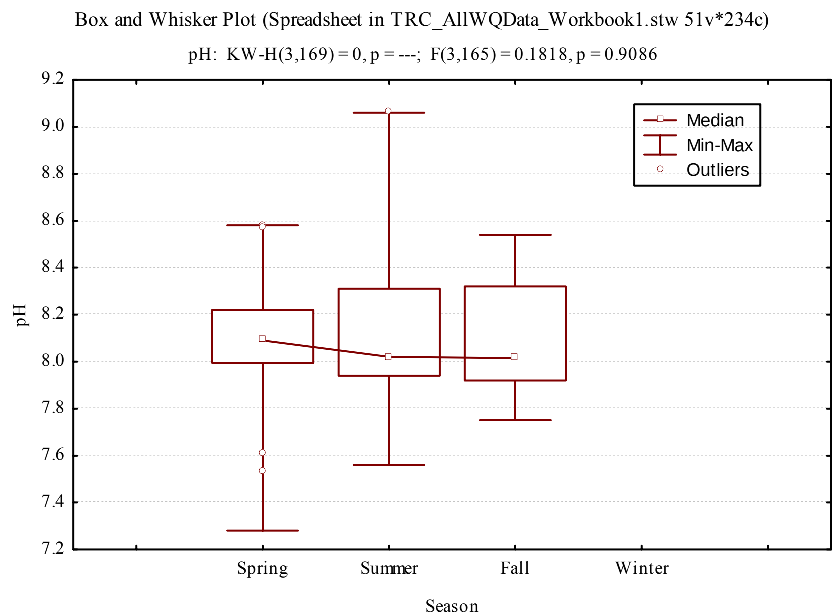



**Figure 32. Seasonal Boxplots for pH.**

### *Water Temperature*

Water temperature ranged from a minimum of -0.04° C (TRC10) and to a maximum of 32.1° C (TRC12) (Table 30). The lowest mean temperature of 14.3° C was observed from Site TRC02 and the highest mean temperature was 18.5° C calculated from TRC12 data. The lowest median temperature of 15.9° C was recorded at TRC04 and the highest median temperature of 19.5° C was from Site TRC12 data (Table 30).

A single grab sample daily maximum temperature of 32.2° C was used to determine the support status of the 26.1 mile segment of Turkey Ridge Creek (Figure 33) that is subject to the criteria established for the warmwater marginal fish life beneficial use (6). No violations of the 32.2° C standard was observed during the course of the study.

No significant differences were detected between monitoring sites using a Kruskal-Wallis analysis (d.f.=8,n=161,p>0.05) (Figure 33).

**Table 30. Summary Statistics for Water Temperature, Turkey Ridge Creek.**

| StationID | N | Means | Median | Std.Dev. | Variance | Minimum | Maximum |
|---|---|---|---|---|---|---|---|
| TRC01 | 19 | 14.5 | 17.5 | 7.0 | 49 | 1.81 | 22.4 |
| TRC02 | 19 | 14.3 | 17.8 | 8.0 | 65 | 0.00 | 23.3 |
| TRC03 | 18 | 14.8 | 16.9 | 8.4 | 70 | 0.72 | 25.9 |
| TRC04 | 18 | 15.0 | 15.9 | 7.9 | 62 | 0.42 | 24.9 |
| TRC05 | 18 | 16.0 | 17.6 | 8.6 | 74 | 0.14 | 27.7 |
| TRC07 | 19 | 17.4 | 18.7 | 9.0 | 81 | 0.41 | 28.6 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| TRC10 | 12 | 15.8 | 18.1 | 9.3 | 86 | -0.04 | 26.1 |
| TRC11 | 19 | 18.0 | 18.8 | 8.6 | 73 | 2.10 | 28.1 |
| TRC12 | 19 | 18.5 | 19.5 | 10.2 | 104 | 3.28 | 32.1 |

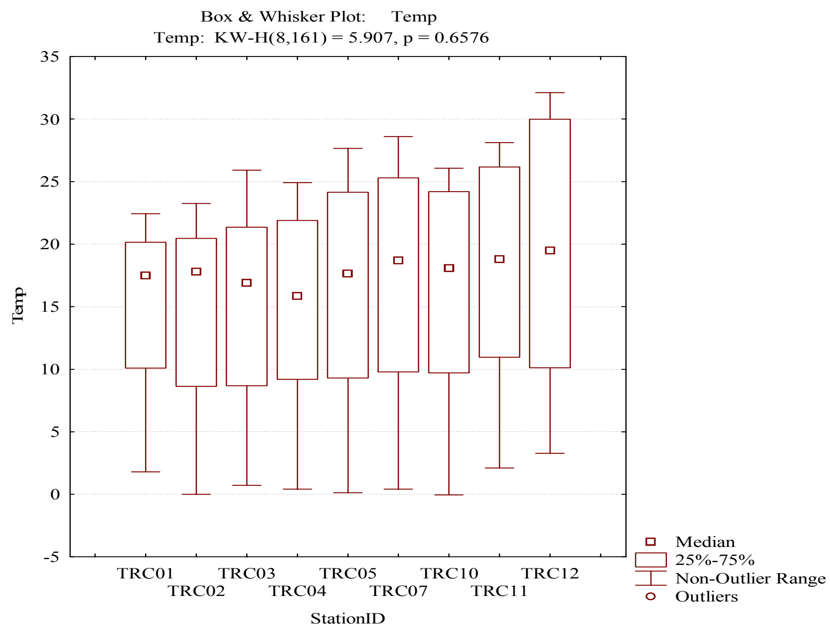



**Figure 33. Site vs. Temperature Boxplots.**

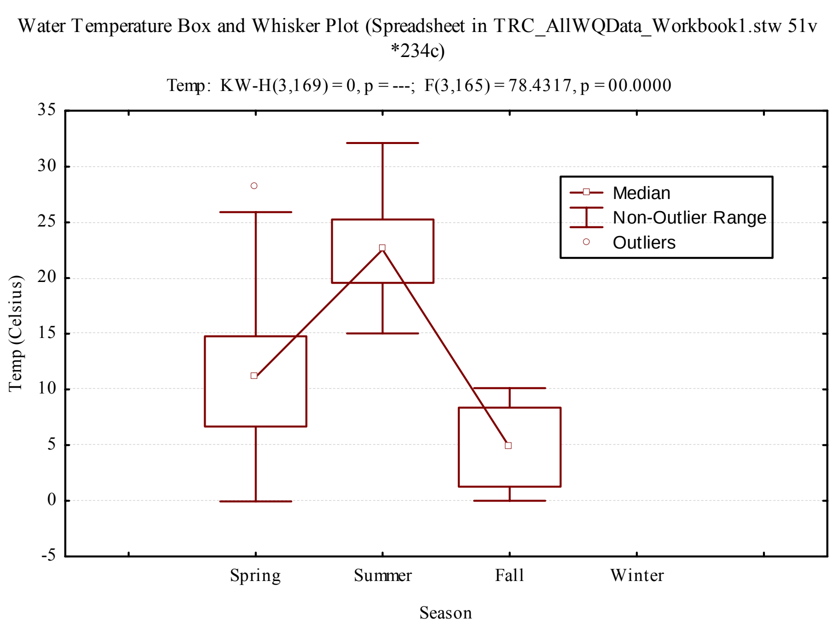



**Figure 34. Seasonal Box plot for Temperature.**

### *Specific Conductivity*

Specific conductivity ranged from a minimum of 435 µmho/cm (TRC12) to a maximum of 3,006 µmho/cm (TRC11) (Table 31). The lowest mean was 1,647 µmho/cm (TRC02) and the highest mean was 1,813 µmho/cm (TRC11). The lowest median of 1,710 µmho/cm was calculated from Site TRC02 data, and the highest median of 1,793 µmho/cm was observed from Site TRC12 (Table 31).

A single grab sample daily maximum of the most restrictive standard of 4,375 mg/L was used to determine the percent violations and assess for the beneficial use support of (9) fish and wildlife propagation, recreation, and stock watering and (10) irrigation for all of the tributary and river sites. Using this criterion, Turkey Ridge Creek is fully supporting of this parameter.

A Kruskal-Wallis analysis did not detect a significant differences between sites (d.f.=8,n=152,p>0.05). Seasonally, Spring concentrations differed from summer (d.f.=2,n=160,p=0.000) but no differences were detected between summer and fall seasons (Figure 36).

**Table 31. Summary Statistics for Specific Conductivity, Turkey Ridge Creek.**

| StationID | N | Means | Median | Std.Dev. | Variance | Minimum | Maximum |
|---|---|---|---|---|---|---|---|
| TRC01 | 18 | 1694 | 1771 | 311 | 96994 | 815 | 2052 |
| TRC02 | 18 | 1647 | 1710 | 327 | 106844 | 960 | 2033 |
| TRC03 | 17 | 1671 | 1721 | 386 | 149319 | 719 | 2111 |
| TRC04 | 18 | 1669 | 1756 | 497 | 247166 | 103 | 2143 |
| TRC05 | 16 | 1748 | 1763 | 438 | 192274 | 826 | 2398 |
| TRC07 | 18 | 1687 | 1756 | 448 | 200356 | 807 | 2315 |
| TRC10 | 11 | 1689 | 1833 | 506 | 255790 | 727 | 2301 |
| TRC11 | 18 | 1813 | 1773 | 552 | 304512 | 537 | 3006 |
| TRC12 | 18 | 1731 | 1793 | 478 | 228192 | 435 | 2326 |

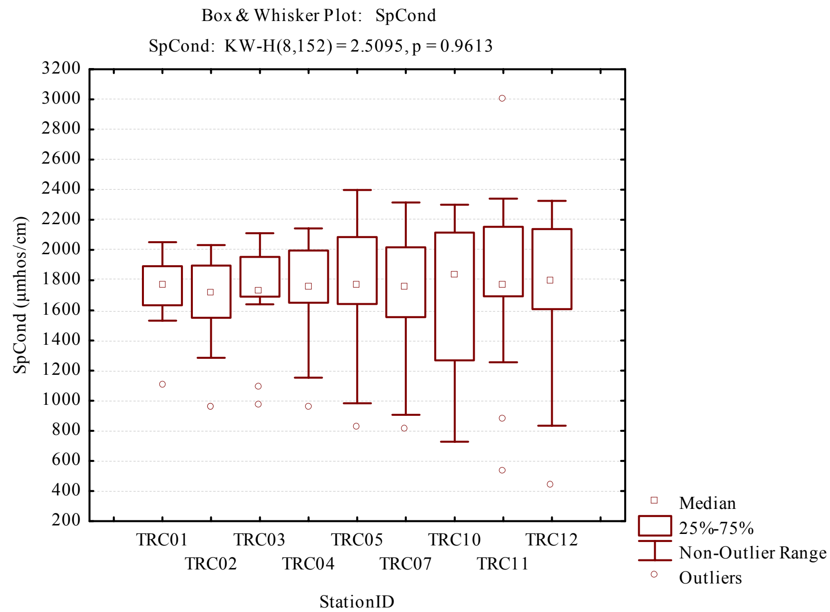



**Figure 35. Site vs. Specific Conductivity Boxplots.**

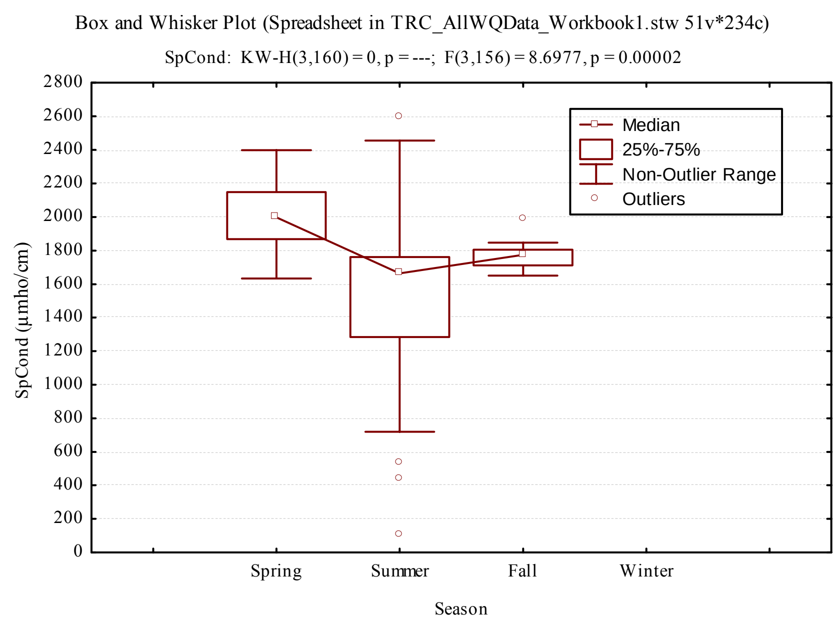



**Figure 36. Seasonal Boxplot for Specific Conductivity.**

### 3.2. Load Duration Curves

Load duration curves serve as a tool that provides a visual representation of the loadings that are allowable based on the frequency of daily flows and a specific water quality standard. The best situation when using these curves is to have flow data for approximately 20 years. The curve shown in Figure 37 represents an exceedence threshold for the fecal coliform daily maximum standard at all flows recorded during the Turkey Ridge Creek project. Points, or water quality samples, plotted above this line represents an exceedence of water quality standards. The load duration curve methodology developed by Dr. Bruce Cleland was used to create the load duration curves for TSS and fecal coliform for Turkey Ridge Creek.

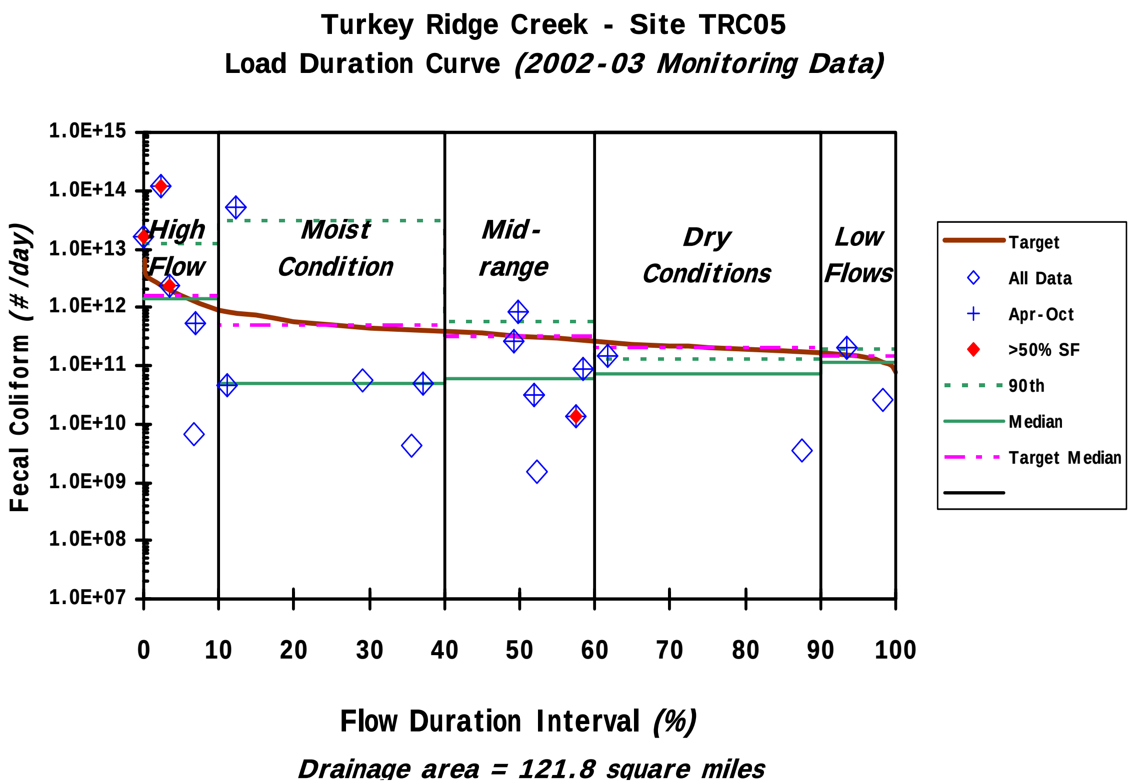



**Figure 37. Site TRC05 Fecal Coliform Load Duration Curve.**

The exceedence is represented by a series of flow monitoring data that are expressed as a percentage of days (ranging from 0 to 100) (frequency of occurrence). Flow conditions can be predicted based on where each sample is plotted. For instance, an exceedence in the 0-10 percent region indicates extremely high flows, i.e. these high flows have a very small probability of being exceeded. The maximum flow recorded for Turkey Ridge Creek, 1233 cfs, would fall within this category. At such high flows, causes of the exceedence are extremely difficult to rectify because of the excessive runoff. In contrast, monitoring data exceeding the water quality criteria found in the 90-100 percent range may indicate a point-source problem such as cattle standing in the stream or a wastewater treatment facility (WWTF). Base flows are at low or drought conditions and the probability is very high that they will be exceeded. There are more options available to control violations at low flow conditions.

### *Fecal Coliform Bacteria Load Duration Curves*

The fecal coliform bacteria load duration curves are located in Appendix G. Each graph corresponds to the fecal exceedence and flow tables located in Appendix I. Each graph serves as a visual indicator for possible causes of the violations, i.e. nonpoint source, and/or point source. The target line on all of the graphs in Appendix I and Figure 38 represents the 2,000 cfu/100mL water quality standard for beneficial use (8) Limited Contact Recreation. Load duration curves were developed for all nine monitoring sites although the standard only applies to Sites TRC05-TRC12.

Using the load duration curve, comparisons can be made between the percent of violations and the actual load reductions to determine where along the hydrologic curve violations of the water quality standard are occurring. Different zones for these violations along the curve indicate different sources and can also be used to determine reductions amounts within each zone in order for the water body to achieve full support status of its beneficial uses.

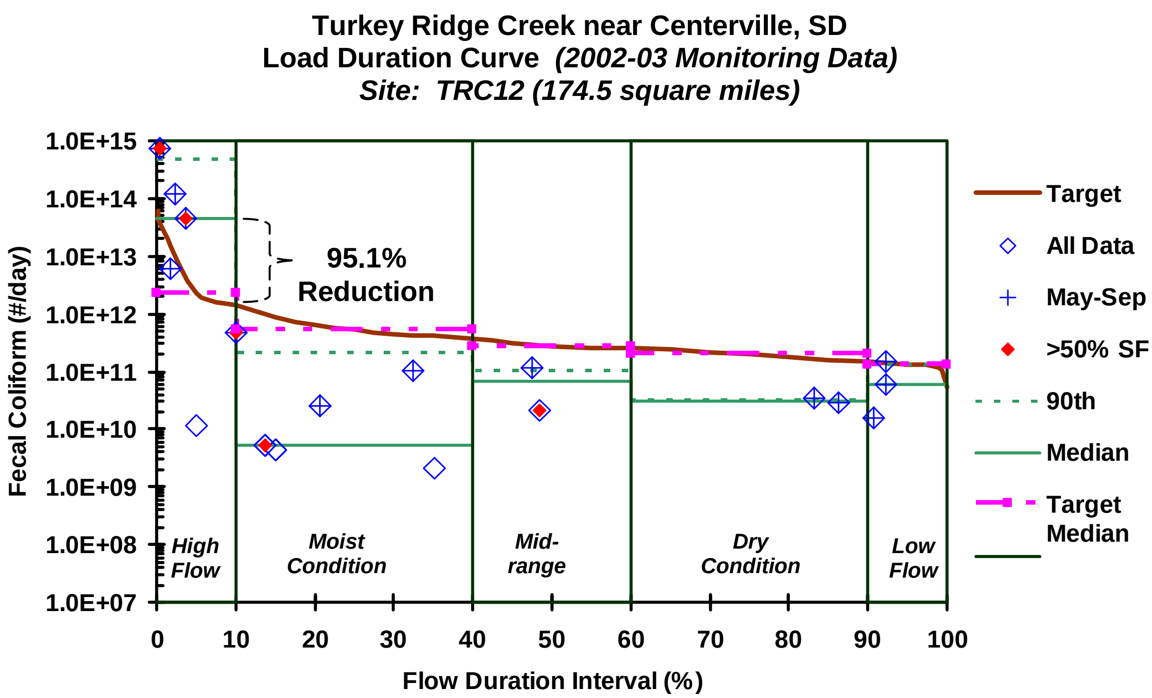



**Figure 38. Site TRC12 fecal coliform load duration curve.**

### *TSS Load Duration Curves*

The TSS load duration curves are located in Appendix J. Each graph corresponds to the TSS exceedence tables located in Appendix K, and serves as a visual aid in determining if there are nonpoint source, point source, and/or unmanageable problems. Although the sediment target load (Figure 39) was exceeded the number of violations was still considerably lower than the TMDL requirement (see water quality parameters section). Figure 39 shows the load duration curve for Site TRC12. All of the violations occurred during high flow conditions making management options very limited. Further analysis and computer modeling for this watershed will occur during the Vermillion River Basin Watershed Assessment to determine the impact of Turkey Ridge Creek sediment loadings on the Vermillion River.

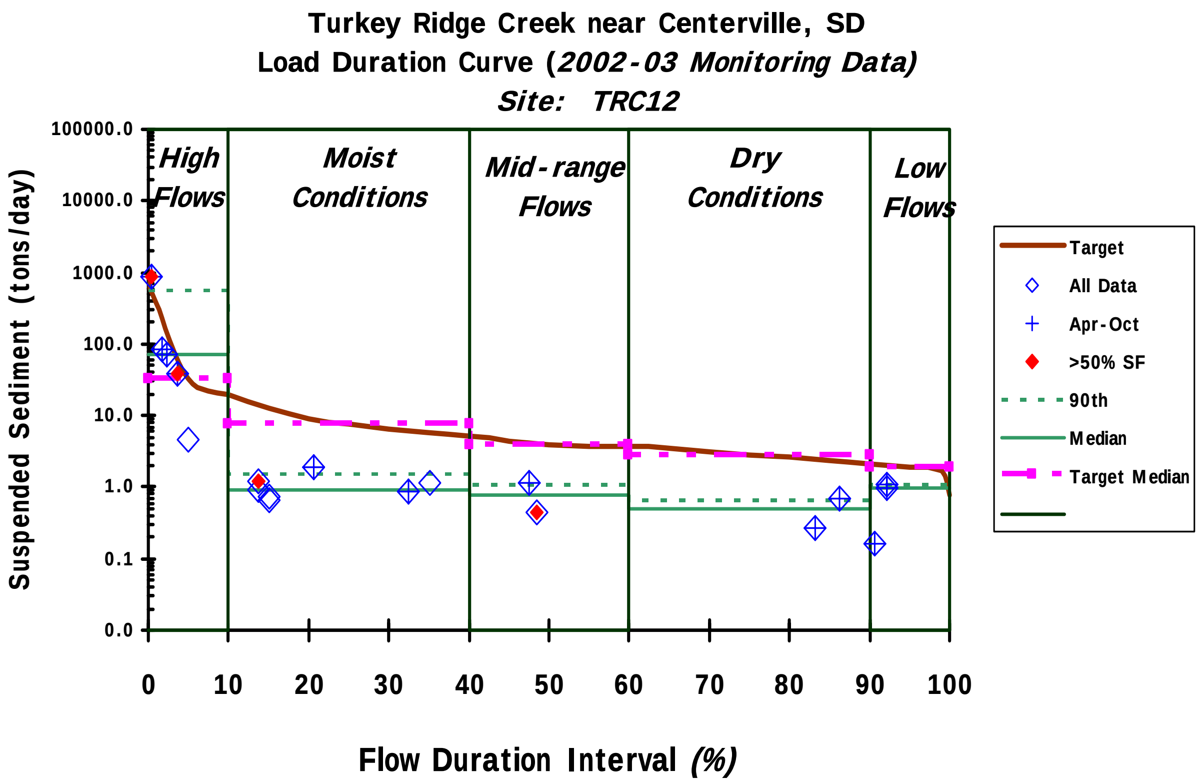



**Figure 39. Site TRC12 Suspended Sediment Load Duration Curve.**

### 3.3. <u>Biological Monitoring</u>

***Rare, Threatened, and Endangered Species***

The Topeka Shiner is listed as federally endangered by the US Fish and Wildlife service. The Northern Cricket Frog is state listed for its rarity. State and federal agencies need notification prior to any implementation work that may affect these species in the Turkey Ridge Creek watershed.

**Table 32. Rare, Threatened, and Endangered Fish Species document in the Turkey Ridge Creek Watershed (SDGFP, 2005).**

| Common Name | Scientific Name | Federal Status | State Status | Global Rank | State Rank |
|---|---|---|---|---|---|
| Topeka Shiner | *Notropis topeka* | LE | | G3 | S2 |
| Northern Cricket Frog | *Acris crepitans* | | | G5 | S1 |

Note: LE = Listed Endangered

| | | | |
|---|---|---|---|
| S1=Critically imperiled because of extreme rarity (5 or fewer occurrences or very few remaining individuals or acres) or because of some factor(s) making it especially vulnerable to extinction. | S2=Imperiled because of rarity (6 to 20 occurrences or few remaining individuals or acres) or because of some factor(s) making it very vulnerable to extinction throughout its range. | G3=Either very rare and local throughout its range, or found locally (even abundantly at some of its locations)in a restricted range, or vulnerable to extinction throughout its range because of other factors; in the range of 21 of 100 occurrences. | G5=Demonstrably secure, though it may be quite rare in parts of its range, especially at the periphery. |

***Macroinvertebrate Sampling***

Macroinvertebrate sampling occurred at all of the monitoring sites during the 2002 sampling year. Only one sample per site was collected. Laboratory work and compilation of the results for each metric were outsourced to EcoAnalyst, Inc., specialists in aquatic taxonomy. These results can be found in Appendix L. Sixty-six metrics were calculated from the macroinvertebrate data. Further analysis beyond sites vs metric scatter plots were not practical with only a single data point for each metric. Scatter plots and trend lines are also located in Appendix L. The most significant trend lines are shown in Table 33.

**Table 33. Trend statistics for metrics calculated from Turkey Ridge Creek, 2002.**

| Metric | Statistic | Trendline Direction | Predicted Response to increasing perturbation |
|---|---|---|---|
| EPT Abundance | $r^2$=0.55,df=8, p=0.0217 | - | Decrease |
| Species Richness | $r^2$=0.66,df=8,p=0.0081 | - | Decrease |
| Trichopteran Richness | $r^2$=0.59,df=8,p=0.0159 | - | Decrease |
| Filterer Richness | $r^2$=0.68,df=8,p=0.0066 | - | Decrease |
| Margalef's Richness | $r^2$=0.58,df=8,p=0.0175 | - | Decrease |
| Clinger Richness | $r^2$=0.64,df=8,p=0.0093 | - | Decrease |
| * - For Turkey Ridge Creek Filter Richness decreased longitudinally. | | | |

Filterer richness shows a significant downward trend in relation to the location of the monitoring sites along Turkey Ridge Creek. Filterer richness is a metric in the functional feeding group. All of the metrics listed in Table 33 are diversity related. In Turkey Ridge Creek, the number of species in various functional groups (niche) gradually decreases with increasing perturbation. Although significant increased trends were not detected, one metric did show a slight increased trend with downstream sites: Hilsenhoff Biotic Index (HBI) ($r^2$=0.38,p=.0758). The HBI uses insect pollution tolerance values to weight abundance of the organisms. A larger presence of higher tolerant insects results in an increased HBI value (Barbour,et al., 1999).

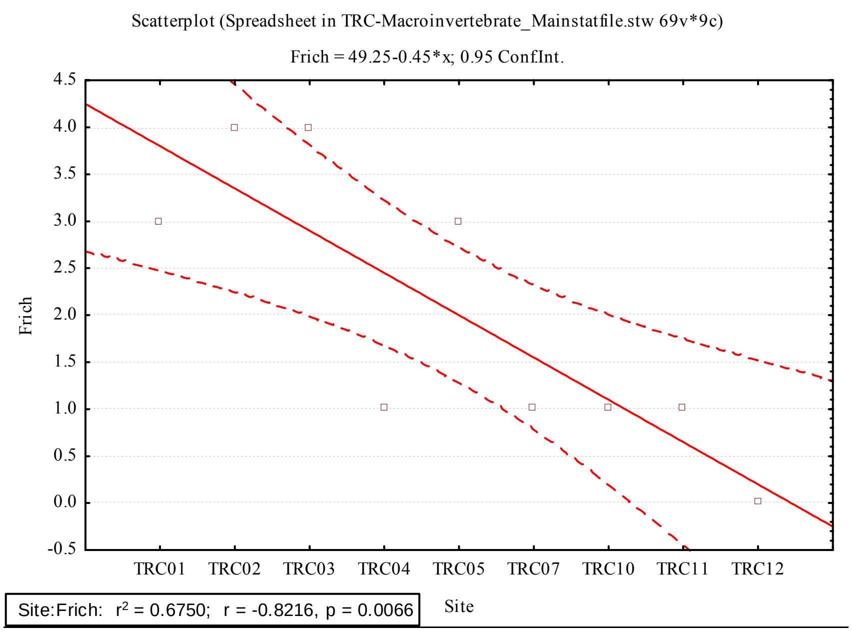



**Figure 40. Site vs. Filter Richness Metric trend analysis.**

## 3.4. Physical Habitat Monitoring

### *Habitat Assessment*

Physical habitat sampling occurred for all the Turkey Ridge Creek Monitoring sites, Physical habitat index (IPI) scores from each monitoring site, n=9, were calculated using the methods developed for the Central Big Sioux River Watershed Assessment (EDWDD, In Press). These methods were subsequently adopted by the SDENR-WRAP as part of the standard operating procedures for habitat assessment (Methods and Material Sections pg. 21).

A physical habitat index was developed from the Central Big Sioux data using EPA's Rapid Bioassessment of substrate, channel morphology, bank structure, and riparian vegetation (Barbour et al. 1999). Habitat measurements collected from 33 tributary sites for the Central Big Sioux Watershed Assessment (EDWDD, In Press) were used to develop the IPI. These final habitat scores exhibited natural breaks in the distribution of the data and were subsequently used to classify the sites into 3-4 categories of habitat quality. Figure 41 shows the range of IPI habitat scores for four categories: 31-46 (poor), 47-64 (fair), 65-80 (good). Final IPI scores ranging above 94 exhibited excellent conditions. The majority of the Big Sioux River sites fell within the 50-64 (fair) category (EDWDD, In Press).

Because of the deficiency of reference site criteria or data for habitat, habitat scores from the Turkey Ridge Creek monitoring sites were compared to Central Big Sioux data. Table 35 outlines the parameters and scores assigned to each. Figure 41 also shows the Turkey Ridge Creek IPI values as they compare to the 33 scores of the Central Big Sioux tributary sites.

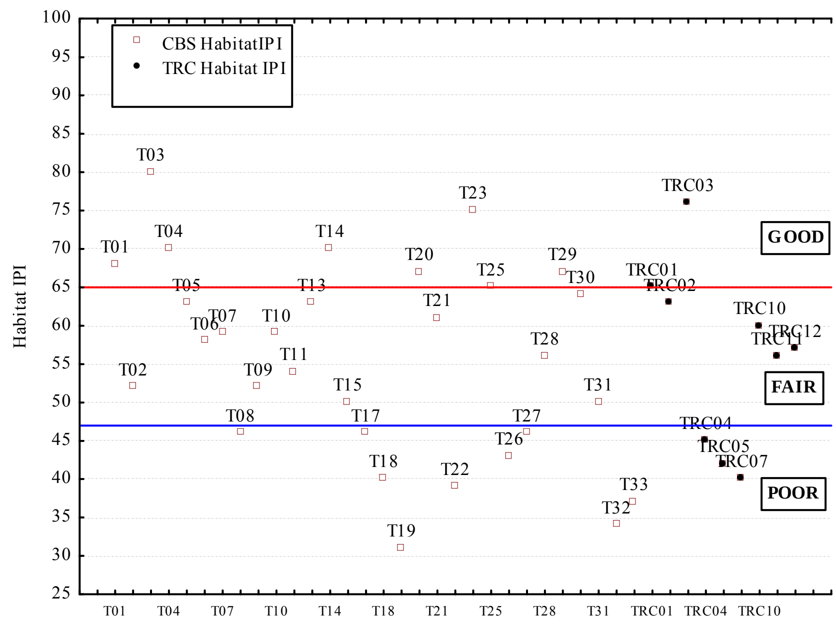



**Figure 41. IPI Scores from the Central Big Sioux and Turkey Ridge Creek.**

**Table 34. Physical Habitat Parameters used to develop IPI scores for the Central Big Sioux River.**

| | Rating | | | | |
|---|---|---|---|---|---|
| **Physical Parameter** | **Excellent** | **Good** | **Fair** | **Poor** | **Very Poor** |
| **1. Channel Flow Status** | Perrenial streamflow. Water surface reaches base of both lower banks, and minimal amount of channel substrate is exposed. | Perrenial streamflows. Water surface covers <100% but >75% of the available channel bottom. | Perrenial streamflows. Water surface covers 50-75% of the available channel bottom. | Perrenial streamflows. Water surface covers >50% of the available channel bottom. | Average Stream Width about 1/3 channel bottom width. Intermittent. |
| **SCORE** | **10** | **7.5** | **5** | **2.5** | **0** |
| **2. Physical Complexity** | high | high/moderate | moderate | moderate/low | low |
| | ≥8 hydrologic units, usually at least 3 riffles present | 6 to 7 hydrologic units, usually 2 to 4 riffles present | 4 to 5 hydrologic units, usually 1 to 3 riffles present | 2 to 3 hydrologic units, usually 0 to 1 riffles present | 1 hydrologic units, no riffles present |
| **SCORE** | **10** | **7.5** | **5** | **2.5** | **0** |
| **3. Coefficient of Variation of Velocity** | ≥1.2 | 0.9 to 1.2 | 0.6 to 0.9 | 0.3 to 0.6 | <0.3 |
| **SCORE** | **10** | **7.5** | **5** | **2.5** | **0** |
| **4. Bed Composition** | ≥ 75% gravel and larger | ≥ 75% gravel and sand (at least 50% gravel) | ≥ 75% coarse gravel, sand, and silt | ≥ 75% sand and silt (at least 50% sand) | > 75% silt or smaller |
| **SCORE *** | **16** | **12** | **8** | **4** | **0** |
| * Add 4 points if cobble size and larger comprise 10% of substrate | | | | | |
| **5. Measure of Incision** | Mean Bank Full Height is ≥70% of mean Bank Height. | Mean Bank Full Height is ≥60 to 69% of mean Bank Height. | Mean Bank Full Height is ≥50 to 59% of mean Bank Height. | Mean Bank Full Height is ≥40 to 49% of mean Bank Height. | Mean Bank Full Height is <40% of mean Bank Height. |
| **SCORE** | **10** | **7.5** | **5** | **2.5** | **0** |
| **6. Bank Stability** | >80% bank vegetated; the remaining erosional or depositional. | ≥60 to 80% bank vegetated; the remaining erosional or depositional. | ≥40 to 60% bank vegetated; the remaining erosional or depositional. | ≥20 to 40% bank vegetated; the remaining erosional or depositional. | <20% bank vegetated; the remaining erosional or depositional. |
| **SCORE** | **20** | **15** | **10** | **5** | **0** |
| **7. Overhanging Vegetation** | Average amount ≥0.5 m | ≥0.3 - 0.49 m | ≥0.2 - 0.29 m | ≥0.1 - 0.19 m | <0.1 m |
| **SCORE** | **10** | **7.5** | **5** | **2.5** | **0** |
| **8. Animal Vegetation Use** | No Use: All the potential plant biomass is present. | Light Use: Almost all of the potential plant biomass is present. | Moderate Use: About 1/2 of plant biomass is present. Plant stubble about half potential height. | High Use: Less than 1/2 of plant biomass is present. Plant stubble greater than 2 inches. | Very High Use: Nearly all plant biomass removed. Plant stubble less than 2 inches. |
| **SCORE** | **10** | **7.5** | **5** | **2.5** | **0** |

Each monitoring site was rated individually using the eight parameters. Scores ranged from 0 to 100. After each site was scored, a standardized metric score based on the 'best value' was calculated and served as the final index value for that site as shown (Table 35).

In the example shown in Table 35, Site T01 scored a 65.5. A score was calculated for each site (Turkey Ridge Creek or Central Big Sioux) where a habitat assessment had been completed. Because established reference sites were not available for comparison, the 95$^{th}$ percentile score of each metric calculated from all monitoring site data was used as the surrogate standard. The following calculation was used to find the metric score for each of the eight physical habitat parameters (Table 37).

(Measured metric value) ÷ (95$^{th}$ percentile standard best value) × 100 = standardized metric score

The final index value was found by averaging the eight standardized metric scores. The values range from 0 (very poor) to 100 (excellent). Score results for each Turkey Creek Ridge site can be found in Table 37. Both projects were located in the same Level III ecoregion (Northern Glaciated Plains) but different Level IV Ecoregions.

**Table 35. Sample Score Sheet for Physical Habitat**

| **SiteID:** T01**:** North Deer Ck (upper)* | | |
|---|---|---|
| | **Parameter** | **Score** |
| 1 | Channel Flow Status (10) | 10 |
| 2 | Hydrologic Complexity (10) | 10 |
| 3 | CV of Velocity (10) | 5 |
| 4 | Bed Composition (20) | 8 |
| 5 | Channel Incision (10) | 10 |
| 6 | Bank Stability (20) | 15 |
| 7 | Overhanging Vegetation (10) | 0 |
| 8 | Animal Vegetation Use (10) | 7.5 |
| | **Total =** | **65.5** |
| * - Central Big Sioux River Tributary Site | | |

**Table 36. Sample Final Score Sheet for Physical Habitat (EDWDD, In Press).**

| **Site T01 Metric** | **Percentile for "best" value** | **Standard (best value)** | **Measured metric value** | **Standardized Metric score** |
|---|---|---|---|---|
| Channel Flow Status | 95th | 10 | 10 | 100 |
| Physical Complexity | 95th | 10 | 10 | 100 |
| CV of Velocity | 95th | 10 | 5 | 50 |
| Bed Composition | 95th | 18 | 8 | 44 |
| Measure of Incision | 95th | 10 | 10 | 100 |
| Bank Stability | 95th | 20 | 15 | 75 |
| Overhanging Vegetation | 95th | 7.5 | 0 | 0 |
| Animal Vegetation Use | 95th | 10 | 7.5 | 75 |
| | | Final index value for this site: | | **68** |

Turkey Ridge Creek values for each of the eight physical parameters are shown in Table 38 and compared to the Central Big Sioux River Sites in Figure 41. Within this scoring system, Site TRC03 was significantly higher than the other sites (Table 37). At the time of the habitat assessment Site TRC03 was the only site that exhibited a riffle indicated by the Physical Complexity score of 100 (Table 37).

**Table 37. Turkey Ridge Creek Physical Habitat Index Values.**

| Site | Channel Flow Status | Phy. Comp | CV of Vel | Bed Comp | Channel Incision | Bank Stability | Ov-Hg Veg | AVU | Final Index |
|---|---|---|---|---|---|---|---|---|---|
| **Standard*** | **100** | **100** | **100** | **100** | **100** | **100** | **100** | **100** | **100** |
| TRC01 | 100 | 0 | 75 | 44 | 50 | 100 | 100 | 50 | 65 |
| TRC02 | 100 | 0 | 50 | 22 | 25 | 75 | 133 | 100 | 63 |
| TRC03 | 100 | 100 | 75 | 22 | 0 | 75 | 133 | 100 | 76 |
| TRC04 | 100 | 0 | 50 | 0 | 0 | 75 | 33 | 100 | 45 |
| TRC05 | 100 | 0 | 50 | 44 | 0 | 75 | 67 | 0 | 42 |
| TRC07 | 100 | 0 | 25 | 0 | 0 | 75 | 100 | 25 | 41 |
| TRC10 | 100 | 0 | 50 | 0 | 25 | 75 | 133 | 100 | 60 |
| TRC11 | 100 | 0 | 100 | 44 | 25 | 50 | 100 | 25 | 56 |
| TRC12 | 100 | 0 | 25 | 0 | 25 | 75 | 133 | 100 | 57 |

* - Central Big Sioux River Watershed Assessment Standard for Index of Physical Integrity.

The middle three sites along Turkey Ridge Creek were rated significantly lower which can be attributed to channel incision, heavy animal vegetation use, and a denuded riparian zone. Although not significant, Figure 42 shows a slight decreasing trend toward habitat degradation with each successive site indicating that water quality, and habitat problems accumulate as stream progresses downstream.

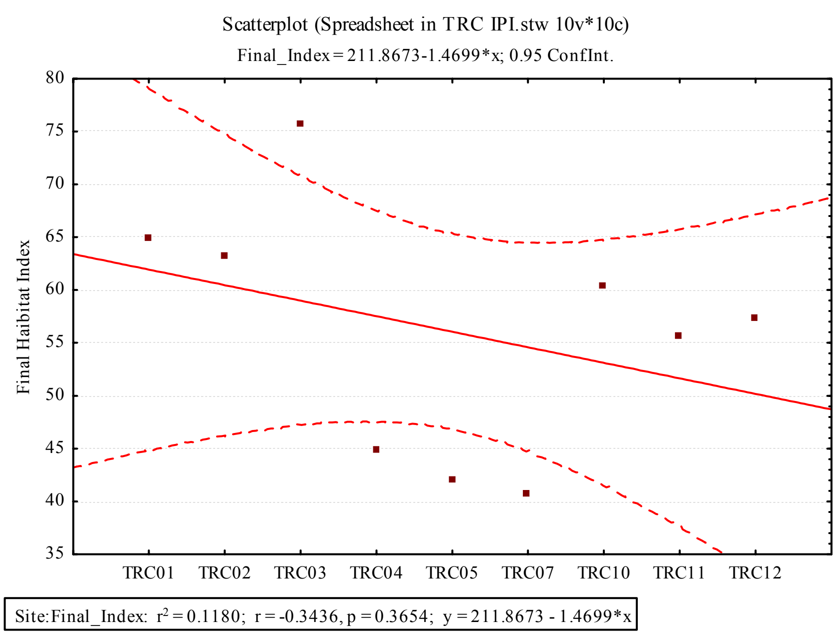



**Figure 42. Turkey Ridge Creek IPI scores ranked upstream to downstream.**

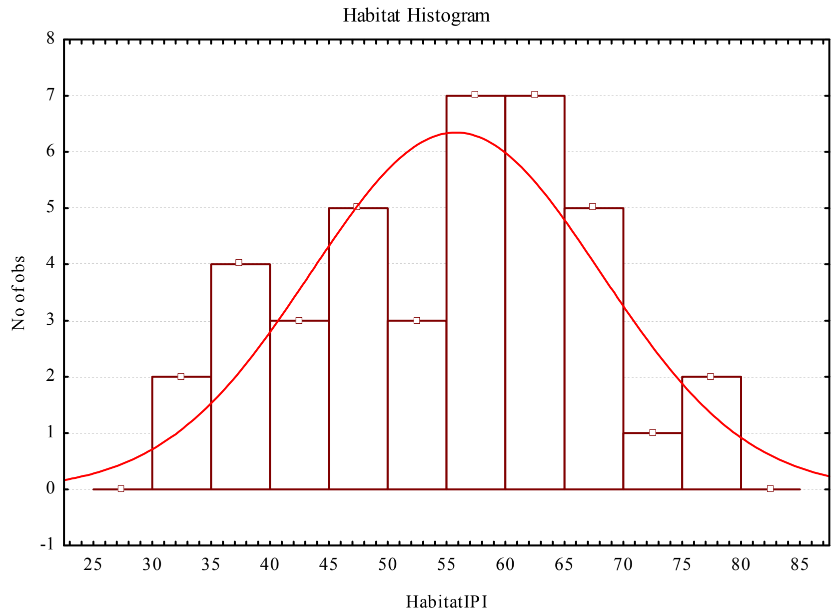



**Figure 43. Statistical distribution of IPI scores.**

The Central Big Sioux River and Turkey Ridge Creek IPI data were pooled and compared. Figure 43 suggests a normal statistical distribution for the raw IPI data (no data transformation). A normal distribution implies that a majority of site scores are centered about the mean with a minority of lower and higher scores located on either side of the distribution. A skewed distribution, i.e. too many low scores or high scores, would imply bias has entered somewhere along the assessment or calculation process. Habitat IPI data from Turkey Ridge Creek fell within the range of data exhibited by the Central Big Sioux Data. A one-way ANOVA indicated no significant differences between the two projects ($n=39, d.f.=1, p>0.05$).

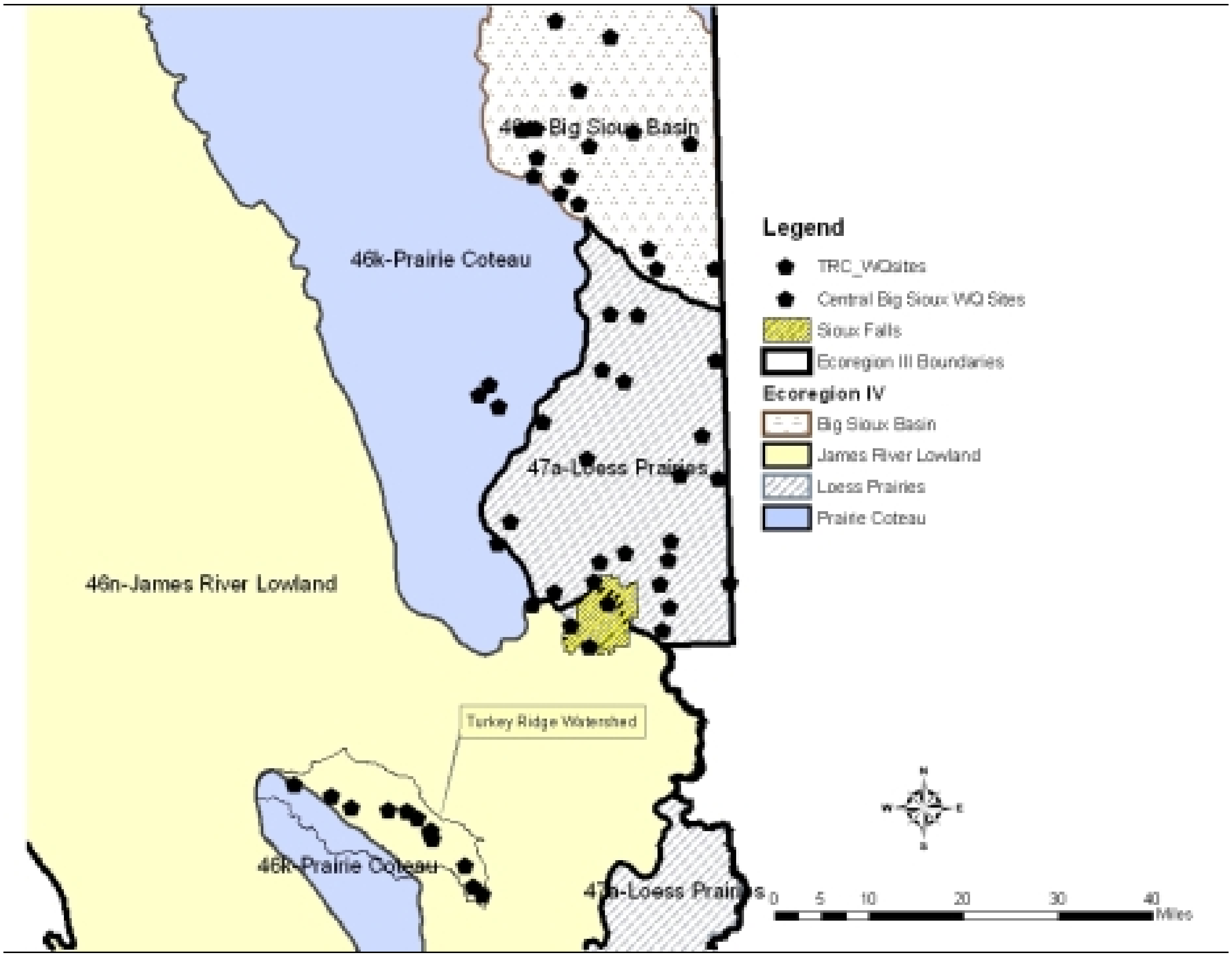



**Figure 44. Site locations and associated ecoregions for Turkey Ridge Creek and the Central Big Sioux River Projects.**

***Rapid Geomorphic Assessments***

Rapid geomorphic assessments are another tool used to gather channel stability information. This information was collected at 36 locations at each bridge/road crossing along the entire length of Turkey Ridge Creek. Questions concerning nine parameters are used to assess various geomorphic characteristics along either side of the channel (Table 38). The RGAs rate the channel in terms of bed material, bed and bank protection, etc. With each question a score is given depending on the relative channel characteristics of each site. A lower total score usually signifies a channel that exhibits fewer problems with erosion, evolution, and incision. Once the extent and severity of unstable reaches is quantified, a more comprehensive ground survey will be used to determine causes of the instability. For Turkey Ridge Creek, a more intensive survey will take place during the Vermillion River Watershed. All tributaries within the 1.4 million acre Vermillion River watershed will be compared using the RGA method. A determination will then be made for each tributary for more detailing surveys and computer modeling.

**Table 38. RGA Channel-Stability Ranking Datasheet.**

| CHANNEL-STABILITY RANKING SCHEME (RGA) | | | | | |
|---|---|---|---|---|---|
| **1. Primary Bed Material** | | | | | |
| Bedrock | Boulder/Cobble | Gravel | Sand | Silt/Clay | |
| 0 | 1 | 2 | 3 | 4 | |
| **2. Bed/Bank Protection** | | | | | |
| Yes | No | (with) | 1 bank | 2 banks | |
| 0 | 1 | | 2 | 3 | |
| **3. Degree of incision (Relative elevation of "normal" low water; floodplain/terrace @ 100%)** | | | | | |
| 0-10% | 11-25% | 26-50% | 51-75% | 76-100% | |
| 4 | 3 | 2 | 1 | 0 | |
| **4. Degree of constriction (Relative decrease in top-bank width from up to downstream)** | | | | | |
| 0-10% | 11-25% | 26-50% | 51-75% | 76-100% | |
| 0 | 1 | 2 | 3 | 4 | |
| **5. Streambank erosion (Each Bank)** | | | | | |
| | None | Fluvial | Mass Wasting (failures) | | |
| Left/ Inside | 0 | 1 | 2 | | |
| Right/ Outside | 0 | 1 | 2 | | |
| **6. Streambank instability (Percent of each bank failing)** | | | | | |
| | 0-10% | 11-25% | 26-50% | 51-75% | 76-100% |
| Left/ Inside | 0 | 0.5 | 1 | 1.5 | 2 |
| Right/ Outside | 0 | 0.5 | 1 | 1.5 | 2 |
| **7. Established riparian woody-vegetative cover (each bank)** | | | | | |
| | 0-10% | 11-25% | 26-50% | 51-75% | 76-100% |
| Left/ Inside | 2 | 1.5 | 1 | 0.5 | 0 |
| Right/ Outside | 2 | 1.5 | 1 | 0.5 | 0 |
| **8. Occurrence of bank accretion (percent of each bank with fluivial deposition)** | | | | | |
| | 0-10% | 11-25% | 26-50% | 51-75% | 76-100% |
| Left/ Inside | 2 | 1.5 | 1 | 0.5 | 0 |
| Right/ Outside | 2 | 1.5 | 1 | 0.5 | 0 |
| **9. Stage of channel evolution** | | | | | |
| I | II | III | IV | V | VI |
| 0 | 1 | 2 | 4 | 3 | 1.5 |
| | | | **TOTAL SCORE:** | | |

Figure 45 on the following page shows all 36 RGA scores collected for the Turkey Ridge Assessment. There is a slight trend toward declining channel instability with downstream locations. Scatterplots and individual trend analyses were completed for all nine parameters for each RGA site. A general decline in overall stream stability seems to be evident primarily related to stage of channel evolution. It should be noted that the stage of channel evolution parameter was recorded as Stage I or Stage IV at 17 and 15 RGA sites, respectively. The problems with the channel become more evident towards the center of the watershed. Appendix RGA shows scatterplots for each RGA site with each parameter on the RGA score sheet.

The RGA uses Andrew Simon's (1989) Channel Evolution Model where:

Stage I: The waterway is a stable, undisturbed natural channel.
Stage II: The channel is disturbed by some drastic change such as forest clearing, urbanization, dam construction, or channel dredging.
Stage III: Instability sets in with scouring of the bed.
Stage IV: Destructive bank erosion and channel widening occur by collapse of bank sections.
Stage V: The banks continue to cave into the stream, widening the channel. The stream also begins to aggrade, or fill in, with sediment from eroding channel sections upstream.
Stage VI: Aggradation continues to fill the channel, re-equilibrium occurs, and bank erosion ceases. Riparian vegetation once again becomes established.

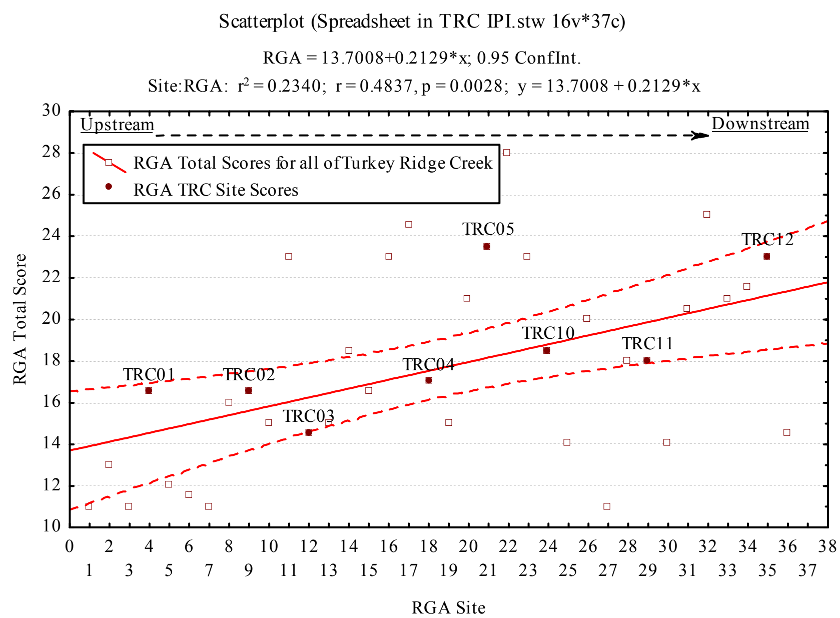



**Figure 45. RGA Scores for Turkey Ridge Creek Road Crossings.**

### *AGNPS Feedlot Model*

AGNPS feedlot model ranked 129 feedlots within the Turkey Ridge Creek watershed. Table 39 shows the monitoring sites broken out by AGNPS feedlot ratings and also by total number of feedlots.

AGNPS feedlot model ranked the feedlots on a scale from 0 to 100 with larger numbers indicating the potential for severe pollution hazard. The feedlot rating is based upon the mass load, in pounds of COD, contributed by the feedlot itself during a 25 year, 24 hour storm event for Turner County, SD. The 0 to 100 rating is used to assess the relative potential pollution hazard posed by any feedlot within the watershed (Young, et al., April 1982). Introduction taken from Agricultural Reviews and Manuals, Agricultural Research Service, U.S. Department of Agriculture, April 1982.

Of the 129 small feeding operations identified in the watershed, 45 exhibited a rating greater then 50 (Table 39). Table 39 also shows the number of AFOs per subwatershed area and the fecal coliform violation rate.

**Table 39. AFOs per subwatershed for Turkey Ridge Creek.**

| AGNPS Feedlot Rating | | Predominant Animal Type | Avg # of Animals |
|---|---|---|---|
| # Lots > 50 | 45 | Beef Cow (Young Beef) | 74 |
| # Lots > 60 | 18 | Beef Cow (Slaughter Steer) | 56 |

| Subwatershed | Subwatershed Size | # of Feedlots | Avg AGNPS Feedlot Rating | Range of AGNPS Rating | **N>2,000 cfu/100ml** | **Coliform Violation Rate** |
|---|---|---|---|---|---|---|
| TRC01 | 7594.6 | 6 | 43 | 18-59 | 3 | 15.0% |
| TRC02 | 12132 | 22 | 44 | 20-61 | 6 | 33.3% |
| TRC03 | 15992.4 | 21 | 45 | 19-66 | 8 | 42.1% |
| TRC04 | 9607.5 | 6 | 36 | 23-46 | 5 | 25.0% |
| TRC05 | 32626.7 | 28 | 50 | 17-81 | 5 | 26.3% |
| TRC07 | 3242.3 | 4 | 50 | 32-64 | 4 | 20.0% |
| TRC10 | 11428.6 | 24 | 38 | 0-59 | 5 | 35.7% |
| TRC11 | 8877.1 | 2 | 45 | 45-45 | 5 | 27.8% |
| TRC12 | 10188.8 | 16 | 41 | 24-55 | 4 | 18.2% |

## 3.5. Assessment of Fecal Coliform Sources

The Bacterial Indictor Tool was used to allocate all possible sources for fecal coliform bacteria in the Turkey Ridge Creek Watershed with the exception of the point sources (NPDES).

***Landuse and Model Description***

Cropland, built-up (urban or suburban), forest and pastureland areas (acres) were estimated by using GIS coverages assembled by the Farm Services Agency (USDA-FSA). Landowners and operators each spring need to certify their crops within each county FSA office in order to become eligible for farm support payments (subsidies). The crop type and acreages for each field are recorded in the attribute table of the FSA common land unit GIS coverage. These coverages contain ten different landuse classifications (see below). Using this GIS coverage, acreages were calculated for each landuse type within the 112,435-acre Turkey Ridge Creek Watershed.

| | |
|---|---|
| Urban | Cropland |
| Rangeland | Forest |
| Waterbody | Mined |
| Barren (1) | Barren(2) |
| Perennial Ice/Snow | Other Agland (building/farmstead) |

Contributions from these landuses and possible fecal coliform accumulations are asymptotic, i.e. they will reach a maximum possible accumulation level. The rate of fecal coliform accumulation and the maximum storage of fecal coliform bacteria are based on the specific land use type. The monthly accumulation rates are based on research conducted by Horsely and Whitten, 1986 and excerpted here from the Bacterial Indicator Tool User Manual, 2000, pg 15.

1) The values are simply the total fecal coliform bacteria accumulation rates from each land use worksheet (Cropland, Pastureland, Forest, and Built-up).
2) the value is derived using the following die-off equation from Horsely & Whitten (1986):

$N_t = N_0(10^{(-kt)})$ where: $N_t$ = number of fecal coliform present at time t.
$N_0$ = number of fecal coliforms present at time 0
t = time in days
k = first order die-off rate constant. Typical values for warm months = 0.51/day and fro cold months = 0.36/day

The following table was excerpted from the Bacterial Indicator Tool user manual which can be found in Appendix E. The output from the Bacterial Indicator Tool is primarily used as input file for the WinHSPF and the Hydrological Simulation Program Fortran (HSPF) water quality model within BASINS. This tool is used here to estimate potential daily accumulation rates from diffuse nonpoint sources and daily loading rates from direct nonpoint sources for fecal coliform bacteria in the Turkey Ridge Creek Watershed.

| **Worksheet Name** | **Purpose** |
|---|---|
| Landuse | Breakdown of the acres of each landuse category. |
| Animal | Documents the kinds and numbers of livestock in the watershed. |
| Wildlife | Calculates the fecal coliform bacteria produced by wildlife by land use category. |
| Cropland | Calculates the monthly rate of accumulation of fecal coliform bacteria on cropland from wildlife, hog, cattle, and poultry manure. |
| Forest | Calculates the rate of accumulation of fecal coliform bacteria on forestland from wildlife. |
| Built-up | Calculates the rate of accumulation of fecal coliform bacteria on built-up land using literature values. |
| Pastureland | Calculates the monthly rate of accumulation of fecal coliform bacteria on pastureland from wildlife, cattle, and horse manure, and cattle, horse, sheep, and other grazing. |
| Cattle in Streams | Calculates the monthly loading and flow rate of fecal coliform bacteria contributed directly to the stream by beef cattle. |
| Septics | Calculates the monthly loading and flow rate of fecal coliform bacteria from failing septic systems. |
| ACQOP&SQOLIM (for land uses) | Summarizes the monthly rate of accumulation of fecal coliform bacteria on the four land uses; calculates the build-up limit for each land use. Provides input parameters for HSPF (ACQOP/MON-ACCUM and SQOLIM). |
| Feedlots rated > 60 | Not part of the original worksheet. Feedlots rated greater than 60 by AGNPS Standalone Feedlot Model were treated as separate direct nonpoint source by calculating a daily loading rate from the numbers of livestock confined within the lot. Literature values were used to calculate daily bacterial loading rate from an average animal (beef cow, dairy cow, hog, etc.) |

After a potential daily loading rate (cfu/day) was determined for each nonpoint source, point source contributions were determined. The daily fecal loading rate for the period of May 1 – September 30 was calculated and added to a daily fecal loading rate for all sources within the watershed resulting in a total contribution from each source. These three general sources (nonpoint diffuse, nonpoint direct, and point) were summed to calculate a potential daily percent contribution

### *Animal Numbers and Estimates (Livestock, Wildlife, Domestic Pets)*

The number of livestock within the watershed was determined by completing an animal feeding operation inventory (AFO) during the watershed assessment. In addition, data from the 2002 AG Census completed by the National Agricultural Statistics Service (NASS) for Turner County was used to estimate total confined/unconfined livestock animals (grazing animals) (NASS, 2002). The NASS Statistical Survey estimated 55,000 dairy and beef cattle for Turner County. This number was used to estimate total number of cows present in the Turkey Ridge Creek Watershed during 2002.

The AFO inventory indicated that 10,762 beef and dairy cattle were confined in 129 feedlots within the 112,435 acres. Each AFO was assessed for pollution potential using the Agricultural Nonpoint Source_(AGNPS) Standalone Feedlot Model. The AGNPS feedlot results identified 17 AFOs rated higher than 60 on a scale 0-100, 100 being extremely severe for pollution potential. These lots contained 2,150 cattle. The cattle in these lots were considered to be confined year round and were treated as a direct nonpoint source during the May 1 – September 30 period (Table 40).

**Table 40. Livestock (beef cattle) Estimations for Turkey Ride Creek Watershed in Turner, SD, 2002.**

| **Turner County** | | **TRC Watershed** | | |
|---|---|---|---|---|
| | | | **Direct Input** | **Diffuse Input**<br>(manure is land applied to cropland or pastureland) |
| Total Cattle | Stocking Rate per Acre | Total Cattle in TRC Watershed | Cattle in Lots | Remaining cattle left for part-time confinement and turned out for grazing (manure application worksheet, Bacterial Source Indicator Tool)<br>Cattle per Acre) |
| Estimated Cattle for Turner County (Source: NASS Ag Census Data, 2002) | Cattle per Acre (Turner County = 393, 600 acres) | Cattle in TRC Watershed (0.14 X 119,430 FSA acres) | Cattle in Lots rated > 60 (assumed year round confinement) treated as a direct nonpoint source | (16,720-2,105)=14,615 cattle available for grazing or confinement depending on time of year (see grazing worksheet or Manure Management worksheet in Bacterial Source Indicator Tool |
| 55,000 | 0.14 | 16,720 | 2,105 | **14,615***used in Table 42a |

The remaining cattle, other livestock, wildlife, and pets in the watershed were assessed by the using worksheets in the Bacterial Indicator Tool in the following manner:

*Animal Feeding Operations Rated >60 Daily Contributions*

The 2,105 beef cattle confined in the 17 AFOs rated greater than 60 by the AGNPS Standalone Feedlot Model were treated as direct inputs to the stream during the entire year. The potential daily contribution in fecal colony counts/day is shown in Table 41. Literature values for beef cattle daily output of fecal coliform colonies was taken from the Bacterial Source Indicator Tool References Worksheet.

**Table 41. Monthly Contributions for AFOs Rated >60.**

| AFO> 60, monthly contributions | FC Loading Rate (counts/day) |
|---|---|
| May | 1.97E+15 |
| June | 1.97E+15 |
| July | 1.97E+15 |
| August | 1.97E+15 |
| September | 1.97E+15 |

*Remaining Livestock*

Livestock numbers from the AFO inventory, wildlife, and domestic pets were included in these worksheets (Table 42a, b, and c). Wildlife densities were calculated using estimates from the South Dakota Game Report No. 2003-11 (SDGFP, 2003).

**Table 42a. Agricultural Animals** (used with Cropland and Pastureland Worksheets)

| SUBWATERSHED | BEEF CATTLE* | SWINE (HOGS) | DAIRY CATTLE | CHICKENS | HORSES | SHEEP | OTHER |
|---|---|---|---|---|---|---|---|
| **TRC** | 14,615 | 38,246 | 760 | - | 3 | 3,991 | - |
| **TOTAL** | 14,615 | 38,246 | 760 | - | 3 | 3,991 | - |

*Wildlife and Domestic Pets Daily Contributions*

**Table 42b. Daily Wildlife Contributions for Various Landuses**

| | LANDUSE | | | | Direct to Stream (Proportion)* | Coliform Per Day (cfu per day) |
|---|---|---|---|---|---|---|
| | CROPLAND | PASTURELAND | FOREST | Built-Up | | |
| | Density/acre | Density/acre | Density/acre | Animals/acre | | |
| **Ducks** | 0.0046875 | 0.0046875 | 0.001265625 | 0.0046875 | 0.25 | 2.51E+11 |
| **Geese** | 0.0046875 | 0.0046875 | 0 | 0.0046875 | 0.25 | 2.73E+10 |
| **Deer** | 0.0043125 | 0.0043125 | 0.0043125 | 0 | 0.01 | 1.74E+10 |
| **Beaver** | 0.00278125 | 0.00278125 | 0.00278125 | 0 | 1 | 6.49E+07 |
| **Raccoons** | 0.005828125 | 0.005828125 | 0.005828125 | 0.005828125 | 0.05 | 8.50E+09 |
| **Other** | 0.00203125 | 0.00203125 | 0.00203125 | 0.00203125 | 0.3 | 5.33E+08 |
| *** Proportion deposited directly into the stream.** | | | | | | |

**Table 42c. Domestic Pets Daily Contributions.**

| *402 residence X 1 pet = 402 pets, 5% of pet waste deposited directly into streams. Assume the following: | | | | | |
|---|---|---|---|---|---|
| **All Months** | **# Pets (assume 1/house)** | **#pets in streams** | **FC Loading Rate (#/hr)** | **Waste Flow (cfs)** | **FC rate** (#/day) |
| **TRC** | 402 | 20 | 7.75E+07 | 1.16E-05 | 1.86E+09 |
| Domestic Pet waste 0.50 (lbs/animal/day), density of domestic pet manure (including urine) is approximately the density of water: 10 (lbs/cubic foot) | | | | | |
| *From SDDOT Road Coverage (GIS) there were 402 rural residence or farms classified as occupied when data was collected. | | | | | |

### *Manure Application Rates*

Table 43 shows the resulting fraction of annual manure application available for runoff each month based on the monthly fraction applied and incorporation into the soil. The fraction of manure available for runoff is dependent on the method of manure application. The fraction available is computed based on incorporation into soil.

**Table 43. Monthly fraction of annual manure application for Turkey Ridge Creek.**

| Month | Hog | Beef Cattle | Horse | Poultry | Dairy Cattle | Imported Manure |
|---|---|---|---|---|---|---|
| January | - | - | 0.01 | - | - | - |
| February | - | 0.03 | 0.01 | 0.04 | 0.05 | 0.04 |
| March | 0.15 | 0.16 | 0.01 | 0.19 | 0.24 | 0.19 |
| April | 0.23 | 0.13 | 0.01 | 0.15 | 0.19 | 0.15 |
| May | 0.15 | 0.02 | 0.01 | 0.04 | 0.02 | 0.02 |
| June | 0.00 | 0.02 | 0.01 | 0.04 | 0.02 | 0.02 |
| July | 0.00 | 0.02 | 0.17 | 0.04 | 0.02 | 0.02 |
| August | 0.00 | 0.03 | 0.17 | 0.04 | 0.05 | 0.04 |
| September | 0.08 | 0.11 | 0.17 | 0.08 | 0.17 | 0.13 |
| October | 0.07 | 0.06 | 0.01 | 0.08 | 0.10 | 0.08 |
| November | 0.08 | 0.06 | 0.01 | 0.08 | 0.10 | 0.08 |
| December | - | - | 0.01 | - | - | - |
| Fraction incorporated into soil (assumed)* | 0.50 | 0.25 | 0.75 | 0.50 | 0.10 | 0.50 |
| Fraction available for runoff* | 0.75 | 0.88 | 0.63 | 0.75 | 0.95 | 0.75 |
| = (1 - [fraction incorporated]) + ([fraction incorporated] * 0.5) | | | | | | |
| % Applied to Cropland | 100% | 50% | | 100% | 75% | 50% |
| % Applied to Pastureland | 0% | 50% | 100% | | 25% | 50% |

### *Grazing Rates*

Table 44 shows the fraction of time that the remaining 14,165 cattle in the watershed spend confined and grazing during the year. An estimate of the time spent in the streams by the grazing cattle is also indicated. The time spent in the stream is used to calculate the contribution of cattle in the streams as direct inputs. Similar calculations are completed for the other livestock as well (Appendix E). The grazing worksheet was used to calculate daily fecal loading rates by using the other landuse worksheets (Pastureland – diffuse input and Cattle in Streams – direct input)

**Table 44. Monthly fraction of time for livestock spent grazing for the Turkey Ridge Creek Watershed.**

| | *Beef Cattle Confined* | *Beef Cattle Grazing* | *Beef Cattle In Streams* | *Beef Cattle in Pasture* |
|---|---|---|---|---|
| **Month** | **Time Spent Confined (0.00 to 1.00)** | **Time Spent Grazing (0.00 to 1.00)** | **Grazing Time Spent in Streams (0.00 to 1.00)** | **Grazing Time Spent in Pasture (0.00 to 1.00)** |
| January | 1.00 | 0.00 | 0.02000 | 0.9800 |
| February | 1.00 | 0.00 | 0.02000 | 0.9800 |
| March | 0.40 | 0.60 | 0.02000 | 0.9800 |
| April | 0.30 | 0.70 | 0.03000 | 0.9700 |
| May | 0.20 | 0.80 | 0.04000 | 0.9600 |
| June | 0.20 | 0.80 | 0.05000 | 0.9500 |
| July | 0.20 | 0.80 | 0.05000 | 0.9500 |
| August | 0.20 | 0.80 | 0.05000 | 0.9500 |
| September | 0.20 | 0.80 | 0.05000 | 0.9500 |
| October | 0.60 | 0.40 | 0.03000 | 0.9700 |
| November | 1.00 | 0.00 | 0.02000 | 0.9800 |
| December | 1.00 | 0.00 | 0.02000 | 0.9800 |

### *Nonpoint Source (Diffuse Sources)*

Fecal coliform estimates (cfu/day) from each landuse type (Table 45) were calculated using the Remaining Animals (Table 42a-c), Manure Management (Table 43), and Grazing Rate Animals and Wildlife worksheets previously described.

**Table 45. Turkey Ridge Creek Landuse.**

| Land Use | Percentage | Acres |
|---|---|---|
| Built-Up | 2.4% | 2,705 |
| Cropland | 85.0% | 95,570 |
| Pastureland | 13.0% | 14,617 |
| Forest | 0.06% | 70 |
| Total | 100.0% | 112,435 |

*Cropland*

Cropland in the Turkey Ridge Creek Watershed constitutes 85% (95,570 acres) of the watershed. The Bacterial Source Indicator Tool outlines four possible sources of bacteria for cropland: wildlife, hog manure, cattle manure, and poultry litter. Daily accumulation rates based on the animal numbers and the manure management found within the watershed were used to estimate application rates of manure on cropland. The fraction of manure is substantially reduced during the summer months (Table Manure). Hog manure is applied during the spring of the year after the ground has thawed or it is applied during late fall (Surface Water Quality Program, 2005). Fifty percent of the manure applied to the cropland was assumed to be injected into ground. Because of these management practices and because this landuse constitutes 85% of the watershed, cropland ranges from a low of 8.8% of the potential daily bacterial load in June to 30.3% of the potential daily bacterial load calculated for the month of May (Table 47).

Pastureland

There are 14,617 acres of documented pastureland comprising only 13.0% of the watershed. Using the Bacterial Source Indicator Tool which takes into consideration the amount of livestock grazing, how much manure is applied to grassland versus cropland, this diffuse source amounts up to 22.3% of the possible washoff during a storm event from May through September (Table 41).

Forest and Builtup

Forest and built-up (urban and farmsteads) comprise approximately 3% of the overall watershed. The City of Viborg is the only municipality (pop. 832) in the watershed Consequently, these two landuse categories are insignificant diffuse sources comprising less than 1% of the overall coliform input (Table 41).

***Nonpoint Source (Direct Sources)***

Cattle standing in streams, AFO's with AGNPS ratings > 60, wildlife and pets in streams, and failing septic tanks were considered as direct sources of nonpoint pollution.

Cattle in Streams

The Animal and Grazing worksheets in the Bacterial Source Indicator Tool were used to estimate the contribution of the cattle standing in streams for the period of May 1 through September 30. Based on the number of cattle grazing in the watershed during this period, this source could constitute from 9.4% to 15% of the daily input into Turkey Ridge Creek (Table 41).

AFO >60

The 2,105 cattle located within these 17 feedlots constituted 22% of the overall confined animal documented in the feedlot inventory. Based on the load duration curve and the fact that the violations of the water quality standard occurred during high flow the manure pack becomes mobile. The animals within these small lots were assumed to be confined during the entire year classifying them as a potential daily input to the stream. Compared to the other sources in the watershed, these feedlots constituted from 41.2% to 54% of the potential daily sources of bacteria. This translates into the largest potential source of both diffuse and direct sources.

Wildlife and Pets

Both wildlife and pets were considered as potential bacterial sources. However, they constituted less than 1 percent of the overall problem for Turkey Ridge Creek for the months of May through September (Table 41).

Septic Systems

There were 402 document occupied residences within the watershed. This estimate was based on the SD Department of Transportation GPS roads survey that documented occupied rural residences. Using the Septic Worksheet in the Bacterial Indicator Tool, 2.5 people (total rural pop. 1005) were assumed to live in each of these residences, 5% of the septic tanks were failing, and the average bacterial concentration of the septic overcharge was 10,000 cfus/day. Failing septic tanks constituted less than 1% of the overall daily input to Turkey Ridge Creek for May through September timeframe (Table 47).

*Agricultural*

Agricultural animals are the source of several types of non-point sources as indicated in the Future Recommendations section of the Assessment Report. Agricultural activities including runoff from pastureland and cattle in streams, can affect water quality. Livestock data collected during AGNPS Feedlot modeling are listed in Table 41.

***Point Sources (NPDES)***

The NPDES facilities taken into consideration within this watershed include four concentrated animal feeding operations (CAFOs) and one municipal wastewater treatment facility (Viborg-pop.832). The City of Viborg discharged during the study period but this occurred outside the applicable period for the fecal coliform standard (May 1 – September 30). At the time of discharge, the City of Viborg is required to notify SDDENR and they must maintain water quality standards. The 2,000 cfu daily maximum (1,000 geometric mean from 5 samples collected over five 24-hour periods) would have to be maintained should a discharge event occur during applicable period. The CAFOs do not discharge at any time and constitute 0 fecal loadings to Turkey Ridge Creek.

To estimate the percent contribution for the City of Viborg should a discharge event occur during May 1 – September 30 a daily fecal coliform loading rate was calculated. Numbers were provided by the SDDENR-Surface Water Quality Program. The total storage capacity of the sewage lagoons from the City of Viborg was calculated (Table 46, Equation 1).

Using the 2,000 cfu/day daily maximum allowable as the maximum possible concentration for fecal coliform, the total amount of coliform that could be discharged would be $3.08 \times 10^{17}$ cfu's (Table 46, Equation 2).

The water quality standards for limited contact recreation are only applied during the months of May 1 through September 30, which constitutes 153 days. In Equation 3 of Table 46, the daily fecal coliform contribution to Turkey Ridge Creek would be $2.33 \times 10^{10}$ cfu/day.

**Table 46. Bacterial Contributions from the City of Viborg.**

$$1)\ 13.15\,\text{surface acres} \times \frac{43{,}560.17\,\text{ft}^2}{acre} = 572{,}816.2\,\text{ft}^2 \times 5.5\,\text{ft} = 3{,}150{,}489\,\text{ft}^3 \times 2(\textit{doubling rate}) = 6{,}300{,}978\,\text{ft}^3$$

$$2)\ 6{,}300{,}978\,ft^3 \times \frac{28{,}317\,ml}{1\,ft^3} \times \frac{86{,}400\,\text{sec}}{day} \times \frac{2{,}000\,cfu\,(\textit{daily}\ \text{max})}{100\,ml} = 3.08 \times 10^{17}\,cfu$$

$$3)\ \frac{3.08 \times 10^{17}\,cfu}{153\,days_{\text{(From May 1 through September 30)}}} = 2.33 \times 10^{10}\,cfu/day$$

Assuming the fecal load from all NPDES sources would be a 2.33 x $10^{10}$ cfu/day, this would constitute less than one percent of the overall potential load in the watershed (Table 47).

Nonpoint source pollution, unlike pollution from municipalities and NPDES facilities, comes from many diffuse and direct sources. Potential nonpoint direct sources of fecal coliform include loadings from wildlife, livestock, pets, and leaking septic tanks.

**Table 47. Fecal Coliform Source Allocations for Turkey Ridge Creek.**

| Diffuse Nonpoint Sources | Month ⟶ | May | June | July | Aug | Sept | May | June | July | Aug | Sept |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Monthly Accumulation Rates (Possible washoff on any one day) (cfu/day) | Cropland | 1.41E+15 | 3.20E+14 | 3.17E+14 | 3.97E+14 | 1.37E+15 | 30.3% | 8.8% | 8.7% | 10.6% | 28.7% |
| | Forest | 2.02E+11 | 2.02E+11 | 2.02E+11 | 2.02E+11 | 2.02E+11 | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | Built-Up | 4.99E+10 | 4.99E+10 | 4.99E+10 | 4.99E+10 | 4.99E+10 | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | Patureland | 8.21E+14 | 8.15E+14 | 8.15E+14 | 8.27E+14 | 8.90E+14 | 17.7% | 22.3% | 22.3% | 22.1% | 18.6% |
| **Direct Nonpoint Sources** | Cattle In Streams | 4.38E+14 | 5.47E+14 | 5.47E+14 | 5.47E+14 | 5.47E+14 | 9.4% | 15.0% | 15.0% | 14.6% | 11.4% |
| Daily Inputs (cfu/day) | Feedlots>60 | 1.97E+15 | 1.97E+15 | 1.97E+15 | 1.97E+15 | 1.97E+15 | 42.5% | 53.9% | 54.0% | 52.7% | 41.2% |
| | Wildlife | 3.05E+11 | 3.05E+11 | 3.05E+11 | 3.05E+11 | 3.05E+11 | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | Pets | 1.86E+09 | 1.86E+09 | 1.86E+09 | 1.86E+09 | 1.86E+09 | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | Septics | 1.33E+09 | 1.33E+09 | 1.33E+09 | 1.33E+09 | 1.33E+09 | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | City of Viborg | 2.33E+10 | 2.33E+10 | 2.33E+10 | 2.33E+10 | 2.33E+10 | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | Total cfu/day possible | 4.64E+15 | 3.65E+15 | 3.65E+15 | 3.74E+15 | 4.78E+15 | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% |

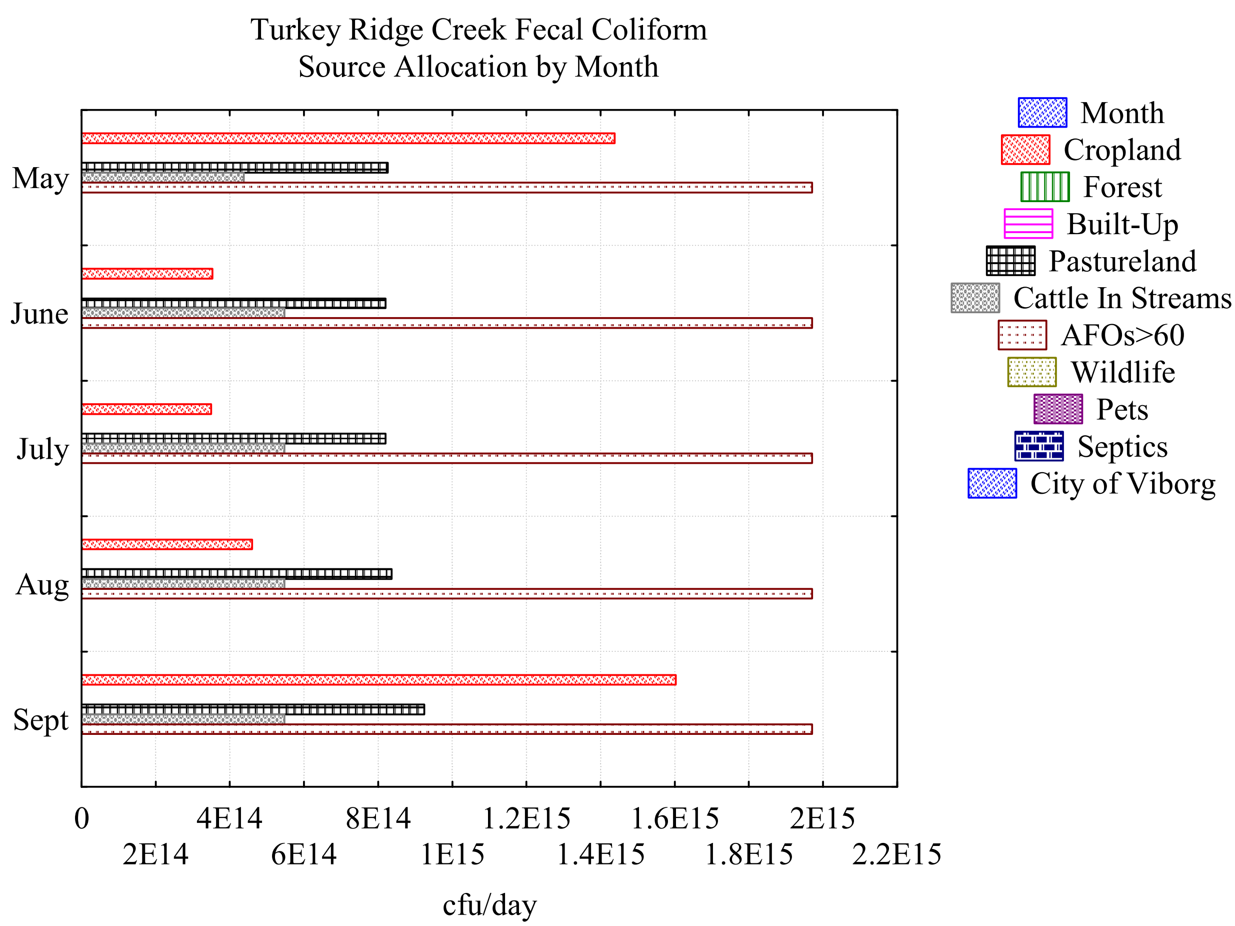



**Figure 46. Fecal Coliform Source Allocation by Month.**

### 3.6. Modeling

***Flux Modeling***

The FLUX Model was used to estimate the nutrient and sediment loadings for each site. These loads and their standard errors (coefficient of variation or CV) were calculated and are presented in Appendix F. All sample and flow data collected during this project were utilized in the calculation of the loads and concentrations. Nutrient and sediment export coefficients (lbs/acre) were calculated for each subwatershed of each monitoring site. To determine the amount of material derived from within each subwatershed the amount of material documented at the previous upstream site was removed from the following downstream sites, i.e. Site TRC01 TP loadings were removed from Site TRC02 TP loadings. These within-site loadings were compared with all other monitoring sites to determine which subwatersheds may provide higher erosional rates (kg/acre) of nutrients and sediments. Table 48 shows the amount of nutrients and solids delivered from each subwatershed and that which was derived from within the subwatershed.

As Figure 47 indicates, the Turkey Ridge Creek Subwatershed was divided into individual subwatersheds and the surface areas (acres) were determined. Because the number of total suspended solids violations did not exceed the threshold for the TMDL requirement an Annualized-AGNPS modeling run was not completed. The Vermillion River Watershed Assessment project will be modeling the entire 1.4 million acre watershed and, Turkey Ridge Creek Watershed as part of the overall river basin assessment, will be assessed, compared, and rated with all the other subwatersheds. The FLUX model was used as the only sediment model. Table 48 shows the nutrient and sediment loading and delivery export coefficients from the watershed.

A downstream trend analysis was completed on the sediment export coefficients. Figure 48 shows the significant increasing or downstream trend for sediment (kg/acre) ($r^2$=0.51, df=7, p=0.03). The last four subwatersheds show a significantly higher contribution for sediment on a per-acre basis when compared to the upstream subwatersheds.

**Table 48. Subwatershed Export coefficients for Turkey Ridge Creek monitoring Sites.**

| Site | Acres | | TSS (Kg/acre) | | TP (Kg/acre) | | TN (Kg/acre) | |
|---|---|---|---|---|---|---|---|---|
| | Total | Within Subwater-shed | Total | Within Subwater-shed | Total | Within Subwater-shed | Total | Within Subwater-shed |
| TRC01 | 7,594.6 | 7,594.6 | 5.76 | 5.76 | 0.05 | 0.05 | 0.31 | 0.31 |
| TRC02 | 19,726.6 | 12,132.0 | 7.94 | 9.30 | 0.06 | 0.07 | 0.23 | 0.18 |
| TRC03 | 35,719.0 | 15,992.4 | 19.16 | 33.00 | 0.09 | 0.13 | 0.45 | 0.72 |
| TRC04 | 45,326.5 | 9,607.5 | 20.78 | 26.81 | 0.04 | -0.13 | 0.22 | -0.63 |
| TRC05 | 77,953.2 | 32,626.7 | 14.07 | 4.74 | 0.05 | 0.05 | 0.24 | 0.26 |
| TRC07 | 81,195.5 | 3,242.3 | 22.15 | 216.36 | 0.06 | 0.31 | 0.25 | 0.56 |
| TRC10 | 92,624.1 | 11,428.6 | 33.35 | 112.93 | 0.10 | 0.44 | 0.35 | 1.07 |
| TRC11 | 101,501.2 | 8,877.1 | 45.50 | 172.28 | 0.13 | 0.41 | 0.35 | 0.29 |
| TRC12 | 111,690.0 | 10,188.8 | 51.09 | 106.81 | 0.12 | -0.04 | 0.50 | 2.04 |

### *Correlation of the FLUX model to Physical Habitat*

A comparison of the FLUX model output, physical habitat measurements, and the RGA was completed to determine if the relationships between these variables shows some statistical significance. Total suspended solids and phosphorus yields from within each subwatershed shown in Figure 47 were regressed to all other habitat parameters. None of the relationships shown in the table below were significant (p>0.05).

**Table 49 Regression Analysis for the Habitat Parameters vs. Flux Modeling Results (d.f.=7, p>0.05, all relationships were insignificant).**

| $r^2$ values, d.f. =7 | FluxTSS | FluxTP |
|---|---|---|
| IPI | 0.11 | 0.004 |
| Channel Flow Status | N/A | N/A |
| Physical Complexity | 0.04 | 0.000 |
| CV of Velocity | 0.02 | 0.08 |
| Bed Composition | 0.12 | 0.003 |
| Channel Incision | 0.01 | 0.011 |
| Bank Stability | 0.28 | 0.20 |
| Overhanging Vegetation | 0.04 | 0.157 |
| Animal Vegetation Use | 0.07 | 0.078 |
| RGA | 0.03 | 0.0198 |

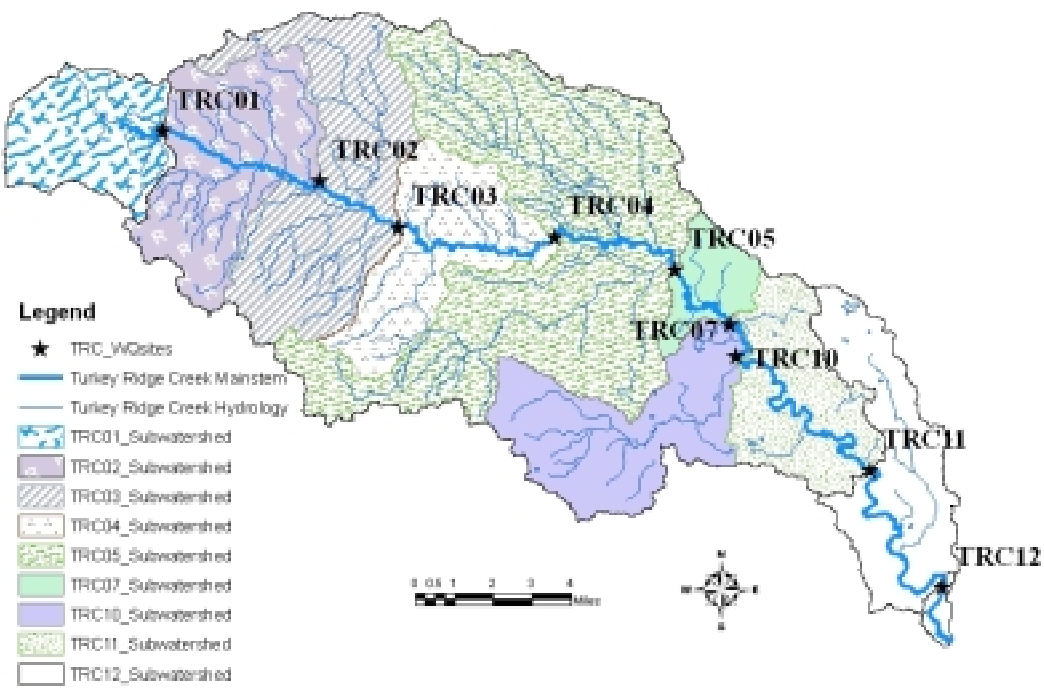



**Figure 47. Turkey Ridge Creek Subwatersheds.**

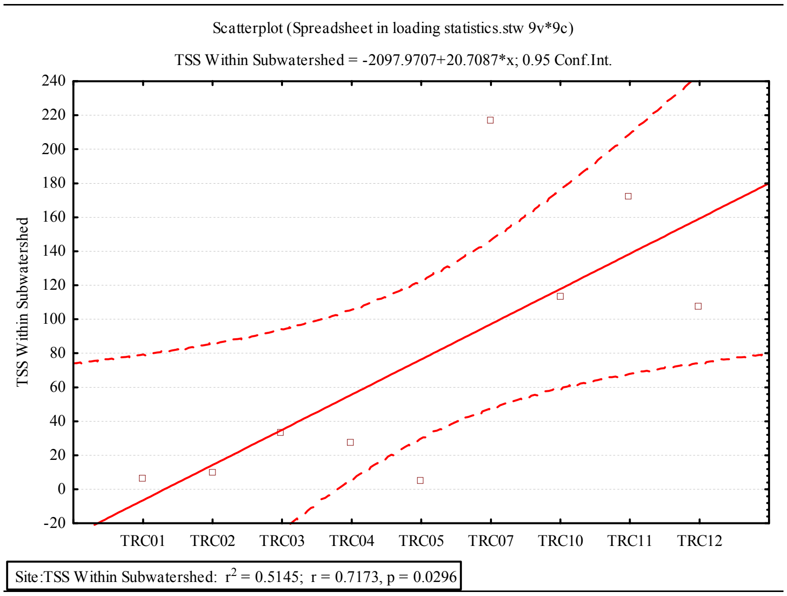



**Figure 48. Trends for sediment derived within each subwatershed.**

## 4.0 SUMMARY and CONCLUSION

### 4.1. Impairments

The final analysis of the water quality data indicates that, in fact, Turkey Ridge Creek is impaired by fecal coliform bacteria, when evaluated using the criteria for beneficial use: (6) warmwater marginal fishlife propagation; and (8) limited contact recreation. The 26.1 mile segment of Turkey Ridge Creek (total length = 47.5 miles) exhibited multiple violations exceeding the Section 303(d) TMDL criteria requiring a TMDL for the fecal coliform parameter. No other chemical impairments were identified as part of the Turkey Ridge Creek Watershed Assessment.

Habitat assessments using SDDENR-WRAP field methods were completed for each of the nine monitoring locations. These assessments indicated significant stream channel impairments throughout the length of Turkey Ridge Creek. In general, the habitat quality decreases as the creeks progresses toward its mouth. The cumulative effects of chemical and physical impairments primarily cause this longitudinal degradation. The range of index of physical integrity (IPI) values and rapid geomorphic assessments (RGA) are summarized in Table 44. Note that significant impairments begin to occur after Site TRC03 where entrenchment, channel instability, hydrologic modification, poor grazing management, and sediment runoff are affecting the stream (Table 50). Site TRC 4, 5, and 7 results indicate more significant habitat degradation than the remaining six sites. Implementation efforts used to improve instream channel conditions, physical, chemical, and biological, should focus in this area of the watershed (Site TRC03-TRC10).

**Table 50. Summary Table for Turkey Ridge Creek.**

| Subwatershed | RGA | IPI | TSSFlux Kg/yr | TPFlux Kg/yr | Fecal Coliform samples N>2000 | %Fecal Violation | AFO | Total Acres | %Crop land | %Range land |
|---|---|---|---|---|---|---|---|---|---|---|
| TRC01 | 16.5 | 65 | 5.76 | 0.05 | 3 | 15.0% | 6 | 7594.6 | 80.1% | 14.9% |
| TRC02 | 16.5 | 63 | 9.3 | 0.07 | 6 | 33.3% | 22 | 12132 | 75.3% | 20.3% |
| TRC03 | 14.5 | 76 | 33 | 0.13 | 8 | 42.1% | 21 | 15992.4 | 76.7% | 19.0% |
| TRC04 | 17 | 45 | 26.81 | -0.13 | 5 | 25.0% | 6 | 9607.5 | 85.2% | 9.3% |
| TRC05 | 23.5 | 42 | 4.74 | 0.05 | 5 | 26.3% | 28 | 32626.7 | 82.7% | 12.0% |
| TRC07 | | 41 | 216.36 | 0.31 | 4 | 20.0% | 4 | 3242.3 | 79.7% | 14.8% |
| TRC10 | 18.5 | 60 | 112.93 | 0.44 | 5 | 35.7% | 24 | 11428.6 | 79.3% | 12.6% |
| TRC11 | 18 | 56 | 172.28 | 0.41 | 5 | 27.8% | 2 | 8877.1 | 86.5% | 5.2% |
| TRC12 | 23 | 57 | 106.81 | -0.04 | 4 | 18.2% | 16 | 10188.8 | 85.1% | 9.6% |

The stream is currently meeting the suspended solids criteria for the warmwater marginal fishlife propagation beneficial use (6) where the TSS daily maximum criterion is 263 mg/L. Although the stream is meeting the existing TSS standard, negative correlations between the mean TSS concentration and several macroinvertebrate metrics were identified (Table 51). Further evaluation of the potential affects of the sediment and possible sources (upland vs. bed and bank) within the Turkey Ridge Creek Watershed will take place during the Vermillion River Watershed Assessment.

| Table 51. Landuse and Macroinvertebrate Metric Correlations. | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **EPT Abund** | **Species Richness** | **Trichopteran Richness** | **Filterer Richness** | **Margalef's Richness** | **HBI** | **Clinger Richenss** | **%clinger** |
| **RGA*** | **-0.80** | -0.35 | **-0.81** | -0.46 | -0.32 | 0.48 | -0.15 | 0.29 |
| **IPI** | **0.73** | 0.25 | **0.74** | 0.49 | 0.17 | -0.17 | 0.33 | -0.44 |
| **TSSFlux1** | -0.61 | -0.52 | -0.59 | **-0.68** | -0.41 | 0.27 | **-0.79** | 0.55 |
| **MeanTSS (mg/L)** | -0.50 | **-0.79** | -0.67 | -0.47 | **-0.72** | 0.48 | **-0.80** | -0.09 |
| **TPFlux** | -0.39 | -0.40 | -0.20 | -0.19 | -0.26 | -0.05 | -0.50 | 0.42 |
| **Fecal Samples N>2000** | 0.58 | 0.12 | 0.32 | 0.53 | 0.16 | -0.52 | -0.11 | -0.14 |
| **%FecalViolation** | 0.44 | 0.00 | 0.32 | 0.45 | 0.05 | -0.52 | -0.14 | -0.12 |
| **AFO** | 0.13 | 0.23 | 0.09 | 0.44 | 0.27 | -0.38 | 0.34 | -0.08 |
| **%Cropland** | -0.58 | **-0.74** | -0.57 | **-0.72** | **-0.79** | **0.87** | -0.53 | -0.30 |
| **%Range** | 0.66 | **0.86** | 0.58 | **0.77** | **0.89** | **-0.86** | 0.63 | 0.26 |
| **Marked correlations in bold are significant at p < .05 N=9 (Casewise deletion of missing data)** | | | | | | | | |
| * N=8 (Casewise deletion of missing data). | | | | | | | | |

Fecal coliform violations occurred throughout the lower 26.1-mile segment of Turkey Ridge Creek where five of the nine monitoring sites were located. The upper four monitoring sites exhibited high concentrations as well (Table 50). Although the upper watershed is not subject to the (8) limited contact beneficial use, it still has a significant effect on those lower five monitoring sites where the daily fecal coliform standard applies.

Using the 2-years of flow and water quality data, load duration curves were calculated for all sites using the daily maximum standard of 2,000 cfu/100ml as the target level. Load duration curves for each site can be viewed in Appendix G. Using the last downstream site as the watershed endpoint, the load duration curve for Site TRC12 indicated that a 95% reduction in fecal coliform colonies within the 0-10% high flow range is needed before the creek would meet and maintain its beneficial uses (Figure 49).

Although Figure 49 shows Site TRC12 exhibiting very few violations for Turkey Ridge Creek outside of the 0-10% high flow range, 13% of the violations in the 26.1-mile segment occurred during mid-range or lower flow conditions (40-100%). Typically, these kinds of violations at the lower flows can be attributed to point sources or livestock instream (Table 52). Preventing livestock from entering the stream by installing alternative watering sites and allowing them to cross only at specific points (rock crossings) will reduce the number fecal coliform violations that occur within the stream at the lower flow conditions.

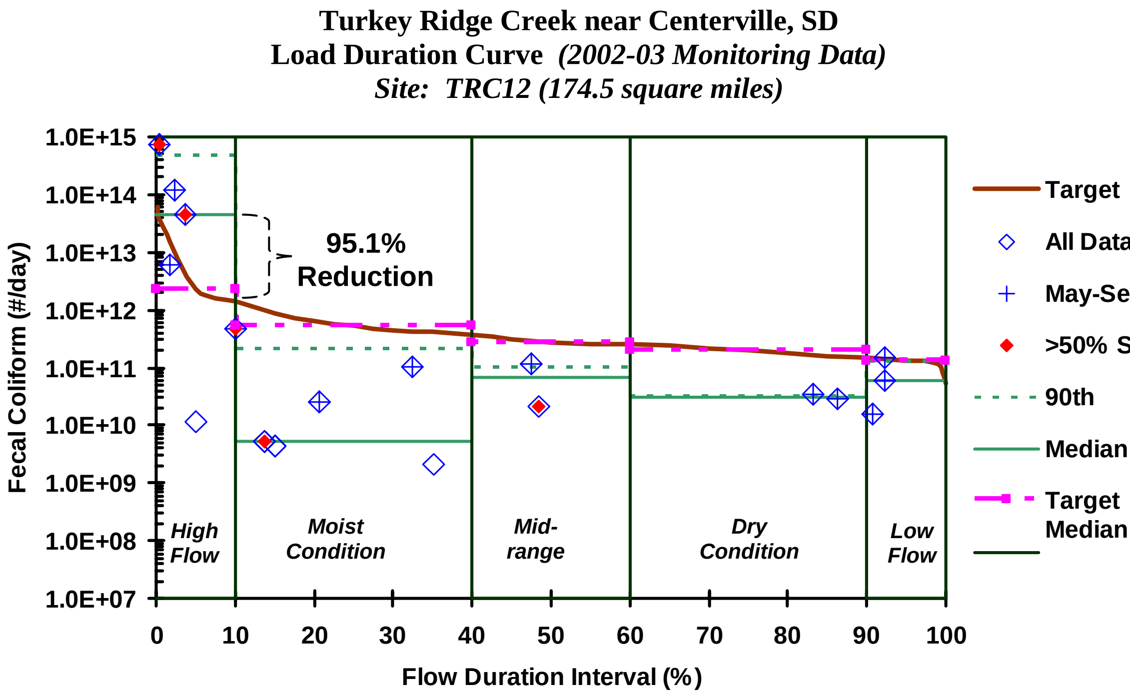



**Figure 49. Fecal coliform Load Duration Curve for Site TRC12.**

**Table 52. Generalized flow-based source assessment (Cleland, Sept. 2003).**

| Possible Sources | Range of Flows | | | | |
|---|---|---|---|---|---|
| | High Flow | Transitional Flow | Typical Flow | Dry Flow | Low Flow |
| Point Sources | L | L | L | M | H |
| Failing On-Site Wastewater (Septic) Systems | L | L | H | M | L |
| Direct Delivery (i.e., swimmers, wildlife, pets, livestock in-stream, illegal dumping) | L | L | M | H | H |
| Riparian Areas | L | H | H | H | L |
| Combined Sewer Over-Flows | H | H | H | L | L |
| Wastewater Treatment Plant Overflow | H | M | L | L | L |
| Stormwater: Upland | H | H | M | L | L |
| Stormwater: Impervious Areas | L | H | H | H | L |
| Re-Suspension | H | H | M | L | L |
| Overland Flow | H | H | M | L | L |
| Bank Erosion | H | M | L | L | L |
| Note: Potential relative importance of source area to contribute loads under given hydrologic condition (H: High; M: Medium; L: Low) | | | | | |

## 4.2. Best Management Practices for Reductions in Fecal Coliform Bacteria

The Agricultural Non-Point Source Pollution (AGNPS) model is a GIS-integrated water quality model that predicts non-point source sediment and nutrient loadings within agricultural watersheds. Although not designed as a predictive model for bacteria, the subwatersheds or cells derived from the 30-meter digital elevation model (DEM) were used to determine runoff conditions for a 4.3 inch rainstorm (Figure 50). The runoff ($ft^3$/sec) from each subwatershed cell within the Turkey Ridge Creek drainage network was then used in conjunction with: estimated bacteria concentrations from the landuse conditions (livestock, wildlife and pasture or cropland), channel length within the cell, and the average velocity of the stream within each subwatershed cell. The decay rate equation for bacteria:

$$C = C_o \times \exp(-KX / U)$$

where: C = concentration of fecal indicator bacteria,
K = decay coefficient,
X = distance along axis of flow, and
U= flow velocity

was then applied to the bacterial concentrations derived within the cell (EPA Pathogen Protocol, 2001). After the decay rate was applied the coliform loading was exported out of the cell and added to the receiving cell. For each subwatershed cell the decay rate was applied to the output until the outlet had been reached (see Appendix-O for further information, FecalWorksheet.xls worksheets). A series of modeling scenarios used to develop potential reductions for bacterial concentrations within the watershed.

**Table 53. ANN-AGNPS and Bacterial Decay Rate Modeling Setup**

| | Pasture Condition | Stocking Rate[1] | Feedlots | Simulated Rainfall | Fecal Coliform Output | Percent Reduction[2] |
|---|---|---|---|---|---|---|
| Current Watershed Conditions | Poor | 3 cows/acre | 129 | 4.3” | 31,625 cfu/100mL | Baseline |
| BMP Implementation | Good | 3 cows/acre | 129 | 4.3” | 21,917 cfu/100mL | 30.7% |
| | Good | 3 acres/cow | 129 | 4.3” | 13,784 cfu/100mL | 56.4% |
| | Good | 3 acres/cow | 0 | 4.3” | 1,806 cfu/100mL | 94.3% |

[1] - Personal communication with NRCS District Conservationist for Turner County, SD.

[2] – CTIC reports that buffer strips installed along sensitive areas can filter up to 60% of pathogens. http://www.ctic.purdue.edu/Core4/Buffer/Bufferfact.html

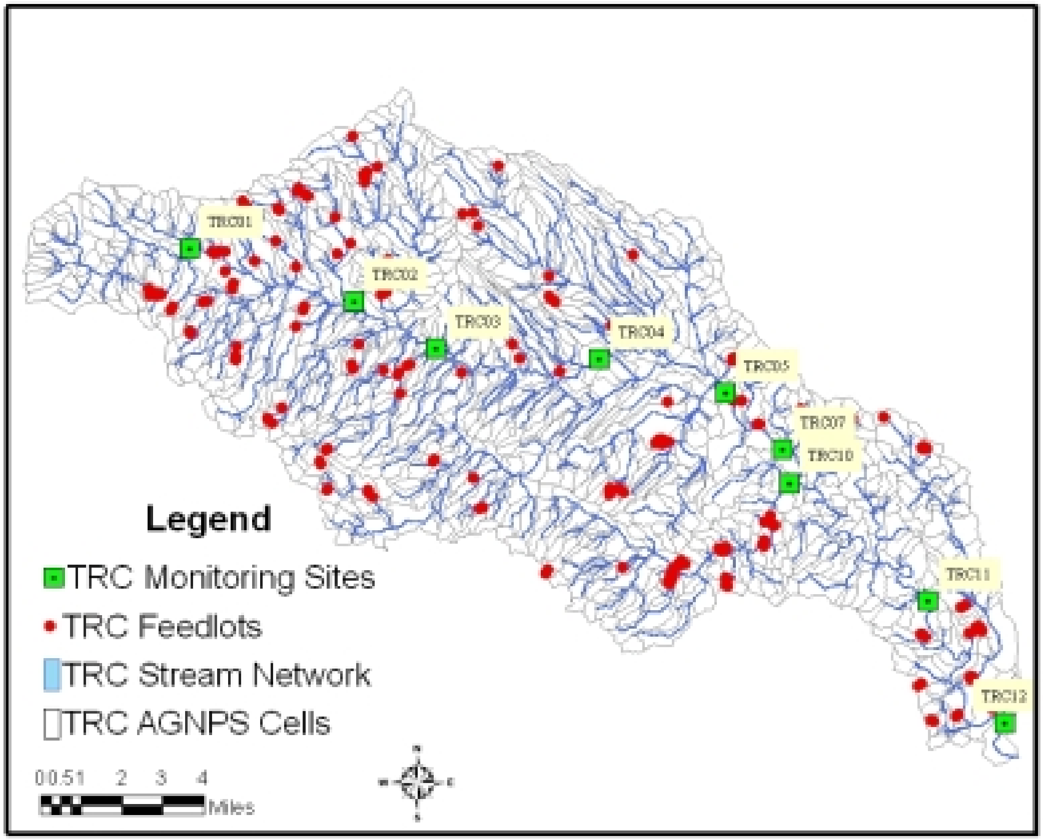



**Figure 50. ANN-AGNPS Cells and Stream Network for Turkey Ridge Creek.**

Additional reductions can be achieved through installation of buffer and filter strips along drainages within the Turkey Ridge Watershed. Reducing the velocity of the water during rainfall events by increase the time it takes for the watershed to drain will increase the exposure time of the bacteria to the buffer and filter strips as well as sunlight (decay rate through ultraviolet radiation).

Higher flow events can also resuspend fecal coliform bacteria that may be stored in the sediments of the stream (Howell, et.al, 1996). Bacteria can survive in the sediments depending on the characteristics of the soils and the ambient temperature (Doran and Linn, 1979; Stephenson and Street, 1978). Reductions in sources of bacteria to the stream sediments, i.e. animal feeding operations or livestock in the stream, should have an effect on the bacterial populations that survive in the sediments between storm events.

### 4.3. <u>Conclusion</u>

The 26.1-mile segment of Turkey Ridge Creek requires a 95.1% reduction in fecal coliform bacteria during high flow (storm) events. This reduction will lead to the full support status of the (8) limited contact beneficial use. An implementation project targeting animal feeding operations, grazing management, manure management on cropland, filter strips along the riparian zone of the creek will result in the necessary reductions in fecal coliform bacteria. Although sediment was not identified as a specific Turkey Ridge Creek impairment, further analysis of the watershed will take place during the 1.4 million acre Vermillion River Basin Watershed Assessment. The biological community suggests that sediment may be an impairment primarily because of the habitat degradation, i.e. channel incision and hydrologic modification. Sediment contribution from Turkey Ridge Creek to the Vermillion River will be rated and compared to all tributaries as part of this assessment.

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## 6.0 APPENDIX A – Turkey Ridge Creek Fecal Coliform TMDL

# TOTAL MAXIMUM DAILY LOAD EVALUATION
# (Fecal Coliform Bacteria)

**for**

**Turkey Ridge Creek**

**(HUC 10170102)**

**Turner County, South Dakota**

**South Dakota Department of**
**Environment and Natural Resources**
**Pierre, South Dakota**

**December 4, 2006**

# Turkey Ridge Creek Total Maximum Daily Load

| | |
|---|---|
| **Waterbody Type:** | Stream |
| **303(d) Listing Parameter:** | Fecal Coliform Bacteria |
| **Designated Uses:** | Warmwater Marginal Fish Life Propagation<br>Limited Contact Recreation<br>Fish and Wildlife Propagation Recreation and Stock Watering<br>Irrigation |
| **Size of Waterbody:** | 26.1 mile (42.0 km) segment of the 47.5 mile (76.4 km) total stream distance |
| **Size of Watershed:** | 112,435 acres (45,501 hectares) |
| **Water Quality Standards:** | Narrative and Numeric |
| **Indicators:** | Water Chemistry |
| **Analytical Approach:** | Modeling and Assessment Techniques used include Flow and Load Duration Interval Zones, FCLET.XLS and AGNPS Feedlot Model |
| **Location:** | HUC Code: 10170102 |
| **Goal:** | Reduce the median fecal coliform counts during high flows by 95 percent |
| **Target:** | Full support of the limited contact recreation use during the months of May through the September, at 2000 cfu/100mL or less of fecal coliform bacteria per grab sample |

## Objective

The intent of this summary is to clearly identify the components of the total maximum daily load (TMDL) submittal to support adequate public participation and facilitate the US Environmental Protection Agency (EPA) review and approval. The TMDL was developed in accordance with Section 303(d) of the federal Clean Water Act and guidance developed by EPA.

## Introduction

Turkey Ridge Creek is a 47.5 mile perennial stream with a watershed of approximately 112,435 acres (45,501 ha) and is a tributary of the Vermillion River in southern Turner County. The entire study area for this project is shown in Figure 1.

Turkey Ridge Creek is a natural perennial stream in Turner County, South Dakota. The stream receives runoff from agricultural operations and has experienced declining water quality. The landuse within the watershed is predominately cropland (85%) and pastureland (13%) (USDA, 2003). The watershed is located in two level IV ecoregions (46K – Prairie Couteau, and 46N James River Lowland) which are both heavily agriculturalized areas.

In 2002, SDDENR began a watershed assessment project that was intended to be the initial phase of a watershed wide restoration project. Feedlots and winter feeding areas for livestock are present in the watershed. Through water quality monitoring, stream gauging, stream channel analysis and land use analysis, the sources of impairment to the stream and the watershed were determined. The watershed ultimately drains to the Vermillion River which is also suffering from sediment and coliform impairments (SDDENR, 2004).

The water quality data collected during the assessment indicates Turkey Ridge Creek is not fully supporting the limited contact beneficial use. Over 20% of the fecal coliform samples exceeded the daily maximum concentration allowable (2,000 cfu/100ml) indicating that a TMDL was required. Supporting information and data collected during the period of March 2002 –September 2003 is summarized in the final report for the watershed assessment.

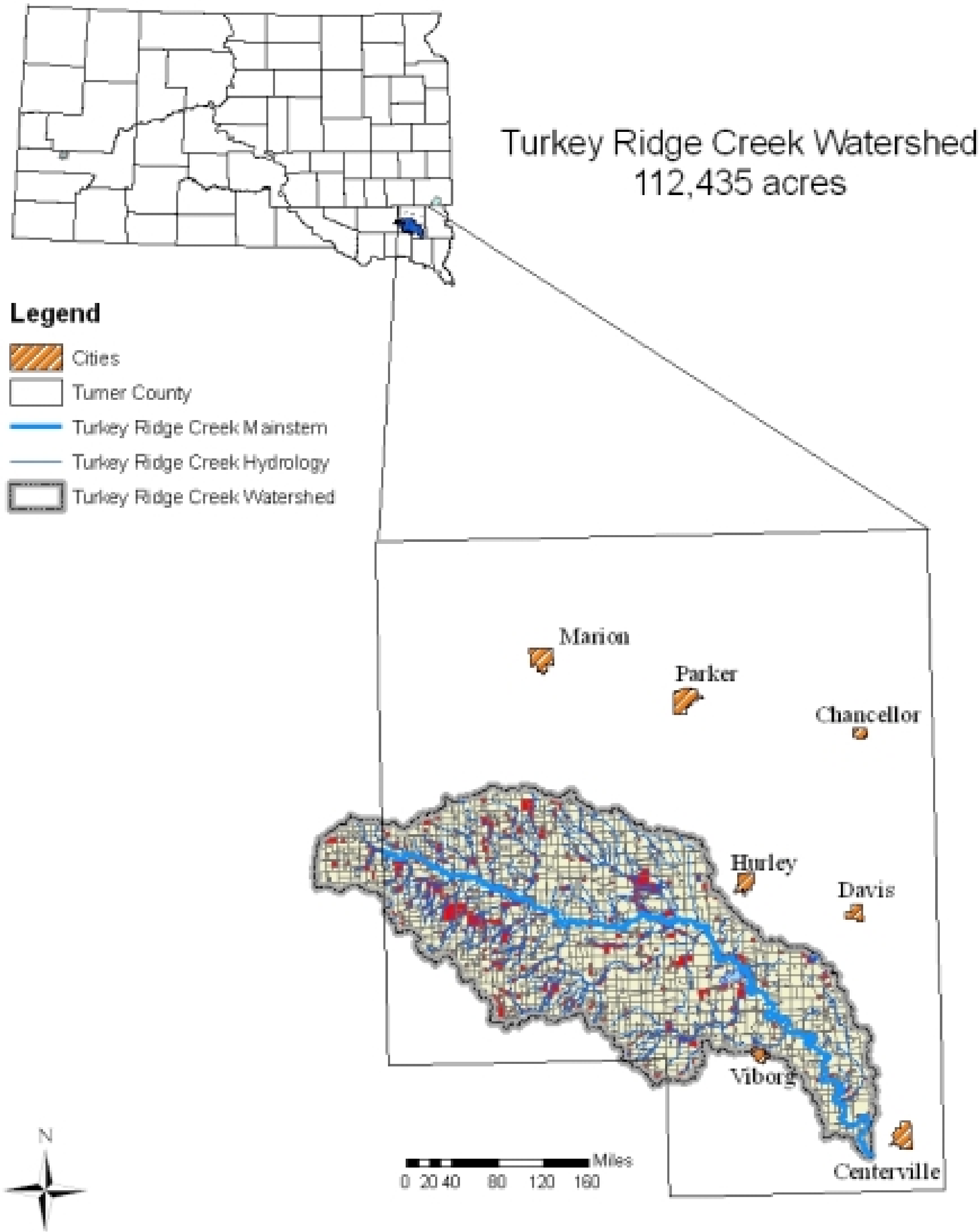


**Figure 51. Location of the Turkey Ridge Creek Watershed in South Dakota**

## Problem Identification

The watershed for Turkey Ridge Creek begins in extreme eastern Hutchinson County and runs through southern Turner County merging with the Vermillion River near Centerville, SD. As part of the watershed assessment project nine (9) monitoring sites were stationed along the mainstem of the creek (Figures 2 and 3). Water quality data collected from these stations indicated that high concentrations of fecal coliform bacteria were only present during high flow storm events. Because over 10% (of 20 or more samples) exceeded the 2,000 colony-forming units (cfus) per 100-milliliter (ml) daily maximum standard, a TMDL for fecal coliform bacteria became necessary. Table 1 displays the fecal coliform data collected from May to September for 2002 and 2003.

The landuse within the watershed is dominated by agricultural uses. Approximately 13% of the watershed is used for pasture and 85% consists of cropland acres (Figure 52). The over-grazed pastures are primarily located along the creek and livestock have direct access to the stream. During the assessment 129 animal feeding operation (AFOs) were identified in the watershed. The AFOs were modeled using the Agricultural Nonpoint Source (AGNPS) stand-alone feedlot model. The model rated the AFOs relative to their pollution potential and indicated that 35% of the operations rated greater than 50 on a scale of 0 (no pollution potential) to 100 (severe pollution potential). The only National Pollution Discharge Elimination System (NPDES) permitted facilities within the watershed are the city of Viborg (pop. 832) and four confined animal feeding operations (CAFOs).

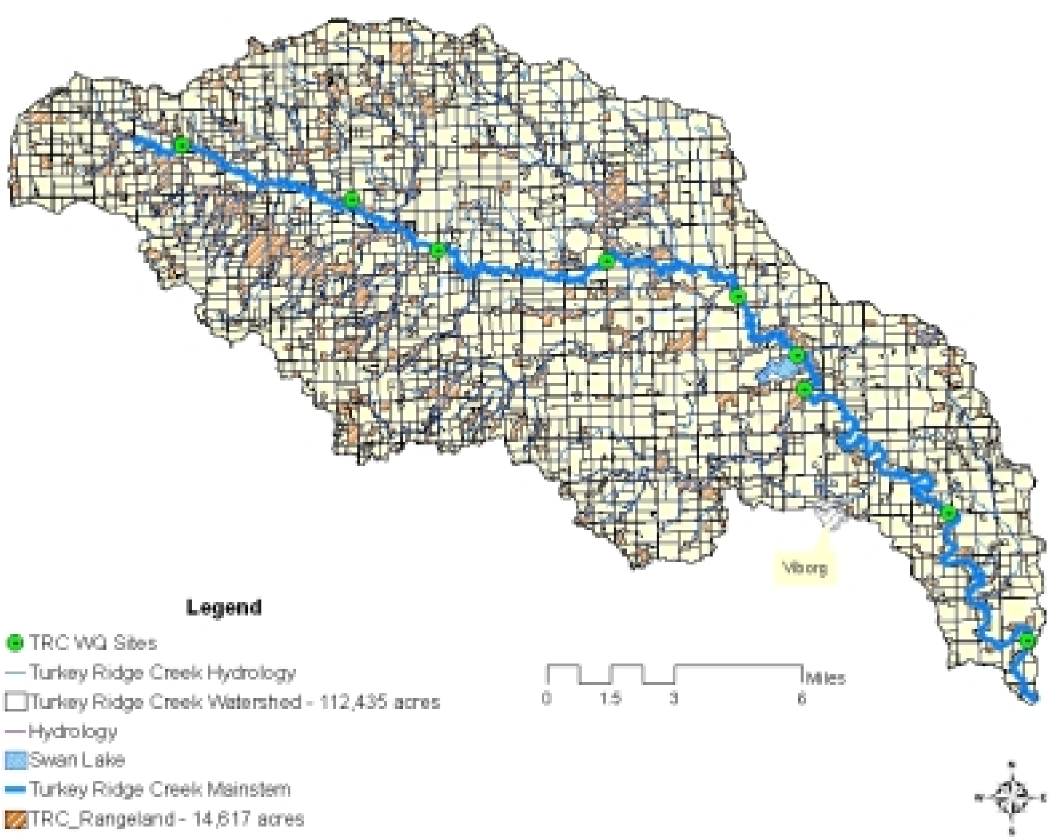


**Figure 52. Turkey Ridge Creek Watershed and Landuse.**

The water quality target set for Turkey Ridge Creek is a median concentration of < 2,000 cfus/100ml daily maximum. The target, where the median concentration from samples collected during storm events must be less than the allowable standard (2,000 cfus/100ml), was determined by using load duration curves. Using the water quality and discharge information collected during the watershed assessment, five hydrologic zones were calculated (high, moist, mid-range, dry, and low). Fecal coliform concentrations and the subsequent discharge information were compared to the allowable target load. As a result, a 95% reduction in coliform loads during storm events (high flow hydrologic zone) is needed for Turkey Ridge Creek to meet the required water quality criteria for the limited contact beneficial use (8).

**Table 54. Summary of Fecal Coliform Data for Turkey Ridge Creek.**

| Parameter Causing Impairment | Location | Number of Samples (May-Sep) | Percent of Samples > 2000 counts/100mL | Minimum Concentration (counts/100mL) | Maximum Concentration (counts/100mL) |
|---|---|---|---|---|---|
| Fecal Coliform | All Samples | 81 | 29.6% | 10 | 130,000 |
| Fecal Coliform | TRC05 | 15 | 33.3% | 100 | 130,000 |
| Fecal Coliform | TRC06 | 4 | 25.0% | 60 | 5,000 |
| Fecal Coliform | TRC07 | 16 | 25.0% | 40 | 31,000 |
| Fecal Coliform | TRC10 | 13 | 38.5% | 10 | 24,000 |
| Fecal Coliform | TRC11 | 15 | 33.3% | 20 | 9,000 |
| Fecal Coliform | TRC12 | 18 | 22.2% | 10 | 44,000 |

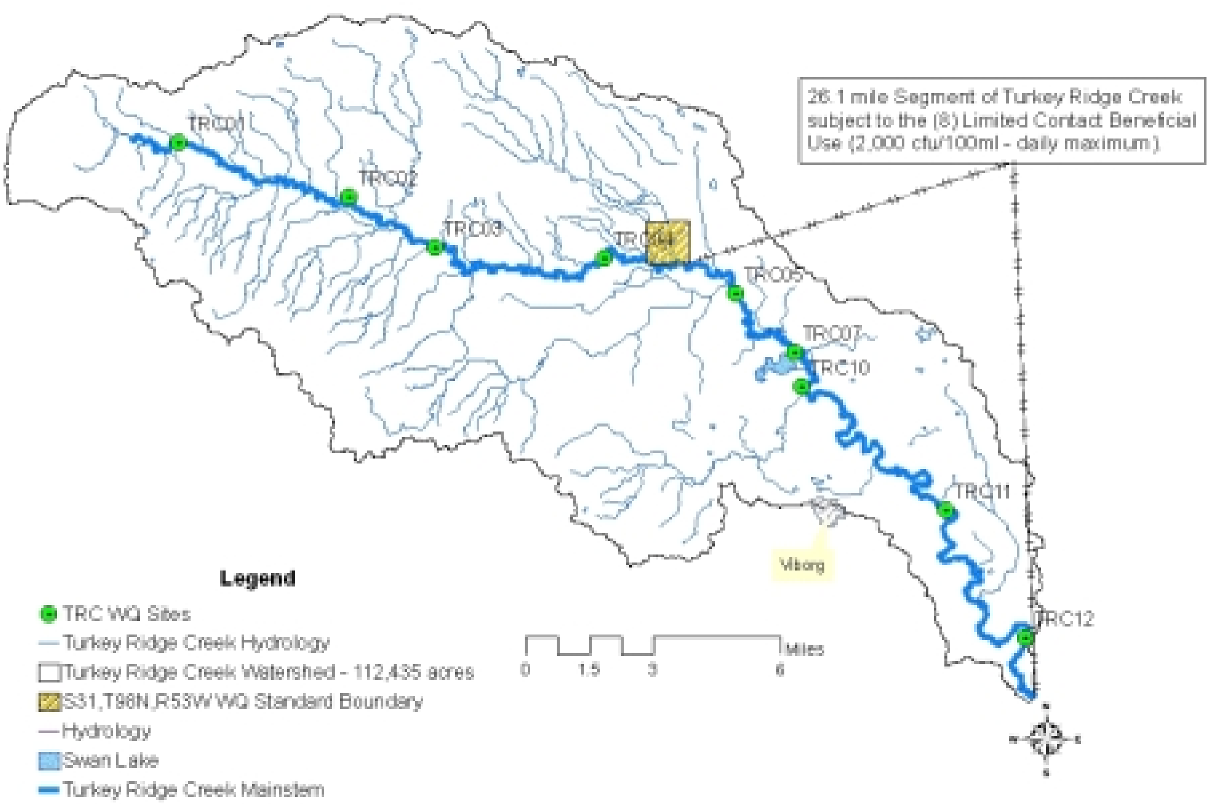


**Figure 53. Segment of Turkey Ridge Creek subject to fecal coliform water quality standards.**

**Description of Applicable Water Quality Standards & Numeric Water Quality Targets**

As part of the Administrative Rules of South Dakota (ARSD 74:51), waterbodies within the state of South Dakota are assigned one or more of eleven (11) possible beneficial uses. Turkey Ridge Creek or segments of Turkey Ridge Creek have been assigned four (4) of these beneficial uses:

6) Warmwater marginal fish life propagation
8) Limited contact recreation
9) Fish & wildlife propagation, recreation & stock watering
10) Irrigation

Note that only a 26.1 mile segment of the entire 47.5 mile length of Turkey Ridge Creek has been assigned the Warmwater Marginal Fish Life and Limited Contact Recreational Uses (Figure 53). Established narrative and numeric criteria are used to determine if the water quality of the stream is achieving full support of its assigned beneficial use(s).

Use support for limited contact recreation was determined by monitoring the levels of fecal coliform from May 1 through September 30. Turkey Ridge Creek exhibits high fecal coliform loadings due to poor riparian vegetation health and stormwater runoff from diffuse and direct nonpoint sources. During 2002 and 2003, event-based and baseflow water quality samples were collected using SDDENR-Water Resources Assistance Program (WRAP) standard operating procedures (SOP). Exceedances of the fecal coliform water quality standard (2,000 cfu/100ml daily maximum) were documented and a violation rate (percent) was calculated. The violation rate exceeded the threshold (10% of 20 or more samples) necessary for requiring the development of a TMDL for any of the parameters identified in ARSD 74:51 for (6) warmwater marginal fish life propagation and/or (8) limited contact recreation (8) uses.

To determine a water quality target for a pathogen indicator, calculation methods must consider the innate variability associated with this parameter. A flow duration interval was used to segment the coliform data into hydrologic zones. This methodology, developed by Dr. Bruce Cleland, can be used to develop water quality targets by dividing the range of flows and pollutant loadings into hydrologic conditions. These hydrologic zones can be used to characterize the pattern of impairment, i.e. does the problem occur across all flow conditions or is it confined to high flow events.

For Turkey Ridge Creek daily average flow values for the years 2002 and 2003 were used to calculate five hydrologic zones: High Flows (0-10 percent), Moist Conditions (10-40 percent), Mid-Range Flows (40-60 percent), Dry Conditions (60-90 percent), and Low Flows (90-100 percent). These zones are based on the frequency of occurrence where the flows are ranked and percentiles (zones) are calculated. Using this method base flows (0-5 cfs) have a much higher probability (90-100%) of being exceeded whereas the peak flows have much less probability of being exceeded (max = 1233 cfs) (0%). For targeting bacteria or other parameters, which can be attributed to nonpoint pollutant inputs, a single number for targeting does not work well. The flow duration interval method allows natural resource managers to take into consideration the extreme variability of stream flows when developing TMDLs and BMPs targeted for each of the different flow zones (Cleland, 2002).

The load/flow duration curve method can be used to allocate general bacterial sources during the different flow zones. Dr. Cleland (2003) identifies typical sources for the different flow zones for fecal coliform bacteria (Table 55).

Each of the six monitoring stations located along 26.1 mile segment of Turkey Ridge Creek were assessed for their level of fecal coliform loading and compared to the 2,000 cfu/100mL numeric standard. However, at the mouth of Turkey Ridge Creek using the 2,000 cfu/100mL standard, a 95% reduction for daily fecal coliform colonies during high flow conditions will ensure that the entire segment will achieve full support (Table 56).

**Table 55. Generalized flow-based source assessment (Cleland, Sept. 2003)**

| | Range of Flows | | | | |
|---|---|---|---|---|---|
| Possible Sources | High Flow | Transitional Flow | Typical Flow | Dry Flow | Low Flow |
| Point Sources | L | L | L | M | H |
| Failing On-Site Wastewater (Septic) Systems | L | L | H | M | L |
| Direct Delivery (i.e., swimmers, wildlife, pets, livestock in-stream, illegal dumping) | L | L | M | H | H |
| Riparian areas | L | H | H | H | L |
| Combined Sewer Over-Flows | H | H | H | L | L |
| Wastewater Treatment Plant Overflow | H | M | L | L | L |
| Stormwater: Upland | H | H | M | L | L |
| Stormwater: Impervious Areas | L | H | H | H | L |
| Re-Suspension | H | H | M | L | L |
| Overland Flow | H | H | M | L | L |
| Bank Erosion | H | M | L | L | L |
| Note: Potential relative importance of source area to contribute loads under given hydrologic condition (H: High; M: Medium; L: Low) | | | | | |

**Table 56. Turkey Ridge Creek Fecal Coliform Reductions.**

| Station ID: | TRC12 | | | | |
|---|---|---|---|---|---|
| Station name: | Turkey Ridge Creek near Centerville, SD | | | | |
| 174.5 | = Drainage Area *(square miles)* | | | | |
| Flow Zone → | High | Moist | Mid | Dry | Low |
| Median Flow (cfs) | 46.33 | 10.75 | 5.64 | 4.05 | 2.68 |
| Median Runoff (mm/day) | 0.251 | 0.058 | 0.031 | 0.022 | 0.015 |
| Target Load (cfu/day) | 2.27E+12 | 5.26E+11 | 2.76E+11 | 1.98E+11 | 1.31E+11 |
| Actual Load (cfu/day) | 4.64E+13 | 5.11E+09 | 6.80E+10 | 3.15E+10 | 6.01E+10 |
| Reduction | 95.1% | -10197.6% | -306.0% | -528.5% | -118.5% |

**Pollutant Assessment**

The Bacterial Indictor Tool was used to allocate all possible sources for fecal coliform bacteria in the Turkey Ridge Creek Watershed with the exception of the point sources (NPDES). This spreadsheet tool estimates contributions from a variety of sources and was used to potential daily bacterial loadings from these sources (EPA, 2002).

Bacterial contributions from four landuse types were estimated using this tool. Cropland, built-up (urban or suburban), forest and pastureland areas (acres) were estimated by using GIS coverages assembled by the Farm Services Agency (USDA-FSA). Landowners and operators each spring need to certify their crops within each county FSA office in order to become eligible for farm support payments (subsidies). The crop type and acreages for each field are recorded in GIS coverage. These coverages contain ten different landuse classifications (see below). Using this GIS coverage acreages were calculated for each of the different landuse types within the 112,435 acre Turkey Ridge Creek Watershed.

| | |
|---|---|
| Urban | Cropland |
| Rangeland | Forest |
| Waterbody | Mined |
| Barren (1) | Barren(2) |
| Perennial Ice/Snow | Other Agland (building/farmstead) |

Contributions from these landuses and possible fecal coliform accumulations are asymptotic and will reach a maximum possible accumulation level. The rate of fecal coliform accumulation and the maximum storage of fecal coliform bacteria on land uses. The monthly accumulation rates are based on research conducted by Horsely and Whitten, 1986 and excerpted here from the Bacterial Indicator Tool User Manual, 2000, pg 15.

1. The values are simply the total fecal coliform bacteria accumulation rates from each land use worksheet (Cropland, Pastureland, Forest, and Built-up).
2. the value is derived using the following die-off equation from Horsely & Whitten (1986):

$N_t = N_0(10^{(-kt)})$ where:

$N_t$ = number of fecal coliform present at time t.
$N_0$ = number of fecal coli forms present at time 0
t = time in days
k = first order die-off rate constant. Typical values for warm months = 0.51/day and fro cold months = 0.36/day

The following table was excerpted from the Bacterial Indicator Tool user manual. The output from the Bacterial Indicator Tool is primarily used as input file for the WinHSPF and the Hydrological Simulation Program Fortran (HSPF) water quality model within BASINS. This tool is used here to estimate potential daily accumulation rates from diffuse nonpoint sources and daily loading rates from direct nonpoint sources for fecal coliform bacteria in the Turkey Ridge Creek Watershed.

| **Worksheet Name** | **Purpose** |
|---|---|
| Landuse | Breakdown of the acres of each landuse category. |
| Animal | Documents the kinds and numbers of livestock in the watershed. |
| Wildlife | Calculates the fecal coliform bacteria produced by wildlife by land use category. |
| Cropland | Calculates the monthly rate of accumulation of fecal coliform bacteria on cropland from wildlife, hog, cattle, and poultry manure. |
| Forest | Calculates the rate of accumulation of fecal coliform bacteria on forestland from wildlife. |
| Built-up | Calculates the rate of accumulation of fecal coliform bacteria on built-up land using literature values. |
| Pastureland | Calculates the monthly rate of accumulation of fecal coliform bacteria on pastureland from wildlife, cattle, and horse manure, and cattle, horse, sheep, and other grazing. |
| Cattle in Streams | Calculates the monthly loading and flow rate of fecal coliform bacteria contributed directly to the stream by beef cattle. |
| Septics | Calculates the monthly loading and flow rate of fecal coliform bacteria from failing septic systems. |
| ACQOP&SQOLIM (for land uses) | Summarizes the monthly rate of accumulation of fecal coliform bacteria on the four land uses; calculates the build-up limit for each land use. Provides input parameters for HSPF (ACQOP/MON-ACCUM and SQOLIM). |
| Feedlots rated > 60 | Not part of the original worksheet. Feedlots rated greater than 60 by AGNPS Standalone Feedlot Model were treated as separate direct nonpoint source by calculating a daily loading rate from the numbers of livestock confined within the lot. Literature values were used to calculate daily bacterial loading rate from an average animal (beef cow, dairy cow, hog, etc.) |

After a potential daily loading rate (cfu/day) was determined for, each source daily contributions were calculated for the point sources. The daily fecal loading rate for the period (May 1 – September 30) was calculated and added to a daily fecal loading rate for the point sources within the watershed for total contribution from each source.

Point Sources

The NPDES facilities taken into consideration within this watershed include four concentrated animal feeding operations (CAFOs) and one municipal wastewater treatment facility (Viborg-pop.832). The city of Viborg discharged during the study period but this occurred outside the applicable period for the fecal coliform standard (May 1 – September 30). It should be noted that should the City of Viborg discharge they would be required to maintain water quality standards. The 2,000 cfu daily maximum (1,000 geometric mean from five samples collected over five 24-hour periods) would have to be maintained. The CAFOs have been designated as zero discharge facilities as part of their NPDES permits and constitute 0% of the direct point source fecal loadings to Turkey Ridge Creek. The CAFOs, as part of their nutrient management plan, are required to land apply the manure on minimum amount of acreage. The manure application and resulting fecal coliform contribution to Turkey Ridge Creek is taken into consideration in the manure management section of the Bacterial Indicator Tool.

To estimate the percent contribution for the City of Viborg should a discharge event occur during May 1 – September 30 a daily fecal coliform loading rate was calculated. The total storage capacity of the sewage lagoons from the city of Viborg was calculated (Table 57, equation 1).

Using the 2,000 cfu/day daily maximum allowable as the maximum possible concentration for fecal coliform, the total amount of coliform that could be discharged would be 3.08 x $10^{17}$ cfu's (Table 57, equation 2).

The water quality standards for limited contact recreation is only applied during the months of May 1 through September 30 which constitutes 153 days. In equation 3 of Table 57 the daily fecal coliform contribution to Turkey Ridge Creek would be 2.33 x $10^{10}$ cfu/day.

**Table 57. Point Source Contribution Calculations.**

1) $$13.15\,\text{surface acres} \times \frac{43{,}560.17\,\text{ft}^2}{acre} = 572{,}816.2\,\text{ft}^2 \times 5.5\,\text{ft} = 3{,}150{,}489\,\text{ft}^3 \times 2(doublingrate) = 6{,}300{,}978\,\text{ft}^3$$

2) $$6{,}300{,}978\,ft^3 \times \frac{28{,}317\,ml}{1\,ft^3} \times \frac{86{,}400\,\text{sec}}{day} \times \frac{2{,}000\,cfu\,(daily\,\max)}{100\,ml} = 3.08 \times 10^{17}\,cfu$$

3) $$\frac{3.08 \times 10^{17}\,cfu}{153\,days\ \text{(From May 1 through September 30)}} = 2.33 \times 10^{10}\,cfu/day$$

Assuming the fecal load from the NPDES sites would be a 2.33 x $10^{10}$ cfu/day contribution to the overall potential load from the watershed this would constitute less than one percent (Table 3).

Nonpoint Sources (breakout livestock before diffuse and direct nonpoint sources)

Nonpoint source pollution, unlike pollution from municipalities and NPDES, comes from many diffuse and direct sources. Potential nonpoint sources of fecal coliform include loadings from surface runoff, wildlife, livestock, pets, and leaking septic tanks.

***ANIMAL INPUTS (livestock, wildlife, pets)***

The number of livestock within the watershed was determined by completing an animal feeding operation inventory (AFO) during the watershed assessment. In addition, data from the 2002 AG Census completed by the National Agricultural Statistics Service (NASS) for Turner County was used to estimate confined/unconfined livestock animals (grazing animals) (NASS, 2002). The NASS Statistical Survey estimated 55,000 dairy and beef cattle for Turner County. This number was used to estimate total number of cows present in the Turkey Ridge Creek Watershed during 2002.

Animal Feeding Operations

The AFO inventory indicated that 10,762 beef and dairy cattle were confined in 129 feedlots within the 112,435 acres. Each of AFO was assessed for pollution potential using the Agricultural Nonpoint Source (AGNPS) Standalone Feedlot Model. The AGNPS feedlot results identified 17 AFOs rated higher than 60 on a scale 0-100, 100 being extremely severe for pollution potential. These lots contained 2,150 cattle. The cattle in these lots were considered to be confined year round and were treated as a direct nonpoint source during the May 1 – September 30 period (Table 58).

**Table 58. Livestock (beef cattle) Estimations for Turkey Ride Creek Watershed in Turner, SD, 2002.**

| Turner County | | TRC Watershed | | |
|---|---|---|---|---|
| Estimated Cattle for Turner County (Source: NASS Ag Census Data, 2002) | Cattle per Acre (Turner County = 393, 600 acres) | Cattle in TRC Watershed (0.14 X 119,430 FSA acres) | Cattle in Lots > 60 (assumed year round confinement) treated as a direct nonpoint source | Remaining cattle left for part-time confinement and turned out for grazing (manure application worksheet, Bacterial Source Indicator Tool)<br>Cattle per Acre)<br><br>(16,720-2,105)=14,615 cattle available for grazing or confinement depending on time of year (see grazing worksheet or. Manure Management worksheet in Bacterial Source Indicator Tool |
| 55,000 | 0.14 | 16,720 | 2,105 | 14,615 |

The remaining cattle, other livestock, wildlife, and pets in the watershed were assessed by the using worksheets in the Bacterial Indicator Tool in the following manner:

Livestock numbers from the AFO inventory, wildlife, and domestic pets were included in these worksheets (Table 59).

**Table 59. Agricultural Animals for the Turkey Rigdge Creek Watershed.**

| SUBWATERSHED | BEEF CATTLE | SWINE (HOGS) | DAIRY CATTLE | CHICKENS | HORSES | SHEEP | OTHER |
|---|---|---|---|---|---|---|---|
| TRC | 14,615 | 38,246 | 760 | - | 3 | 3,991 | - |
| TOTAL | 14,615 | 38,246 | 760 | - | 3 | 3,991 | - |

| ***Table 59a. Wildlife*** | LANDUSE | | | | Direct to Stream (Proportion) | Coliform cfu per day |
|---|---|---|---|---|---|---|
| | CROPLAND | PASTURELAND | FOREST | Built-Up | | |
| | Density/acre | Density/acre | Density/acre | Animals/acre | | |
| **Ducks** | 0.0046875 | 0.0046875 | 0.001265625 | 0.0046875 | 0.25 | 2.51E+11 |
| **Geese** | 0.0046875 | 0.0046875 | 0 | 0.0046875 | 0.25 | 2.73E+10 |
| **Deer** | 0.0043125 | 0.0043125 | 0.0043125 | 0 | 0.01 | 1.74E+10 |
| **Beaver** | 0.00278125 | 0.00278125 | 0.00278125 | 0 | 1 | 6.49E+07 |
| **Raccoons** | 0.005828125 | 0.005828125 | 0.005828125 | 0.005828125 | 0.05 | 8.50E+09 |
| **Other** | 0.00203125 | 0.00203125 | 0.00203125 | 0.00203125 | 0.3 | 5.33E+08 |

| *Table 59b. Domestic Pets* | *402 residence X 1 pet = 402 pets, 5% of pet waste deposited directly into streams. Assume the following: | | | | |
|---|---|---|---|---|---|
| **All Months** | **# Pets (assume 1/house)** | **#pets in streams** | **FC Loading Rate (#/hr)** | **Waste Flow (cfs)** | **FC rate** (#/day) |
| **TRC** | 402 | 20 | 7.75E+07 | 1.16E-05 | 1.86E+09 |
| Domestic Pet waste 0.50 (lbs/animal/day), density of domestic pet manure (including urine) is approximately the density of water: 10 (lbs/cubic foot) | | | | | |
| *From SDDOT Road Coverage there were 402 rural residence or farms classified as occupied when data was collected. | | | | | |

## Manure Management

The following table shows the resulting fraction of annual manure application available for runoff each month based on the monthly fraction applied and incorporation into the soil. The fraction of manure available for runoff is dependent on the method of manure application. The fraction available is computed based on incorporation into soil.

| **Month** | **Hog** | **Beef Cattle** | **Horse** | **Poultry** | **Dairy Cattle** | **Imported Manure** |
|---|---|---|---|---|---|---|
| January | - | - | 0.01 | - | - | - |
| February | - | 0.03 | 0.01 | 0.04 | 0.05 | 0.04 |
| March | 0.15 | 0.16 | 0.01 | 0.19 | 0.24 | 0.19 |
| April | 0.23 | 0.13 | 0.01 | 0.15 | 0.19 | 0.15 |
| May | 0.15 | 0.02 | 0.01 | 0.04 | 0.02 | 0.02 |
| June | 0.00 | 0.02 | 0.01 | 0.04 | 0.02 | 0.02 |
| July | 0.00 | 0.02 | 0.17 | 0.04 | 0.02 | 0.02 |
| August | 0.00 | 0.03 | 0.17 | 0.04 | 0.05 | 0.04 |
| September | 0.08 | 0.11 | 0.17 | 0.08 | 0.17 | 0.13 |
| October | 0.07 | 0.06 | 0.01 | 0.08 | 0.10 | 0.08 |
| November | 0.08 | 0.06 | 0.01 | 0.08 | 0.10 | 0.08 |
| December | - | - | 0.01 | - | - | - |
| Fraction incorporated into soil (assumed)* | 0.50 | 0.25 | 0.75 | 0.50 | 0.10 | 0.50 |
| Fraction available for runoff* | 0.75 | 0.88 | 0.63 | 0.75 | 0.95 | 0.75 |
| = (1 - [fraction incorporated]) + ([fraction incorporated] * 0.5) | | | | | | |
| % Applied to Cropland | 100% | 50% | | 100% | 75% | 50% |
| % Applied to Pastureland | 0% | 50% | 100% | | 25% | 50% |

## Grazing

The following table shows the fraction of time that the remaining 14,165 cattle in the watershed spend confined and grazing during the year. An estimate of the time spent in the streams by the grazing cattle is also indicated. The time spent in the stream is used to calculate the contribution of cattle in the streams as direct inputs. Similar calculations are completed for the other livestock as well (Appendix Bacterial Source Indicator Data for Turkey Ridge Creek). The grazing worksheet was used to calculate daily fecal loading rates by using the other landuse worksheets (Pastureland – diffuse input and Cattle in Streams – direct input)

| | ***Beef Cattle Confined*** | ***Beef Cattle Grazing*** | ***Beef Cattle In Streams*** | ***Beef Cattle in Pasture*** |
|---|---|---|---|---|
| **Month** | **Time Spent Confined (0.00 to 1.00)** | **Time Spent Grazing (0.00 to 1.00)** | **Grazing Time Spent in Streams (0.00 to 1.00)** | **Grazing Time Spent in Pasture (0.00 to 1.00)** |
| January | 1.00 | 0.00 | 0.02000 | 0.9800 |
| February | 1.00 | 0.00 | 0.02000 | 0.9800 |
| March | 0.40 | 0.60 | 0.02000 | 0.9800 |
| April | 0.30 | 0.70 | 0.03000 | 0.9700 |
| May | 0.20 | 0.80 | 0.04000 | 0.9600 |
| June | 0.20 | 0.80 | 0.05000 | 0.9500 |

| | | | | |
|---|---|---|---|---|
| July | 0.20 | 0.80 | 0.05000 | 0.9500 |
| August | 0.20 | 0.80 | 0.05000 | 0.9500 |
| September | 0.20 | 0.80 | 0.05000 | 0.9500 |
| October | 0.60 | 0.40 | 0.03000 | 0.9700 |
| November | 1.00 | 0.00 | 0.02000 | 0.9800 |
| December | 1.00 | 0.00 | 0.02000 | 0.9800 |

Animal Feeding Operations Rated >60 (combine with previous section)

The 2,105 beef cattle confined in the 17 AFOs rated greater than 60 by the AGNPS Standalone Feedlot Model were treated as direct inputs to the stream during the entire year. The potential daily contribution in fecal colony counts/day is shown in Table 60. Literature values for beef cattle daily output of fecal coliform colonies was taken from the Bacterial Source Indicator Tool References Worksheet.

**Table 60**

| AFO>60 | FC Loading Rate |
|---|---|
| **Month** | **(count/day)** |
| May | 1.97E+15 |
| June | 1.97E+15 |
| July | 1.97E+15 |
| August | 1.97E+15 |
| September | 1.97E+15 |

*DIFFUSE NONPOINT SOURCES (cropland, pasture, forest, builtup)*

Estimates from each landuse type (Table 62-landuse) were calculated using the Manure Management, Animals, and Wildlife worksheets previously described.

Cropland

Cropland in the Turkey Ridge Creek Watershed constitutes 85% (95,570 acres) of the watershed. The Bacterial Source Indicator Tool outlines four possible sources of bacteria for cropland: wildlife, hog manure, cattle manure, and poultry litter. Daily accumulation rates based on the animal numbers and the manure management found within the watershed were used to estimate application rates of manure on cropland. The fraction of manure is substantially reduced during the summer months (Manure Management). Hog manure is applied during the spring of the year after the ground has thawed or it is applied during late fall. Fifty percent of the manure applied to the cropland was assumed to be injected into ground. Because of these management practices and because this landuse constitutes 85% of the watershed cropland ranges from 8.8% to 30.3% of the potential daily bacterial load for June and May, respectively (Table 61).

Pastureland

There are 14,617 acres of documented pastureland comprising only 13.0% of the watershed. Using the Bacterial Source Indicator Tool which takes into consideration the amount of livestock grazing, how much manure is applied to grassland versus cropland, this diffuse source amounts up to 22.3% of the possible washoff during a storm event from May through September (Table 61).

Forest and Builtup

Forest and built-up (urban and farmsteads) comprise approximately 3% of the overall watershed. The City of Viborg is the only municipality (pop. 832) in the watershed Consequently, these two landuse categories are insignificant diffuse sources comprising less than 1% of the overall coliform input (Table 61).

*DIRECT NONPOINT SOURCES*

Cattle standing in streams, AFO's with AGNPS ratings > 60, wildlife and pets in streams, and failing septic tanks were considered as direct sources of nonpoint pollution.

Cattle in Streams

The Animal and Grazing worksheets in the Bacterial Source Indicator Tool were used to estimate the contribution of the cattle standing in streams for the period of May 1 through September 30. Based on the number of cattle grazing in the watershed during this period, this source could constitute from 9.4% to 15% of the daily input into Turkey Ridge Creek (Table 61).

AFO >60

The 2,105 cattle located within these 17 feedlots constituted 22% of the overall confined animals documented in the feedlot inventory. Based on the load duration curve and the fact that the violations of the water quality standard occurred during high flow the manure pack becomes mobile. The animals within these small lots were assumed to be confined during the entire year classifying them as a potential daily input to the stream. Compared to the other sources in the watershed, these feedlots constituted from 41.2% to 54% of the potential daily sources of bacteria. This translates into the largest potential source of both diffuse and direct sources.

Wildlife and Pets

Both wildlife and pets were considered as potential bacterial sources. However, they constituted less than 1 percent of the overall problem for Turkey Ridge Creek for the months of May through September (Table 61).

Septic Systems

There were 402 document occupied residences within the watershed. This estimate was based on the SD Department of Transportation GPS roads survey that documented occupied rural residences. Using the Septic Worksheet in the Bacterial Indicator Tool, 2.5 people (total rural pop. 1005) were assumed to live in each of these residences, 5% of the septic tanks were failing, and the average bacterial concentration of the septic overcharge was 10,000 cfus/day. Failing septic tanks constituted less than 1% of the overall daily input to Turkey Ridge Creek for May through September timeframe (Table 61).

*Agricultural*

Agricultural animals are the source of several types of non-point sources as indicated in the Future Recommendations section of the Assessment Report. Agricultural activities including runoff from pastureland and cattle in streams, can affect water quality. Livestock data collected during AGNPS Feedlot modeling are listed in Table 61.

**Table 61. Fecal Coliform Source Allocations for Turkey Ridge Creek.**

| Diffuse Nonpoint Sources | Month → | May | June | July | Aug | Sept | May | June | July | Aug | Sept |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Monthly Accumulation Rates (Possible washoff on any one day) (cfu/day) | Cropland | 1.41E+15 | 3.20E+14 | 3.17E+14 | 3.97E+14 | 1.37E+15 | 30.3% | 8.8% | 8.7% | 10.6% | 28.7% |
| | Forest | 2.02E+11 | 2.02E+11 | 2.02E+11 | 2.02E+11 | 2.02E+11 | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | Built-Up | 4.99E+10 | 4.99E+10 | 4.99E+10 | 4.99E+10 | 4.99E+10 | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | Patureland | 8.21E+14 | 8.15E+14 | 8.15E+14 | 8.27E+14 | 8.90E+14 | 17.7% | 22.3% | 22.3% | 22.1% | 18.6% |
| **Direct Nonpoint Sources** | Cattle In Streams | 4.38E+14 | 5.47E+14 | 5.47E+14 | 5.47E+14 | 5.47E+14 | 9.4% | 15.0% | 15.0% | 14.6% | 11.4% |
| Daily Inputs (cfu/day) | Feedlots>60 | 1.97E+15 | 1.97E+15 | 1.97E+15 | 1.97E+15 | 1.97E+15 | 42.5% | 53.9% | 54.0% | 52.7% | 41.2% |
| | Wildlife | 3.05E+11 | 3.05E+11 | 3.05E+11 | 3.05E+11 | 3.05E+11 | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | Pets | 1.86E+09 | 1.86E+09 | 1.86E+09 | 1.86E+09 | 1.86E+09 | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | Septics | 1.33E+09 | 1.33E+09 | 1.33E+09 | 1.33E+09 | 1.33E+09 | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | City of Viborg | 2.33E+10 | 2.33E+10 | 2.33E+10 | 2.33E+10 | 2.33E+10 | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | Total cfu/day possible | 4.64E+15 | 3.65E+15 | 3.65E+15 | 3.74E+15 | 4.78E+15 | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% |

**Table 62. Turkey Ridge Creek Landuse.**

| Land Use | Percentage | Acres |
|---|---|---|
| Built-Up | 2.4% | 2,705 |
| Cropland | 85.0% | 95,570 |
| Pastureland | 13.0% | 14,617 |
| Forest | 0.06% | 70 |
| Total | 100.0% | 112,435 |

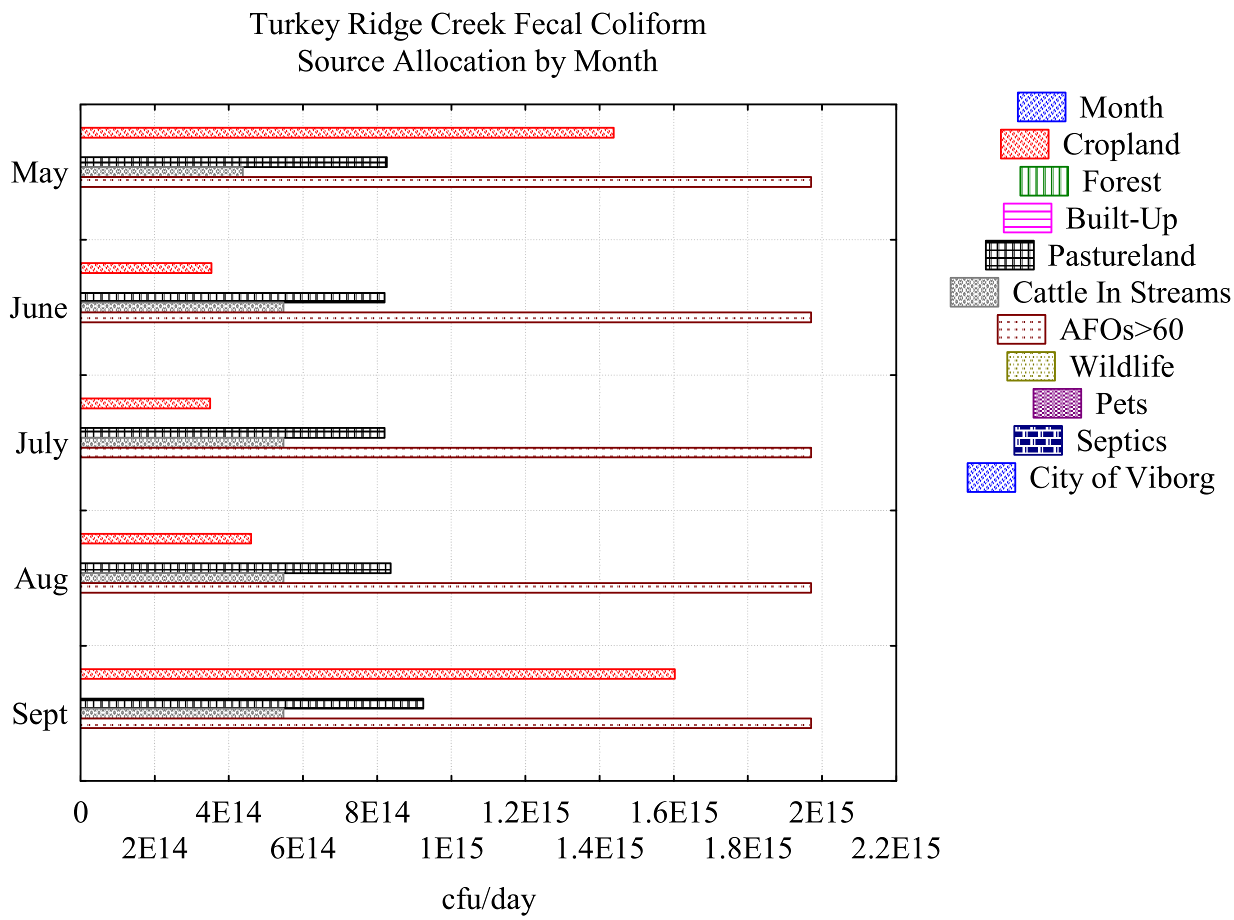


**Figure 54. Fecal Coliform Source Allocation by Month.**

**Linkage Analysis**

Water quality data was collected at nine monitoring sites on Turkey Ridge Creek, five of which were located on the 26.1 mile segment subject to the limited contact beneficial use (8) where the fecal coliform water quality standard (2,000 cfu/day) daily maximum concentration.. Samples were collected according to South Dakota's EPA approved Standard Operating Procedures for Field Samplers. Water samples were sent to the SD Health Laboratory in Pierre, SD for analysis. Quality Assurance/Quality Control samples were collected on 10% of the samples according to South Dakota's EPA approved Non-point Source Quality Assurance/Quality Control Plan. Details concerning water sampling techniques, analysis, and quality control are addressed in the assessment final report.

The Flow Duration Interval Zone method calculates fecal coliform bacteria loading, (concentration) x (flow), using zones based on hydrologic conditions. Reductions are calculated using the median of the fecal coliform bacteria samples in each zone. This method shows that while a TMDL may be expressed as a single point it can also be thought of as a continuum of points representing the criterion value with corresponding flow values. In order to assess the impact of fecal coliform bacteria for Turkey Ridge Creek, the range of flows from the most downstream site, Site TRC12, was used as the watershed indicator necessary to form the flow duration interval curve and "flow zones". The purpose of the zones is to differentiate hydrologic conditions, between peak and low flows, as ranges. For this tributary, the ranges or flow zones are High Flows (0-10), Moist Conditions (10-40), Mid-Range Flows (40-60), Dry Conditions (60-90), and Low Flows (90-100). Load duration curves were calculated using the following equation:

(flow) × (conversion factor) × (state criteria) = quantity/day or daily load

This curve represents the threshold of the load. In Figure 55, any samples occurring above the threshold line constitutes an exceedence of the water quality standard (2,000 cfu/100mL). Table 63 depicts the allowable coliform bacteria load for peak flow, low flow, and 5th percentile increments in flow. Flow duration intervals and exceedence tables for each of the tributaries influencing this stream can be found in Appendix G of the Turkey Ridge Creek Watershed Assessment Final Report.

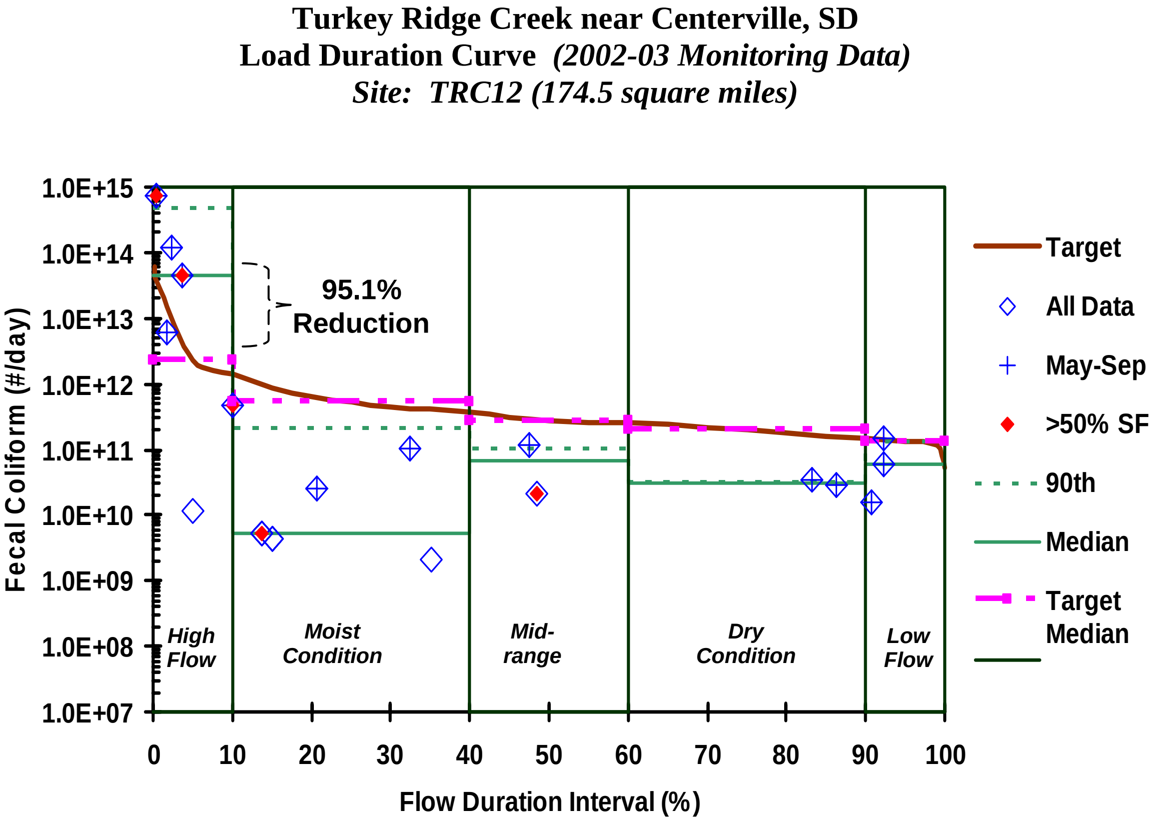


**Figure 55. Flow Duration Interval for Turkey Ridge Creek at 2000 cfu/100mL**

**Table 63. Fecal Coliform Target Loads**

| Flow Rank (percent) | cfs | Runoffm m/day | Allowable Loads 2000 cfu/100mL Fecal Coliform (counts/day) | Flow Conditions |
|---|---|---|---|---|
| **0.245%** | **1233.98** | 6.679 | 6.04E+13 | Peak |
| **0.100%** | **1111.10** | 6.014 | 5.44E+13 | |
| **0.274%** | **904.51** | 4.896 | 4.43E+13 | |
| **1%** | **523.28** | 2.832 | 2.56E+13 | |
| **5%** | **46.33** | 0.251 | 2.27E+12 | |
| **10%** | **28.28** | 0.153 | 1.38E+12 | |
| **15%** | **17.73** | 0.096 | 8.68E+11 | |
| **20%** | **13.03** | 0.071 | 6.38E+11 | |
| **25%** | **10.75** | 0.058 | 5.26E+11 | |
| **30%** | **9.33** | 0.050 | 4.56E+11 | |
| **35%** | **8.39** | 0.045 | 4.10E+11 | |
| **40%** | **7.38** | 0.040 | 3.61E+11 | |
| **45%** | **6.33** | 0.034 | 3.10E+11 | |
| **50%** | **5.64** | 0.031 | 2.76E+11 | |
| **55%** | **5.31** | 0.029 | 2.60E+11 | |
| **60%** | **5.21** | 0.028 | 2.55E+11 | |
| **65%** | **4.90** | 0.027 | 2.40E+11 | |
| **70%** | **4.51** | 0.024 | 2.20E+11 | |
| **75%** | **4.05** | 0.022 | 1.98E+11 | |
| **80%** | **3.71** | 0.020 | 1.81E+11 | |
| **85%** | **3.31** | 0.018 | 1.62E+11 | |
| **90%** | **3.01** | 0.016 | 1.47E+11 | |
| **95%** | **2.68** | 0.015 | 1.31E+11 | |
| **99%** | **2.43** | 0.013 | 1.19E+11 | |
| **100%** | **1.10** | 0.006 | 5.39E+10 | Low |

ARCVIEW software was used to spatially analyze animal feeding operations and their pollution potential. The feedlot assessment assumed the probable sources of fecal coliform bacteria loadings within the Turkey Ridge Creek watershed were agricultural related and rated the feedlots based on runoff potential. Feedlot ratings ranged from 0-81. A rating of 50 or greater warrants concern in regards to potential pollution problems.

The Bacterial Indicator Tool (EPA, 2002) was used to estimate the extent of potential sources for both diffuse (landuses) and direct sources. This EXCEL spreadsheet tool uses the surface area of the landuse, feedlot inventory and other livestock estimates, manure management of the livestock, septic and pets, as well as wildlife numbers to derive potential daily sources of fecal coliform bacteria within the watershed.

The Agricultural Non-Point Source Pollution (AGNPS) model is a GIS-integrated water quality model that predicts non-point source sediment and nutrient loadings within agricultural watersheds. Although not designed as a predictive model for bacteria, the subwatersheds or cells derived from the 30-meter digital elevation model (DEM) were used to determine runoff conditions for a 4.3 inch rainstorm (Figure 56). The runoff (cf/sec) from each subwatershed cell within the Turkey Ridge Creek drainage network was then used in conjunction with estimated bacteria from the landuse conditions (livestock, wildlife and pasture or cropland), channel length within the cell, and the average velocity within the cell. The decay rate equation for bacteria:

$$C = C_o \times \exp(-KX / U)$$

where: C = concentration of fecal indicator bacteria,
K = decay coefficient,

X = distance along axis of flow, and
U= flow velocity

was then applied to the bacterial concentrations derived within the cell (EPA Pathogen Protocol, 2001). After the decay rate was applied the coliform loading was exported out of the cell and added to the receiving cell. Each time the decay rate was applied to the output of each subwatershed cell until the outlet had been reached (see Appendix-O). This model setup was used to develop potential reductions for bacterial concentrations within the watershed.

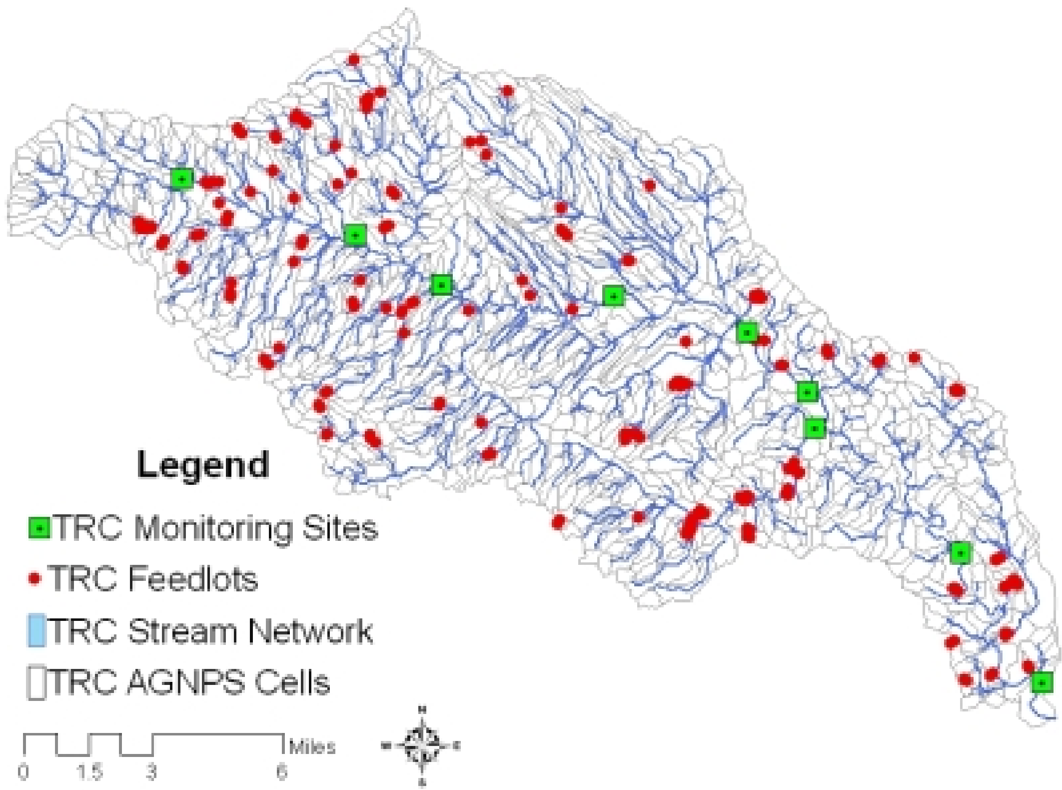


**Figure 56. ANN-AGNPS Cells and Stream Network for Turkey Ridge Creek.**

**TMDL and Allocations**

TMDL

| TMDL Component | Duration Curve Zone | | | | |
|---|---|---|---|---|---|
| | High | Moist | Mid | Dry | Low |
| **Loading Allocation** | 2.13E+12 | 4.76E+11 | 2.39E+11 | 1.65E+11 | 1.01E+11 |
| **Background*** | 1.13E+11 | 2.63E+10 | 1.38E+10 | 9.90E+09 | 6.56E+09 |
| **MOS**** | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| **Wasteload Allocation** | 2.33E+10 | 2.33E+10 | 2.33E+10 | 2.33E+10 | 2.33E+10 |
| **TMDL** | 2.27E+12 | 5.26E+11 | 2.76E+11 | 1.98E+11 | 1.313E+11 |

*Wildlife, **Implicit Margin of Safety

Wasteload Allocations (WLAs)
Identified point sources in this watershed are contributing an insignificant amount to the fecal coliform load. Therefore, the percent reduction for the "wasteload allocation" component of this TMDL will be zero.

Load Allocations (LAs)
Load allocations account for the portion of the TMDL assigned to non-point sources and is based on the flow duration interval approach. Natural background (wildlife) constitutes five percent of the total and the remainder of the LA is assigned to those land uses likely to contribute fecal coliform bacteria loads at rates above natural background. This includes all sources identified in Table 5 fecal sourcing table. A reduction of 95 percent is needed from non-point sources during high flow conditions

Using the ANN-AGNPS output files and subwatershed cells, and the exponential decay rate equation found in the USEPA Protocol for developing Pathogen TMDLs, a series of modeling scenarios were derived to determine possible reduction percentages using typical BMPs.

| ANN-AGNPS and Bacterial Decay Rate Modeling Setup | | | | | | |
|---|---|---|---|---|---|---|
| Current Watershed Conditions | Pasture Condition | Stocking Rate[1] | Feedlots | Rainfall | Fecal Coliform Output | Percent Reduction[2] |
| | Poor | 3 cows/acre | 129 | 4.3" | 31,625 cfu/100mL | Baseline |
| BMP Implementation | Good | 3 cows/acre | 129 | 4.3" | 21,917 cfu/100mL | 30.7% |
| | Good | 3 acres/cow | 129 | 4.3" | 13,784 cfu/100mL | 56.4% |
| | Good | 3 acres/cow | 0 | 4.3" | 1,806 cfu/100mL | 94.3% |
| [1] - Personal communication with NRCS District Conservationist for Turner County, SD. | | | | | | |
| [2] – CTIC reports that buffer strips installed along sensitive areas can filter up to 60% of pathogens. http://www.ctic.purdue.edu/Core4/Buffer/Bufferfact.html | | | | | | |

Additional reductions can be achieved through installation of buffer strips along drainages within the Turkey Ridge Watershed. Higher flow events can also resuspend fecal coliform bacteria that may be stored in the sediments of the stream (Howell, et.al, 1996). Bacteria can survive in the sediments depending on the characteristics of the soils and the ambient temperature (Doran and Linn, 1979; Stephenson and Street, 1978). Reductions in source of bacteria to the stream sediments, i.e. feedlots or cattle in the stream, will also have a corresponding reduction in the resuspension of those bacteria during storm events.

**Seasonal Variation**
Different seasons of the year can yield differences in water quality due to changes in precipitation and agricultural practices. When a rainfall event occurs, fecal coliform bacteria that have built up on the land surface under dry conditions are washed off and finally deposited into lakes, rivers, and wetlands. The variability between seasons is addressed through the use of load duration curve and the Bacterial Indicator Tool. The violations of the fecal coliform standard occurred during high flow events. All water quality samples collected were compared with the corresponding discharging resulting in the load duration curve. The Bacterial Indicator Tool was used to determine the potential contribution from various landuse categories throughout the applicable period and indicated how percent contribution can changed relative to landuse changes during the year.

**Margin of Safety**
The margin of safety is implicit as all fecal coliform bacteria reductions were calculated using extremely conservative estimates. Additional reductions may be achieved through the use of buffers along the margins of cropland that abut small streams and creeks draining into Turkey Ridge Creek.

**Critical Conditions**

The critical condition for fecal coliform loadings in any watershed depends on the presence of point sources and land use within that watershed and the existing hydrologic conditions. One of the advantages of using the load duration curve methodology is the ability to determine the critical conditions for the parameter of concern. For Turkey Ridge Creek, high flow conditions typically result in violations of the fecal coliform water quality standard. High flow conditions usually follow dry periods of varying lengths. During these periods of dry weather, the fecal coliform bacteria accumulate on the land surface and in feedlots becoming mobile during storm events resulting in the high flow exceedences.

**Follow-Up Monitoring**

Monitoring will continue for Turkey Ridge Creek as part of the Vermillion River Basin Watershed Assessment. Turkey Ridge Creek is a main tributary of the Vermillion River, which is currently being assessed because of sediment and fecal coliform bacteria impairments. This project will last throughout the end of 2007.

A FY2005 Section 319 implementation project has been approved for Turkey Ridge Creek. As part of this project monitoring and evaluation efforts will be targeted toward the effectiveness of implemented BMPs.

Once the implementation project is completed, post-implementation monitoring will be necessary to assure that the TMDL has been reached and improvement to the beneficial uses occurs.

**Public Participation**

Efforts taken to gain public education, review, and comment during development of the TMDL involved:

- Turner County Conservation District Board meetings and Vermillion Basin Water Development District Board meetings.
- Field demonstrations for the public
- Articles in the local newspapers

The findings from these public meetings and comments have been taken into consideration in development of the Turkey Ridge Creek TMDL

**Implementation Plan**

The TMDL analysis was performed using the best data available to specify the fecal coliform reductions necessary to achieve water quality criteria. The intent of meeting the criteria is to support the designated use classifications of this segment. A preliminary implementation plan was developed targeting animal feeding operations and grazing management within the watershed (Appendix O). The involvement of local land owners and agencies were considered during the development of the phase of the implementation project. As part of the preliminary implementation project a more detailed workplan will be developed targeting additional animal feeding operations, buffer strips, and alternative measures for improving pasture conditions.

**Enclosure 3**

# EPA REGION VIII TMDL REVIEW FORM

| | |
|---|---|
| **Document Name:** | **Turkey Ridge Creek Watershed Assessment Final Report – Fecal Coliform TMDL** |
| **Submitted by:** | **Gene Stueven, SD DENR** |
| **Date Received:** | **August 31, 2006** |
| **Review Date:** | **September 22, 2006** |
| **Reviewer:** | **Vern Berry, EPA** |
| **Formal or Informal Review?** | **Formal – Final Approval** |

This document provides a standard format for EPA Region 8 to provide comments to the South Dakota Department of Environment and Natural Resources on TMDL documents provided to the EPA for either official formal or informal review. All TMDL documents are measured against the following 12 review criteria:

1. Water Quality Impairment Status
2. Water Quality Standards
3. Water Quality Targets
4. Significant Sources
5. Technical Analysis
6. Margin of Safety and Seasonality
7. Total Maximum Daily Load
8. Allocation
9. Public Participation
10. Monitoring Strategy
11. Restoration Strategy
12. Endangered Species Act Compliance

Each of the 12 review criteria are described below to provide the rational for the review, followed by EPA's comments. This review is intended to ensure compliance with the Clean Water Act and also to ensure that the reviewed documents are technically sound and the conclusions are technically defensible.

## 1. Water Quality Impairment Status

| ***Criterion Description – Water Quality Impairment Status*** |
|---|
| *TMDL documents must include a description of the listed water quality impairments.* ***.*** *While the 303(d) list identifies probable causes and sources of water quality impairments, the information contained in the 303(d) list is generally not sufficiently detailed to provide the reader with an adequate understanding of the impairments. TMDL documents should include a thorough description/summary of all available water quality data such that the water quality impairments are clearly defined and linked to the impaired beneficial uses and/or appropriate water quality standards.* |

☒ Satisfies Criterion
☐ Satisfies Criterion. Questions or comments provided below should be considered.
☐ Partially satisfies criterion. Questions or comments provided below need to be addressed.
☐ Criterion not satisfied. Questions or comments provided below need to be addressed.
☐ Not a required element in this case. Comments or questions provided for informational purposes.

**SUMMARY –** Turkey Ridge Creek is located in the Vermillion River Basin, Turner County, South Dakota. Turkey Ridge Creek is not listed on South Dakota's 2004 303(d) list as impaired. The stream segment described in the assessment report (headwaters to mouth) is 47.5 miles long and drains a watershed of approximately 112,430 acres. However, only the 26.1 mile lower segment, of the 47.5 mile length of Turkey Ridge Creek, is classified for warmwater marginal fish life propagation and limited contact recreation. The predominant landuses in the watershed are cropland (approximately 85 percent) and pastureland (approximately 13 percent). One hundred twenty nine animal feeding operations are located in the watershed. Assessment data show fecal coliform violated the applicable surface water quality standards. Twenty-five percent of the fecal coliform samples exceeded the daily maximum standard. Although the stream is meeting the existing TSS standard, negative correlations between the mean TSS concentration and several macroinvertebrate metrics were identified. Further evaluation of the potential affects of the sediment and possible sources within the Turkey Ridge Creek Watershed will take place during the Vermillion River Watershed Assessment.

## 2. Water Quality Standards

| ***Criterion Description – Water Quality Standards*** |
|---|
| *The TMDL document must include a description of all applicable water quality standards for all affected jurisdictions. TMDLs result in maintaining and attaining water quality standards. Water quality standards are the basis from which TMDLs are established and the TMDL targets are derived, including the numeric, narrative, use classification, and antidegradation components of the standards.* |

☒ Satisfies Criterion
☐ Satisfies Criterion. Questions or comments provided below should be considered.
☐ Partially satisfies criterion. Questions or comments provided below need to be addressed.
☐ Criterion not satisfied. Questions or comments provided below need to be addressed.
☐ Not a required element in this case. Comments or questions provided for informational purposes.

**SUMMARY –** The Turkey Ridge Creek segment addressed by this TMDL is impaired by fecal coliform. South Dakota has applicable numeric standards for fecal coliform that may be applied to this creek segment. The numeric standards being implemented in this TMDL is: fecal coliform ≤ 2000 colonies/100 mL in any one sample (May 1 – Sept 30) which is based on the limited contact recreation classification.

Other applicable water quality standards are included on pages 13 and 14 of the assessment report.

### 3. Water Quality Targets

***Criterion Description – Water Quality Targets***

*Quantified targets or endpoints must be provided to address each listed pollutant/water body combination. Target values must represent achievement of applicable water quality standards and support of associated beneficial uses. For pollutants with numeric water quality standards, the numeric criteria are generally used as the TMDL target. For pollutants with narrative standards, the narrative standard must be translated into a measurable value. At a minimum, one target is required for each pollutant/water body combination. It is generally desirable, however, to include several targets that represent achievement of the standard and support of beneficial uses (e.g., for a sediment impairment issue it may be appropriate to include targets representing water column sediment such as TSS, embeddeness, stream morphology, up-slope conditions and a measure of biota).*

☒ Satisfies Criterion
☐ Satisfies Criterion. Questions or comments provided below should be considered.
☐ Partially satisfies criterion. Questions or comments provided below need to be addressed.
☐ Criterion not satisfied. Questions or comments provided below need to be addressed.
☐ Not a required element in this case. Comments or questions provided for informational purposes.

**SUMMARY –** Water quality target for this TMDL is based on the numeric water quality standards for fecal coliform. The fecal coliform target is to maintain water quality at 2000 cfu/100mL from May 1st through September 30th in any one sample. This target is based on the limited contact recreation beneficial use classifications of the listed Turkey Ridge Creek segment. A reduction target (expressed as a percentage) is also specified in the TMDL summary, and is based on the mean fecal coliform value derived from the data collected during the period of assessment for the listed segment.

### 4. Significant Sources

**Criterion Description – Significant Sources**

*TMDLs must consider all significant sources of the stressor of concern. All sources or causes of the stressor must be identified or accounted for in some manner. The detail provided in the source assessment step drives the rigor of the allocation step. In other words, it is only possible to specifically allocate quantifiable loads or load reductions to each significant source when the relative load contribution from each source has been estimated. Ideally, therefore, the pollutant load from each significant source should be quantified. This can be accomplished using site-specific monitoring data, modeling, or application of other assessment techniques. If insufficient time or resources are available to accomplish this step, a phased/adaptive management approach can be employed so long as the approach is clearly defined in the document.*

☒ Satisfies Criterion
☐ Satisfies Criterion. Questions or comments provided below should be considered.
☐ Partially satisfies criterion. Questions or comments provided below need to be addressed.
☐ Criterion not satisfied. Questions or comments provided below need to be addressed.
☐ Not a required element in this case. Comments or questions provided for informational purposes.

**SUMMARY –** The TMDL identifies the major sources fecal coliform as coming from nonpoint source agricultural landuses within the watershed. These landuses in the watershed include cropland (approximately 85 percent) and pastureland (approximately 13 percent). The over-grazed pastures are primarily located along the creek and livestock have direct access to the stream in some places in the watershed. One hundred twenty nine animal feeding operations are located in the watershed. One wastewater treatment facility (i.e., Viborg) and four concentrated animal feeding operations are located in the watershed, however these are considered to be minor sources.

## 5. Technical Analysis

***Criterion Description – Technical Analysis***

*TMDLs must be supported by an appropriate level of technical analysis. It applies to **all** of the components of a TMDL document. It is vitally important that the technical basis for **all** conclusions be articulated in a manner that is easily understandable and readily apparent to the reader. Of particular importance, the cause and effect relationship between the pollutant and impairment and between the selected targets, sources, TMDLs, and allocations needs to be supported by an appropriate level of technical analysis.*

☒ Satisfies Criterion
☐ Satisfies Criterion. Questions or comments provided below should be considered.
☐ Partially satisfies criterion. Questions or comments provided below need to be addressed.
☐ Criterion not satisfied. Questions or comments provided below need to be addressed.
☐ Not a required element in this case. Comments or questions provided for informational purposes.

**SUMMARY –** The technical analysis addresses the needed fecal coliform reductions to achieve the desired water quality in the impaired creek segment. The load reduction necessary to meet the water quality target was derived using the load duration curve method. The Turkey Ridge Creek daily average flow values for 2002 and 2004 were used to define five hydrologic zones (i.e., high flow, moist, mid-range, dry and low flow) for the watershed. The TMDL recommends a 95% reduction in average annual fecal coliform loads during high flow in Turkey Ridge Creek.

The Bacterial Indicator Tool was used to allocate all possible nonpoint sources for fecal coliform in the Turkey Ridge Creek watershed. Bacterial contributions from four landuse types (i.e., cropland, forest, pastureland and urban/suburban build-up) were estimated using this tool.

The Agricultural Non-Point Source Model (AGNPS) model was used to estimate fecal coliform export loads from the 40 acre cells within the watershed during a large precipitation event (i.e., high flow). This information was used to develop potential reductions for bacterial concentrations within the watershed.

## 6. Margin of Safety and Seasonality

***Criterion Description – Margin of Safety and Seasonality***

*A margin of safety (MOS) is a required component of the TMDL that accounts for the uncertainty about the relationship between the pollutant loads and the quality of the receiving water body (303(d)(1)(c)). The MOS can be implicitly expressed by incorporating a margin of safety into conservative assumptions used to develop the TMDL. In other cases, the MOS can be built in as a separate component of the TMDL (in this case, quantitatively, a TMDL = WLA + LA + MOS). In all cases, specific documentation describing the rational for the MOS is required.*

*Seasonal considerations, such as critical flow periods (high flow, low flow), also need to be considered when establishing TMDLs , targets, and allocations.*

☒ Satisfies Criterion
☐ Satisfies Criterion. Questions or comments provided below should be considered.
☐ Partially satisfies criterion. Questions or comments provided below need to be addressed.
☐ Criterion not satisfied. Questions or comments provided below need to be addressed.
☐ Not a required element in this case. Comments or questions provided for informational purposes.

**SUMMARY –** An appropriate margin of safety is included through conservative assumptions in the derivation of the target and in the modeling. Additionally, more BMPs were specified than are necessary to meet the targets, and ongoing monitoring has been proposed to assure water quality goals are achieved. Seasonality was adequately considered by evaluating the cumulative impacts of the various seasons on water quality and by proposing BMPs that can be tailored to seasonal needs.

## 7. TMDL

***Criterion Description – Total Maximum Daily Load***

*TMDLs include a quantified pollutant reduction target. According to EPA regulations (see 40 CFR 130.2(i)). TMDLs can be expressed as mass per unit of time, toxicity, % load reduction, or other measure. TMDLs must address, either singly or in combination, each listed pollutant/water body combination.*

☒ Satisfies Criterion
☐ Satisfies Criterion. Questions or comments provided below should be considered.
☐ Partially satisfies criterion. Questions or comments provided below need to be addressed.
☐ Criterion not satisfied. Questions or comments provided below need to be addressed.
☐ Not a required element in this case. Comments or questions provided for informational purposes.

**SUMMARY –** The TMDL was calculated for fecal coliform loading into Turkey Ridge Creek. The TMDL recommends an average annual fecal coliform load of $2.27 \times 10^{12}$ cfu/day during high flow conditions (from May 1 – Sept 30, 95% reduction). Loads for other hydrologic conditions are specified, however reductions are only necessary during high flows. The TMDL load and reduction is based on the "modeled load" which is derived from the concentration data collected during the period of the assessment and the modeled loading from the Bacterial Indicator Tool and AGNPS. The annual loading will vary from year-to-year; therefore, the TMDL is considered a long term average percent reduction in fecal coliform loading.

## 8. Allocation

| ***Criterion Description – Allocation*** |
|---|
| *TMDLs apportion responsibility for taking actions or allocate the available assimilative capacity among the various point, nonpoint, and natural pollutant sources. Allocations may be expressed in a variety of ways such as by individual discharger, by tributary watershed, by source or land use category, by land parcel, or other appropriate scale or dividing of responsibility. A performance based allocation approach, where a detailed strategy is articulated for the application of BMPs, may also be appropriate for nonpoint sources. Every effort should be made to be as detailed as possible and also, to base all conclusions on the best available scientific principles.*<br><br>*In cases where there is substantial uncertainty regarding the linkage between the proposed allocations and achievement of water quality standards, it may be necessary to employ a phased or adaptive management approach (e.g., establish a monitoring plan to determine if the proposed allocations are, in fact, leading to the desired water quality improvements).* |

☒ Satisfies Criterion
☐ Satisfies Criterion. Questions or comments provided below should be considered.
☐ Partially satisfies criterion. Questions or comments provided below need to be addressed.
☐ Criterion not satisfied. Questions or comments provided below need to be addressed.
☐ Not a required element in this case. Comments or questions provided for informational purposes.

**SUMMARY –** These TMDLs address the need to achieve reductions in fecal coliform to attain water quality standards in the Turkey Ridge Creek watershed. The TMDL includes both load allocations and wasteload allocations attributed to nonpoint sources and point sources respectively as specified in the TMDL. The nonpoint source allocations and the specified reductions of fecal coliform concentrations can be achieved through the implementation of BMPs including improvements to grazing management practices, targeting animal feeding operations and adding buffer strips.

## 9. Public Participation

| ***Criterion Description – Public Participation*** |
|---|
| *The fundamental requirement for public participation is that all stakeholders have an opportunity to be part of the process. Notifications or solicitations for comments regarding the TMDL should clearly identify the product as a TMDL and the fact that it will be submitted to EPA for review. When the final TMDL is submitted to EPA for review, a copy of the comments received by the state should be also submitted to EPA.* |

☒ Satisfies Criterion
☐ Satisfies Criterion. Questions or comments provided below should be considered.
☐ Partially satisfies criterion. Questions or comments provided below need to be addressed.
☐ Criterion not satisfied. Questions or comments provided below need to be addressed.
☐ Not a required element in this case. Comments or questions provided for informational purposes.

**SUMMARY –** The State's submittal includes a summary of the public participation process that has occurred which describes the ways the public has been given an opportunity to be involved in the TMDL development process. In particular, the State has encouraged participation through public meetings in the watershed, individual contact with landowners, newspaper articles and a presentation of final results. Also, the draft TMDL was posted on the State's internet site to solicit comments during the public notice period.

**10. Monitoring Strategy**

| ***Criterion Description – Monitoring Strategy*** |
|---|
| *TMDLs may have significant uncertainty associated with selection of appropriate numeric targets and estimates of source loadings and assimilative capacity. In these cases, a phased TMDL approach may be necessary. For Phased TMDLs, it is EPA's expectation that a monitoring plan will be included as a component of the TMDL documents to articulate the means by which the TMDL will be evaluated in the field, and to provide supplemental data in the future to address any uncertainties that may exist when the document is prepared.* |

☐ Satisfies Criterion
☐ Satisfies Criterion. Questions or comments provided below should be considered.
☐ Partially satisfies criterion. Questions or comments provided below need to be addressed.
☐ Criterion not satisfied. Questions or comments provided below need to be addressed.
☒ Not a required element in this case. Comments or questions provided for informational purposes.

**SUMMARY –** Turkey Ridge Creek will continue to be monitored as part of the Vermillion River Basin watershed assessment. Post-implementation monitoring will be necessary to assure the TMDL has been reached and maintenance of the beneficial use occurs.

**11. Restoration Strategy**

| ***Criterion Description – Restoration Strategy*** |
|---|
| *At a minimum, sufficient information should be provided in the TMDL document to demonstrate that if the TMDL were implemented, water quality standards would be attained or maintained. Adding additional detail regarding the proposed approach for the restoration of water quality is not currently a regulatory requirement, but is considered a value added component of a TMDL document.* |

☐ Satisfies Criterion
☐ Satisfies Criterion. Questions or comments provided below should be considered.
☐ Partially satisfies criterion. Questions or comments provided below need to be addressed.
☐ Criterion not satisfied. Questions or comments provided below need to be addressed.
☒ Not a required element in this case. Comments or questions provided for informational purposes.

**SUMMARY –** The Turner County Conservation District is sponsoring an implementation project for the Turkey Ridge Creek watershed. The implementation project was approved and funded through SD DENR in 2005.

### 12. Endangered Species Act Compliance

| ***Criterion Description – Endangered Species Act Compliance*** |
|---|
| *EPA's approval of a TMDL may constitute an action subject to the provisions of Section 7 of the Endangered Species Act (ESA). EPA will consult, as appropriate, with the US Fish and Wildlife Service (USFWS) to determine if there is an effect on listed endangered and threatened species pertaining to EPA's approval of the TMDL. The responsibility to consult with the USFWS lies with EPA and is not a requirement under the Clean Water Act for approving TMDLs. States are encouraged, however, to participate with USFWS and EPA in the consultation process and, most importantly, to document in its TMDLs the potential effects (adverse or beneficial) the TMDL may have on listed as well as candidate and proposed species under the ESA.* |

☐ Satisfies Criterion
☐ Satisfies Criterion. Questions or comments provided below should be considered.
☐ Partially satisfies criterion. Questions or comments provided below need to be addressed.
☐ Criterion not satisfied. Questions or comments provided below need to be addressed.
☒ Not a required element in this case. Comments or questions provided for informational purposes.

**SUMMARY –** EPA has received ESA Section 7 concurrence from the FWS for this TMDL.

### 13. Miscellaneous Comments/Questions

**UNITED STATES ENVIRONMENTAL PROTECTION AGENCY**
**REGION 8**
**999 18$^{TH}$ STREET- SUITE 300**
**DENVER, CO 80202-2466**
**Phone 800-227-8917**
**http://www.epa.gov/region08**

September 27, 2006

Ref: 8EPR-EP

Steven M. Pirner, Secretary
Department of Environment & Natural Resources
Joe Foss Building
523 East Capitol
Pierre, SD 57501-3181

Re: TMDL Approvals
*Dante Lake*
*Turkey Ridge Creek*

Dear Mr. Pirner:

We have completed our review, and have received Endangered Species Act Section 7 concurrence from the U.S. Fish and Wildlife Service, on the total maximum daily loads (TMDLs) as submitted by your office for the waterbodies listed in the enclosure to this letter. In accordance with the Clean Water Act (33 U.S.C. 1251 *et. seq*.), we approve all aspects of the TMDLs as developed for the water quality limited waterbodies as described in Section 303(d)(1).

Based on our review, we feel the separate elements of the TMDLs listed in the enclosed table adequately address the pollutants of concern as given in the table, taking into consideration seasonal variation and a margin of safety. In the enclosed table, we have distinguished between TMDLs developed under Section 303(d)(1) *vs.* Section 303(d)(3) of the Clean Water Act. Section 303(d)(1) TMDLs are those for waterbodies that are water quality limited for the pollutant(s) of concern. The determination of whether a particular TMDL is (d)(1) or (d)(3) is made on a waterbody-by-waterbody and pollutant-by-pollutant basis.

Some of the TMDLs designated on the enclosed table as Section 303(d)(1) TMDLs, as distinguished from Section 303(d)(3) TMDLs, may be for waters not found on the current state 303(d) waterbody list. EPA understands that such waters would have been included on the list had the state been aware, at the time the list was compiled, of the information developed in the context of calculating these TMDLs. This information demonstrates that the non-listed water is in fact a water quality limited segment in need of a TMDL.

The state need not include these waters that have such TMDLs associated with them on its next Section 303(d) list for the pollutant covered by the TMDL.

Thank you for your submittal. If you have any questions concerning this approval, feel free to contact Vernon Berry of my staff at 303-312-6234.

Sincerely,

Original signed by Max H. Dodson

Max H. Dodson
Assistant Regional Administrator
Office of Ecosystems Protection and

Remediation

Enclosures

**ENCLOSURE 1**

## APPROVED TMDLS

| Waterbody Name* | TMDL Parameter/ Pollutant | Water Quality Goal/Endpoint | TMDL | Section 303(d)1 or 303(d)3 TMDL | Supporting Documentation (not an exhaustive list of supporting documents) |
|---|---|---|---|---|---|
| Dante Lake* | Phosphorous | Maintain a mean annual TSI at or below 63.86 | 1,474 kg/yr total phosphorous (6.4% reduction in average annual total phosphorous loads) | Section 303(d)(1) | ■ Phase I Watershed Assessment and TMDL Final Report, Dante Lake, Charles Mix County, South Dakota (SD DENR, January 2006) |
| | Dissolved Oxygen | Dissolved Oxygen ≥ 5.0 mg/L. | It is anticipated that meeting the phosphorous load reduction target will result in the dissolved oxygen target being met.** | Section 303(d)(1) | |
| Turkey Ridge Creek | Fecal Coliform | Fecal coliform ≤ 2000 cfu/100mL | $2.27 \times 10^{12}$ cfu/day (during high flow from May 1 to Sept. 30; 95% reduction in average annual, high flow fecal coliform loads) | Section 303(d)(1) | ■ Watershed Assessment Final Report, Turkey Ridge Creek, Turner County, South Dakota (SD DENR, July 2005) |

* An asterisk indicates the waterbody has been included on the State's Section 303(d) list of waterbodies in need of TMDLs.

** Improvements in the dissolved oxygen concentration of the lake can be achieved through reduction of organic loading to the lake as a result of proposed BMP implementation. The TMDL contains a linkage analysis between phosphorous loading and low dissolved oxygen in lakes and reservoirs.

## 7.0 APPENDIX B – TURKEY RIDGE CREEK WATER QUALITY DATA

| StationID | StartDate | StartTime | Sample Type | Fecal Coliform | E_Coli | Alkalinity | Total Solids | Total Susp Sol | Total Vol SS | Ammonia | Nitrate | TKN | Total_P | Total Diss P | Temp | SpCond | DO Conc | pH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | cfu/100ml | cfu/100ml | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | | | mg/L | su |
| TRC01 | 3/26/2002 | 10:00 AM | GRAB | 10 | 2 | | 1762 | 2 | 3 | 0.02 | 2.4 | 0.55 | 0.031 | 0.03 | 2.19 | 1954 | 9.24 | 7.53 |
| TRC01 | 3/30/2002 | 8:00 AM | GRAB | 10 | 14.5 | NA | 794 | 5 | 1 | 0.43 | 1.8 | 1.66 | 0.299 | 0.235 | 1.81 | 815 | 5.99 | 7.28 |
| TRC01 | 4/17/2002 | 9:15 AM | GRAB | 10 | 1 | NA | 1667 | 30 | 9 | 0.02 | 0.4 | 0.84 | 0.135 | 0.054 | 13.05 | 1634 | 7.59 | 7.61 |
| TRC01 | 5/1/2002 | 9:30 AM | GRAB | 10 | 1 | NA | 1707 | 5 | 4 | 0.02 | 0.4 | 0.61 | 0.066 | 0.046 | 10.62 | 1652 | 8.49 | 7.68 |
| TRC01 | 5/29/2002 | 9:40 AM | GRAB | 1400 | 1986 | NA | 1736 | 31 | 8 | 0.04 | 0.5 | 0.69 | 0.155 | 0.09 | 19.10 | 1792 | | 7.61 |
| TRC01 | 6/26/2002 | 8:30 AM | GRAB | 1900 | 1300 | NA | 1783 | 18 | 6 | 0.02 | 0.5 | 1.01 | 0.166 | 0.121 | 20.77 | 1664 | 4.12 | 7.56 |
| TRC01 | 7/10/2002 | 8:05 AM | GRAB | 630 | 727 | NA | 1967 | 15 | 5 | 0.02 | 0.3 | 0.84 | 0.253 | 0.192 | 22.44 | 1807 | 3.82 | 7.58 |
| TRC01 | 7/31/2002 | 7:25 AM | GRAB | 240 | 180 | NA | 1968 | 24 | 5 | 0.02 | 0.6 | 0.7 | 0.245 | 0.184 | 19.62 | 1930 | 4.26 | 7.61 |
| TRC01 | 8/5/2002 | 9:45 AM | GRAB | 600 | 387 | NA | 2078 | 23 | 8 | 0.06 | 0.4 | 0.99 | 0.293 | NA | 20.96 | 2052 | 4.01 | 7.64 |
| TRC01 | 8/5/2002 | 9:45 AM | Duplicate | 520 | 548 | NA | 2093 | 20 | 6 | 0.06 | 0.4 | 0.67 | 0.306 | NA | 20.96 | 2052 | 4.01 | 7.64 |
| TRC01 | 8/21/2002 | 9:46 AM | GRAB | 50,000 | 2420 | NA | 1548 | 114 | 22 | 0.19 | 0.4 | 2.57 | 0.66 | 0.362 | 19.49 | 1532 | 5.37 | 7.67 |
| TRC01 | 10/31/2002 | 9:00 AM | GRAB | 20 | 12.2 | NA | 1751 | 5 | 1 | 0.02 | 1.2 | 0.32 | 0.082 | 0.07 | 2.44 | 1774 | 13.06 | 8.03 |
| TRC01 | 3/20/2003 | 7:53 AM | GRAB | 10 | 1 | | 994 | 8 | 2 | 0.43 | 1.1 | 0.93 | 0.188 | 0.131 | | | | |
| TRC01 | 5/1/2003 | 9:15 AM | GRAB | 20 | 23.3 | | | | | | | | | | 50.18 | 1767 | 10.51 | 7.91 |
| TRC01 | 5/9/2003 | 8:30 AM | GRAB | 50 | 62 | | 1807 | 18 | 7 | 0.02 | 0.3 | 0.81 | 0.127 | 0.065 | 52.59 | 1892 | 11.58 | 8.58 |
| TRC01 | 6/10/2003 | 9:15 AM | GRAB | 1200 | 1990 | 311 | 1717 | 18 | 4 | 0.02 | 0.4 | 0.94 | 0.182 | 0.117 | 62.27 | 1807 | 7.50 | 8.10 |
| TRC01 | 6/25/2003 | 8:00 AM | GRAB | 6000 | 2420 | | 1004 | 62 | 19 | 0.03 | 3.2 | 1.76 | 0.481 | 0.304 | 68.28 | 1099 | 5.58 | 8.31 |
| TRC01 | 7/10/2003 | 9:30 AM | GRAB | 921 | 800 | | 1398 | 30 | 5 | 0.02 | 0.4 | 0.7 | 0.279 | 0.197 | 66.18 | 1544 | 9.17 | 8.39 |
| TRC01 | 9/11/2003 | 10:00 AM | GRAB | 20000 | 2420 | | 1410 | 20 | 2 | 0.06 | 0.7 | 1.05 | 0.389 | 0.314 | 63.50 | | | 7.62 |
| TRC01 | 10/2/2003 | 8:30 AM | GRAB | 330 | 308 | | 1704 | 12 | 4 | 0.02 | 0.8 | 0.61 | 0.141 | 0.111 | 45.95 | 1733 | 9.20 | 7.75 |
| TRC02 | 3/26/2002 | 10:40 AM | GRAB | 10 | 1 | | 1837 | 11 | 1 | 0.02 | 1.6 | 0.41 | 0.043 | 0.032 | 0.11 | 2033 | 8.37 | 8.24 |
| TRC02 | 3/30/2002 | 9:00 AM | GRAB | 10 | 2 | NA | 986 | 27 | 3 | 0.35 | 1.4 | 1.51 | 0.309 | 0.206 | 1.76 | 960 | 6.92 | 8 |
| TRC02 | 4/17/2002 | 9:40 AM | GRAB | 10 | 75.4 | NA | 1815 | 6 | 3 | 0.02 | 0.2 | 0.57 | 0.075 | 0.038 | 11.48 | 1764 | 12.66 | 8.12 |
| TRC02 | 5/1/2002 | 9:52 AM | GRAB | 60 | 60.1 | NA | 2000 | 5 | 4 | 0.02 | 0.4 | 0.54 | 0.054 | 0.036 | 9.36 | 1872 | 11.76 | 8.13 |
| TRC02 | 5/29/2002 | 10:10 AM | GRAB | 280 | 517 | NA | 1887 | 15 | 5 | 0.08 | 0.5 | 0.62 | 0.132 | 0.096 | 18.13 | 1947 | | 7.95 |
| TRC02 | 6/26/2002 | 8:55 AM | GRAB | 2000 | 1986 | NA | 1850 | 31 | 14 | 0.18 | 0.6 | 1.9 | 0.229 | 0.072 | 22.79 | 1704 | 6.66 | 7.97 |
| TRC02 | 7/10/2002 | 8:30 AM | GRAB | 1300 | 2420 | NA | 1689 | 26 | 6 | 0.17 | 0.5 | 0.86 | 0.227 | 0.179 | 23.25 | 1596 | 6.06 | 8 |
| TRC02 | 7/31/2002 | 7:55 AM | GRAB | 600 | 344 | NA | 1829 | 30 | 7 | 0.13 | 0.3 | 0.79 | 0.188 | 0.138 | 22.94 | 1806 | 5.78 | 7.97 |
| TRC02 | 8/5/2002 | 10:15 AM | GRAB | 540 | 579 | NA | 2012 | 36 | 9 | 0.1 | 0.3 | 1.06 | 0.218 | NA | 22.51 | 1972 | 6.51 | 8.12 |
| TRC02 | 8/21/2002 | 10:38 AM | GRAB | 3600 | 2420 | NA | 1207 | 44 | 9 | 0.07 | 0.5 | 0.32 | 0.235 | 0.138 | 20.46 | 1284 | 7.73 | 7.98 |
| TRC02 | 8/21/2002 | 10:38 AM | Duplicate | NA | NA | NA | 1214 | 47 | 9 | 0.08 | 0.5 | 0.46 | 0.299 | 0.135 | 20.46 | 1284 | 7.73 | 7.98 |
| TRC02 | 10/31/2002 | 9:40 AM | GRAB | 90 | 161 | NA | 1712 | 14 | 3 | 0.02 | 0.8 | 0.32 | 0.108 | 0.083 | 0.00 | 1693 | 16.34 | 8.43 |
| TRC02 | 3/20/2003 | 8:30 AM | GRAB | 10 | 5.2 | | 1223 | 13 | 3 | 0.33 | 1 | 0.81 | 0.151 | 0.113 | | | | |
| TRC02 | 5/1/2003 | 8:20 AM | GRAB | 1300 | 2420 | | | | | | | | | | 47.52 | 1897 | 11.59 | 8.12 |
| TRC02 | 5/9/2003 | 9:30 AM | GRAB | | | | 1893 | 15 | 6 | 0.02 | 0.5 | 0.63 | 0.125 | 0.079 | 51.40 | 1947 | 13.26 | 8.57 |
| TRC02 | 6/10/2003 | 8:20 AM | GRAB | 380000 | 2420 | 245 | 1569 | 176 | 36 | 0.1 | 1.1 | 2.78 | 1.2 | 0.629 | 60.67 | 1550 | 7.51 | 8.34 |
| TRC02 | 6/25/2003 | 8:45 AM | GRAB | 84000 | 2420 | | 941 | 158 | 40 | 0.13 | 1.4 | 2.14 | 1.01 | 0.648 | 67.98 | 960 | 9.57 | 8.29 |
| TRC02 | 7/10/2003 | 10:00 AM | GRAB | 3400 | 1990 | | 1595 | 72 | 14 | 0.04 | 0.6 | 0.9 | 0.631 | 0.452 | 66.20 | 1716 | 9.91 | 8.20 |
| TRC02 | 9/11/2003 | 10:50 AM | GRAB | 22000 | 2420 | | 1579 | 86 | 14 | 0.06 | 0.5 | 1.32 | 0.435 | 0.273 | 64.04 | | | 7.98 |

| StationID | StartDate | StartTime | Sample Type | Fecal Coliform | E_Coli | Alkalinity | Total Solids | Total Susp Sol | Total Vol SS | Ammonia | Nitrate | TKN | Total_P | Total Diss P | Temp | SpCond | DO Conc | pH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TRC02 | 10/2/2003 | 9:30 AM | GRAB | 670 | 727 | | 1653 | 20 | 4 | 0.02 | 0.4 | 0.57 | 0.122 | 0.08 | 42.95 | 1652 | 12.19 | 8.00 |
| TRC03 | 3/26/2002 | 11:30 AM | GRAB | 10 | 1 | NA | 1802 | 7 | 3 | 0.02 | 1.4 | 0.37 | 0.086 | 0.078 | 1.03 | 2000 | 8.48 | 8.26 |
| TRC03 | 3/30/2002 | 10:00 AM | GRAB | 10 | 5.2 | NA | 1008 | 31 | 2 | 0.37 | 1.5 | 1.65 | 0.371 | 0.255 | 2.81 | 970 | 6.92 | 8.02 |
| TRC03 | 4/17/2002 | 10:30 AM | GRAB | 320 | 387 | NA | 1912 | 36 | 8 | 0.02 | 0.3 | 0.53 | 0.108 | 0.043 | 12.72 | 1822 | 10.18 | 7.99 |
| TRC03 | 5/1/2002 | 10:11 AM | GRAB | 430 | 816 | NA | 2110 | 11 | 4 | 0.02 | 0.4 | 0.55 | 0.063 | 0.032 | 9.93 | 1955 | 10.07 | 8.03 |
| TRC03 | 5/29/2002 | 10:40 AM | GRAB | 300 | 613 | NA | 1974 | 27 | 5 | 0.07 | 0.4 | 0.69 | 0.123 | 0.065 | 20.98 | 2014 | | 7.87 |
| TRC03 | 6/26/2002 | 9:20 AM | GRAB | 6400 | 2420 | NA | 1876 | 51 | 15 | 0.06 | 0.3 | 1.55 | 0.25 | 0.073 | 25.91 | 1713 | 6.98 | 7.99 |
| TRC03 | 7/10/2002 | 9:20 AM | GRAB | 3000 | 1410 | NA | 1785 | 74 | 19 | 0.32 | 0.4 | 1.1 | 0.289 | 0.137 | 24.16 | 1639 | 5.66 | 7.92 |
| TRC03 | 7/31/2002 | 9:00 AM | GRAB | 600 | 63 | NA | 1861 | 28 | 6 | 0.2 | 0.3 | 0.91 | 0.233 | 0.102 | 23.97 | 1843 | 6.06 | 7.86 |
| TRC03 | 8/5/2002 | 10:45 AM | GRAB | 24,000 | 2420 | NA | 1671 | 45 | 10 | 0.13 | 0.4 | 0.95 | 0.243 | 0.153 | 73.28 | 1691 | 4.97 | 7.99 |
| TRC03 | 8/21/2002 | 11:54 AM | GRAB | 1,060,000 | 2420 | NA | 993 | 57 | 13 | 0.2 | 0.7 | 1.49 | 0.582 | 0.378 | 21.36 | 1088 | 7.1 | 7.9 |
| TRC03 | 10/31/2002 | 10:15 AM | GRAB | 240 | 313 | NA | 1713 | 13 | 1 | 0.02 | 0.6 | 0.34 | 0.095 | 0.073 | 0.72 | 1710 | 15.28 | 8.54 |
| TRC03 | 3/20/2003 | 9:00 AM | GRAB | 20 | 36.4 | | 1318 | 18 | 3 | 0.33 | 0.9 | 0.82 | 0.18 | 0.124 | | | | |
| TRC03 | 5/1/2003 | 10:15 AM | GRAB | 1000 | 2420 | | | | | | | | | | 47.63 | 1963 | 11.92 | 8.02 |
| TRC03 | 5/9/2003 | 10:45 AM | GRAB | 400 | 162 | | 2103 | 17 | 7 | 0.02 | 0.8 | 0.62 | 0.16 | 0.107 | 51.95 | 2111 | 14.39 | 8.41 |
| TRC03 | 6/10/2003 | 10:00 AM | GRAB | 80000 | 2420 | | 1699 | 172 | 36 | 0.31 | 3.1 | 2.83 | 1.19 | 0.675 | 60.83 | 1741 | 7.19 | 8.05 |
| TRC03 | 6/25/2003 | 10:00 AM | GRAB | 95000 | >2420 | | 916 | 400 | 96 | 0.61 | 4.1 | 2.24 | 1.34 | 0.252 | 67.70 | 719 | 3.50 | 8.02 |
| TRC03 | 7/10/2003 | 10:45 AM | GRAB | 3300 | 1990 | | 1664 | 122 | 20 | 0.07 | 0.8 | 0.97 | 0.632 | 0.39 | 68.31 | 1721 | 9.29 | 8.08 |
| TRC03 | 9/11/2003 | 11:40 AM | GRAB | 35000 | 2420 | | 1650 | 192 | 32 | 0.15 | 0.7 | 1.44 | 0.691 | 0.36 | 64.04 | | | 8.00 |
| TRC03 | 10/2/2003 | 10:00 AM | GRAB | 1600 | 1200 | | 1743 | 21 | 4 | 0.02 | 0.4 | 0.47 | 0.105 | 0.062 | 42.53 | 1711 | 12.75 | 7.94 |
| TRC04 | 3/26/2002 | 12:30 PM | GRAB | 10 | 4.1 | NA | 1716 | 7 | 2 | 0.02 | 1.1 | 0.32 | 0.058 | 0.043 | 0.42 | 1915 | 10.07 | 8.23 |
| TRC04 | 3/30/2002 | 10:55 AM | GRAB | 10 | 2 | NA | 1024 | 50 | 7 | 0.42 | 1.6 | 1.63 | 0.392 | 0.235 | 4.72 | 956 | 6.74 | 8 |
| TRC04 | 4/17/2002 | 11:00 AM | GRAB | 110 | 128 | NA | 5536 | 23 | 7 | 0.1 | 0.2 | 0.58 | 0.124 | 0.057 | 14.80 | 1853 | 13.59 | 8.09 |
| TRC04 | 5/1/2002 | 10:36 AM | GRAB | 110 | 325 | NA | 2163 | 21 | 6 | 0.02 | 0.4 | 0.58 | 0.065 | 0.032 | 14.40 | 1997 | 11.48 | 8.14 |
| TRC04 | 5/1/2002 | 10:36 AM | Duplicate | 100 | 261 | NA | 2174 | 22 | 7 | 0.02 | 0.4 | 0.77 | 0.079 | 0.03 | 14.14 | 1997 | 11.48 | 8.14 |
| TRC04 | 5/29/2002 | 11:10 AM | GRAB | 1300 | 2420 | NA | 1963 | 68 | 15 | 0.13 | 0.3 | 1.26 | 0.162 | 0.06 | 21.91 | 1974 | UNAVA ILABLE | 8.01 |
| TRC04 | 6/26/2002 | 9:45 AM | GRAB | 1000 | 214 | NA | 1871 | 64 | 18 | 0.4 | 0.2 | 1.47 | 0.211 | 0.074 | 24.91 | 1724 | 7.44 | 7.89 |
| TRC04 | 7/10/2002 | 9:50 AM | GRAB | 4300 | 2420 | NA | 1686 | 72 | 17 | 0.2 | 0.2 | 0.89 | 0.23 | 0.062 | | | | |
| TRC04 | 7/31/2002 | 9:20 AM | GRAB | 900 | 411 | NA | 1760 | 35 | 10 | 0.02 | 0.1 | 0.78 | 0.167 | 0.044 | 23.48 | 1773 | 9.21 | 7.91 |
| TRC04 | 8/5/2002 | 11:15 AM | GRAB | 1000 | 579 | NA | 1635 | 56 | 15 | 0.05 | 0.2 | 0.35 | 0.176 | 0.048 | 23.02 | 1664 | 6.93 | 7.99 |
| TRC04 | 8/21/2002 | 12:30 PM | GRAB | 1500 | 613 | NA | 1602 | 158 | 24 | 0.06 | 0.2 | 0.34 | 0.534 | 0.049 | 22.82 | 1577 | 8.21 | 7.99 |
| TRC04 | 10/31/2002 | 10:45 AM | GRAB | 50 | 58.3 | NA | 1647 | 17 | 3 | 0.02 | 0.3 | 0.36 | 0.064 | 0.038 | 1.01 | 1651 | 18.07 | 8.06 |
| TRC04 | 3/20/2003 | 10:00 AM | GRAB | 30 | 20.1 | | 1282 | 13 | 4 | 0.35 | 0.8 | 0.95 | 0.149 | 0.115 | | | | |
| TRC04 | 5/1/2003 | 11:00 AM | GRAB | 2300 | 2420 | | | | | | | | | | 48.56 | 2001 | 12.50 | 8.06 |
| TRC04 | 5/9/2003 | 11:30 AM | GRAB | 330 | 299 | | 2188 | 24 | 9 | 0.02 | 0.9 | 0.58 | 0.164 | 0.088 | 53.84 | 2143 | 14.28 | 8.34 |
| TRC04 | 6/10/2003 | 11:00 AM | GRAB | 700 | 921 | | 2059 | 15 | 6 | 0.12 | 1.1 | 0.52 | 0.145 | 0.108 | 62.50 | 2127 | 9.45 | 8.12 |
| TRC04 | 6/25/2003 | 11:39 AM | GRAB | 50000 | 2420 | 173 | 1454 | 504 | 108 | 0.22 | 3.5 | 2 | 1.14 | 0.638 | 68.14 | 1154 | 4.83 | 7.93 |
| TRC04 | 7/10/2003 | 11:30 AM | GRAB | 2000 | 1410 | | 1686 | 184 | 32 | 0.09 | 0.9 | 0.77 | 0.602 | 0.27 | 70.35 | 1702 | 9.00 | 8.06 |
| TRC04 | 9/11/2003 | 12:15 PM | GRAB | 17000 | 2420 | | 1455 | 204 | 16 | 0.17 | 0.8 | 1.31 | 0.687 | 0.32 | 65.12 | | | 7.90 |
| TRC04 | 10/2/2003 | 10:30 AM | GRAB | 160 | 186 | | 1748 | 14 | 2 | 0.02 | 0.2 | 0.5 | 0.062 | 0.038 | 44.11 | 1739 | 13.11 | 7.90 |

| StationID | StartDate | StartTime | Sample Type | Fecal Coliform | E_Coli | Alkalinity | Total Solids | Total Susp Sol | Total Vol SS | Ammonia | Nitrate | TKN | Total_P | Total Diss P | Temp | SpCond | DO Conc | pH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TRC05 | 3/26/2002 | 2:10 PM | GRAB | 20 | 21.6 | NA | 1865 | 112 | 14 | NA | 0.7 | 0.76 | 0.195 | 0.062 | 0.14 | 1972 | 9.74 | 8.32 |
| TRC05 | 3/30/2002 | 11:50 AM | GRAB | 10 | 5.2 | NA | 1077 | 65 | 6 | 0.37 | 1.4 | 1.34 | 0.392 | 0.222 | 5.72 | 983 | 6.66 | 8.03 |
| TRC05 | 4/17/2002 | 11:30 AM | GRAB | 40 | 53.8 | NA | 2212 | 38 | 9 | 0.02 | 0.3 | 0.77 | 0.161 | 0.063 | 14.73 | 2046 | 14.34 | 8.11 |
| TRC05 | 5/1/2002 | 10:58 AM | GRAB | 200 | 517 | NA | 2466 | 19 | 4 | 0.02 | 0.4 | 0.67 | 0.092 | 0.056 | 9.77 | 2212 | 11.83 | 8.12 |
| TRC05 | 5/29/2002 | 11:50 AM | GRAB | 240 | 548 | NA | 2067 | 29 | 9 | 0.02 | 0.4 | 0.84 | 0.098 | 0.027 | 24.11 | 2125 | | 8.14 |
| TRC05 | 6/26/2002 | 10:10 AM | GRAB | 1160 | 649 | NA | 1892 | 45 | 12 | 0.05 | 0.1 | 0.98 | 0.112 | 0.038 | 27.66 | 1758 | 9.67 | 7.96 |
| TRC05 | 7/10/2002 | 10:10 AM | GRAB | 5100 | 2420 | NA | 1286 | 204 | 60 | 0.04 | 0.1 | 1.75 | 0.558 | 0.033 | 75.48 | 1184 | 12.06 | 8.41 |
| TRC05 | 7/31/2002 | 10:15 AM | GRAB | 2600 | 2420 | NA | 1911 | 184 | 36 | 0.02 | 0.1 | 1.23 | 0.407 | 0.031 | 24.89 | 1796 | 10.52 | 8.1 |
| TRC05 | 8/5/2002 | 11:45 AM | GRAB | 650 | 148 | NA | 1664 | 108 | 26 | 0.15 | 0.1 | 1.03 | 0.257 | 0.038 | 24.30 | 1663 | 7.04 | 8.06 |
| TRC05 | 8/21/2002 | 1:00 PM | GRAB | 1600 | 1986 | NA | 1667 | 62 | 8 | 0.09 | 0.1 | 0.41 | 0.159 | 0.04 | 24.43 | 1705 | 8.92 | 8.11 |
| TRC05 | 10/31/2002 | 11:15 AM | GRAB | 260 | 291 | NA | 1817 | 39 | 6 | 0.02 | 0.2 | 0.44 | 0.096 | 0.025 | 1.97 | 1767 | 17.04 | 8.23 |
| TRC05 | 3/20/2003 | 10:30 AM | GRAB | 10 | 14.3 | | 1264 | 23 | 4 | 0.35 | 0.6 | 1.28 | 0.289 | 0.214 | | | | |
| TRC05 | 5/1/2003 | 11:24 AM | GRAB | 100 | 613 | | | | | | | | | | 48.74 | 2177 | 12.28 | 7.82 |
| TRC05 | 5/9/2003 | 12:30 PM | GRAB | 110 | 192 | | 2452 | 27 | 8 | 0.02 | 0.6 | 0.71 | 0.156 | 0.096 | 54.16 | 2398 | 14.10 | 8.31 |
| TRC05 | 6/10/2003 | 11:45 AM | GRAB | 2200 | 1730 | 196 | 1617 | 66 | 8 | 0.02 | 2.3 | 0.95 | 0.446 | 0.304 | 62.36 | 1741 | 8.52 | 8.04 |
| TRC05 | 6/25/2003 | 12:30 PM | GRAB | 5000 | 2420 | | 811 | 196 | 56 | 0.12 | 1.8 | 1.2 | 0.651 | 0.346 | 67.67 | 826 | 5.58 | 8.01 |
| TRC05 | 7/10/2003 | 12:00 PM | GRAB | 800 | 387 | | 1597 | 176 | 30 | 0.07 | 0.7 | 1.1 | 0.501 | 0.261 | 70.78 | 1622 | 8.26 | 7.99 |
| TRC05 | 9/11/2003 | 1:00 PM | GRAB | 130000 | 2420 | | 1380 | 244 | 28 | 0.2 | 0.9 | 1.14 | 0.639 | 0.385 | 65.12 | | | 7.80 |
| TRC05 | 10/2/2003 | 11:00 AM | GRAB | 430 | 461 | | 1889 | 31 | 6 | 0.02 | 0.1 | 0.47 | 0.074 | 0.036 | 47.06 | | 13.24 | 7.94 |
| TRC06 | 10/15/2001 | 9:30 AM | | | | | | 33 | | | | | | | | | | |
| TRC06 | 10/22/2001 | 8:30 AM | | | | | | 32 | | | | | | | | | | |
| TRC06 | 10/29/2001 | 8:30 AM | | | | | | 25 | | | | | | | | | | |
| TRC06 | 11/13/2001 | 9:30 AM | | | | | | 37 | | | | | | | | | | |
| TRC06 | 11/19/2001 | 9:30 AM | | | | | | 18 | | | | | | | | | | |
| TRC06 | 12/12/2001 | 1:00 PM | GRAB | | | | | 12 | | | | | | | | | | |
| TRC06 | 12/12/2001 | 1:00 PM | BLANK | | | | | 1 | | | | | | | | | | |
| TRC06 | 12/12/2001 | 1:00 PM | GRAB | | | | | 10 | | | | | | | | | | |
| TRC06 | 12/20/2001 | 2:00 PM | | | | | | 7 | | | | | | | | | | |
| TRC06 | 12/27/2001 | 2:00 PM | GRAB | | | | | 11 | | | | | | | | | | |
| TRC06 | 1/4/2002 | 10:00 AM | GRAB | | | | | 11 | | | | | | | | | | |
| TRC06 | 1/10/2002 | 10:00 AM | GRAB | | | | | 5 | | | | | | | | | | |
| TRC06 | 1/17/2002 | 2:15 PM | GRAB | | | | | 2 | | | | | | | | | | |
| TRC06 | 1/25/2002 | 12:00 PM | GRAB | | | | | 4 | | | | | | | | | | |
| TRC06 | 2/1/2002 | 2:30 PM | GRAB | | | | | 5 | | | | | | | | | | |
| TRC06 | 2/7/2002 | 2:30 PM | GRAB | | | | | 4 | | | | | | | | | | |
| TRC06 | 2/7/2002 | 2:30 PM | GRAB | | | | | 3 | | | | | | | | | | |
| TRC06 | 2/14/2002 | 3:30 PM | GRAB | | | | | 5 | | | | | | | | | | |
| TRC06 | 2/22/2002 | 1:15 PM | GRAB | | | | | 4 | | | | | | | | | | |
| TRC06 | 5/29/2002 | 11:50 AM | Duplicate | 310 | 649 | NA | 2076 | 27 | 7 | 0.02 | 0.4 | 0.75 | 0.102 | 0.038 | 24.11 | 2125 | | 8.14 |
| TRC06 | 5/29/2002 | 12:15 PM | GRAB | 470 | 214 | NA | 2078 | 39 | 12 | 0.04 | 0.1 | 0.81 | 0.116 | 0.026 | 23.89 | 2118 | | 7.78 |

| StationID | StartDate | StartTime | Sample Type | Fecal Coliform | E_Coli | Alkalinity | Total Solids | Total Susp Sol | Total Vol SS | Ammonia | Nitrate | TKN | Total_P | Total Diss P | Temp | SpCond | DO Conc | pH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TRC06 | 7/10/2002 | 10:45 AM | GRAB | 5000 | 2420 | NA | 1253 | 200 | 56 | 0.02 | 0.3 | 2.12 | 0.639 | 0.036 | 24.66 | 1137 | 8.14 | 8.21 |
| TRC06 | 7/23/2002 | 12:00 PM | GRAB | 60 | 4.1 | NA | 1936 | 228 | 72 | 0.06 | 0.1 | 2.17 | 0.534 | 0.031 | 23.98 | 1187 | 9.34 | 8.75 |
| TRC07 | 10/9/2001 | 6:30 AM | | | | | | 20 | | | | | | | | | | |
| TRC07 | 10/15/2001 | 10:30 AM | | | | | | 35 | | | | | | | | | | |
| TRC07 | 10/22/2001 | 10:00 AM | | | | | | 42 | | | | | | | | | | |
| TRC07 | 10/29/2001 | 10:00 AM | | | | | | 21 | | | | | | | | | | |
| TRC07 | 11/13/2001 | 8:30 AM | | | | | | 35 | | | | | | | | | | |
| TRC07 | 11/19/2001 | 8:30 AM | | | | | | 19 | | | | | | | | | | |
| TRC07 | 12/12/2001 | 1:45 PM | GRAB | | | | | 9 | | | | | | | | | | |
| TRC07 | 12/20/2001 | 3:00 PM | | | | | | 14 | | | | | | | | | | |
| TRC07 | 12/27/2001 | 3:00 PM | GRAB | | | | | 7 | | | | | | | | | | |
| TRC07 | 1/4/2002 | 10:30 AM | GRAB | | | | | 6 | | | | | | | | | | |
| TRC07 | 1/10/2002 | 10:30 AM | GRAB | | | | | 5 | | | | | | | | | | |
| TRC07 | 1/17/2002 | 2:30 PM | GRAB | | | | | 2 | | | | | | | | | | |
| TRC07 | 1/25/2002 | 12:30 PM | GRAB | | | | | 3 | | | | | | | | | | |
| TRC07 | 2/1/2002 | 3:00 PM | GRAB | | | | | 4 | | | | | | | | | | |
| TRC07 | 2/7/2002 | 3:00 PM | GRAB | | | | | 3 | | | | | | | | | | |
| TRC07 | 2/14/2002 | 3:45 PM | GRAB | | | | | 4 | | | | | | | | | | |
| TRC07 | 2/22/2002 | 1:45 AM | GRAB | | | | | 4 | | | | | | | | | | |
| TRC07 | 3/27/2002 | 11:00 AM | GRAB | 10 | 10 | NA | 1772 | 7 | 3 | 0.02 | 0.5 | 0.56 | 0.066 | 0.024 | 0.41 | 1958 | 9.98 | 8 |
| TRC07 | 3/30/2002 | 1:20 PM | GRAB | 10 | 9.8 | NA | 971 | 30 | 3 | 0.38 | 1.3 | 1.98 | 0.352 | 0.218 | 6.54 | 906 | 7 | 8.08 |
| TRC07 | 4/17/2002 | 12:30 PM | GRAB | 150 | 140 | NA | 2153 | 34 | 12 | 0.1 | 0.1 | 0.83 | 0.141 | 0.054 | 15.82 | 2017 | 10.31 | 7.9 |
| TRC07 | 5/1/2002 | 11:18 AM | GRAB | 100 | 224 | NA | 2502 | 22 | 5 | 0.02 | 0.2 | 0.83 | 0.094 | 0.034 | 11.13 | 2234 | 9.85 | 8.06 |
| TRC07 | 5/29/2002 | 12:50 PM | GRAB | 420 | 151 | NA | 2103 | 52 | 14 | 0.04 | 0.1 | 0.91 | 0.15 | 0.027 | 24.81 | 2116 | | 7.82 |
| TRC07 | 6/26/2002 | 11:35 AM | GRAB | 40 | 4.1 | NA | 1937 | 98 | 40 | 0.02 | 0.1 | 1.83 | 0.223 | 0.028 | 28.61 | 1756 | 11.22 | 8.31 |
| TRC07 | 6/26/2002 | 11:35 AM | Duplicate | 40 | 1 | NA | 1975 | 92 | 32 | 0.02 | 0.1 | 1.89 | 0.225 | 0.027 | 28.61 | 1756 | 11.22 | 8.31 |
| TRC07 | 7/10/2002 | 11:30 AM | GRAB | 20000 | 2420 | NA | 1261 | 204 | 48 | 0.03 | 0.1 | 2.45 | 0.645 | 0.033 | 25.57 | 1136 | 9.91 | 8.56 |
| TRC07 | 7/31/2002 | 10:45 AM | GRAB | 220 | 11.8 | NA | 1930 | 360 | 68 | 0.05 | 0.1 | 1.64 | 0.648 | 0.03 | 26.54 | 1671 | 6.32 | 7.84 |
| TRC07 | 8/5/2002 | 12:15 PM | GRAB | 200 | 6.1 | NA | 1566 | 126 | 44 | 0.02 | 0.1 | 1.9 | 0.362 | 0.028 | 25.31 | 1555 | 8.12 | 8.49 |
| TRC07 | 8/21/2002 | 2:17 PM | GRAB | 160 | 12.8 | NA | 1695 | 144 | 22 | 0.02 | 0.1 | 0.75 | 0.191 | 0.022 | 24.71 | 1664 | 9.46 | 8.28 |
| TRC07 | 10/31/2002 | 11:45 AM | GRAB | 40 | 90.6 | NA | 1804 | 18 | 1 | 0.02 | 0.1 | 0.35 | 0.041 | 0.018 | 1.26 | 1805 | 16.63 | 8.3 |
| TRC07 | 3/20/2003 | 11:00 AM | GRAB | 10 | 6.3 | | 1215 | 15 | 2 | 0.38 | 0.6 | 1.36 | 0.267 | 0.195 | | | | |
| TRC07 | 5/1/2003 | 12:15 PM | GRAB | 1100 | 1990 | | | | | | | | | | 49.63 | 2177 | 13.50 | 8.09 |
| TRC07 | 5/9/2003 | 1:30 PM | GRAB | 1400 | 1120 | | 2341 | 41 | 10 | 0.02 | 0.6 | 0.85 | 0.173 | 0.075 | 54.97 | 2315 | 13.67 | 8.33 |
| TRC07 | 6/10/2003 | 12:45 PM | GRAB | 16000 | 2420 | | 983 | 37 | 8 | 0.21 | 2.4 | 1.13 | 0.39 | 0.261 | 62.93 | 1104 | 8.98 | 8.13 |
| TRC07 | 6/25/2003 | 1:50 PM | GRAB | 19000 | 2420 | | 944 | 360 | 72 | 0.18 | 1.4 | 0.81 | 0.791 | 0.244 | 67.82 | 807 | 5.93 | 7.99 |
| TRC07 | 7/10/2003 | 12:45 PM | GRAB | 700 | 549 | | 1528 | 188 | 40 | 0.12 | 0.7 | 1.08 | 0.53 | 0.213 | 72.60 | 1556 | 8.24 | 7.95 |
| TRC07 | 9/11/2003 | 2:00 PM | GRAB | 31000 | 2420 | | 1227 | 244 | 24 | 0.26 | 1.2 | 1.39 | 0.539 | 0.192 | 65.66 | | | 7.74 |
| TRC07 | 9/11/2003 | 4:30 PM | BLANK | | | | 9 | 1 | 1 | 0.07 | <0.1 | 0.11 | 0.005 | 0.003 | | | | |
| TRC07 | 10/2/2003 | 11:45 AM | COMPOSI | 200 | 150 | | 1902 | 45 | 10 | 0.02 | 0.1 | 0.62 | 0.114 | 0.037 | 49.33 | 1826 | 9.70 | 7.92 |

| StationID | StartDate | StartTime | Sample Type | Fecal Coliform | E_Coli | Alkalinity | Total Solids | Total Susp Sol | Total Vol SS | Ammonia | Nitrate | TKN | Total_P | Total Diss P | Temp | SpCond | DO Conc | pH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TRC09 | 3/20/2003 | 1:15 PM | BLANK | 10 | 1 | | 7 | 1 | 1 | 0.02 | 0.1 | 0.11 | 0.002 | 0.004 | | | | |
| TRC10 | 10/9/2001 | 6:30 AM | | | | | | 17 | | | | | | | | | | |
| TRC10 | 10/15/2001 | 8:30 AM | | | | | | 19 | | | | | | | | | | |
| TRC10 | 10/22/2001 | 8:00 AM | | | | | | 37 | | | | | | | | | | |
| TRC10 | 10/29/2001 | 8:00 AM | | | | | | 19 | | | | | | | | | | |
| TRC10 | 11/13/2001 | 8:00 AM | | | | | | 14 | | | | | | | | | | |
| TRC10 | 11/19/2001 | 8:00 AM | | | | | | 20 | | | | | | | | | | |
| TRC10 | 12/12/2001 | 2:00 PM | GRAB | | | | | 12 | | | | | | | | | | |
| TRC10 | 12/20/2001 | 3:30 PM | GRAB | | | | | 13 | | | | | | | | | | |
| TRC10 | 12/27/2001 | 3:30 PM | GRAB | | | | | 10 | | | | | | | | | | |
| TRC10 | 1/4/2002 | 11:00 AM | GRAB | | | | | 5 | | | | | | | | | | |
| TRC10 | 1/10/2002 | 11:00 AM | GRAB | | | | | 4 | | | | | | | | | | |
| TRC10 | 1/17/2002 | 3:00 PM | GRAB | | | | | 3 | | | | | | | | | | |
| TRC10 | 1/25/2002 | 1:00 PM | GRAB | | | | | 5 | | | | | | | | | | |
| TRC10 | 2/1/2002 | 3:30 PM | GRAB | | | | | 5 | | | | | | | | | | |
| TRC10 | 2/7/2002 | 3:30 PM | GRAB | | | | | 3 | | | | | | | | | | |
| TRC10 | 2/14/2002 | 4:00 PM | GRAB | | | | | 7 | | | | | | | | | | |
| TRC10 | 2/22/2002 | 2:15 PM | GRAB | | | | | 7 | | | | | | | | | | |
| TRC10 | 3/27/2002 | 12:10 PM | GRAB | 10 | 1 | NA | 1754 | 6 | 2 | 0.02 | 0.6 | 0.61 | 0.084 | 0.027 | -0.04 | 1939 | 10.93 | 8.23 |
| TRC10 | 5/29/2002 | 1:20 PM | GRAB | 40 | 7.4 | NA | 2091 | 49 | 14 | 0.02 | 0.1 | 1.06 | 0.166 | 0.03 | 25.91 | 2115 | | 8.09 |
| TRC10 | 7/10/2002 | 12:40 PM | GRAB | 3500 | 2420 | NA | 1550 | 348 | 84 | 0.02 | 0.1 | 1.08 | 0.733 | 0.029 | 26.08 | 1268 | 11.4 | 8.64 |
| TRC10 | 7/23/2002 | 12:40 PM | GRAB | 690 | 127 | NA | 1931 | 140 | 56 | 0.04 | 0.1 | 2.07 | 0.414 | 0.032 | 25.72 | 1833 | 16.13 | 9.06 |
| TRC10 | 10/31/2002 | 12:15 PM | GRAB | 10 | 26.3 | NA | 1778 | 26 | 2 | 0.02 | 0.1 | 0.4 | 0.05 | 0.019 | 0.46 | 1782 | 16.8 | 8.32 |
| TRC10 | 3/20/2003 | 11:45 AM | GRAB | 10 | 19.9 | | 1206 | 24 | 5 | 0.52 | 0.6 | 1.93 | 0.315 | 0.256 | | | | |
| TRC10 | 3/20/2003 | 12:45 PM | GRAB | 10 | 23.1 | | 1022 | 19 | 7 | 0.9 | 0.5 | 2.38 | 0.5 | 0.319 | | | | |
| TRC10 | 5/1/2003 | 12:15 PM | GRAB | 900 | 2420 | | | | | | | | | | 50.06 | 2247 | 12.79 | 7.97 |
| TRC10 | 5/9/2003 | 2:30 PM | GRAB | 2000 | 2420 | | 2340 | 66 | 11 | 0.02 | 0.5 | 0.88 | 0.218 | 0.092 | 55.42 | 2301 | 13.34 | 8.31 |
| TRC10 | 6/10/2003 | 1:45 PM | GRAB | 20000 | 2420 | | 1060 | 222 | 34 | 0.6 | 2.1 | 1.93 | 0.644 | 0.28 | 63.47 | 1035 | 8.68 | 7.98 |
| TRC10 | 6/25/2003 | 2:25 PM | GRAB | 24000 | 2420 | | 903 | 364 | 80 | 0.16 | 1.5 | 1.3 | 2.03 | 0.237 | 67.82 | 727 | 5.96 | 7.96 |
| TRC10 | 7/10/2003 | 3:15 PM | GRAB | 1900 | 1300 | | 1216 | 182 | 32 | 0.12 | 0.6 | 1.1 | 0.727 | 0.4 | 72.82 | 1481 | 8.24 | 7.95 |
| TRC10 | 9/11/2003 | 2:45 PM | GRAB | 9000 | 2420 | | 1190 | 296 | 28 | 0.26 | 1.1 | 1.47 | 0.624 | 0.148 | 65.66 | | | 7.69 |
| TRC10 | 10/2/2003 | 12:15 PM | GRAB | 70 | 56 | | 1917 | 35 | 7 | 0.02 | 0.1 | 0.6 | 0.095 | 0.031 | 48.95 | 1847 | 13.03 | 7.97 |
| TRC11 | 3/27/2002 | 1:00 PM | GRAB | 10 | 1 | NA | 1785 | 8 | 5 | 0.02 | 0.2 | 1.1 | 0.202 | 0.084 | 3.15 | 1951 | 11.06 | 8.18 |
| TRC11 | 3/30/2002 | 2:45 PM | GRAB | 10 | 2 | NA | 926 | 30 | 5 | 0.47 | 1.1 | 2.05 | 0.36 | 0.189 | 6.78 | 883 | 6.69 | 7.98 |
| TRC11 | 4/17/2002 | 1:15 PM | GRAB | 10 | 1 | NA | 2337 | 38 | 14 | 0.13 | 0.1 | 0.94 | 0.232 | 0.086 | 17.58 | 2154 | 10.82 | 7.98 |
| TRC11 | 5/1/2002 | 11:49 AM | GRAB | 40 | 54.5 | NA | 2535 | 25 | 5 | 0.02 | 0.1 | 1.12 | 0.151 | 0.61 | 11.78 | 2254 | 9.69 | 8.1 |
| TRC11 | 5/29/2002 | 1:45 PM | GRAB | 170 | 26.5 | NA | 2184 | 27 | 12 | 0.02 | 0.1 | 0.9 | 0.173 | 0.042 | 25.26 | 2209 | | 8.2 |
| TRC11 | 6/26/2002 | 12:35 PM | GRAB | 600 | 10.1 | NA | 1860 | 104 | 50 | 0.02 | 0.1 | 2.09 | 0.497 | 0.063 | 28.11 | 1692 | 12.26 | 8.37 |
| TRC11 | 7/10/2002 | 1:00 PM | GRAB | 3500 | 1990 | NA | 1839 | 88 | 34 | 0.02 | 0.1 | 2.41 | 0.547 | 0.061 | 26.93 | 1701 | 13.19 | 8.39 |
| TRC11 | 7/31/2002 | 12:00 PM | GRAB | 600 | 29.6 | NA | 1844 | 148 | 52 | 0.02 | 0.1 | 2.53 | 0.803 | 0.062 | 27.10 | 1761 | 11.5 | 8.33 |

| StationID | StartDate | StartTime | Sample Type | Fecal Coliform | E_Coli | Alkalinity | Total Solids | Total Susp Sol | Total Vol SS | Ammonia | Nitrate | TKN | Total_P | Total Diss P | Temp | SpCond | DO Conc | pH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TRC11 | 7/31/2002 | 12:00 PM | Duplicate | 430 | 29.2 | NA | 1975 | 288 | 68 | 0.02 | 0.1 | 2.85 | 0.752 | 0.063 | 27.10 | 1761 | 11.5 | 8.33 |
| TRC11 | 8/5/2002 | 12:30 PM | GRAB | 490 | 164 | NA | 1729 | 124 | 36 | 0.02 | 0.1 | 2.19 | 0.764 | 0.092 | 26.17 | 1736 | 6.39 | 7.96 |
| TRC11 | 8/21/2002 | 2:46 AM | GRAB | 4000 | 2420 | NA | 1487 | 68 | 18 | 0.02 | 0.1 | 1.24 | 0.457 | 0.079 | 24.21 | 1618 | 8.86 | 8.14 |
| TRC11 | 10/31/2002 | 1:15 PM | GRAB | 20 | 84.2 | NA | 1738 | 14 | 3 | 0.02 | 0.1 | 0.37 | 0.048 | 0.015 | 2.10 | 1785 | 17.01 | 8.52 |
| TRC11 | 5/1/2003 | 1:30 PM | GRAB | 170 | 178 | | | | | | | | | | 51.72 | 2134 | 12.97 | 8.00 |
| TRC11 | 5/9/2003 | 3:30 PM | GRAB | | | | 2377 | 78 | 18 | 0.02 | 0.4 | 1.28 | 0.247 | 0.059 | 57.33 | 2341 | 12.55 | 8.18 |
| TRC11 | 6/10/2003 | 2:30 PM | GRAB | 4100 | 2420 | | 1875 | 134 | 24 | 0.05 | 1.2 | 0.94 | 0.374 | 0.01 | 65.70 | 1859 | 9.45 | 7.93 |
| TRC11 | 6/25/2003 | 3:06 PM | GRAB | 7000 | 2420 | | 941 | 552 | 104 | 0.28 | 1.4 | 1.29 | 1.15 | 0.213 | 68.02 | 537 | 5.48 | 7.99 |
| TRC11 | 7/10/2003 | 3:15 PM | GRAB | 1000 | 423 | | | | | | | | | | 74.68 | 1254 | 8.16 | 7.94 |
| TRC11 | 9/11/2003 | 3:03 PM | GRAB | 9000 | 2420 | | 936 | 196 | 16 | 0.29 | 1.1 | 1.41 | 0.531 | 0.107 | 65.84 | | | 7.68 |
| TRC11 | 10/2/2003 | 12:45 PM | GRAB | 260 | 185 | | 2032 | 20 | 7 | 0.02 | 0.1 | 0.81 | 0.118 | 0.027 | 49.27 | 3006 | 14.98 | 7.91 |
| TRC11 | 10/2/2003 | 12:45 PM | BLANK | 10 | 1 | | 7 | 1 | 1 | 0.02 | 0.1 | 0.11 | 0.002 | 0.002 | | | | |
| TRC12 | 3/27/2002 | 2:45 PM | GRAB | 10 | 6.1 | NA | 1711 | 15 | 4 | 0.02 | 0.1 | 0.84 | 0.127 | 0.043 | 3.28 | 1868 | 10.35 | 8.27 |
| TRC12 | 3/27/2002 | 2:45 PM | Duplicate | 10 | 4.1 | NA | 1701 | 14 | 4 | 0.02 | 0.1 | 0.89 | 0.138 | 0.04 | 3.28 | 1868 | 10.35 | 8.27 |
| TRC12 | 3/27/2002 | 2:45 PM | BLANK | 2 | 10 | NA | 7 | 1 | 1 | 0.02 | 0.1 | 0.32 | 0.002 | 0.008 | NA | NA | NA | NA |
| TRC12 | 3/30/2002 | 3:30 PM | GRAB | 10 | 1 | NA | 870 | 36 | 7 | 0.52 | 1.1 | 1.84 | 0.337 | 0.156 | 7.77 | 833 | 6.42 | 8.01 |
| TRC12 | 4/17/2002 | 1:45 PM | GRAB | 10 | 8.6 | NA | 2361 | 50 | 14 | 0.02 | 0.1 | 1.3 | 0.258 | 0.08 | 19.48 | 2164 | 12.72 | 8.14 |
| TRC12 | 4/17/2002 | 1:45 PM | BLANK | 2 | 1 | NA | 6 | 1 | 1 | 0.02 | 0.1 | 0.32 | 0.002 | 0.002 | NA | NA | NA | NA |
| TRC12 | 5/1/2002 | 12:11 PM | GRAB | 80 | 148 | NA | 2444 | 53 | 10 | 0.02 | 0.1 | 1.1 | 0.194 | 0.068 | 11.18 | 2164 | 10.21 | 8.21 |
| TRC12 | 5/1/2002 | 12:11 PM | BLANK | 10 | 1 | NA | 7 | 1 | 1 | 0.02 | 0.1 | 0.32 | 0.002 | 0.002 | NA | NA | NA | NA |
| TRC12 | 5/29/2002 | 2:10 PM | GRAB | 480 | 1120 | NA | 2206 | 36 | 14 | 0.02 | 0.1 | 0.79 | 0.2 | 0.053 | 28.27 | 2229 | | 8.33 |
| TRC12 | 5/29/2002 | 2:10 PM | BLANK | 10 | 1 | NA | 6 | 1 | 1 | 0.02 | 0.1 | 0.32 | 0.003 | 0.004 | NA | NA | NA | NA |
| TRC12 | 6/26/2002 | 1:05 PM | GRAB | 370 | 8.1 | NA | 1951 | 82 | 32 | 0.02 | 0.1 | 1.82 | 0.401 | 0.078 | 30.39 | 1781 | 13.68 | 8.49 |
| TRC12 | 6/26/2002 | 1:45 PM | BLANK | 10 | 1 | NA | 7 | 1 | 1 | 0.02 | 0.1 | 0.32 | 0.002 | 0.004 | NA | NA | NA | NA |
| TRC12 | 7/10/2002 | 1:25 PM | GRAB | 2100 | 397 | NA | 1774 | 128 | 40 | 0.02 | 0.1 | 2.14 | 0.682 | 0.082 | 29.99 | 1630 | 13.09 | 8.67 |
| TRC12 | 7/10/2002 | 1:25 PM | Duplicate | 860 | 64.2 | NA | 1782 | 140 | 44 | 0.02 | 0.1 | 2.38 | 0.706 | 0.08 | 29.99 | 1630 | 13.09 | 8.67 |
| TRC12 | 7/10/2002 | 2:00 PM | BLANK | 10 | 1 | NA | 7 | 1 | 1 | 0.02 | 0.1 | 0.32 | 0.004 | 0.007 | NA | NA | NA | NA |
| TRC12 | 7/31/2002 | 12:55 PM | GRAB | 210 | 58.8 | NA | 1557 | 20 | 8 | 0.22 | 0.1 | 1.78 | 0.358 | 0.206 | 32.12 | 1608 | 15.66 | 8.63 |
| TRC12 | 7/31/2002 | 12:55 PM | BLANK | 10 | 1 | NA | 8 | 1 | 1 | 0.03 | 0.1 | 0.32 | 0.002 | 0.002 | NA | NA | NA | NA |
| TRC12 | 8/5/2002 | 1:00 PM | GRAB | 400 | 154 | NA | 1477 | 29 | 11 | 0.17 | 0.1 | 2.23 | 0.401 | 0.182 | 30.23 | 1548 | 14.57 | 8.75 |
| TRC12 | 8/5/2002 | 1:00 PM | BLANK | 10 | 1 | NA | 13 | 1 | 1 | 0.04 | 0.1 | 0.32 | 0.002 | 0.004 | NA | NA | NA | NA |
| TRC12 | 8/21/2002 | 3:18 PM | GRAB | 800 | 1120 | NA | 1433 | 72 | 22 | 0.02 | 0.1 | 1.9 | 0.361 | 0.067 | 26.73 | 1492 | 13.29 | 8.72 |
| TRC12 | 8/21/2002 | 3:15 PM | BLANK | 2 | 1 | NA | 7 | 1 | 1 | 0.02 | 0.1 | 0.32 | 0.004 | 0.004 | NA | NA | NA | NA |
| TRC12 | 10/31/2002 | 1:45 PM | GRAB | 150 | 167 | NA | 1805 | 29 | 5 | 0.02 | 0.1 | 0.59 | 0.103 | 0.034 | 3.75 | 1804 | 16.4 | 8.39 |
| TRC12 | 3/20/2003 | 1:30 PM | Duplicate | 10 | 15.8 | | 835 | 22 | 5 | 0.84 | 0.5 | 2.3 | 0.435 | 0.382 | | | | |
| TRC12 | 3/20/2003 | 1:30 PM | GRAB | 10 | 11 | | 819 | 16 | 8 | 0.92 | 0.5 | 2.16 | 0.436 | 0.288 | | | | |
| TRC12 | 5/1/2003 | 2:35 PM | GRAB | 700 | 1200 | | | | | | | | | | 53.82 | 2140 | 13.85 | 8.02 |
| TRC12 | 6/10/2003 | 3:15 PM | GRAB | 27000 | 2420 | 171 | 1588 | 204 | 26 | 0.55 | 3.7 | 1.45 | 0.444 | 0.117 | 59.02 | 2326 | 14.32 | 8.25 |
| TRC12 | 6/25/2003 | 4:45 PM | GRAB | 32000 | 2420 | | 667 | 356 | 84 | 0.17 | 2.3 | 1.55 | 0.896 | 0.221 | 68.11 | 1643 | 9.36 | 8.04 |
| TRC12 | 7/10/2003 | 4:00 PM | GRAB | 1500 | 1300 | | 1008 | 184 | 28 | 0.12 | 0.7 | 0.88 | 0.689 | 0.319 | 67.18 | 435 | 6.41 | 8.04 |

| StationID | StartDate | StartTime | Sample Type | Fecal Coliform | E_Coli | Alkalinity | Total Solids | Total Susp Sol | Total Vol SS | Ammonia | Nitrate | TKN | Total_P | Total Diss P | Temp | SpCond | DO Conc | pH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TRC12 | 9/11/2003 | 4:00 PM | GRAB | 44000 | 2420 | | 1351 | 236 | 24 | 0.12 | 0.6 | 0.82 | 0.646 | 0.171 | 66.20 | | | 7.69 |
| TRC12 | 10/2/2003 | 1:45 PM | Duplicate | 540 | 517 | | 2020 | 33 | 11 | 0.02 | 0.1 | 1.03 | 0.201 | 0.05 | 50.21 | 1995 | 16.91 | 7.92 |
| TRC12 | 10/2/2003 | 1:30 PM | GRAB | 570 | 488 | | 2078 | 91 | 12 | 0.02 | 0.1 | 1.18 | 0.295 | 0.042 | | | | |
| SWL09 | 5/31/2002 | 8:40 AM | GRAB | | | NA | 2330 | 38 | 14 | 0.02 | 0.1 | 2.04 | 0.125 | | 24.15 | 2342 | 7.94 | 8.39 |
| SWL09 | 6/20/2002 | 9:25 AM | GRAB | NA | NA | NA | NA | NA | NA | NA | NA | NA | 0.176 | NA | 25.26 | 2381 | 6 | 8.57 |
| SWL09 | 7/30/2002 | 9:30 AM | GRAB | 10 | 1 | NA | 2595 | 48 | 42 | 0.02 | 0.1 | 2.94 | 0.146 | 0.022 | 27.44 | 2456 | 4.75 | 8.21 |
| SWL09 | 9/4/2002 | 9:15 AM | GRAB | 10 | 3 | NA | 2633 | 42 | 24 | 0.02 | 0.1 | 3.16 | 0.126 | 0.016 | 22.75 | 2594 | 8.33 | 8.56 |

# 8.0 APPENDIX C – STAGE DISCHARGE EQUATIONS AND AVERAGE DAILY FLOW

| Site | Stage | Discharge Equations | Units = Feet |
|---|---|---|---|
| TRC01 | | =10^(-0.649193+(0.817084*Stage)) | TRC02 2002 flows estimated by regressing flows from TRC03 vs TRC02 in 2003. |
| TRC02A | 0.01 to 0.81 | =10^((1.541511*log10stage)+0.496453) | Beaver Dam caused problems in stage readings throughout 2002 |
| TRC02B | 0.82 to end | =10^((0.933366*log10stage^2)+(1.136710*log10 stage)+0.451992) | |
| TRC03 | All | =(10^((5.08847*log10stage)+(-1.87412*log10stage^2)-0.28333)) | |
| TRC04A | 0.01 to 0.84 | =(10^((1.207083*logstage)+0.882949)) | |
| TRC04B | 0.85 to end | =((9.4814*Stage^2)+(-15.9453*Stage)+12.8960) | |
| TRC05A | 0.01 to 1.24 | =1.321647*(10^((1.808445*log10stage)+0.57086 8)) | |
| TRC05B | 1.25 to end | =(-0.0581*Stage^2)+(16.5081*Stage)-13.1387 | Site TRC07 Equation |
| TRC07 | All | =EXP((2.365671*lnstage)+2.101069)) | =1.25306787*(EXP((2.36567*lnstage)+2.101069)) |
| TRC10 | All | =1.136625*(10^((2.776475*log10stage)+0.74640 1)) | |
| TRC11A | 0.01 to 3.49 | =EXP((4.468949*lnStg)-0.093877) | |
| TRC11B | 3.50 to end | =((12.004*Stage^2)+(62.203*Stage)-120.163) | |
| **TRC12** | **All** | **=10^((3.857796*log10stage)-0.358781)** | |
| TRC11new | All | =10^((5.032196*logstage)-0.234083) from 0 to 3.19 the use =(Stage*126.766)-205.315) or =10^((5.032196*logstage)-0.234083) from 0 to 3.05 then use =((Stage^2*24.5951)+(stage*(-7.8690))-44.8213) | |

| Date | TRC01 | TRC02 | TRC02 (estimate) | TRC03 | TRC04 | TRC05 | TRC07 | TRC10 | TRC11 | TRC12 |
|---|---|---|---|---|---|---|---|---|---|---|
| 4/9/2002 | 1.42 | 0.80 | 2.09 | 3.91 | 3.83 | 6.23 | 7.98 | 20.64 | 12.39 | 9.33 |
| 4/10/2002 | 1.59 | 0.90 | 2.13 | 4.03 | 3.78 | 6.23 | 7.98 | 21.02 | 12.18 | 9.17 |
| 4/11/2002 | 2.03 | 1.65 | 2.55 | 5.29 | 4.19 | 8.40 | 9.84 | 24.61 | 13.03 | 9.83 |
| 4/12/2002 | 1.59 | 1.58 | 2.55 | 5.29 | 4.79 | 12.01 | 12.48 | 33.43 | 14.61 | 11.07 |
| 4/13/2002 | 1.34 | 1.02 | 2.29 | 4.50 | 4.16 | 9.72 | 12.05 | 32.92 | 17.13 | 13.03 |
| 4/14/2002 | 1.27 | 0.76 | 2.13 | 4.03 | 3.83 | 7.84 | 10.44 | 27.66 | 15.33 | 11.63 |
| 4/15/2002 | 1.22 | 0.67 | 2.01 | 3.69 | 3.61 | 6.09 | 8.61 | 23.78 | 7.21 | 10.52 |
| 4/16/2002 | 1.15 | 0.49 | 1.89 | 3.38 | 3.32 | 4.97 | 7.82 | 20.27 | 6.61 | 9.33 |
| 4/17/2002 | 1.11 | 0.40 | 1.74 | 2.99 | 3.05 | 3.55 | 6.19 | 16.13 | 5.96 | 8.39 |
| 4/18/2002 | 1.05 | 0.31 | 1.67 | 2.81 | 2.83 | 2.97 | 4.85 | 13.13 | 4.96 | 7.38 |
| 4/19/2002 | 1.03 | 0.26 | 1.53 | 2.46 | 2.60 | 2.31 | 4.41 | 11.26 | 4.52 | 6.47 |
| 4/20/2002 | 1.01 | 0.27 | 1.53 | 2.46 | 2.54 | 2.02 | 3.75 | 9.80 | 4.11 | 5.76 |
| 4/21/2002 | 1.31 | 0.73 | 1.82 | 3.18 | 2.98 | 2.71 | 3.06 | 12.31 | 4.67 | 6.22 |
| 4/22/2002 | 1.50 | 1.28 | 2.21 | 4.26 | 3.55 | 4.15 | 4.23 | 15.82 | 5.36 | 6.72 |
| 4/23/2002 | 1.24 | 0.81 | 2.01 | 3.69 | 3.47 | 4.45 | 5.67 | 19.54 | 6.57 | 7.95 |
| 4/24/2002 | 1.11 | 0.54 | 1.74 | 2.99 | 3.14 | 3.55 | 5.97 | 16.46 | 6.13 | 8.39 |
| 4/25/2002 | 0.99 | 0.37 | 1.60 | 2.63 | 2.72 | 2.44 | 4.79 | 12.58 | 5.12 | 7.11 |
| 4/26/2002 | 0.99 | 0.76 | 1.53 | 2.46 | 2.87 | 2.18 | 3.99 | 10.52 | 7.17 | 5.21 |
| 4/27/2002 | 1.65 | 2.34 | 2.13 | 4.03 | 3.97 | 3.49 | 4.41 | 13.42 | 8.76 | 6.47 |
| 4/28/2002 | 2.10 | 3.98 | 3.56 | 8.76 | 6.21 | 13.68 | 9.84 | 35.51 | 11.01 | 8.24 |
| 4/29/2002 | 1.37 | 2.79 | 2.87 | 6.32 | 5.68 | 13.95 | 14.14 | 53.09 | 13.91 | 10.52 |
| 4/30/2002 | 1.17 | 2.31 | 2.37 | 4.76 | 4.70 | 8.11 | 13.31 | 36.58 | 20.00 | 15.24 |
| 5/1/2002 | 1.27 | 3.91 | 2.29 | 4.50 | 4.41 | 6.41 | 9.46 | 27.66 | 17.13 | 13.03 |
| 5/2/2002 | 1.29 | 5.30 | 2.46 | 5.02 | 4.68 | 6.51 | 6.04 | 26.77 | 15.33 | 11.63 |
| 5/3/2002 | 1.11 | 4.94 | 2.21 | 4.26 | 4.36 | 5.58 | 4.85 | 24.61 | 14.85 | 11.25 |
| 5/4/2002 | 1.03 | 5.74 | 1.93 | 3.48 | 4.09 | 4.13 | 4.53 | 19.90 | 13.24 | 10.00 |
| 5/5/2002 | 1.03 | 5.61 | 1.85 | 3.28 | 3.93 | 3.36 | 4.41 | 16.46 | 11.78 | 8.85 |
| 5/6/2002 | 1.07 | 6.26 | 1.82 | 3.18 | 3.98 | 3.04 | 4.47 | 15.19 | 10.82 | 8.09 |

| Date | TRC01 | TRC02 | TRC02 (estimate) | TRC03 | TRC04 | TRC05 | TRC07 | TRC10 | TRC11 | TRC12 |
|---|---|---|---|---|---|---|---|---|---|---|
| 5/7/2002 | 1.05 | 6.54 | 1.85 | 3.28 | 4.09 | 4.04 | 3.81 | 4.23 | 10.09 | 7.52 |
| 5/8/2002 | 1.24 | 8.93 | 2.33 | 4.63 | 4.91 | 9.16 | 5.12 | 2.45 | 6.39 | 7.95 |
| 5/9/2002 | 1.29 | 9.17 | 2.50 | 5.15 | 5.22 | 13.06 | 4.91 | 3.88 | 9.36 | 10.52 |
| 5/10/2002 | 1.09 | 8.03 | 2.13 | 4.03 | 4.67 | 9.03 | 0.74 | 4.28 | 10.21 | 13.03 |
| 5/11/2002 | 1.37 | 9.42 | 2.46 | 5.02 | 5.07 | 10.49 | 0.26 | 3.89 | 9.39 | 12.22 |
| 5/12/2002 | 1.42 | 9.67 | 2.82 | 6.16 | 6.02 | 16.85 | 2.06 | 5.25 | 12.27 | 13.45 |
| 5/13/2002 | 1.17 | 7.80 | 2.50 | 5.15 | 5.52 | 13.95 | 3.75 | 6.39 | 14.75 | 17.20 |
| 5/14/2002 | 1.03 | 7.07 | 2.09 | 3.91 | 4.93 | 13.27 | 15.52 | 4.94 | 11.62 | 15.24 |
| 5/15/2002 | 0.99 | 7.70 | 1.82 | 3.18 | 4.60 | 14.76 | 19.93 | 3.75 | 9.09 | 12.62 |
| 5/16/2002 | 1.03 | 6.94 | 1.71 | 2.90 | 4.35 | 12.70 | 21.91 | 3.28 | 8.11 | 10.70 |
| 5/17/2002 | 1.07 | 6.94 | 1.74 | 2.99 | 4.46 | 11.86 | 20.83 | 2.66 | 6.82 | 9.49 |
| 5/18/2002 | 1.01 | 6.77 | 1.64 | 2.72 | 4.32 | 11.14 | 20.08 | 2.35 | 6.17 | 8.54 |
| 5/19/2002 | 0.99 | 6.84 | 1.60 | 2.63 | 4.24 | 10.22 | 19.79 | 2.20 | 5.87 | 7.11 |
| 5/20/2002 | 0.99 | 5.80 | 1.57 | 2.55 | 4.22 | 9.72 | 19.06 | 2.19 | 5.85 | 7.11 |
| 5/21/2002 | 0.99 | 5.80 | 1.53 | 2.46 | 4.26 | 9.54 | 18.20 | 2.18 | 5.83 | 7.11 |
| 5/22/2002 | 0.99 | 6.17 | 1.64 | 2.72 | 4.56 | 9.59 | 19.06 | 5.34 | 5.87 | 5.87 |
| 5/23/2002 | 0.94 | 6.26 | 1.71 | 2.90 | 4.74 | 9.37 | 18.20 | 6.88 | 5.81 | 8.69 |
| 5/24/2002 | 0.90 | 6.69 | 1.64 | 2.72 | 4.65 | 8.73 | 16.68 | 6.16 | 5.54 | 8.39 |
| 5/25/2002 | 0.92 | 7.22 | 1.64 | 2.72 | 4.80 | 8.36 | 15.64 | 5.82 | 5.47 | 8.09 |
| 5/26/2002 | 1.03 | 8.06 | 1.67 | 2.81 | 4.86 | 8.36 | 15.24 | 5.50 | 5.47 | 7.95 |
| 5/27/2002 | 1.34 | 10.39 | 2.09 | 3.91 | 5.66 | 8.52 | 13.65 | 5.50 | 5.47 | 7.95 |
| 5/28/2002 | 1.15 | 11.52 | 1.97 | 3.59 | 5.95 | 9.03 | 15.77 | 6.70 | 5.47 | 8.39 |
| 5/29/2002 | 0.97 | 11.21 | 1.89 | 3.38 | 6.04 | 8.40 | 16.17 | 5.99 | 5.22 | 8.85 |
| 5/30/2002 | 0.92 | 11.21 | 1.82 | 3.18 | 6.12 | 7.72 | 15.00 | 5.03 | 5.02 | 8.24 |
| 5/31/2002 | 0.84 | 11.56 | 1.78 | 3.08 | 6.19 | 6.84 | 10.96 | 4.17 | 6.02 | 8.09 |
| 6/1/2002 | 0.85 | 12.07 | 1.78 | 3.08 | 6.20 | 6.34 | 9.65 | 3.65 | 6.95 | 7.38 |
| 6/2/2002 | 0.97 | 14.10 | 2.01 | 3.69 | 6.28 | 6.66 | 8.52 | 3.53 | 7.23 | 6.85 |
| 6/3/2002 | 1.03 | 13.99 | 2.05 | 3.80 | 6.41 | 6.99 | 10.24 | 4.04 | 7.94 | 6.98 |
| 6/4/2002 | 1.03 | 14.27 | 2.13 | 4.03 | 6.53 | 7.21 | 10.44 | 4.31 | 8.33 | 7.52 |
| 6/5/2002 | 1.05 | 14.06 | 2.13 | 4.03 | 6.56 | 7.03 | 9.16 | 4.17 | 8.33 | 7.38 |
| 6/6/2002 | 1.05 | 13.74 | 2.05 | 3.80 | 6.59 | 6.73 | 9.96 | 3.78 | 8.33 | 6.98 |
| 6/7/2002 | 1.27 | 13.46 | 1.97 | 3.59 | 6.60 | 6.26 | 10.24 | 3.53 | 8.33 | 4.60 |
| 6/8/2002 | 1.65 | 14.82 | 2.29 | 4.50 | 6.96 | 6.59 | 11.50 | 3.53 | 8.33 | 4.60 |
| 6/9/2002 | 1.50 | 14.35 | 2.37 | 4.76 | 7.41 | 7.45 | 12.95 | 3.53 | 8.58 | 4.60 |
| 6/10/2002 | 1.34 | 13.70 | 2.21 | 4.26 | 7.24 | 7.18 | 9.96 | 3.91 | 8.68 | 4.60 |
| 6/11/2002 | 1.27 | 13.06 | 2.17 | 4.14 | 6.98 | 6.55 | 7.05 | 3.65 | 9.17 | 4.60 |
| 6/12/2002 | 1.20 | 13.06 | 2.17 | 4.14 | 6.88 | 6.12 | 5.90 | 2.96 | 8.38 | 2.88 |
| 6/13/2002 | 1.13 | 14.95 | 2.13 | 4.03 | 6.72 | 6.02 | 4.85 | 2.55 | 7.94 | 2.68 |
| 6/14/2002 | 1.15 | 15.60 | 2.13 | 4.03 | 6.73 | 5.85 | 5.97 | 2.45 | 7.66 | 2.68 |
| 6/15/2002 | 1.17 | 15.92 | 2.17 | 4.14 | 6.60 | 5.68 | 4.99 | 2.26 | 7.91 | 2.68 |
| 6/16/2002 | 1.17 | 17.50 | 2.17 | 4.14 | 6.68 | 5.52 | 4.85 | 2.26 | 7.70 | 2.62 |
| 6/17/2002 | 1.15 | 17.74 | 2.59 | 5.43 | 6.85 | 5.88 | 3.81 | 2.17 | 8.08 | 2.62 |
| 6/18/2002 | 1.20 | 18.48 | 2.82 | 6.16 | 6.88 | 6.51 | 4.23 | 2.45 | 4.67 | 3.24 |
| 6/19/2002 | 1.17 | 17.50 | 2.73 | 5.86 | 6.58 | 6.12 | 7.05 | 2.75 | 7.86 | 5.76 |
| 6/20/2002 | 1.15 | 17.26 | 2.87 | 6.32 | 6.39 | 6.09 | 7.82 | 3.07 | 8.76 | 6.47 |
| 6/21/2002 | 1.22 | 17.21 | 2.96 | 6.63 | 6.26 | 6.02 | 9.46 | 2.55 | 6.28 | 4.51 |
| 6/22/2002 | 1.27 | 16.19 | 3.01 | 6.80 | 6.22 | 6.02 | 8.52 | 2.45 | 5.70 | 4.05 |
| 6/23/2002 | 1.22 | 16.10 | 2.92 | 6.47 | 6.17 | 5.85 | 5.39 | 2.35 | 5.06 | 3.71 |
| 6/24/2002 | 1.15 | 15.30 | 2.64 | 5.57 | 5.66 | 5.25 | 3.75 | 2.45 | 4.97 | 3.55 |
| 6/25/2002 | 1.11 | 9.54 | 2.42 | 4.89 | 5.25 | 4.87 | 5.06 | 2.09 | 5.50 | 3.39 |
| 6/26/2002 | 1.27 | 5.69 | 1.89 | 3.38 | 5.28 | 5.09 | 4.53 | 1.92 | 5.68 | 3.24 |
| 6/27/2002 | 1.29 | 5.48 | 1.85 | 3.28 | 4.79 | 4.90 | 6.35 | 1.84 | 4.63 | 3.02 |
| 6/28/2002 | 1.27 | 5.22 | 1.64 | 2.72 | 4.50 | 4.63 | 6.97 | 1.76 | 4.25 | 2.95 |
| 6/29/2002 | 1.24 | 5.02 | 1.47 | 2.31 | 4.13 | 4.45 | 2.58 | 1.61 | 4.00 | 2.75 |
| 6/30/2002 | 1.27 | 4.62 | 1.34 | 2.01 | 3.56 | 4.10 | 0.96 | 1.46 | 3.92 | 2.62 |

| Date | TRC01 | TRC02 | TRC02 (estimate) | TRC03 | TRC04 | TRC05 | TRC07 | TRC10 | TRC11 | TRC12 |
|---|---|---|---|---|---|---|---|---|---|---|
| 7/1/2002 | 1.15 | 4.44 | 1.28 | 1.87 | 3.49 | 3.90 | 0.04 | 1.33 | 4.01 | 2.91 |
| 7/2/2002 | 1.11 | 4.46 | 1.31 | 1.94 | 3.57 | 3.74 | 0.34 | 1.21 | 3.41 | 2.46 |
| 7/3/2002 | 1.22 | 4.59 | 1.28 | 1.87 | 3.49 | 3.76 | 0.22 | 1.21 | 3.37 | 2.43 |
| 7/4/2002 | 1.20 | 4.59 | 1.22 | 1.74 | 3.34 | 3.82 | 1.88 | 1.21 | 3.36 | 2.42 |
| 7/5/2002 | 1.09 | 4.47 | 1.16 | 1.62 | 3.19 | 3.76 | 3.64 | 1.21 | 3.38 | 2.44 |
| 7/6/2002 | 1.22 | 4.31 | 1.16 | 1.62 | 3.19 | 3.55 | 3.64 | 1.21 | 3.36 | 2.42 |
| 7/7/2002 | 1.39 | 4.27 | 1.16 | 1.62 | 3.19 | 3.47 | 5.90 | 1.09 | 3.38 | 2.44 |
| 7/8/2002 | 1.47 | 4.13 | 1.53 | 2.46 | 4.11 | 3.49 | 5.74 | 1.03 | 3.33 | 2.40 |
| 7/9/2002 | 1.44 | 4.44 | 1.74 | 2.99 | 4.59 | 4.24 | 7.13 | 1.09 | 3.63 | 2.62 |
| 7/10/2002 | 2.79 | 5.24 | 1.57 | 2.55 | 4.19 | 6.81 | 15.40 | 4.31 | 3.94 | 2.86 |
| 7/11/2002 | 2.07 | 5.10 | 1.50 | 2.38 | 4.47 | 5.22 | 10.76 | 4.04 | 4.28 | 3.10 |
| 7/12/2002 | 1.95 | 5.02 | 1.40 | 2.15 | 4.21 | 4.71 | 8.89 | 2.55 | 4.64 | 3.37 |
| 7/13/2002 | 1.74 | 4.63 | 1.31 | 1.94 | 4.06 | 4.42 | 9.46 | 2.17 | 5.02 | 3.65 |
| 7/14/2002 | 1.59 | 4.29 | 1.25 | 1.81 | 3.89 | 4.15 | 9.07 | 2.17 | 5.43 | 3.94 |
| 7/15/2002 | 1.53 | 3.92 | 1.16 | 1.62 | 3.70 | 3.96 | 6.72 | 2.17 | 5.38 | 3.90 |
| 7/16/2002 | 1.39 | 3.82 | 1.16 | 1.62 | 3.70 | 3.84 | 7.13 | 2.00 | 5.21 | 3.78 |
| 7/17/2002 | 1.34 | 3.72 | 1.16 | 1.62 | 3.57 | 3.63 | 6.42 | 1.76 | 4.70 | 3.41 |
| 7/18/2002 | 1.29 | 3.72 | 1.19 | 1.68 | 3.54 | 3.63 | 6.50 | 1.76 | 4.44 | 3.22 |
| 7/19/2002 | 1.29 | 3.64 | 1.10 | 1.50 | 3.58 | 3.52 | 7.23 | 1.68 | 4.22 | 3.06 |
| 7/20/2002 | 1.31 | 3.49 | 1.10 | 1.50 | 3.58 | 3.60 | 6.97 | 1.61 | 4.10 | 2.97 |
| 7/21/2002 | 1.27 | 3.32 | 1.13 | 1.56 | 3.56 | 3.34 | 5.97 | 1.53 | 3.85 | 2.79 |
| 7/22/2002 | 1.29 | 3.37 | 1.13 | 1.56 | 3.70 | 3.16 | 5.61 | 1.53 | 3.69 | 2.68 |
| 7/23/2002 | 1.27 | 3.35 | 1.37 | 2.08 | 3.67 | 3.06 | 5.97 | 1.21 | 3.72 | 2.49 |
| 7/24/2002 | 1.24 | 3.52 | 1.37 | 2.08 | 4.02 | 3.36 | 6.35 | 1.27 | 3.79 | 2.56 |
| 7/25/2002 | 1.53 | 4.15 | 1.37 | 2.08 | 4.87 | 4.66 | 8.98 | 3.07 | 7.72 | 5.64 |
| 7/26/2002 | 1.65 | 3.94 | 1.28 | 1.87 | 4.46 | 4.60 | 8.89 | 2.55 | 5.70 | 4.05 |
| 7/27/2002 | 1.56 | 3.82 | 1.25 | 1.81 | 4.43 | 4.27 | 7.31 | 1.92 | 6.04 | 4.32 |
| 7/28/2002 | 1.47 | 3.63 | 1.19 | 1.68 | 4.21 | 4.39 | 6.57 | 1.84 | 5.59 | 3.96 |
| 7/29/2002 | 1.37 | 3.53 | 1.16 | 1.62 | 4.25 | 3.52 | 5.32 | 1.61 | 4.96 | 3.47 |
| 7/30/2002 | 1.31 | 3.53 | 1.10 | 1.50 | 4.28 | 3.31 | 3.32 | 1.46 | 4.18 | 3.17 |
| 7/31/2002 | 1.29 | 3.45 | 1.05 | 1.39 | 4.26 | 3.21 | 3.52 | 1.33 | 4.22 | 2.95 |
| 8/1/2002 | 1.22 | 3.27 | 1.05 | 1.39 | 4.20 | 3.01 | 0.43 | 1.33 | 3.67 | 2.68 |
| 8/2/2002 | 1.20 | 3.35 | 1.34 | 2.01 | 4.01 | 2.80 | 1.26 | 0.98 | 3.41 | 2.68 |
| 8/3/2002 | 1.24 | 3.60 | 2.09 | 3.91 | 4.29 | 2.94 | 4.04 | 1.03 | 3.43 | 2.49 |
| 8/4/2002 | 2.31 | 4.95 | 2.01 | 3.69 | 5.20 | 4.27 | 4.23 | 1.92 | 3.92 | 2.84 |
| 8/5/2002 | 2.59 | 5.10 | 1.74 | 2.99 | 6.19 | 5.41 | 7.23 | 2.85 | 4.75 | 3.45 |
| 8/6/2002 | 1.81 | 4.27 | 1.74 | 2.99 | 5.90 | 5.81 | 7.13 | 3.53 | 6.43 | 4.66 |
| 8/7/2002 | 1.56 | 3.82 | 1.60 | 2.63 | 5.40 | 4.90 | 7.90 | 3.07 | 6.71 | 4.86 |
| 8/8/2002 | 1.44 | 3.50 | 1.47 | 2.31 | 5.17 | 4.39 | 7.55 | 2.35 | 6.21 | 4.50 |
| 8/9/2002 | 1.24 | 3.35 | 1.40 | 2.15 | 5.05 | 3.96 | 5.67 | 2.00 | 5.41 | 3.93 |
| 8/10/2002 | 1.34 | 3.20 | 1.40 | 2.15 | 5.45 | 3.98 | 4.99 | 2.26 | 5.94 | 4.31 |
| 8/11/2002 | 1.34 | 3.23 | 1.40 | 2.15 | 5.45 | 4.39 | 6.82 | 2.09 | 5.90 | 4.28 |
| 8/12/2002 | 1.31 | 3.41 | 1.47 | 2.31 | 5.88 | 4.04 | 6.50 | 2.26 | 5.83 | 4.23 |
| 8/13/2002 | 1.24 | 3.41 | 1.47 | 2.31 | 6.17 | 4.27 | 5.97 | 2.00 | 6.61 | 4.51 |
| 8/14/2002 | 1.17 | 3.24 | 1.43 | 2.23 | 6.16 | 4.07 | 7.23 | 1.92 | 5.98 | 4.51 |
| 8/15/2002 | 1.17 | 3.17 | 1.34 | 2.01 | 6.05 | 3.71 | 5.19 | 1.84 | 5.90 | 3.79 |
| 8/16/2002 | 1.17 | 3.17 | 1.28 | 1.87 | 6.04 | 3.84 | 5.97 | 1.68 | 6.61 | 3.88 |
| 8/17/2002 | 1.13 | 3.17 | 1.37 | 2.08 | 6.18 | 3.65 | 6.90 | 1.68 | 6.29 | 4.60 |
| 8/18/2002 | 1.34 | 3.17 | 1.34 | 2.01 | 6.19 | 3.76 | 7.05 | 1.46 | 5.61 | 4.41 |
| 8/19/2002 | 1.11 | 3.27 | 1.40 | 2.15 | 6.19 | 3.84 | 4.85 | 1.46 | 5.50 | 3.71 |
| 8/20/2002 | 1.11 | 2.84 | 1.37 | 2.08 | 6.20 | 4.04 | 5.61 | 1.46 | 5.61 | 3.55 |
| 8/21/2002 | 14.07 | 7.40 | 3.88 | 9.97 | 7.19 | 6.81 | 4.85 | 2.96 | 7.80 | 5.87 |
| 8/22/2002 | 3.18 | 8.06 | 5.94 | 18.89 | 11.98 | 14.81 | 7.05 | 8.90 | 10.21 | 6.11 |
| 8/23/2002 | 1.37 | 4.55 | 2.82 | 6.16 | 7.65 | 10.16 | 11.84 | 15.19 | 22.59 | 11.82 |
| 8/24/2002 | 1.31 | 3.17 | 1.82 | 3.18 | 6.35 | 7.56 | 9.07 | 4.88 | 15.91 | 15.96 |

| Date | TRC01 | TRC02 | TRC02 (estimate) | TRC03 | TRC04 | TRC05 | TRC07 | TRC10 | TRC11 | TRC12 |
|---|---|---|---|---|---|---|---|---|---|---|
| 8/25/2002 | 1.31 | 2.87 | 1.71 | 2.90 | 6.20 | 6.16 | 8.35 | 2.35 | 10.89 | 9.66 |
| 8/26/2002 | 1.27 | 2.83 | 1.67 | 2.81 | 6.19 | 5.41 | 8.13 | 1.68 | 7.87 | 6.47 |
| 8/27/2002 | 1.24 | 2.83 | 1.64 | 2.72 | 6.20 | 4.84 | 10.24 | 1.61 | 6.90 | 5.00 |
| 8/28/2002 | 1.22 | 2.71 | 1.67 | 2.81 | 6.26 | 4.66 | 10.66 | 1.40 | 6.04 | 4.32 |
| 8/29/2002 | 1.24 | 2.52 | 1.64 | 2.72 | 6.28 | 4.90 | 9.46 | 1.33 | 5.59 | 3.96 |
| 8/30/2002 | 1.47 | 2.91 | 2.13 | 4.03 | 6.60 | 5.91 | 11.19 | 1.68 | 5.27 | 3.71 |
| 8/31/2002 | 1.50 | 2.98 | 2.01 | 3.69 | 6.51 | 7.40 | 13.54 | 2.75 | 4.96 | 3.47 |
| 9/1/2002 | 1.27 | 2.64 | 1.85 | 3.28 | 6.45 | 6.09 | 12.83 | 2.26 | 4.86 | 3.39 |
| 9/2/2002 | 1.20 | 2.31 | 1.71 | 2.90 | 6.41 | 5.32 | 11.29 | 1.92 | 6.28 | 4.51 |
| 9/3/2002 | 1.15 | 2.13 | 1.64 | 2.72 | 6.38 | 4.66 | 10.56 | 1.33 | 5.81 | 4.14 |
| 9/4/2002 | 1.13 | 2.01 | 1.60 | 2.63 | 6.29 | 4.66 | 9.84 | 1.09 | 5.06 | 3.55 |
| 9/5/2002 | 1.11 | 2.01 | 1.64 | 2.72 | 6.24 | 4.48 | 10.05 | 1.09 | 5.06 | 3.55 |
| 9/6/2002 | 1.07 | 1.84 | 1.60 | 2.63 | 6.24 | 4.33 | 8.24 | 0.98 | 4.67 | 3.24 |
| 9/7/2002 | 0.99 | 1.44 | 1.57 | 2.55 | 6.25 | 4.35 | 7.90 | 0.98 | 4.39 | 3.02 |
| 9/8/2002 | 0.99 | 1.21 | 1.50 | 2.38 | 6.20 | 4.15 | 6.74 | 1.03 | 4.21 | 2.88 |
| 9/9/2002 | 1.01 | 1.08 | 1.50 | 2.38 | 6.19 | 3.88 | 7.05 | 0.87 | 4.13 | 2.82 |
| 9/10/2002 | 1.05 | 1.19 | 1.57 | 2.55 | 6.14 | 4.04 | 7.63 | 0.83 | 4.39 | 3.02 |
| 9/11/2002 | 1.07 | 1.28 | 1.57 | 2.55 | 6.09 | 4.04 | 7.63 | 0.69 | 4.21 | 2.88 |
| 9/12/2002 | 1.09 | 1.26 | 1.60 | 2.63 | 6.08 | 4.24 | 8.07 | 0.73 | 4.13 | 2.82 |
| 9/13/2002 | 1.92 | 2.21 | 2.01 | 3.69 | 6.23 | 5.35 | 10.05 | 1.27 | 4.77 | 3.31 |
| 9/14/2002 | 1.68 | 2.62 | 2.50 | 5.15 | 6.35 | 6.09 | 10.66 | 1.61 | 4.77 | 3.31 |
| 9/15/2002 | 1.50 | 1.84 | 2.05 | 3.80 | 6.29 | 6.55 | 12.26 | 1.92 | 4.48 | 3.09 |
| 9/16/2002 | 1.31 | 1.65 | 1.89 | 3.38 | 6.21 | 5.68 | 11.71 | 1.84 | 4.39 | 3.02 |
| 9/17/2002 | 1.15 | 1.26 | 1.78 | 3.08 | 6.20 | 5.32 | 9.46 | 1.40 | 4.77 | 3.31 |
| 9/18/2002 | 0.99 | 1.25 | 1.74 | 2.99 | 6.19 | 4.93 | 10.05 | 1.15 | 5.16 | 3.63 |
| 9/19/2002 | 1.01 | 1.08 | 1.67 | 2.81 | 6.12 | 4.48 | 8.69 | 1.03 | 4.96 | 3.47 |
| 9/20/2002 | 1.07 | 1.08 | 1.64 | 2.72 | 6.03 | 4.27 | 7.98 | 0.93 | 4.67 | 3.24 |
| 9/21/2002 | 1.17 | 1.08 | 1.60 | 2.63 | 5.86 | 4.27 | 7.23 | 0.83 | 4.58 | 3.17 |
| 9/22/2002 | 1.20 | 1.25 | 1.67 | 2.81 | 5.83 | 4.13 | 6.97 | 0.73 | 4.48 | 3.09 |
| 9/23/2002 | 1.27 | 1.21 | 1.67 | 2.81 | 5.89 | 4.45 | 7.23 | 0.65 | 4.39 | 3.02 |
| 9/24/2002 | 1.24 | 1.19 | 1.60 | 2.63 | 5.92 | 4.66 | 7.55 | 0.57 | 4.13 | 2.82 |
| 9/25/2002 | 1.15 | 1.25 | 1.57 | 2.55 | 5.89 | 4.35 | 8.52 | 0.98 | 4.04 | 2.75 |
| 9/26/2002 | 1.27 | 1.26 | 1.64 | 2.72 | 5.98 | 4.33 | 8.89 | 1.03 | 4.04 | 2.75 |
| 9/27/2002 | 1.22 | 1.43 | 1.67 | 2.81 | 5.96 | 4.35 | 10.24 | 0.98 | 4.13 | 2.82 |
| 9/28/2002 | 1.24 | 1.37 | 1.67 | 2.81 | 6.03 | 4.50 | 10.24 | 0.98 | 4.04 | 2.75 |
| 9/29/2002 | 1.27 | 1.43 | 1.71 | 2.90 | 6.04 | 5.09 | 10.76 | 1.15 | 4.21 | 2.88 |
| 9/30/2002 | 1.17 | 1.43 | 1.67 | 2.81 | 6.06 | 5.91 | 10.44 | 1.21 | 4.39 | 3.02 |
| 10/1/2002 | 1.50 | 1.31 | 1.67 | 2.81 | 6.26 | 6.88 | 10.86 | 1.21 | 4.48 | 3.09 |
| 10/2/2002 | 1.74 | 1.98 | 1.89 | 3.38 | 6.23 | 8.07 | 15.00 | 2.75 | 4.77 | 3.31 |
| 10/3/2002 | 1.62 | 2.03 | 2.01 | 3.69 | 6.28 | 7.03 | 12.16 | 1.76 | 5.16 | 3.63 |
| 10/4/2002 | 3.37 | 3.55 | 2.92 | 6.47 | 6.33 | 11.47 | 18.20 | 4.31 | 12.81 | 9.66 |
| 10/5/2002 | 2.40 | 3.56 | 3.31 | 7.83 | 6.75 | 12.91 | 20.69 | 5.99 | 8.30 | 6.11 |
| 10/6/2002 | 2.23 | 2.82 | 2.55 | 5.29 | 6.48 | 12.40 | 20.98 | 6.70 | 9.41 | 6.98 |
| 10/7/2002 | 1.84 | 2.30 | 2.25 | 4.38 | 6.35 | 9.89 | 16.56 | 4.17 | 6.40 | 4.60 |
| 10/8/2002 | 1.56 | 1.86 | 1.93 | 3.48 | 6.26 | 8.60 | 15.77 | 3.41 | 7.72 | 5.64 |
| 10/9/2002 | 1.47 | 1.71 | 1.85 | 3.28 | 6.23 | 7.56 | 14.64 | 2.55 | 6.04 | 4.32 |
| 10/10/2002 | 1.50 | 1.68 | 1.82 | 3.18 | 6.23 | 7.45 | 13.42 | 2.17 | 6.77 | 4.90 |
| 10/11/2002 | 1.42 | 1.61 | 1.78 | 3.08 | 6.22 | 7.49 | 13.42 | 2.55 | 6.28 | 4.51 |
| 10/12/2002 | 1.39 | 1.61 | 1.67 | 2.81 | 6.21 | 6.69 | 12.48 | 2.75 | 5.59 | 3.96 |
| 10/13/2002 | 1.37 | 1.49 | 1.67 | 2.81 | 6.21 | 6.88 | 12.26 | 2.35 | 5.37 | 3.79 |
| 10/14/2002 | 1.34 | 1.43 | 1.64 | 2.72 | 6.21 | 6.81 | 11.29 | 3.07 | 5.59 | 3.96 |
| 10/15/2002 | 1.29 | 1.43 | 1.64 | 2.72 | 6.20 | 6.88 | 9.74 | 2.55 | 5.16 | 3.63 |
| 10/16/2002 | 1.34 | 1.49 | 1.71 | 2.90 | 6.20 | 7.07 | 10.44 | 2.85 | 5.27 | 3.71 |
| 10/17/2002 | 1.47 | 1.81 | 1.74 | 2.99 | 6.22 | 7.21 | 11.29 | 3.53 | 5.70 | 4.05 |
| 10/18/2002 | 1.47 | 1.81 | 1.78 | 3.08 | 6.22 | 7.26 | 10.24 | 3.78 | 5.70 | 4.05 |

| Date | TRC01 | TRC02 | TRC02 (estimate) | TRC03 | TRC04 | TRC05 | TRC07 | TRC10 | TRC11 | TRC12 |
|---|---|---|---|---|---|---|---|---|---|---|
| 10/19/2002 | 1.47 | 1.61 | 1.74 | 2.99 | 6.22 | 7.37 | 11.16 | 3.78 | 5.70 | 4.05 |
| 10/20/2002 | 1.44 | 1.61 | 1.71 | 2.90 | 6.22 | 7.37 | 12.95 | 3.78 | 5.59 | 3.96 |
| 10/21/2002 | 1.50 | 1.61 | 1.71 | 2.90 | 6.22 | 7.03 | 11.84 | 3.91 | 5.70 | 4.05 |
| 10/22/2002 | 1.50 | 1.61 | 1.71 | 2.90 | 6.22 | 7.03 | 11.50 | 3.65 | 5.81 | 4.14 |
| 10/23/2002 | 1.56 | 1.61 | 1.74 | 2.99 | 6.22 | 7.10 | 12.16 | 3.91 | 5.92 | 4.23 |
| 10/24/2002 | 1.59 | 1.61 | 1.78 | 3.08 | 6.22 | 7.10 | 12.83 | 4.31 | 5.81 | 4.14 |
| 10/25/2002 | 1.62 | 1.74 | 1.82 | 3.18 | 6.22 | 7.10 | 11.71 | 4.31 | 6.04 | 4.32 |
| 10/26/2002 | 1.62 | 1.70 | 1.82 | 3.18 | 6.22 | 7.84 | 11.94 | 4.59 | 6.04 | 4.32 |
| 10/27/2002 | 1.68 | 1.74 | 1.85 | 3.28 | 6.22 | 7.60 | 11.19 | 5.50 | 6.16 | 4.41 |
| 10/28/2002 | 1.99 | 2.30 | 2.05 | 3.80 | 6.22 | 8.11 | 12.83 | 5.99 | 6.90 | 5.00 |
| 10/29/2002 | 1.95 | 2.38 | 2.13 | 4.03 | 15.01 | 8.36 | 12.37 | 6.34 | 6.90 | 5.00 |
| 10/30/2002 | 2.10 | 2.51 | 2.21 | 4.26 | 18.13 | 9.03 | 10.24 | 7.85 | 7.44 | 5.42 |
| 10/31/2002 | 1.78 | 3.24 | 2.13 | 4.03 | 18.60 | 9.03 | 10.24 | 7.85 | 7.86 | 5.76 |
| 11/1/2002 | 1.65 | 3.35 | 1.89 | 3.38 | 20.01 | 9.03 | 10.24 | 6.34 | 4.39 | 3.02 |
| 11/2/2002 | 1.68 | 3.09 | 1.89 | 3.38 | 20.84 | 8.85 | 12.70 | 6.34 | 1.88 | 1.10 |
| 11/3/2002 | 1.78 | 1.91 | 1.93 | 3.48 | 20.61 | 8.48 | 16.27 | 7.26 | 6.40 | 4.60 |
| 11/4/2002 | 1.81 | 2.08 | 2.01 | 3.69 | 21.80 | 8.04 | 17.37 | 6.88 | 6.16 | 4.41 |
| 11/5/2002 | 1.81 | 1.81 | 2.01 | 3.69 | 23.86 | 8.99 | 16.56 | 7.26 | 5.16 | 3.63 |
| 11/6/2002 | 1.81 | 1.81 | 2.01 | 3.69 | 25.58 | 8.73 | 15.77 | 7.45 | 6.16 | 4.41 |
| 11/7/2002 | 1.71 | 1.81 | 1.97 | 3.59 | 28.07 | 8.81 | 15.77 | 7.07 | 7.72 | 5.64 |
| 11/8/2002 | 1.65 | 1.53 | 1.89 | 3.38 | 32.73 | 8.65 | 15.77 | 7.26 | 7.03 | 5.10 |
| 11/9/2002 | 1.62 | 1.43 | 1.85 | 3.28 | 38.82 | 8.95 | 15.40 | 7.26 | 7.72 | 5.64 |
| 11/10/2002 | 1.56 | 1.43 | 1.82 | 3.18 | 44.20 | 9.07 | 14.26 | 7.65 | 7.44 | 5.42 |
| 11/11/2002 | 1.50 | 1.43 | 1.78 | 3.08 | 46.63 | 8.89 | 12.83 | 7.26 | 7.30 | 5.31 |
| 11/12/2002 | 1.44 | 1.43 | 1.74 | 2.99 | 48.69 | 8.75 | 12.34 | 8.26 | 7.30 | 5.31 |
| 11/13/2002 | 1.44 | 1.43 | 1.74 | 2.99 | 50.23 | 8.75 | 12.34 | 8.47 | 6.65 | 4.80 |
| 11/14/2002 | 1.47 | 1.43 | 1.74 | 2.99 | 53.64 | 8.75 | 12.34 | 8.47 | 6.77 | 4.90 |
| 11/15/2002 | 1.53 | 1.43 | 1.78 | 3.08 | 59.05 | 8.75 | 12.34 | 8.47 | 6.28 | 4.51 |
| 11/16/2002 | 1.50 | 1.43 | 1.78 | 3.08 | 63.81 | 8.75 | 12.34 | 8.68 | 6.77 | 4.90 |
| 11/17/2002 | 1.47 | 1.43 | 1.82 | 3.18 | 74.65 | 8.75 | 12.34 | 8.90 | 6.77 | 4.90 |
| 11/18/2002 | 1.50 | 1.43 | 1.78 | 3.08 | 109.39 | 8.75 | 12.34 | 9.12 | 6.77 | 4.90 |
| 11/19/2002 | 1.47 | 1.43 | 1.78 | 3.08 | 290.83 | 8.75 | 12.34 | 8.68 | 7.03 | 5.10 |
| 11/20/2002 | 1.50 | 1.43 | 1.78 | 3.08 | 1093.77 | 8.75 | 12.34 | 8.26 | 7.03 | 5.10 |
| 11/21/2002 | 1.50 | 1.43 | 1.74 | 2.99 | 1564.27 | 8.75 | | 8.26 | 6.90 | 5.00 |
| 11/22/2002 | 1.44 | 1.43 | 1.74 | 2.99 | 1759.65 | 8.75 | | 7.85 | 6.52 | 4.70 |
| 11/23/2002 | 1.44 | 1.43 | 1.74 | 2.99 | 1894.97 | 8.75 | | 8.26 | 6.77 | 4.90 |
| 11/24/2002 | 1.42 | 1.43 | 1.67 | 2.81 | 1886.95 | 8.75 | | 7.45 | 7.03 | 5.10 |
| 11/25/2002 | 1.37 | 1.43 | 1.60 | 2.63 | 1945.08 | 8.75 | | 7.07 | | |
| 11/26/2002 | 1.39 | 1.43 | 1.71 | 2.90 | | 8.75 | | 7.65 | | |
| 11/27/2002 | 0.22 | 1.43 | 1.71 | 2.90 | | 8.75 | | | | |
| 4/3/2003 | 1.42 | 2.01 | na | 3.53 | 5.75 | 11.61 | 6.94 | 10.27 | 11.23 | 9.01 |
| 4/4/2003 | 1.39 | 1.81 | na | 3.25 | 5.36 | 11.49 | 6.89 | 10.04 | 11.23 | 9.17 |
| 4/5/2003 | 1.39 | 1.81 | na | 3.25 | 5.36 | 11.14 | 6.73 | 9.57 | 10.70 | 9.01 |
| 4/6/2003 | 1.42 | 1.98 | na | 3.49 | 5.69 | 11.26 | 6.78 | 9.12 | 10.34 | 8.69 |
| 4/7/2003 | 1.50 | 2.44 | na | 3.18 | 6.22 | 15.81 | 8.95 | 8.68 | 9.98 | 10.70 |
| 4/8/2003 | 1.84 | 2.44 | na | 3.69 | 6.22 | 10.91 | 6.63 | 10.52 | 11.48 | 8.09 |
| 4/9/2003 | 1.95 | 2.67 | na | 5.02 | 6.34 | 14.87 | 8.49 | 12.31 | 12.97 | 9.33 |
| 4/10/2003 | 2.07 | 2.92 | na | 5.29 | 6.53 | 21.39 | 11.91 | 16.78 | 16.85 | 11.44 |
| 4/11/2003 | 1.84 | 2.57 | na | 4.38 | 6.27 | 20.81 | 11.59 | 21.02 | 20.77 | 15.48 |
| 4/12/2003 | 1.62 | 2.34 | na | 3.48 | 6.20 | 16.15 | 9.13 | 17.11 | 17.14 | 16.45 |
| 4/13/2003 | 1.44 | 1.98 | na | 2.99 | 5.69 | 13.13 | 7.65 | 13.99 | 14.40 | 14.33 |
| 4/14/2003 | 1.62 | 1.70 | na | 2.72 | 5.14 | 12.89 | 7.54 | 12.58 | 13.20 | 12.22 |
| 4/15/2003 | 1.95 | 1.70 | na | 5.86 | 5.14 | 11.26 | 6.78 | 11.52 | 12.31 | 10.88 |
| 4/16/2003 | 3.01 | 4.60 | na | 16.18 | 8.95 | 27.31 | 15.38 | 19.18 | 19.03 | 13.67 |
| 4/17/2003 | 2.07 | 4.19 | na | 10.61 | 8.24 | 52.77 | 33.82 | 65.58 | 81.01 | 25.91 |

| Date | TRC01 | TRC02 | TRC02 (estimate) | TRC03 | TRC04 | TRC05 | TRC07 | TRC10 | TRC11 | TRC12 |
|---|---|---|---|---|---|---|---|---|---|---|
| 4/18/2003 | 3.37 | 3.70 | na | 22.22 | 7.47 | 43.12 | 26.20 | 54.47 | 62.35 | 44.32 |
| 4/19/2003 | 2.64 | 8.67 | na | 25.13 | 17.31 | 79.98 | 59.16 | 137.64 | 226.90 | 60.63 |
| 4/20/2003 | 2.14 | 4.77 | na | 15.05 | 9.25 | 71.59 | 50.77 | 158.77 | 251.55 | 129.44 |
| 4/21/2003 | 1.71 | 3.67 | na | 11.06 | 7.43 | 49.56 | 31.20 | 83.42 | 116.86 | 71.00 |
| 4/22/2003 | 1.88 | 2.54 | na | 8.01 | 6.26 | 36.90 | 21.68 | 51.06 | 57.14 | 44.32 |
| 4/23/2003 | 3.77 | 2.13 | na | 6.80 | 5.97 | 29.04 | 16.46 | 34.46 | 35.06 | 32.33 |
| 4/24/2003 | 2.64 | 3.12 | na | 17.35 | 6.73 | 33.32 | 19.24 | 33.43 | 33.85 | 27.33 |
| 4/25/2003 | 1.59 | 4.25 | na | 15.05 | 8.35 | 56.31 | 36.81 | 76.30 | 101.63 | 34.85 |
| 4/26/2003 | 1.27 | 2.92 | na | 9.15 | 6.53 | 46.23 | 28.57 | 75.44 | 99.87 | 55.58 |
| 4/27/2003 | 1.74 | 2.38 | na | 6.63 | 6.21 | 31.47 | 18.02 | 42.83 | 45.55 | 37.97 |
| 4/28/2003 | 1.22 | 1.84 | na | 5.57 | 5.42 | 21.27 | 11.84 | 28.11 | 27.94 | 26.61 |
| 4/29/2003 | 1.42 | 1.40 | na | 5.71 | 4.53 | 12.08 | 7.16 | 21.79 | 21.51 | 20.78 |
| 4/30/2003 | 2.27 | 2.54 | na | 15.05 | 6.26 | 17.55 | 9.84 | 25.03 | 24.73 | 21.68 |
| 5/1/2003 | 1.78 | 3.07 | na | 13.98 | 6.67 | 34.59 | 20.09 | 52.41 | 59.17 | 28.05 |
| 5/2/2003 | 1.42 | 2.38 | na | 10.18 | 6.21 | 29.97 | 17.04 | 53.09 | 60.21 | 40.33 |
| 5/3/2003 | 1.20 | 1.87 | na | 7.83 | 5.47 | 21.50 | 11.97 | 36.04 | 36.94 | 33.15 |
| 5/4/2003 | 1.95 | 2.59 | na | 11.06 | 6.28 | 23.59 | 13.16 | 32.42 | 32.69 | 29.18 |
| 5/5/2003 | 1.78 | 2.72 | na | 13.21 | 6.37 | 32.17 | 18.47 | 48.43 | 53.29 | 31.12 |
| 5/6/2003 | 1.37 | 2.04 | na | 9.15 | 5.81 | 24.87 | 13.91 | 43.43 | 46.35 | 36.61 |
| 5/7/2003 | 1.20 | 1.56 | na | 6.96 | 4.86 | 18.02 | 10.08 | 30.46 | 30.49 | 29.18 |
| 5/8/2003 | 1.22 | 1.61 | na | 6.01 | 4.97 | 14.99 | 8.55 | 24.61 | 24.30 | 23.89 |
| 5/9/2003 | 1.84 | 2.22 | na | 7.65 | 6.14 | 17.44 | 9.78 | 26.77 | 26.52 | 22.61 |
| 5/10/2003 | 1.53 | 2.19 | na | 7.13 | 6.08 | 17.90 | 10.02 | 29.98 | 29.96 | 25.56 |
| 5/11/2003 | 1.88 | 2.67 | na | 9.97 | 6.34 | 23.59 | 13.16 | 34.98 | 35.67 | 28.80 |
| 5/12/2003 | 1.39 | 1.98 | na | 8.57 | 5.69 | 20.46 | 11.39 | 41.06 | 43.22 | 31.52 |
| 5/13/2003 | 2.74 | 4.16 | na | 21.53 | 8.19 | 24.17 | 12.08 | 43.43 | 46.35 | 33.15 |
| 5/14/2003 | 2.07 | 4.04 | na | 27.05 | 8.00 | 53.34 | 37.07 | 116.11 | 200.75 | 50.28 |
| 5/15/2003 | 1.71 | 2.59 | na | 14.24 | 6.28 | 36.67 | 25.53 | 90.95 | 134.36 | 75.49 |
| 5/16/2003 | 1.53 | 2.01 | na | 10.18 | 5.75 | 22.67 | 13.94 | 55.88 | 64.57 | 52.59 |
| 5/17/2003 | 1.37 | 1.48 | na | 7.65 | 4.70 | 14.06 | 8.06 | 38.22 | 39.61 | 37.97 |
| 5/18/2003 | 1.22 | 1.15 | na | 6.32 | 5.82 | 8.46 | 4.20 | 29.51 | 29.44 | 30.33 |
| 5/19/2003 | 1.39 | 1.43 | na | 6.16 | 5.74 | 7.99 | 3.46 | 25.03 | 20.22 | 25.56 |
| 5/20/2003 | 1.29 | 1.51 | na | 5.71 | 5.90 | 8.81 | 4.05 | 21.79 | 17.92 | 23.24 |
| 5/21/2003 | 1.17 | 1.32 | na | 4.63 | 5.79 | 5.35 | 4.05 | 19.54 | 15.67 | 21.08 |
| 5/22/2003 | 1.11 | 1.08 | na | 4.14 | 5.72 | 4.42 | 4.05 | 17.78 | 14.17 | 19.35 |
| 5/23/2003 | 1.11 | 1.08 | na | 3.91 | 5.91 | 3.92 | 4.05 | 17.78 | 12.62 | 17.72 |
| 5/24/2003 | 1.34 | 1.56 | na | 4.76 | 6.19 | 4.22 | 4.05 | 13.99 | 11.45 | 17.46 |
| 5/25/2003 | 1.42 | 1.64 | na | 5.15 | 6.25 | 4.53 | 4.05 | 14.29 | 11.62 | 17.20 |
| 5/26/2003 | 1.15 | 1.30 | na | 4.26 | 6.32 | 4.02 | 4.05 | 13.99 | 10.68 | 16.70 |
| 5/27/2003 | 1.13 | 1.08 | na | 3.38 | 6.33 | 3.12 | 4.05 | 12.31 | 9.78 | 16.20 |
| 5/28/2003 | 1.01 | 1.03 | na | 2.99 | 6.33 | 2.57 | 4.05 | 10.76 | 8.60 | 15.01 |
| 5/29/2003 | 0.95 | 0.87 | na | 2.63 | 6.38 | 2.25 | 4.05 | 9.57 | 7.59 | 12.82 |
| 5/30/2003 | 0.95 | 0.76 | na | 2.38 | 6.41 | 1.81 | 4.05 | 9.12 | 6.99 | 12.02 |
| 5/31/2003 | 0.89 | 0.79 | na | 2.15 | 6.44 | 1.61 | 4.05 | 7.85 | 6.35 | 10.88 |
| 6/1/2003 | 0.97 | 0.96 | na | 2.23 | 6.49 | 1.88 | 4.05 | 7.65 | 5.48 | 9.01 |
| 6/2/2003 | 1.31 | 1.79 | na | 3.18 | 6.70 | 4.07 | 4.05 | 7.45 | 5.66 | 8.85 |
| 6/3/2003 | 1.78 | 2.38 | na | 4.26 | 7.36 | 7.41 | 5.00 | 8.05 | 6.04 | 9.17 |
| 6/4/2003 | 1.39 | 2.16 | na | 3.59 | 7.70 | 8.22 | 5.16 | 9.12 | 6.23 | 9.49 |
| 6/5/2003 | 1.17 | 2.13 | na | 3.28 | 7.55 | 7.41 | 5.16 | 8.68 | 6.80 | 9.33 |
| 6/6/2003 | 1.24 | 2.32 | na | 3.38 | 7.62 | 5.40 | 5.16 | 8.67 | 6.78 | 9.49 |
| 6/7/2003 | 1.53 | 2.72 | na | 3.69 | 7.94 | 7.29 | 5.16 | 8.95 | 6.84 | 9.66 |
| 6/8/2003 | 1.53 | 2.97 | na | 4.03 | 8.38 | 7.87 | 4.05 | 9.67 | 6.35 | 21.68 |
| 6/9/2003 | 1.71 | 3.87 | na | 4.26 | 8.86 | 15.92 | 7.29 | 20.63 | 6.47 | 77.04 |
| 6/10/2003 | 4.55 | 9.72 | na | 20.52 | 10.26 | 43.12 | 32.07 | 62.23 | 20.93 | 70.27 |
| 6/11/2003 | 1.88 | 5.21 | na | 11.75 | 22.84 | 49.90 | 44.87 | 72.54 | 69.56 | 41.79 |

| Date | TRC01 | TRC02 | TRC02 (estimate) | TRC03 | TRC04 | TRC05 | TRC07 | TRC10 | TRC11 | TRC12 |
|---|---|---|---|---|---|---|---|---|---|---|
| 6/12/2003 | 1.39 | 3.95 | na | 5.71 | 14.17 | 28.93 | 27.96 | 40.32 | 56.01 | 25.91 |
| 6/13/2003 | 1.24 | 3.50 | na | 4.03 | 11.57 | 17.90 | 15.65 | 23.53 | 26.89 | 19.35 |
| 6/14/2003 | 1.20 | 3.67 | na | 3.28 | 10.64 | 12.54 | 10.53 | 15.82 | 14.67 | 15.48 |
| 6/15/2003 | 1.20 | 3.84 | na | 3.18 | 10.02 | 9.98 | 7.48 | 12.35 | 10.38 | 14.33 |
| 6/16/2003 | 1.15 | 3.87 | na | 2.90 | 9.83 | 10.09 | 2.38 | 12.50 | 8.40 | 14.10 |
| 6/17/2003 | 1.05 | 4.01 | na | 2.63 | 9.09 | 10.91 | 1.26 | 13.59 | 8.40 | 13.03 |
| 6/18/2003 | 1.01 | 4.04 | na | 2.46 | 8.57 | 9.86 | 1.06 | 12.20 | 7.36 | 11.82 |
| 6/19/2003 | 0.99 | 4.07 | na | 2.38 | 8.07 | 9.16 | 0.72 | 11.29 | 6.37 | 10.70 |
| 6/20/2003 | 0.99 | 3.92 | na | 2.31 | 7.66 | 7.99 | 0.42 | 13.99 | 5.63 | 10.34 |
| 6/21/2003 | 0.97 | 3.92 | na | 2.23 | 7.09 | 7.76 | 0.24 | 17.45 | 5.11 | 11.07 |
| 6/22/2003 | 7.02 | 34.73 | na | 18.58 | 7.20 | 11.26 | 1.46 | 15.19 | 5.06 | 23.89 |
| 6/23/2003 | 5.92 | 26.59 | na | 53.38 | 26.24 | 47.38 | 17.17 | 20.64 | 6.37 | 537.31 |
| 6/24/2003 | 2.23 | 13.61 | na | 14.24 | 23.19 | 36.44 | 26.43 | 165.78 | 23.76 | 1233.98 |
| 6/25/2003 | 11.02 | 99.88 | na | 249.59 | 26.16 | 135.87 | 129.57 | 356.77 | 317.21 | 932.06 |
| 6/26/2003 | 3.77 | 22.41 | na | 87.43 | 193.12 | 61.54 | 411.22 | 149.29 | 386.43 | 553.89 |
| 6/27/2003 | 1.88 | 8.47 | na | 26.66 | 31.76 | 32.24 | 230.11 | 64.02 | 402.78 | 262.69 |
| 6/28/2003 | 2.07 | 6.39 | na | 14.51 | 11.30 | 20.30 | 69.63 | 32.42 | 305.93 | 92.01 |
| 6/29/2003 | 2.03 | 5.25 | na | 10.40 | 7.90 | 14.87 | 39.14 | 19.90 | 174.33 | 31.52 |
| 6/30/2003 | 1.81 | 3.87 | na | 7.65 | 6.77 | 11.80 | 18.22 | 13.70 | 79.11 | 27.33 |
| 7/1/2003 | 1.65 | 3.35 | na | 5.86 | 6.29 | 10.03 | 8.65 | 10.52 | 46.10 | 18.25 |
| 7/2/2003 | 1.71 | 3.07 | na | 4.63 | 6.07 | 12.26 | 4.67 | 14.59 | 28.51 | 10.52 |
| 7/3/2003 | 1.74 | 2.95 | na | 3.80 | 5.38 | 11.12 | 2.38 | 12.44 | 20.07 | 10.52 |
| 7/4/2003 | 3.63 | 6.07 | na | 8.95 | 5.03 | 17.19 | 0.88 | 25.03 | 16.29 | 8.39 |
| 7/5/2003 | 2.74 | 4.41 | na | 7.13 | 8.61 | 15.26 | 2.26 | 20.74 | 20.50 | 8.24 |
| 7/6/2003 | 2.90 | 4.10 | na | 6.32 | 8.09 | 14.34 | 2.02 | 18.79 | 18.67 | 8.54 |
| 7/7/2003 | 2.40 | 3.12 | na | 5.15 | 6.73 | 12.93 | 1.16 | 15.91 | 16.07 | 8.39 |
| 7/8/2003 | 27.70 | 44.95 | na | 61.85 | 85.49 | 57.83 | 13.23 | 138.38 | 227.78 | 692.63 |
| 7/9/2003 | 4.55 | 18.13 | na | 75.82 | 37.42 | 68.21 | 83.45 | 168.84 | 263.01 | 336.96 |
| 7/10/2003 | 2.27 | 5.36 | na | 19.53 | 10.36 | 26.55 | 57.15 | 48.44 | 53.31 | 168.61 |
| 7/11/2003 | 1.84 | 3.09 | na | 9.35 | 6.70 | 17.59 | 24.64 | 25.95 | 25.67 | 42.29 |
| 7/12/2003 | 1.62 | 2.34 | na | 6.16 | 6.20 | 14.16 | 10.96 | 18.41 | 18.32 | 11.07 |
| 7/13/2003 | 1.47 | 1.73 | na | 4.89 | 5.20 | 12.59 | 5.16 | 15.24 | 15.48 | 6.35 |
| 7/14/2003 | 1.53 | 1.75 | na | 3.91 | 5.25 | 11.28 | 4.05 | 12.73 | 13.33 | 6.22 |
| 7/15/2003 | 1.53 | 2.04 | na | 3.28 | 5.81 | 10.33 | 4.05 | 11.04 | 11.91 | 6.35 |
| 7/16/2003 | 1.53 | 1.75 | na | 2.81 | 5.25 | 12.31 | 4.05 | 9.74 | 10.84 | 6.59 |
| 7/17/2003 | 1.53 | 1.67 | na | 2.55 | 5.08 | 9.39 | 4.05 | 9.02 | 10.25 | 6.85 |
| 7/18/2003 | 1.44 | 1.64 | na | 2.38 | 5.03 | 5.35 | 4.05 | 8.55 | 9.87 | 7.11 |
| 7/19/2003 | 1.39 | 1.53 | na | 2.31 | 4.81 | 5.01 | 4.05 | 8.32 | 9.69 | 7.38 |
| 7/20/2003 | 1.31 | 1.32 | na | 2.08 | 4.37 | 4.63 | 4.05 | 7.67 | 9.16 | 7.66 |
| 7/21/2003 | 1.42 | 1.15 | na | 1.87 | 3.98 | 4.22 | 4.05 | 7.04 | 8.66 | 7.95 |
| 7/22/2003 | 1.56 | 1.48 | na | 1.94 | 4.70 | 3.82 | 4.05 | 7.25 | 8.82 | 5.99 |
| 7/23/2003 | 1.37 | 1.45 | na | 1.87 | 4.64 | 3.72 | 4.05 | 7.04 | 8.66 | 5.87 |
| 7/24/2003 | 1.24 | 1.43 | na | 1.68 | 4.59 | 3.72 | 4.05 | 6.70 | 8.38 | 5.42 |
| 7/25/2003 | 1.24 | 1.43 | na | 1.50 | 4.59 | 3.63 | 4.05 | 5.50 | 7.42 | 5.31 |
| 7/26/2003 | 1.17 | 1.15 | na | 1.44 | 3.98 | 3.39 | 4.05 | 5.34 | 7.29 | 5.31 |
| 7/27/2003 | 1.11 | 1.08 | na | 1.39 | 3.81 | 3.12 | 4.05 | 5.50 | 7.42 | 5.21 |
| 7/28/2003 | 1.27 | 1.45 | na | 1.39 | 4.64 | 3.08 | 4.05 | 5.66 | 7.55 | 5.21 |
| 7/29/2003 | 1.15 | 1.40 | na | 1.39 | 4.53 | 3.08 | 4.05 | 5.03 | 7.04 | 5.21 |
| 7/30/2003 | 1.22 | 1.35 | na | 1.39 | 4.42 | 3.08 | 4.05 | 5.18 | 7.16 | 5.21 |
| 7/31/2003 | 1.27 | 1.35 | na | 1.44 | 4.42 | 3.08 | 3.60 | 5.18 | 7.16 | 5.10 |
| 8/1/2003 | 1.27 | 1.10 | na | 1.33 | 3.87 | 2.95 | 3.31 | 5.18 | 7.16 | 5.10 |
| 8/2/2003 | 1.25 | 0.96 | na | 1.23 | 3.54 | 2.86 | 3.46 | 5.03 | 7.04 | 5.10 |
| 8/3/2003 | 1.29 | 1.20 | na | 1.18 | 4.09 | 2.77 | 3.60 | 5.03 | 7.04 | 5.10 |
| 8/4/2003 | 1.33 | 1.43 | na | 1.13 | 4.59 | 3.49 | 6.19 | 5.34 | 7.29 | 5.10 |
| 8/5/2003 | 1.63 | 3.00 | na | 1.09 | 6.60 | 7.76 | 8.06 | 5.34 | 7.29 | 5.21 |

| Date | TRC01 | TRC02 | TRC02 (estimate) | TRC03 | TRC04 | TRC05 | TRC07 | TRC10 | TRC11 | TRC12 |
|---|---|---|---|---|---|---|---|---|---|---|
| 8/6/2003 | 1.72 | 3.40 | na | 1.94 | 7.06 | 4.96 | 4.51 | 8.68 | 9.98 | 5.10 |
| 8/7/2003 | 1.37 | 1.73 | na | 5.02 | 5.20 | 3.53 | 2.77 | 5.99 | 7.82 | 5.10 |
| 8/8/2003 | 1.29 | 1.20 | na | 2.08 | 4.09 | 3.30 | 2.13 | 5.18 | 7.16 | 5.10 |
| 8/9/2003 | 1.25 | 0.96 | na | 1.28 | 3.54 | 3.39 | 2.90 | 5.18 | 7.16 | 5.21 |
| 8/10/2003 | 1.23 | 0.89 | na | 1.18 | 3.37 | 3.63 | 2.63 | 4.34 | 6.48 | 5.10 |
| 8/11/2003 | 1.03 | 0.85 | na | 1.23 | 3.26 | 3.44 | 2.13 | 3.90 | 6.12 | 5.21 |
| 8/12/2003 | 0.95 | 1.08 | na | 1.13 | 3.81 | 3.44 | 2.13 | 3.90 | 6.12 | 5.31 |
| 8/13/2003 | 0.95 | 1.08 | na | 1.09 | 3.81 | 3.39 | 2.13 | 3.79 | 6.03 | 5.42 |
| 8/14/2003 | 0.92 | 1.08 | na | 1.04 | 3.81 | 3.35 | 2.13 | 3.69 | 5.94 | 5.64 |
| 8/15/2003 | 1.27 | 1.08 | na | 1.00 | 1.19 | 3.39 | 2.13 | 3.79 | 2.92 | 5.42 |
| 8/16/2003 | 1.31 | 1.32 | na | 0.92 | 1.18 | 3.21 | 2.13 | 3.38 | 2.95 | 5.31 |
| 8/17/2003 | 1.29 | 1.22 | na | 0.96 | 1.25 | 3.30 | 2.63 | 3.58 | 2.89 | 5.31 |
| 8/18/2003 | 1.23 | 0.89 | na | 0.92 | 1.32 | 3.49 | 1.90 | 4.01 | 2.99 | 5.31 |
| 8/19/2003 | 1.23 | 0.85 | na | 0.88 | 1.36 | 3.39 | 3.60 | 3.79 | 2.78 | 5.42 |
| 8/20/2003 | 1.35 | 1.59 | na | 1.44 | 2.27 | 5.12 | 9.89 | 7.98 | 2.90 | 5.31 |
| 8/21/2003 | 1.35 | 1.59 | na | 1.33 | 2.08 | 3.87 | 1.67 | 4.92 | 2.94 | 5.42 |
| 8/22/2003 | 1.30 | 1.27 | na | 1.23 | 1.83 | 3.72 | 1.67 | 4.57 | 4.24 | 5.31 |
| 8/23/2003 | 1.24 | 0.94 | na | 1.04 | 1.60 | 3.72 | 1.26 | 4.57 | 3.13 | 5.31 |
| 8/24/2003 | 1.24 | 0.94 | na | 1.09 | 1.71 | 3.72 | 1.36 | 4.57 | 2.76 | 5.31 |
| 8/25/2003 | 0.84 | 0.96 | na | 1.04 | 1.85 | 3.72 | 1.36 | 4.57 | 2.77 | 5.31 |
| 8/26/2003 | 0.87 | 0.94 | na | 1.00 | 2.02 | 3.72 | 1.36 | 0.93 | 2.73 | 5.31 |
| 8/27/2003 | 0.82 | 0.89 | na | 1.09 | 1.99 | 3.72 | 1.78 | 0.93 | 2.71 | 5.42 |
| 8/28/2003 | 0.84 | 0.76 | na | 0.96 | 1.97 | 3.72 | 2.13 | 0.78 | 2.94 | 5.31 |
| 8/29/2003 | 0.82 | 0.76 | na | 0.96 | 1.90 | 3.72 | 1.46 | 0.73 | 2.99 | 5.31 |
| 8/30/2003 | 0.82 | 0.76 | na | 1.04 | 1.99 | 3.72 | 0.72 | 0.73 | 2.79 | 5.42 |
| 8/31/2003 | 0.84 | 0.76 | na | 1.13 | 2.11 | 3.72 | 0.72 | 0.65 | 2.68 | 5.53 |
| 9/1/2003 | 0.82 | 0.76 | na | 1.09 | 2.18 | 3.77 | 0.72 | 0.69 | 2.53 | 5.42 |
| 9/2/2003 | 0.84 | 0.76 | na | 1.04 | 2.21 | 4.12 | 0.72 | 0.69 | 2.50 | 5.42 |
| 9/3/2003 | 0.81 | 0.76 | na | 0.96 | 2.14 | 4.02 | 0.72 | 0.73 | 2.41 | 5.64 |
| 9/4/2003 | 0.82 | 0.76 | na | 1.00 | 1.98 | 4.07 | 0.72 | 0.57 | 2.33 | 5.42 |
| 9/5/2003 | 0.81 | 0.61 | na | 1.04 | 1.97 | 3.82 | 0.72 | 0.57 | 2.14 | 5.42 |
| 9/6/2003 | 0.81 | 0.53 | na | 0.96 | 1.92 | 3.72 | 0.72 | 0.65 | 2.10 | 5.31 |
| 9/7/2003 | 0.81 | 0.53 | na | 0.96 | 1.87 | 3.72 | 0.88 | 0.83 | 2.19 | 5.53 |
| 9/8/2003 | 0.81 | 0.53 | na | 0.96 | 1.91 | 3.72 | 1.78 | 0.93 | 2.28 | 5.64 |
| 9/9/2003 | 0.87 | 0.64 | na | 1.09 | 1.75 | 8.69 | 27.34 | 1.27 | 2.24 | 5.76 |
| 9/10/2003 | 10.03 | 10.88 | na | 37.02 | 6.69 | 14.99 | 59.17 | 13.70 | 4.49 | 13.67 |
| 9/11/2003 | 1.53 | 4.70 | na | 11.75 | 16.43 | 16.39 | 38.79 | 56.59 | 36.83 | 113.12 |
| 9/12/2003 | 1.27 | 2.33 | na | 3.69 | 6.17 | 16.39 | 26.73 | 26.77 | 59.38 | 77.82 |
| 9/13/2003 | 1.05 | 1.14 | na | 1.74 | 3.83 | 16.39 | 15.16 | 15.50 | 29.32 | 31.52 |
| 9/14/2003 | 0.99 | 0.88 | na | 1.39 | 3.03 | 15.34 | 9.89 | 7.85 | 17.55 | 19.91 |
| 9/15/2003 | 0.95 | 0.80 | na | 1.28 | 2.77 | 11.38 | 7.10 | 4.45 | 10.18 | 12.02 |
| 9/16/2003 | 0.90 | 0.76 | na | 1.23 | 2.57 | 8.92 | 5.50 | 3.18 | 6.76 | 8.09 |
| 9/17/2003 | 0.94 | 0.76 | na | 1.23 | 2.44 | 7.52 | 6.02 | 2.55 | 4.83 | 5.64 |
| 9/18/2003 | 1.34 | 0.76 | na | 1.23 | 2.63 | 7.99 | 6.55 | 2.55 | 4.24 | 5.53 |
| 9/19/2003 | 1.15 | 0.72 | na | 1.18 | 3.12 | 8.57 | 6.92 | 2.75 | 4.24 | 6.22 |
| 9/20/2003 | 0.97 | 1.01 | na | 1.56 | 3.16 | 8.11 | 7.29 | 2.85 | 4.00 | 6.35 |
| 9/21/2003 | 1.07 | 0.92 | na | 1.44 | 2.95 | 7.41 | 6.19 | 2.65 | 4.35 | 6.22 |
| 9/22/2003 | 1.07 | 0.80 | na | 1.28 | 2.97 | 5.40 | 5.84 | 2.65 | 4.04 | 7.80 |
| 9/23/2003 | 1.07 | 0.88 | na | 1.39 | 2.81 | 5.12 | 3.90 | 2.75 | 3.94 | 8.69 |
| 9/24/2003 | 1.01 | 0.72 | na | 1.18 | 2.63 | 4.87 | 4.05 | 2.09 | 4.14 | 9.49 |
| 9/25/2003 | 0.97 | 0.72 | na | 1.18 | 2.40 | 4.63 | 4.05 | 1.46 | 3.37 | 2.68 |

# 9.0 APPENDIX D – QUALITY ASSURANCE QUALITY CONTROL DATA

## Blank Samples Collected during the Project

| StationID | StartDate | StartTime | QAQC | Fecal Coliform | E Coli | Total Solids | Total Susp_Sol | Total Vol_SS | Ammonia | Nitrate +Nitrite | TKN | Total P | Total_Diss_P |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TRC06 | 12/12/2001 | 1:00:00 PM | BLANK | | | | <1 | | | | | | |
| TRC12 | 3/27/2002 | 2:45:00 PM | BLANK | <2 | <1 | <7 | <1 | <1 | <0.02 | <0.1 | <0.32 | <0.002 | 0.008 |
| TRC12 | 4/17/2002 | 1:45:00 PM | BLANK | <2 | <1 | 6 | <1 | <1 | <0.02 | <0.1 | <0.32 | <0.002 | 0.002 |
| TRC12 | 5/1/2002 | 12:11:00 PM | BLANK | <10 | <1 | <7 | <1 | <1 | <0.02 | <0.1 | <0.32 | 0.002 | 0.002 |
| TRC12 | 5/29/2002 | 2:10:00 PM | BLANK | <10 | <1 | <6 | <1 | <1 | <.02 | <.1 | <.32 | 0.003 | 0.004 |
| TRC12 | 6/26/2002 | 1:45:00 PM | BLANK | <10 | <1 | <7 | <1 | <1 | <.02 | <.1 | <.32 | 0.002 | 0.004 |
| TRC12 | 7/10/2002 | 2:00:00 PM | BLANK | <10 | <1 | <7 | <1 | <1 | <.02 | <.1 | <.32 | 0.004 | 0.007 |
| TRC12 | 7/31/2002 | 12:55:00 PM | BLANK | <10 | <1 | 8 | <1 | <1 | 0.03 | <.1 | <.32 | <.002 | 0.002 |
| TRC12 | 8/5/2002 | 1:00:00 PM | BLANK | <10 | <1 | 13 | <1 | <1 | 0.04 | <.1 | <.32 | 0.002 | 0.004 |
| TRC12 | 8/21/2002 | 3:15:00 PM | BLANK | <2 | <1 | <7 | <1 | <1 | <.02 | <.1 | <.32 | 0.004 | 0.004 |
| TRC09 | 3/20/2003 | 1:15:00 PM | BLANK | <10 | <1 | <7 | <1 | <1 | <0.02 | <0.1 | <0.11 | <0.002 | 0.004 |
| TRC07 | 9/11/2003 | 4:30:00 PM | BLANK | | | 9 | <1 | <1 | 0.07 | <0.1 | <0.11 | 0.005 | 0.003 |
| TRC11 | 10/2/2003 | 12:45:00 PM | BLANK | <10 | <1 | <7 | <1 | <1 | <0.02 | <0.1 | <0.11 | 0.002 | <0.002 |

Duplicate Samples Collected during the Project.

| StationID | StartDate | ActivityClass | Fecal Coliform | E Coli | Total Solids | Total Diss_Sol | Total Susp_Sol | Total Vol_SS | Temp | pH | Amm | Nitrate +Nitrite | TKN | ON | TN | Total P | Total Diss_P | SpCond | DO Conc |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TRC01 | 8/5/2002 | GRAB | 600 | 387 | 2078 | 2055 | 23 | 8 | 20.96 | 7.64 | 0.06 | 0.4 | 0.99 | 0.93 | 1.39 | 0.293 | | 2052 | 4.01 |
| TRC01 | 8/5/2002 | REPLICATE GRAB | 520 | 548 | 2093 | 2073 | 20 | 6 | 20.96 | 7.64 | 0.06 | 0.4 | 0.67 | 0.61 | 1.07 | 0.306 | | 2052 | 4.01 |
| **Industrical Statistic Abs((a-b)/(a+b))** | | | **7.14%** | **17.22%** | **0.36%** | **0.44%** | **6.98%** | **14.29%** | **0.00%** | **0.00%** | **0.00%** | **0.00%** | **19.28%** | **20.78%** | **13.01%** | **2.17%** | | **0.00%** | **0.00%** |
| TRC02 | 8/21/2002 | GRAB | 3600 | >2420 | 1207 | 1163 | 44 | 9 | 20.46 | 7.98 | 0.07 | 0.5 | 0.32 | 0.25 | 0.82 | 0.235 | 0.138 | 1284 | 7.73 |
| TRC02 | 8/21/2002 | REPLICATE GRAB | | | 1214 | 1167 | 47 | 9 | 20.46 | 7.98 | 0.08 | 0.5 | 0.46 | 0.38 | 0.96 | 0.299 | 0.135 | 1284 | 7.73 |
| **Industrical Statistic Abs((a-b)/(a+b))** | | | | | **0.29%** | **0.17%** | **3.30%** | **0.00%** | **0.00%** | **0.00%** | **6.67%** | **0.00%** | **17.95%** | **20.63%** | **7.87%** | **11.99%** | **1.10%** | **0.00%** | **0.00%** |
| TRC04 | 5/1/2002 | GRAB | 110 | 325 | 2163 | 2142 | 21 | 6 | 14.40 | 8.14 | 0.02 | 0.4 | 0.58 | 0.56 | 0.98 | 0.065 | 0.032 | 1997 | 11.48 |
| TRC04 | 5/1/2002 | REPLICATE GRAB | 100 | 261 | 2174 | 2152 | 22 | 7 | 14.14 | 8.14 | 0.02 | 0.4 | 0.77 | 0.75 | 1.17 | 0.079 | 0.03 | 1997 | 11.48 |
| **Industrical Statistic Abs((a-b)/(a+b))** | | | **4.76%** | **10.92%** | **0.25%** | **0.23%** | **2.33%** | **7.69%** | **0.91%** | **0.00%** | **0.00%** | **0.00%** | **14.07%** | **14.50%** | **8.84%** | **9.72%** | **3.23%** | **0.00%** | **0.00%** |
| TRC06 | 5/29/2002 | GRAB | 470 | 214 | 2078 | 2039 | 39 | 12 | 23.89 | 7.78 | 0.04 | 0.1 | 0.81 | 0.77 | 0.91 | 0.116 | 0.026 | 2118 | |
| TRC06 | 5/29/2002 | REPLICATE GRAB | 310 | 649 | 2076 | 2049 | 27 | 7 | 24.11 | 8.14 | 0.02 | 0.4 | 0.75 | 0.73 | 1.15 | 0.102 | 0.038 | 2125 | |
| **Industrical Statistic Abs((a-b)/(a+b))** | | | **20.51%** | **50.41%** | **0.05%** | **0.24%** | **18.18%** | **26.32%** | **0.46%** | **2.26%** | **33.33%** | **60.00%** | **3.85%** | **2.67%** | **11.65%** | **6.42%** | **18.75%** | **0.16%** | |
| TRC07 | 6/26/2002 | GRAB | 40 | 4.1 | 1937 | 1839 | 98 | 40 | 28.61 | 8.31 | 0.02 | 0.1 | 1.83 | 1.81 | 1.93 | 0.223 | 0.028 | 1756 | 11.22 |
| TRC07 | 6/26/2002 | REPLICATE GRAB | 40 | 1 | 1975 | 1883 | 92 | 32 | 28.61 | 8.31 | 0.02 | 0.1 | 1.89 | 1.87 | 1.99 | 0.225 | 0.027 | 1756 | 11.22 |
| **Industrical Statistic Abs((a-b)/(a+b))** | | | **0.00%** | **60.78%** | **0.97%** | **1.18%** | **3.16%** | **11.11%** | **0.00%** | **0.00%** | **0.00%** | **0.00%** | **1.61%** | **1.63%** | **1.53%** | **0.45%** | **1.82%** | **0.00%** | **0.00%** |
| TRC11 | 7/31/2002 | GRAB | 600 | 29.6 | 1844 | 1696 | 148 | 52 | 27.10 | 8.33 | 0.02 | 0.1 | 2.53 | 2.51 | 2.63 | 0.803 | 0.062 | 1761 | 11.5 |
| TRC11 | 7/31/2002 | REPLICATE GRAB | 430 | 29.2 | 1975 | 1687 | 288 | 68 | 27.10 | 8.33 | 0.02 | 0.1 | 2.85 | 2.83 | 2.95 | 0.752 | 0.063 | 1761 | 11.5 |
| **Industrical Statistic Abs((a-b)/(a+b))** | | | **16.50%** | **0.68%** | **3.43%** | **0.27%** | **32.11%** | **13.33%** | **0.00%** | **0.00%** | **0.00%** | **0.00%** | **5.95%** | **5.99%** | **5.73%** | **3.28%** | **0.80%** | **0.00%** | **0.00%** |
| TRC12 | 3/27/2002 | GRAB | 10 | 6.1 | 1711 | 1696 | 15 | 4 | 3.28 | 8.27 | 0.02 | 0.1 | 0.84 | 0.82 | 0.94 | 0.127 | 0.043 | 1868 | 10.35 |
| TRC12 | 3/27/2002 | REPLICATE GRAB | 10 | 4.1 | 1701 | 1687 | 14 | 4 | 3.28 | 8.27 | 0.02 | 0.1 | 0.89 | 0.87 | 0.99 | 0.138 | 0.04 | 1868 | 10.35 |
| **Industrical Statistic Abs((a-b)/(a+b))** | | | **0.00%** | **19.61%** | **0.29%** | **0.27%** | **3.45%** | **0.00%** | **0.00%** | **0.00%** | **0.00%** | **0.00%** | **2.89%** | **2.96%** | **2.59%** | **4.15%** | **3.61%** | **0.00%** | **0.00%** |
| TRC12 | 7/10/2002 | GRAB | 2100 | 397 | 1774 | 1646 | 128 | 40 | 29.99 | 8.67 | 0.02 | 0.1 | 2.14 | 2.12 | 2.24 | 0.682 | 0.082 | 1630 | 13.09 |
| TRC12 | 7/10/2002 | REPLICATE GRAB | 860 | 64.2 | 1782 | 1642 | 140 | 44 | 29.99 | 8.67 | 0.02 | 0.1 | 2.38 | 2.36 | 2.48 | 0.706 | 0.08 | 1630 | 13.09 |
| **Industrical Statistic Abs((a-b)/(a+b))** | | | **41.89%** | **72.16%** | **0.22%** | **0.12%** | **4.48%** | **4.76%** | **0.00%** | **0.00%** | **0.00%** | **0.00%** | **5.31%** | **5.36%** | **5.08%** | **1.73%** | **1.23%** | **0.00%** | **0.00%** |
| TRC12 | 3/20/2003 | GRAB | 10 | 11 | 819 | 803 | 16 | 8 | | | 0.92 | 0.5 | 2.16 | 1.24 | 2.66 | 0.436 | 0.288 | | |
| TRC12 | 3/20/2003 | REPLICATE GRAB | 10 | 15.8 | 835 | 813 | 22 | 5 | | | 0.84 | 0.5 | 2.3 | 1.46 | 2.8 | 0.435 | 0.382 | | |
| **Industrical Statistic Abs((a-b)/(a+b))** | | | **0.00%** | **17.91%** | **0.97%** | **0.62%** | **15.79%** | **23.08%** | | | **4.55%** | **0.00%** | **3.14%** | **8.15%** | **2.56%** | **0.11%** | **14.03%** | | |
| TRC12 | 10/2/2003 | GRAB | 570 | 488 | 2078 | 1987 | 91 | 12 | | | 0.02 | 0.1 | 1.18 | 1.16 | 1.28 | 0.295 | 0.042 | | |
| TRC12 | 10/2/2003 | REPLICATE GRAB | 540 | 517 | 2020 | 1987 | 33 | 11 | 10.12 | 7.92 | 0.02 | 0.1 | 1.03 | 1.01 | 1.13 | 0.201 | 0.05 | 1995 | 16.91 |
| **Industrical Statistic Abs((a-b)/(a+b))** | | | **2.70%** | **2.89%** | **1.42%** | **0.00%** | **46.77%** | **4.35%** | | | **0.00%** | **0.00%** | **6.79%** | **6.91%** | **6.22%** | **18.95%** | **8.70%** | | |

# 10.0 APPENDIX E – USEPA BACTERIAL INDICATOR TOOL MANUAL

United States Environmental Protection Agency
Office of Water 4305
EPA-823-B-01-003
March 2000

# Bacterial Indicator Tool

## User's Guide

**Bacterial Indicator Tool**
**User's Guide**
**March 31, 2000**

INTRODUCTION

The Bacterial Indicator Tool is a spreadsheet that estimates the bacteria contribution from multiple sources. Currently, the tool is enabled for fecal coliform. However, the tool could be adapted for other bacterial indicators, such as *E. coli*, if the necessary bacteria production information is available. Output from the tool is used as input to WinHSPF and the Hydrological Simulation Program Fortran (HSPF) water quality model within BASINS. The tool estimates the monthly accumulation rate of fecal coliform bacteria on four land uses (cropland, forest, built-up, and pastureland), as well as the asymptotic limit for that accumulation should no washoff occur. The tool also estimates the direct input of fecal coliform bacteria to streams from grazing agricultural animals and failing septic systems. The Bacterial Indicator Tool was developed to provide starting values for model input, however a thorough calibration of the model is still recommended.

The Bacterial Indicator Tool is based on a modeling study of 10 subwatersheds, composed of four land uses (cropland, forest, built-up, and pastureland). BLUE text found throughout the spreadsheet presents valuable information and assumptions. RED text designates values that should be specified by the user. BLACK text usually presents information that is calculated by the spreadsheet or that should not be changed. The tool contains the following worksheets:

| Worksheet Name | Purpose |
|---|---|
| Land Use | Lists the distributions of built-up land, forestland, cropland, and pastureland in up to 10 subwatersheds. |
| Animals | Lists the number of agricultural animals in each subwatershed (beef cattle, dairy cattle, swine, chickens, horses, sheep, and other [user-defined]), and the densities of wildlife by land use category (ducks, geese, deer, beaver, raccoons, and other [user-defined]). |
| Manure Application | Calculates the fraction of the annual manure produced that is available for washoff based on the amount applied to cropland and pastureland in each month and the fraction of manure incorporated into the soil (for hog, beef cattle, dairy cattle, horse, and poultry manure). |
| Grazing | Lists the days spent confined and grazing for beef cattle, horses, sheep, and other. Beef cattle are assumed to have access to streams while grazing. |
| References | Lists literature and assumed values for manure content, wildlife densities, and built-up fecal coliform accumulation rates. These values are used in calculations in the remaining worksheets. |

| Worksheet Name | Purpose |
|---|---|
| Wildlife | Calculates the fecal coliform bacteria produced by wildlife by land use category. |
| Cropland | Calculates the monthly rate of accumulation of fecal coliform bacteria on cropland from wildlife, hog, cattle, and poultry manure. |
| Forest | Calculates the rate of accumulation of fecal coliform bacteria on forestland from wildlife. |
| Built-up | Calculates the rate of accumulation of fecal coliform bacteria on built-up land using literature values. |
| Pastureland | Calculates the monthly rate of accumulation of fecal coliform bacteria on pastureland from wildlife, cattle, and horse manure, and cattle, horse, sheep, and other grazing. |
| Cattle in Streams | Calculates the monthly loading and flow rate of fecal coliform bacteria contributed directly to the stream by beef cattle. |
| Septics | Calculates the monthly loading and flow rate of fecal coliform bacteria from failing septic systems. |
| ACQOP&SQOLIM (for land uses) | Summarizes the monthly rate of accumulation of fecal coliform bacteria on the four land uses; calculates the build-up limit for each land use. Provides input paramters for HSPF (ACQOP/MON-ACCUM and SQOLIM/MON-SQOLIM). |

The following information must be input by the user:

- Land use distribution for each subwatershed (built-up, forest, cropland, and pastureland, including, to the extent possible, the breakout of built-up land into commercial and services, mixed urban or built-up, residential, and transportation/communications/utilities).
- Agricultural animals in each subwatershed
- Wildlife densities for forest, cropland, and pastureland in the study area (built-up land is assumed not to have wildlife)
- Number of septic systems in the study area
- Number of people served by septic systems in the study area
- Failure rate of septic systems in the study area

Default values are supplied for the following inputs, but they should be modified to reflect patterns in the study watershed:

- Fraction of each manure type that is applied each month
- Fraction of each manure type that is incorporated into the soil
- Time spent grazing and confined by agricultural animals (and in stream for beef cattle only)

Literature values are supplied for the following inputs, but they may be replaced with user values if better information is available for the study watershed:

- Animal waste production rates and fecal coliform bacteria content
- Fecal coliform bacteria accumulation rates for built-up land uses
- Raw sewage fecal coliform bacteria content and per capita waste production

The remainder of this document describes the purpose and use of each worksheet within the Bacterial Indicator Tool, as well as the input required by the user (if any). The symbol "**U**" indicates that user input is required in the sheet being described; the symbol " - " indicates that no input is needed.

## LAND USE

| **U** | User Input Required |
|---|---|

The modeled land uses are derived from the original land uses by reassigning the original categories to the corresponding model categories. Only four categories are considered in this tool: Cropland, Forest, Built-up, and Pastureland. Reassign the categories in your existing land use database, and calculate the acres of each of the four model land use categories within each subwatershed. Enter the values in the appropriate cells on the Land Use sheet. Total acres by subwatershed and land use category will be calculated automatically.

## ANIMALS

| **U** | User Input Required |
|---|---|

Fecal contributions from the animals listed in this worksheet are used to derive loading estimates for all land uses except for built-up. Only manure from cattle, swine, and poultry is assumed to be collected and applied to cropland. Cattle manure is also assumed to be applied to pastureland. Horse manure is assumed to be collected and applied to pastureland only. Manure from cattle, horses, sheep and "other" agricultural animals is assumed to be contributed to pastureland in proportion to time spent grazing. Wildlife densities are provided for all land uses except built-up and are assumed to be the same in all subwatersheds. An "other" category is provided for both agricultural animals and wildlife to allow the user to include animals that are not already available in the tool.

In the absence of site-specific data, the number of agricultural animals present in each subwatershed can be determined using county-level data from the Census of Agriculture (http://www.nass.usda.gov/census/census97/highlights/ag-state.htm). The total number of agricultural animals can be estimated for each subwatershed based on a ratio of subwatershed-level pastureland to county-level pastureland area. For example, assume Subwatershed 1 is located entirely within County A and that County A contains 1000 acres of pastureland and 200 dairy cows. If Subwatershed 1 contains 100 acres of pastureland, this subwatershed is assigned [(200/1000)*100] = 20 dairy cows. Calculate the number of agricultural animals (dairy and beef cattle, swine, chickens, horses, sheep, and "other") in each subwatershed and enter these values in the appropriate cells on the Animals sheet. Totals by subwatershed and animal type will be calculated automatically.

The densities of wildlife are estimated based on the best available information. It is assumed that no wildlife are present on built-up land and that the densities of wildlife on each of the remaining land use types (forest, cropland and pastureland) are the same across all subwatersheds. Enter the density for each form of wildlife (ducks, geese, deer, beaver, raccoons, and "other") on each land use type in animals per square mile. The wildlife densities per acre will be calculated automatically.

## MANURE APPLICATION

| **U** | User Input Required |
|---|---|

This sheet contains information regarding the land application of waste produced by agricultural animals in the study area. Application of hog manure, cattle manure, horse manure, and poultry litter is considered. The information is presented based on the monthly variability of waste application. The annual production of manure is calculated and then applied each month using the information in this sheet. It is assumed that cattle manure is applied to both cropland and pastureland using the same method. Hog manure and poultry litter are assumed to be applied only to cropland. Horse manure is assumed to be applied only to pastureland.

For each of the four major manure sources (hogs, cattle, horses, and poultry), specify the fraction of the annual manure produced that is applied each month (January through December) and the fraction of the manure applied that is incorporated into the soil. The fraction of manure available for washoff each month for each type of manure will then be calculated automatically. Note that the equation used to calculate the fraction available for runoff can be updated if necessary.

## GRAZING

| **U** | User Input Required |
|---|---|

This sheet contains information relevant to cattle, horses, sheep, and "other" animals grazing in the study area. Dairy cattle are assumed to be kept only in feedlots. Therefore, all of their waste is used for manure application (divided between cropland and pastureland). Beef cattle are assumed to be kept in feedlots or allowed to graze (depending on the season). When they are grazing, a certain proportion is assumed to have direct access to streams. The grazing time spent in streams actually represents a combination of the number of animals with stream access and the percent of time these animals spend contributing waste directly to the streams. Beef cattle waste is therefore applied as manure to cropland and pastureland, contributed directly to pastureland, or contributed directly to streams (referred to by the tool as Cattle in Streams). Horses are assumed to be either kept in stables or allowed to graze. Horse waste is therefore either applied as manure to pastureland or contributed directly to pastureland; horse manure is not applied to cropland. Sheep are assumed to be allowed to graze year-round. Sheep waste is therefore contributed only directly to pastureland. The purpose of the “other” animal category is to allow you to define the grazing patterns of an agricultural animal not available in the default information. To use this category, you must be sure to enter the number of “other” animals in each subwatershed (on the Animals sheet) and to specify a fecal coliform bacteria production rate for this animal (on the References sheet). "Other" animal waste is contributed directly to pastureland only while grazing.

For cattle, horses, sheep, and “other,” enter the fraction of time spent confined each month (from 0, never confined, to 1, always confined). The fraction of time and the number of days per year spent grazing will be calculated automatically. For cattle, you should also specify the fraction of time grazing that is spent in streams. The fraction of time grazing spent in pasture will be calculated automatically.

## REFERENCES

| - | User Input Required |
|---|---|

The data from the References sheet are accessed in the remaining worksheets. Fecal coliform production rates for various animals are presented from several sources, and you may select the source you prefer or enter a value of your own in the “Best Professional Judgement” column. The spreadsheet is set up to use the ASAE values by default. If you prefer to use a different source, be sure to change the values in cells B9 through B23 on the References sheet. To use the “other” agricultural and wildlife animal categories, you must provide the number of “other” animals in each subwatershed (on the Animals sheet) and a fecal coliform bacteria production rate for this animal (on the References sheet). The References sheet also contains fecal coliform accumulation rates for five Built-up land use types. These numbers may also be changed if appropriate.

WILDLIFE

| - | User Input Required |
|---|---|

This sheet calculates the total fecal coliform bacteria produced by wildlife each day per acre of cropland, pastureland, and forest. This calculation is performed by multiplying the density (animals per acre) of each type of wildlife on each land use by the rate of fecal coliform production for that wildlife type (count per animal per day). The number of fecal coliform bacteria produced is then summed across all wildlife types for each land use to obtain a total wildlife fecal coliform production rate (count per acre per day), which will be used in subsequent sheets.

To use the “other” wildlife category, you must be sure to enter the number of “other” animals in each subwatershed (on the Animals sheet) and to specify a fecal coliform bacteria production rate for this animal (on the References sheet). No user input is required on the Wildlife sheet.

CROPLAND

| - | User Input Required |
|---|---|

This sheet calculates the total fecal coliform bacteria applied to each acre of cropland by month. The sources of fecal coliform bacteria for cropland are wildlife, hog manure application, cattle manure application, and poultry litter application. No user input is required on the cropland sheet. Chickens and hogs are assumed to be confined all of the time, and their manure is applied only to cropland. Dairy cattle are also assumed to be confined all of the time, and their manure is applied to both cropland and pastureland. Beef cattle are assumed to be either kept in feedlots or allowed to graze, depending on the season. When they are grazing, a certain proportion is assumed to have direct access to streams (as specified in the Grazing sheet.) Beef cattle manure is therefore either applied to cropland and pastureland, contributed directly to pastureland during grazing, or contributed directly to streams (referred to by the tool as Cattle in Streams.)

*Wildlife*
The fecal coliform bacteria produced by wildlife per acre of cropland is determined for each month as follows:

1. The total wildlife population of each subwatershed is calculated (acres of cropland from the Land Use sheet multiplied by the cropland wildlife density from the Wildlife sheet.)
2. The total daily fecal coliform bacteria load generated by that population is calculated (acres of cropland from the Land Use sheet multiplied by the fecal coliform generated per acre of cropland from the Wildlife sheet).

3. The daily per acre accumulation rate of fecal coliform bacteria from wildlife is calculated by dividing the total load generated by the number of acres of cropland in each subwatershed.

*Hog Manure*

The fecal coliform bacteria from hog manure applied per acre of cropland is determined for each month as follows:

1. The number of hogs in each subwatershed (from the Animals sheet) is multiplied by the daily fecal coliform production rate per hog (from the References sheet) to obtain the daily hog fecal coliform production rate.
2. The daily rate is then multiplied by 365 to obtain the amount of fecal coliform produced by hogs per year.
3. The fecal coliform bacteria available for washoff is then calculated by multiplying the annual fecal coliform produced by the amount applied and available for washoff in each subwatershed in each month (from the hog manure section of the Manure Application sheet).
4. The monthly total is then divided by the number of days in each month to obtain the daily accumulation rate.
5. Finally, the daily accumulation rate is divided by the number of acres of cropland in each subwatershed to obtain the daily per acre load of fecal coliform bacteria from hog manure.

*Cattle Manure*

The fecal coliform bacteria from cattle manure applied per acre of cropland is determined for each month as follows:

1. The number of dairy and beef cattle in each subwatershed (from the Animals sheet) is multiplied by the daily fecal coliform production rate per dairy and beef cow (from the References sheet) to obtain the daily dairy and beef cattle fecal coliform production rates.
2. The daily dairy fecal coliform production rate is then multiplied by 365 to obtain the amount of fecal coliform produced by dairy cattle and available for application as manure per year. The daily beef fecal coliform production rate is multiplied by 365 minus the days spent grazing (from the cattle section of the Grazing sheet) to obtain the amount of fecal coliform produced by beef cattle and available for application as manure per year. (The fecal coliform bacteria produced by beef cattle while grazing is assumed to be delivered directly to pastureland.) The total fecal coliform load from cattle manure application is the sum of the dairy and beef loads.
3. The fecal coliform bacteria available for washoff is then calculated by multiplying the annual fecal coliform produced by the amount applied and available for washoff in each subwatershed in each month (from the cattle manure section of the Manure Application sheet).
4. The monthly total is then divided by the number of days in each month to obtain the daily accumulation rate.

5. Finally, the daily accumulation rate is divided between cropland and pastureland and the portion applied to cropland is divided by the number of acres of cropland in each subwatershed to obtain the daily per acre load of fecal coliform bacteria from cattle manure.

*Poultry Litter*

The fecal content of the litter is considered here, despite the fact that litter is the combination of manure and bedding. As such, the fecal coliform bacteria produced by chickens and applied to cropland is estimated from the rate of manure production per chicken and the bacteria content of that manure, rather than from the bacteria content of the combined manure and bedding.

The fecal coliform bacteria from poultry litter applied per acre of cropland is determined for each month as follows:

1. The number of chickens in each subwatershed (from the Animals sheet) is multiplied by the daily fecal coliform production rate per chicken (from the References sheet) to obtain the daily poultry fecal coliform production rate.
2. The daily rate is then multiplied by 365 to obtain the amount of fecal coliform produced by chickens per year.
3. The fecal coliform bacteria available for washoff is then calculated by multiplying the annual fecal coliform produced by the amount applied and available for washoff in each subwatershed in each month (from the poultry litter section of the Manure Application sheet).
4. The monthly total is then divided by the number of days in each month to obtain the daily accumulation rate.
5. Finally, the daily accumulation rate is divided by the number of acres of cropland in each subwatershed to obtain the daily per acre load of fecal coliform bacteria from poultry litter.

The total accumulation rate of fecal coliform bacteria from cropland is calculated as the sum of the accumulation rates from wildlife and hog, cattle, and poultry manure applications.

FOREST

| | |
|---|---|
| - | User Input Required |

The wildlife population is the only fecal coliform contributor to forest considered. No user input is required on the Forest sheet. The fecal coliform bacteria produced by wildlife per acre of forest is determined for each month as follows:

1. The total wildlife population of each subwatershed is calculated (acres of forest from the Land Use sheet multiplied by the forest wildlife density from the Wildlife sheet).

2. The total daily fecal coliform bacteria load generated by that population is calculated (acres of forest from the Land Use sheet multiplied by the fecal coliform generated per acre of forest from the Wildlife sheet).
3. The daily per acre accumulation of fecal coliform bacteria from wildlife is calculated by dividing the total load generated by the number of acres of forest in each subwatershed.

BUILT-UP

| **U** | User Input Required |
|---|---|

Because of the lack of animal counts and other specific source information for built-up land, literature values are used. Built-up land is broken out into four categories:

- Commercial and Services
- Mixed Urban or Built-Up
- Residential
- Transportation, Communications and Utilities

1. The percentage breakout of these categories is specified by the user in the Built-up sheet. The acres of each built-up category in each subwatershed are calculated by multiplying the total built-up acres (from the Land Use sheet) by the percentage breakouts specified by the user.
2. A daily per acre fecal coliform bacteria loading rate is calculated for each built-up category using literature values. The loading rates provided in Horner (1992) and presented in the References sheet are applied as follows:

| **Built-up category** | **Fecal coliform loading rate (count per acre per day)** |
|---|---|
| Commercial and Services | Commercial |
| Mixed Urban or Built-Up | Average of road, commercial, single-family low-density, single-family high-density, and multifamily residential |
| Residential | Average of single-family low-density, single-family high-density, and multifamily residential |
| Transportation, Communications and Utilities | Road |

3. A weighted average built-up fecal coliform bacteria accumulation rate is calculated for each subwatershed based on the individual built-up land use categories present and their corresponding accumulation rates.

PASTURELAND

| - | User Input Required |
|---|---|

This sheet calculates the total fecal coliform bacteria applied to each acre of pastureland by month. The sources of fecal coliform bacteria for pastureland are wildlife, cattle and horse manure application, and beef cattle, horse, sheep, and other grazing. No user input is required on the Pastureland sheet. It is assumed that dairy cattle are confined all of the time and their manure is applied to both cropland and pastureland. Beef cattle are assumed to be kept in feedlots or allowed to graze, depending on the season. When they are grazing, a certain proportion of the cattle is assumed to have direct access to streams (as specified on the Grazing sheet.) Beef cattle manure is therefore applied to cropland and pastureland, contributed directly to pastureland during grazing, or contributed directly to streams (referred to by the tool as Cattle in Streams.) Horse manure that is not deposited in pastureland during grazing is assumed to be collected and applied to pastureland. Sheep and "other" animal manure that is not deposited in pastureland during grazing is assumed to be collected and treated or transported out of the watershed and is tabulated in the last column of the Pastureland sheet (FC collected).

*Wildlife*

The fecal coliform bacteria produced by wildlife per acre of pastureland is determined for each month as follows:

1. The total wildlife population of each subwatershed is calculated (acres of pastureland from the Land Use sheet multiplied by the pastureland wildlife density from the Wildlife sheet).
2. The total daily fecal coliform bacteria load generated by that population is calculated (acres of pastureland from the Land Use sheet multiplied by the fecal coliform generated per acre of pastureland from the Wildlife sheet).
3. The daily per acre accumulation rate of fecal coliform bacteria from wildlife is calculated by dividing the total load generated by the number of acres of pastureland in each subwatershed.

*Cattle Manure*

The fecal coliform bacteria from cattle manure applied per acre of pastureland is determined for each month as follows:

1. The number of dairy and beef cattle in each subwatershed (from the Animals sheet) is multiplied by the daily fecal coliform production rate per dairy and beef cow (from the References sheet) to obtain the daily dairy and beef cattle fecal coliform production rates.
2. The daily dairy fecal coliform production rate is then multiplied by 365 days to obtain the annual amount of fecal coliform produced by dairy cattle and available for application as manure. The daily beef fecal coliform production rate is multiplied by 365 days minus the days spent grazing (from the cattle section of the Grazing sheet) to obtain the annual amount of fecal coliform produced by beef cattle and available for application as manure.

(The fecal coliform bacteria produced by beef cattle while grazing is assumed to be delivered directly to pastureland; see below.) The total fecal coliform load from cattle manure application is the sum of the dairy and beef loads.

3. The fecal coliform bacteria available for washoff is then calculated by multiplying the annual fecal coliform produced by the amount applied and available for washoff in each subwatershed in each month (from the cattle manure section of the Manure Application sheet).
4. The monthly total is then divided by the number of days in each month to obtain the daily accumulation rate.
5. Finally, the daily accumulation rate is divided between Cropland and Pastureland and the portion applied to Pastureland is divided by the number of acres of pastureland in each subwatershed to obtain the daily per acre accumulation of fecal coliform bacteria from cattle manure.

*Horse Manure*

The fecal coliform bacteria from horse manure applied per acre of pastureland is determined for each month as follows:

1. The number of horses in each subwatershed (from the Animals sheet) is multiplied by the daily fecal coliform production rate per horse (from the References sheet) to obtain the daily horse fecal coliform production rate.
2. The daily rate is then multiplied by 365 days minus the days spent grazing (from the horse section of the Grazing sheet) to obtain the amount of fecal coliform produced by horses and available for application as manure per year. (The fecal coliform bacteria produced by horses while grazing is assumed to be delivered directly to pastureland; see below.)
3. The fecal coliform bacteria available for washoff is then calculated by multiplying the annual fecal coliform produced by the amount applied and available for washoff in each subwatershed in each month (from the horse manure section of the Manure Application sheet).
4. The monthly total is then divided by the number of days in each month to obtain the daily accumulation rate.
5. Finally, the daily accumulation rate is divided by the number of acres of pastureland in each subwatershed to obtain the daily per acre accumulation of fecal coliform bacteria from the application of horse manure.

*Beef Cattle Grazing*

The fecal coliform bacteria from beef cattle manure deposited during grazing per acre of pastureland is determined for each month as follows:

1. The number of beef cattle grazing is calculated by multiplying the number of beef cattle per subwatershed (from the Animals sheet) by the fraction of time spent grazing (from the Grazing sheet).
2. The fecal coliform load delivered directly to pastureland is calculated by multiplying the number of cattle grazing by the fraction of time spent in pasture (as opposed to in

streams, from the Grazing sheet) and by the rate of fecal coliform bacteria production per beef cow (from the References sheet).

3. Finally, the daily grazing beef cattle fecal coliform production is divided by the number of acres of pastureland in each subwatershed to obtain the daily per acre accumulation rate of fecal coliform bacteria from beef cattle grazing.

*Horse Grazing*

The fecal coliform bacteria from horse manure deposited during grazing per acre of pastureland is determined for each month as follows:

1. The number of horses grazing is calculated by multiplying the number of horses per subwatershed (from the Animals sheet) by the fraction of time spent grazing (from the Grazing sheet).
2. The fecal coliform load delivered directly to Pastureland is calculated by multiplying the number of horses grazing by the rate of fecal coliform bacteria production per horse (from the References sheet).
3. The fecal coliform load in manure collected for application is calculated by subtracting the number of horses grazing from the total number of horses and multiplying by the rate of fecal coliform bacteria production per horse (from the References sheet).
4. Finally, the daily grazing horse fecal coliform production is divided by the number of acres of pastureland in each subwatershed to obtain the daily per acre accumulation rate of fecal coliform bacteria from horse grazing.

*Sheep Grazing*

The fecal coliform bacteria from sheep manure deposited during grazing per acre of pastureland is determined for each month as follows:

1. The number of sheep grazing is calculated by multiplying the number of sheep per subwatershed (from the Animals sheet) by the fraction of time spent grazing (from the Grazing sheet).
2. The fecal coliform load delivered directly to Pastureland is calculated by multiplying the number of sheep grazing by the rate of fecal coliform bacteria production per sheep (from the References sheet).
3. The fecal coliform load in manure collected for disposal is calculated by subtracting the number of sheep grazing from the total number of sheep and multiplying by the rate of fecal coliform bacteria production per sheep (from the References sheet).
4. Finally, the daily grazing sheep fecal coliform production is divided by the number of acres of pastureland in each subwatershed to obtain the daily per acre accumulation rate of fecal coliform bacteria from sheep grazing.

*Other Animal Grazing*

The purpose of the “other” animal category is to allow you to define an agricultural animal not available in the default information. To use this category, you must be sure to enter the number of “other” agricultural animals in each subwatershed (on the Animals sheet), to enter the time spent grazing (on the Grazing sheet), and to specify a fecal coliform bacteria production rate (on the References sheet). The fecal coliform bacteria from "other" animal manure deposited during grazing per acre of pastureland is determined for each month as follows:

1. The number of "other" animals grazing is calculated by multiplying the number of "other" animals per subwatershed (from the Animals sheet) by the fraction of time spent grazing (from the Grazing sheet).
2. The fecal coliform load delivered directly to pastureland is calculated by multiplying the number of "other" animals grazing by the rate of fecal coliform bacteria production per "other" animal (from the References sheet).
3. The fecal coliform load in manure collected for disposal is calculated by subtracting the number of "other" animals grazing from the total number of "other" animals and multiplying by the rate of fecal coliform bacteria production per "other" animal (from the References sheet).
4. Finally, the daily grazing "other" animal fecal coliform production is divided by the number of acres of pastureland in each subwatershed to obtain the daily per acre accumulation rate of fecal coliform bacteria from "other" animal grazing.

The total accumulation rate of fecal coliform bacteria from pastureland is calculated as the sum of the accumulation rates from wildlife, cattle and horse manure applications, and beef cattle, horse, sheep and "other" grazing.

CATTLE IN STREAMS

| - | User Input Required |
|---|---|

This sheet contains information related to the direct contribution of beef cattle fecal coliform bacteria to streams. This contribution can be represented as a point source in HSPF, which requires input of a flow rate (cubic feet per second, or cfs) and a fecal coliform bacteria loading rate (count per hour). No user input is required on this sheet. It is assumed that only beef cattle have access to streams when grazing. The fraction of grazing time spent in streams is specified on the Grazing sheet.

1. The number of beef cattle in streams is calculated by multiplying the total number of beef cattle (from the Animals sheet) by the fraction of time spent grazing and the fraction of grazing time spent in streams (from the Grazing sheet).
2. The fecal coliform bacteria loading rate (count/hr) is calculated by multiplying the number of beef cattle in streams by the fecal coliform production rate per beef cow (from the References sheet.)
3. The beef cattle waste flow rate is calculated by multiplying the number of cattle in streams by the waste production rate per beef cow (from the References sheet) and an assumed beef cattle waste density of 62.4 pounds per cubic foot.

SEPTICS

| U | User Input Required |
|---|---|

This sheet contains information related to the contribution of failing septic systems to streams. The direct contribution of fecal coliform from septics to a stream can be represented as a point source in the model, which requires input of a flow rate (cfs) and a fecal coliform bacteria loading rate (count/hr).

To estimate the contribution of fecal coliform bacteria from failing septic systems, the number of septic systems, the number of people served by septic systems, and the estimated rate of septic system failure in the study area must be entered. Population and septic tank data can be retrieved from the U.S. Census Bureau web site (http://venus.census.gov/cdrom/lookup). For example, county level populations and septic tank information can be retrieved from this web site as follows:

- Under “Choose a Database to Browse” select STF3A
- On the next screen, click on “Go to level State--County” and choose a State from the list below, and then click on “Submit.”
- On the next screen, choose “Retrieve the areas you've selected below” and select a county on the list, and submit.
- Select “Choose TABLES to retrieve” and submit.
- From the list of tables, select “P1” and “H24” and submit
- Select the format for the retrieval (e.g., HTML)
- The information displayed will include a county level summary of population and of housing units with public sewer, septic tank or cesspool, or other.

The estimated rate of septic system failure in the area of interest should be estimated based on local knowledge. From the preceding information, the average number of people served by each septic system, number of failing septic systems, and density of failing septic systems in the study area are calculated.

1. The number of failing septic systems in each subwatershed is calculated by multiplying the total area of each subwatershed (from the Land Use sheet) by the density of failing septic systems.
2. The number of people served by failing septic systems in each subwatershed is calculated by multiplying the number of failing septic systems by the average number of people served by each septic system.
3. The failing septic system flow rate is calculated by multiplying the number of people served by failing septic systems by an assumed daily waste flow of 70 gallons per person.
4. The fecal coliform bacteria loading rate from failing septic systems is calculated by multiplying the failing septic system flow rate by an assumed fecal coliform bacteria

concentration of 10,000 counts per 100 mL of waste flow. Note that any of the assumed values can be updated to represent more appropriate site-specific information.

ACQOP&SQOLIM (FOR LAND USES)

| - | User Input Required |
|---|---|

This sheet summarizes HSPF input parameter values calculated based on designations made throughout the spreadsheet. It contains values for model inputs ACQOP (or MON-ACCUM if monthly) and SQOLIM (or MON-SQOLIM if monthly). These parameters represent the rate of fecal coliform accumulation and the maximum storage of fecal coliform bacteria on land uses.

1. The values for ACQOP are simply the total fecal coliform bacteria accumulation rates from each land use sheet (Cropland, Pastureland, Forest, and Built-up).
2. The value for SQOLIM is derived using the following die-off equation from Horsley & Whitten (1986):

$N_t = N_0(10^{(-kt)})$ where: $N_t$ = number of fecal coliforms present at time t
$N_0$ = number of fecal coliforms present at time 0
t = time in days
k = first order die-off rate constant. Typical values for warm months = 0.51/day and for cold months = 0.36/day

In the above equation, $N_0$ is the count of fecal coliforms applied per acre per day (MON-ACCUM). $N_t$ is the count of fecal coliforms applied on a given day that survive for some number t of days. The maximum buildup of fecal coliform (MON-SQOLIM) is equal to the sum of the fecal coliforms applied on a given day and of the fecal coliforms that were applied on previous days and have survived until that day. When this calculation is done, the maximum buildup is estimated to be approximately 1.5 times the daily buildup rate during warm months (die-off rate of 0.51/day) and 1.8 times the daily buildup rate for colder months (die-off rate of 0.36/day). Warmer months are assumed to be April through September; colder months are October through March. A buildup limit of 1.8 times the daily buildup rate is assumed for nonmonthly varying SQOLIM (Forest and Built-up).

TRANSFERRING DATA FROM THE BACTERIAL INDICATOR TOOL TO WINHSPF

Information contained in three sheets of the Bacterial Indicator Tool can be transferred to WinHSPF. These sheets are Cattle in Streams, Septics, and ACQOP&SQOLIM (for land uses). The information in the Cattle in Streams and Septics sheets are input into the model as point sources.  Each sheet contains the fecal coliform loading rate (in count/hr) and flow rate (in cfs) for each subwatershed.  The Cattle in Streams loading and flow rates vary monthly, while the septic rates are constant.  See “Detailed Functions - Points Sources” of the *WinHSPF Version 2.0 Manual* (USEPA, March 2001) found in the “\basins\docs” folder for detailed instructions on how to incorporate point sources into WinHSPF.

The information contained in the ACQOP&SQOLIM (for land uses) sheet should be input into WinHSPF using the Input Data Editor.  See “Detailed Functions - Input Data Editor” of the *WinHSPF Version 2.0 Manual* (USEPA, March 2001) for detailed instructions on using WinHSPF’s Input Data Editor.  The constant values for forest and built-up land should be input using the *ACQOP* and *SQOLIM* columns in the PERLND\PQUAL\QUAL-INPUT and the IMPLND\IQUAL\QUAL-INPUT tables.

The monthly varying values for cropland and pastureland should be input using the *MON-ACCUM* and *MON-SQOLIM* tables under PERLND\PQUAL\ and IMPLND\IQUAL\.

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Long Island Regional Planning Board. 1978. *Long Island Comprehensive Waste Treatment Management Plan. Volume II: Summary Documentation*. Nassau-Suffolk Regional Planning Board. Hauppauge, NY.

Horner, R.R. 1992. Water quality criteria/pollutant loading estimation/treatment effectiveness estimation. In R.W. Beck and Associates. *Covington Master Drainage Plan*. King County Surface Water Management Division. Seattle, WA.

Horsley & Whitten. 1996. *Identification and Evaluation of Nutrient and Bacteriological Loadings to Maquoit Bay, Brunswick, and Freeport, Maine. Final Report*. Casco Bay Estuary Project, Portland, ME.

USEPA. 2001. *WinHSPF Version 2.0, User's Manual.* Aqua Terra Consultants under contract number 68-C-98-010 to U.S. Environmental Protection Agency, Office of Water, Office of Science and Technology, Standards and Health Protection Division, Health Protection and Modeling Branch, Washington, DC.

USEPA. 2001. *Better Assessment Science Integrating point and Nonpoint Sources, BASINS Version 3.0 User's Manual.* EPA-823-B-01-001. U.S. Environmental Protection Agency, Office of Water, Office of Science and Technology, Standards and Health Protection Division, Health Protection and Modeling Branch, Washington, DC.

## APPENDIX F - ANNUAL FLUX LOADINGS AND COEFFICIENT OF VARIATION VALUES FOR NUTRIENT AND SOLIDS PARAMETERS

## Turkey Ridge Creek Suspended Sediment Loadings
### 2002 - 2003 sampling years

| Sites | METHOD | MASS (KG) | Export | FLUX (KG/YR) | Export | FLUX VARIANCE | CONC (PPB) | CV |
|---|---|---|---|---|---|---|---|---|
| TRC01 | 2 Q WTD C | 48652.10 | 6.41 | 43768.90 | 5.76 | 5.27E+07 | 30941.11 | 0.166 |
| TRC02 | 2 Q WTD C | 175349.80 | 8.89 | 156592.90 | 7.94 | 1.61E+09 | 66591.78 | 0.256 |
| TRC03 | 6 REG-3 | 766389.40 | 21.46 | 684410.10 | 19.16 | 2.89E+10 | 140376.4 | 0.248 |
| TRC04 | 2 Q WTD C | 985231.80 | 21.74 | 942031.20 | 20.78 | 2.20E+11 | 162185 | 0.498 |
| TRC05 | 2 Q WTD C | 1227998.00 | 15.75 | 1096641.00 | 14.07 | 6.58E+10 | 120823 | 0.234 |
| TRC07 | 2 Q WTD C | 1949518.00 | 24.01 | 1798135.00 | 22.15 | 3.38E+11 | 173738.4 | 0.323 |
| TRC10 | 2 Q WTD C | 3450326.00 | 37.25 | 3088803.00 | 33.35 | 8.44E+11 | 253248.5 | 0.297 |
| TRC11 | 2 Q WTD C | 5171274.00 | 50.95 | 4618112.00 | 45.50 | 7.18E+12 | 285353.1 | 0.58 |
| TRC12 | 2 Q WTD C | 6374291.00 | 57.07 | 5706396.00 | 51.09 | 6.07E+12 | 287798.9 | 0.432 |

## TRC TOTAL PHOSPHORUS LOADINGS
### 2002 - 2003 sampling years

| Sites | METHOD | MASS (KG) | Export | FLUX (KG/YR) | Export | FLUX VARIANCE | CONC (PPB) | CV |
|---|---|---|---|---|---|---|---|---|
| TRC01 | 2 Q WTD C | 415.9 | 0.05 | 374.2 | 0.05 | 2.25E+03 | 264.5 | 0.127 |
| TRC02 | 2 Q WTD C | 1335.5 | 0.07 | 1192.6 | 0.06 | 1.20E+05 | 507.17 | 0.291 |
| TRC03 | 2 Q WTD C | 3621.4 | 0.10 | 3234.1 | 0.09 | 7.23E+05 | 663.33 | 0.263 |
| TRC04 | 6 REG-3 | 2123.4 | 0.05 | 2030.3 | 0.04 | 1.48E+05 | 349.54 | 0.189 |
| TRC05 | 2 Q WTD C | 4059.9 | 0.05 | 3625.6 | 0.05 | 3.52E+05 | 399.46 | 0.164 |
| TRC07 | 2 Q WTD C | 5031 | 0.06 | 4640.3 | 0.06 | 7.69E+05 | 448.35 | 0.189 |
| TRC10 | 6 REG-3 | 10749.1 | 0.12 | 9622.8 | 0.10 | 6.40E+06 | 788.97 | 0.263 |
| TRC11 | 2 Q WTD C | 14887.5 | 0.15 | 13295 | 0.13 | 2.04E+07 | 821.5 | 0.34 |
| TRC12 | 2 Q WTD C | 14389.2 | 0.13 | 12881.5 | 0.12 | 8.53E+06 | 649.67 | 0.227 |

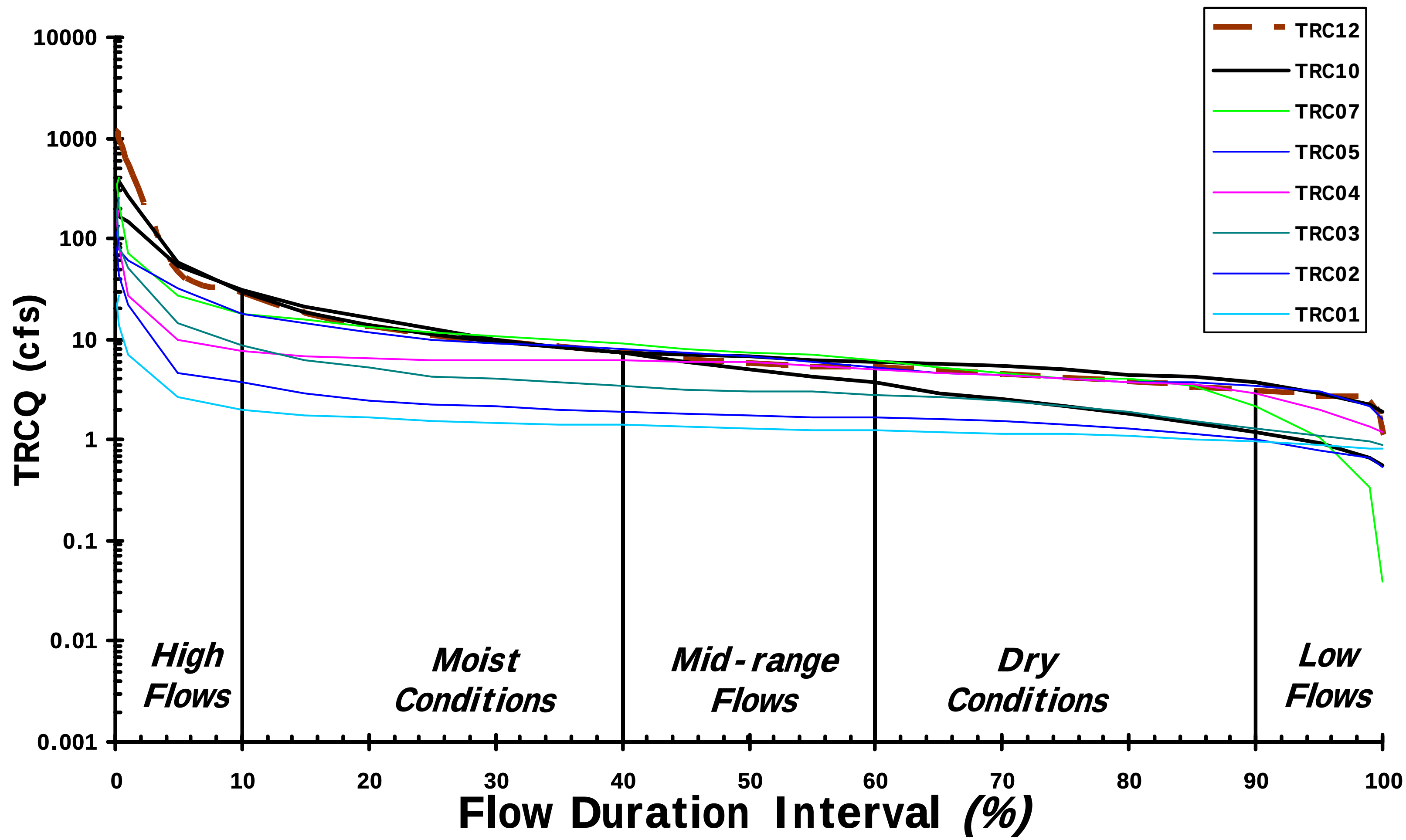
## TRC TOTAL NITROGEN LOADINGS
### 2002-2003 sampling years

| Sites | METHOD | MASS (KG) | Export | FLUX (KG/YR) | Export | FLUX VARIANCE | CONC (PPB) | CV |
|---|---|---|---|---|---|---|---|---|
| TRC01 | 2 Q WTD C | 2637.9 | 0.13 | 2373.1 | 0.31 | 4.90E+04 | 1677.59 | 0.093 |
| TRC02 | 2 Q WTD C | 5148.4 | 0.26 | 4597.7 | 0.23 | 2.07E+05 | 1955.2 | 0.099 |
| TRC03 | 2 Q WTD C | 18099.8 | 0.51 | 16163.7 | 0.45 | 1.75E+07 | 3315.27 | 0.259 |
| TRC04 | 6 REG-3 | 10591.1 | 0.23 | 10126.7 | 0.22 | 1.37E+06 | 1743.46 | 0.116 |
| TRC05 | 2 Q WTD C | 20812.7 | 0.27 | 18586.4 | 0.24 | 2.89E+06 | 2047.77 | 0.091 |
| TRC07 | 2 Q WTD C | 22131.4 | 0.27 | 20412.9 | 0.25 | 2.44E+06 | 1972.32 | 0.077 |
| TRC10 | 2 Q WTD C | 36410.1 | 0.39 | 32595.1 | 0.35 | 1.13E+07 | 2672.44 | 0.103 |
| TRC11 | 2 Q WTD C | 39402.8 | 0.39 | 35187.9 | 0.35 | 9.34E+06 | 2174.26 | 0.087 |
| TRC12 | 2 Q WTD C | 62558.7 | 0.56 | 56003.8 | 0.50 | 2.14E+08 | 2824.52 | 0.261 |

## 12.0 APPENDIX G – FECAL COLIFORM DURATION CURVES FOR ALL SITES

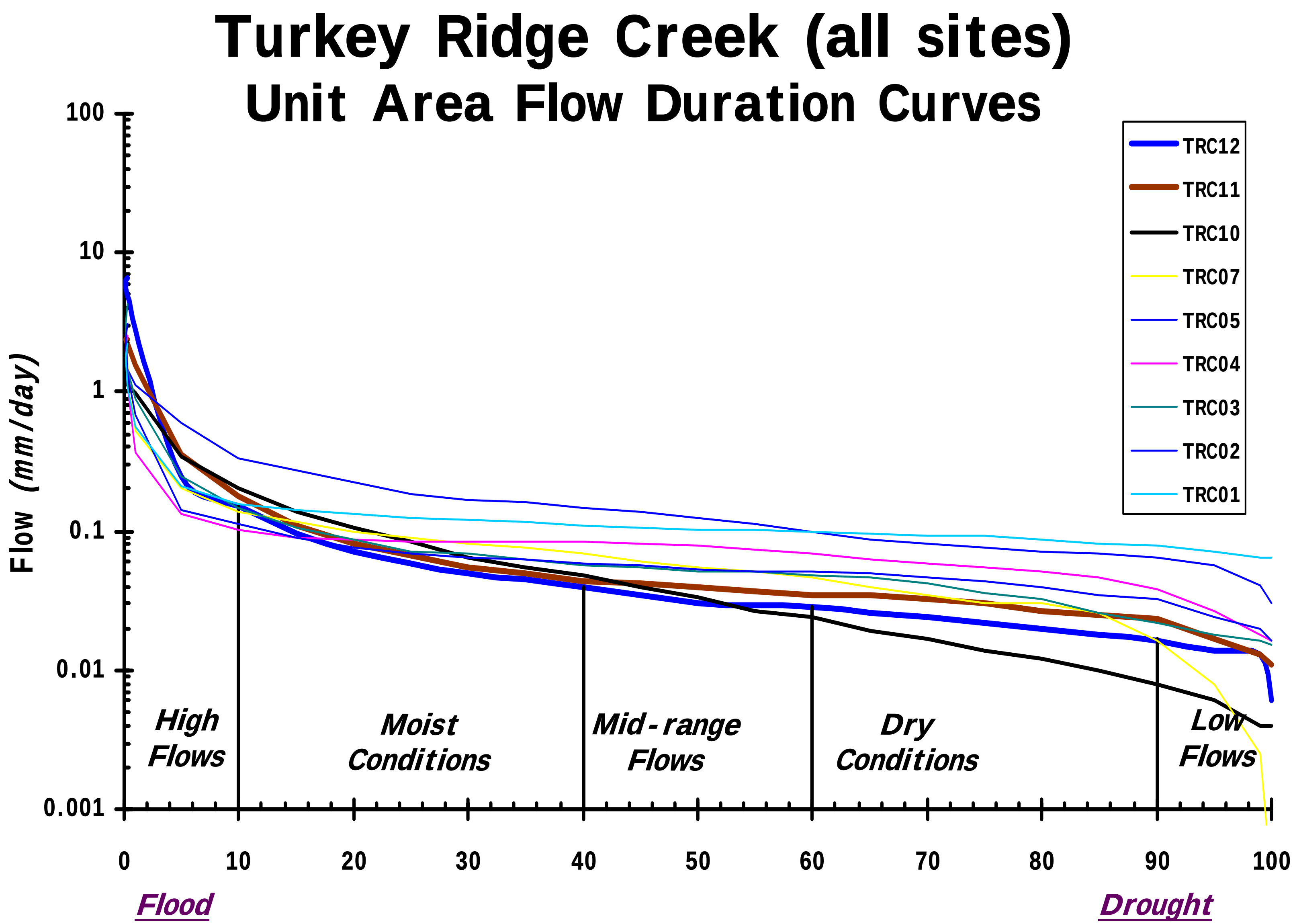
# Turkey Ridge Creek *(All Sites)*

## Flow Duration Curve



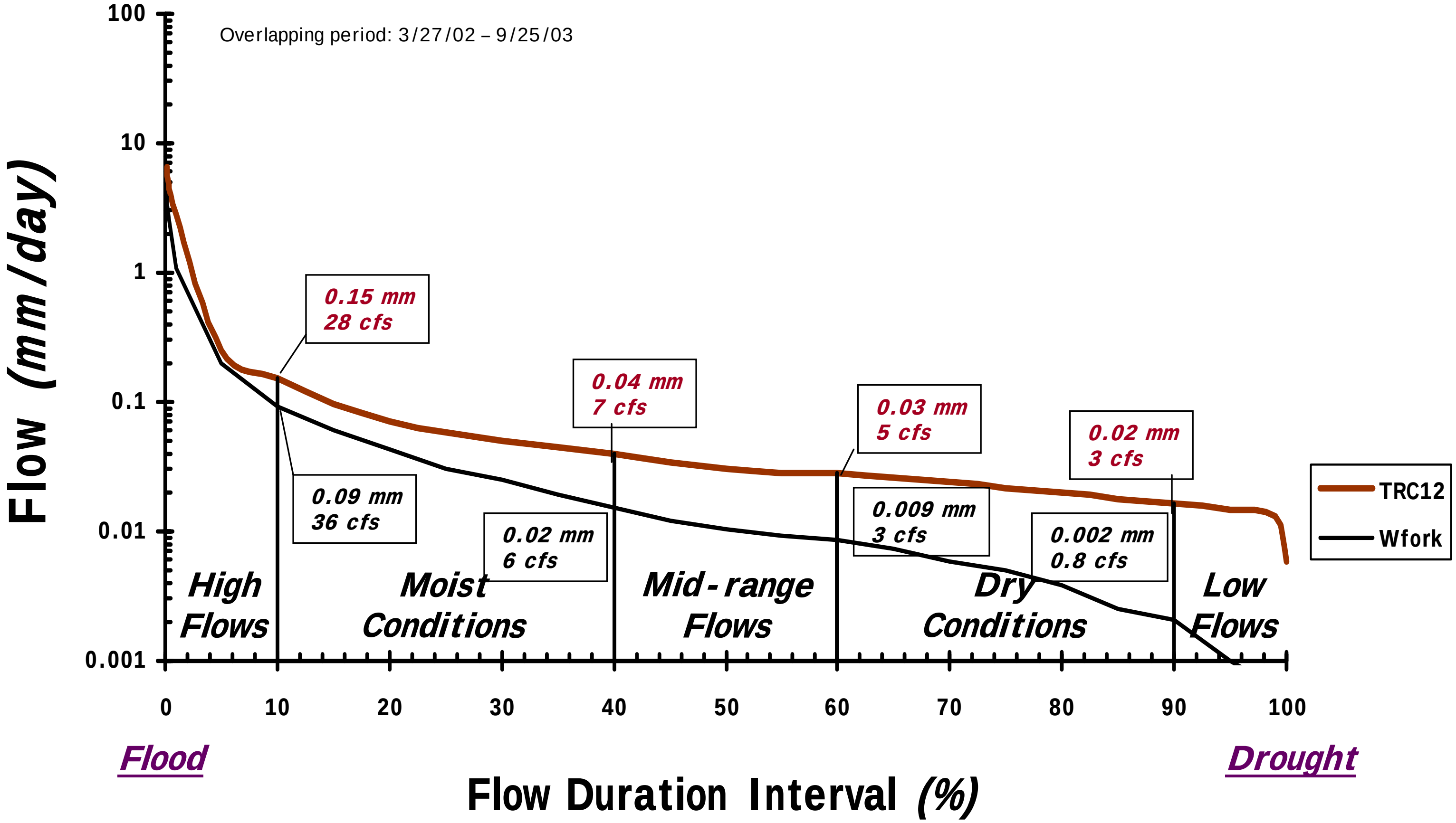

*SDDENR Flow Data*

*175 square miles*




*SDDENR Flow Data*

# Turkey Ridge Creek *(TRC12)* Flow Comparison to the West Fork of the Vermillion River *(USGS Gage: 06478690)*



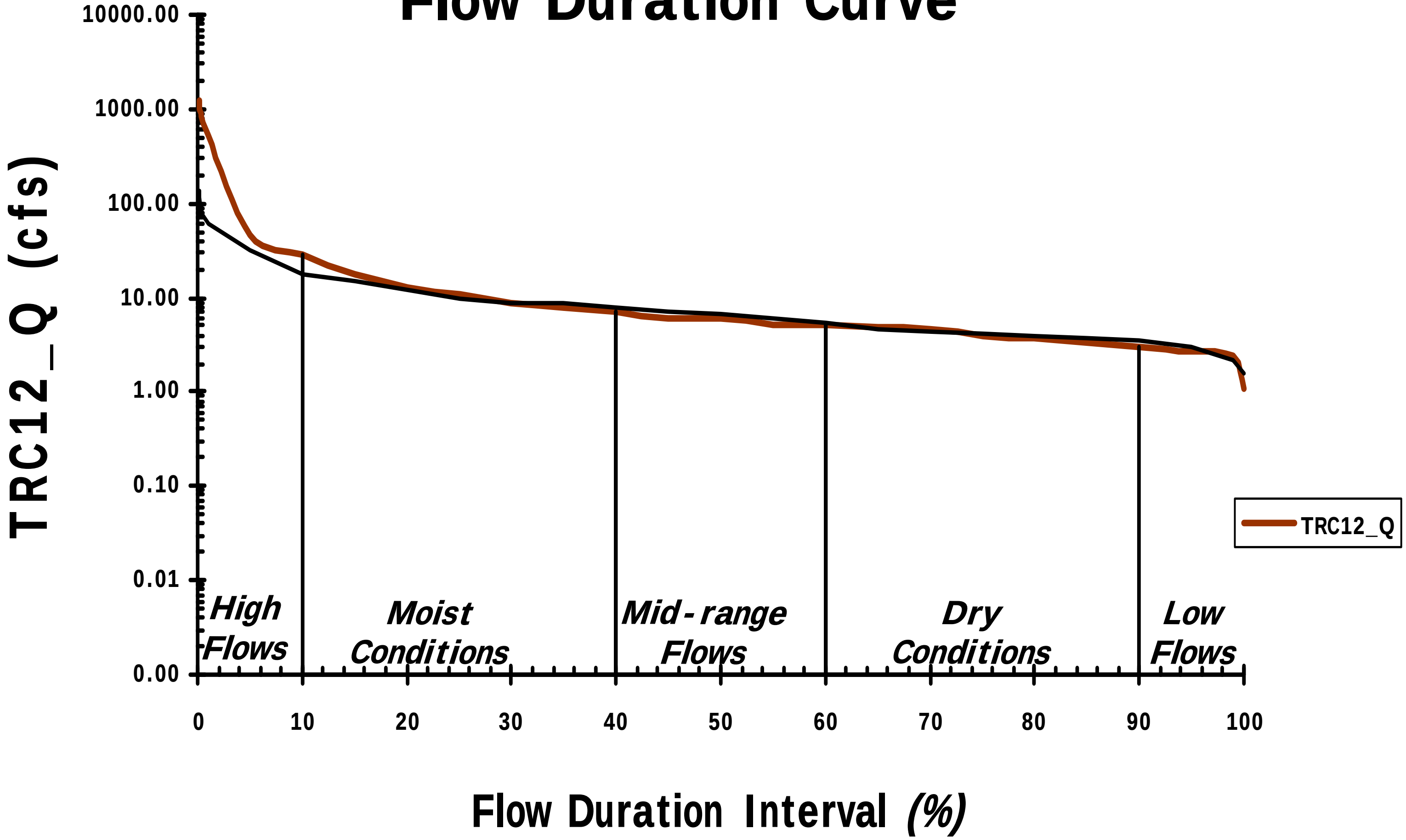

*USGS and SDDENR Flow Data*

*175, 388 square miles*

# Turkey Ridge Creek *(TRC12)*

Centerville, SD

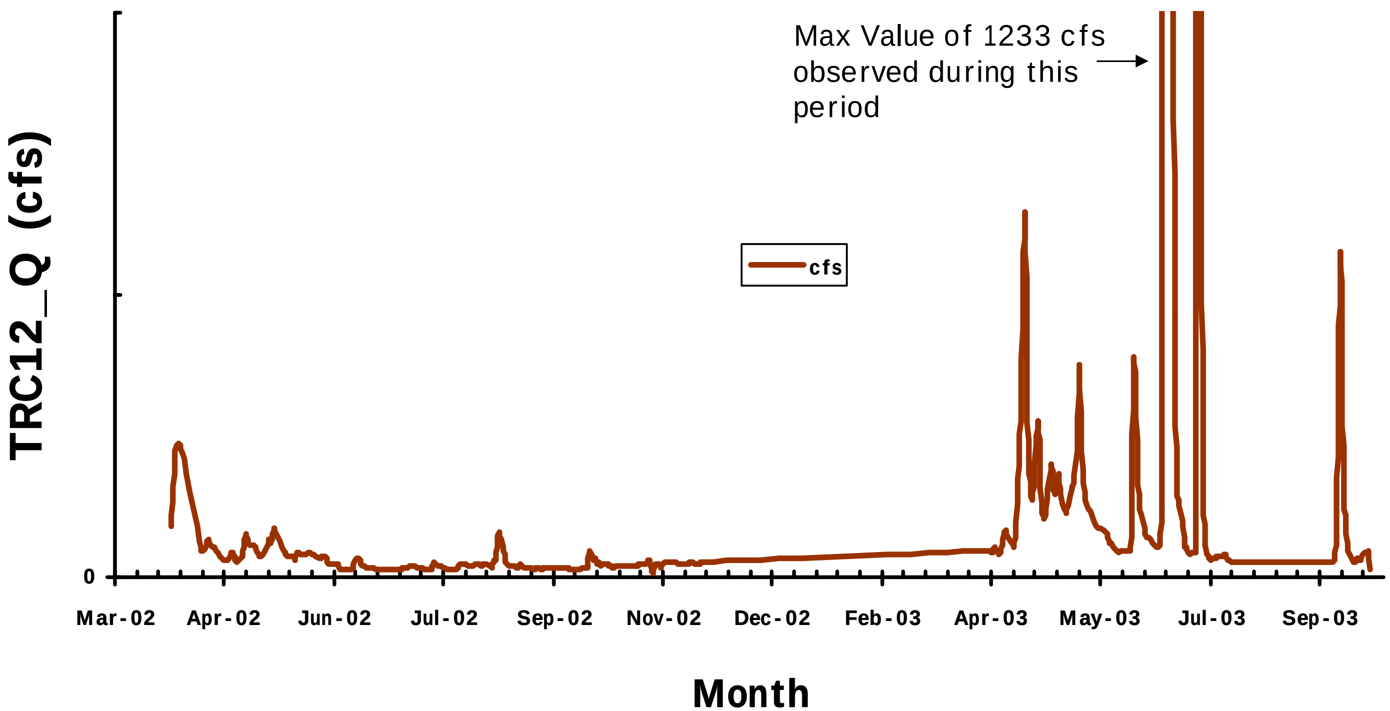
## Flow Duration Curve




*SDDENR Flow Data*

*175 square miles*

# **Turkey Ridge Creek** *(TRC12)*
## Centerville, SD
## **Seasonal Flow Pattern**

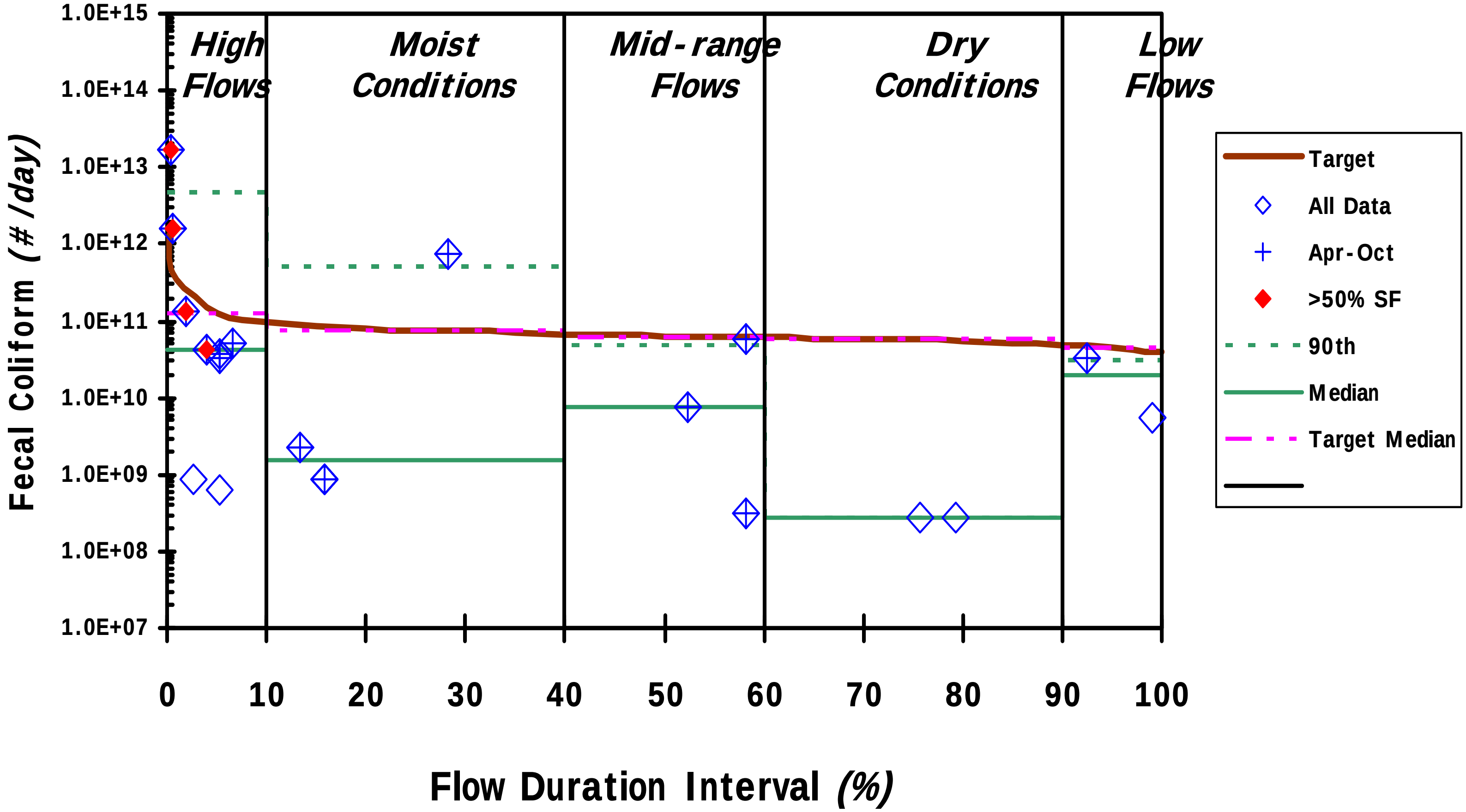



***SDDENR Flow Data*** ***175 square miles***

# Turkey Ridge Creek near Freeman, SD

## Load Duration Curve *(2002-03 Monitoring Data)*

### *Site: TRC01*

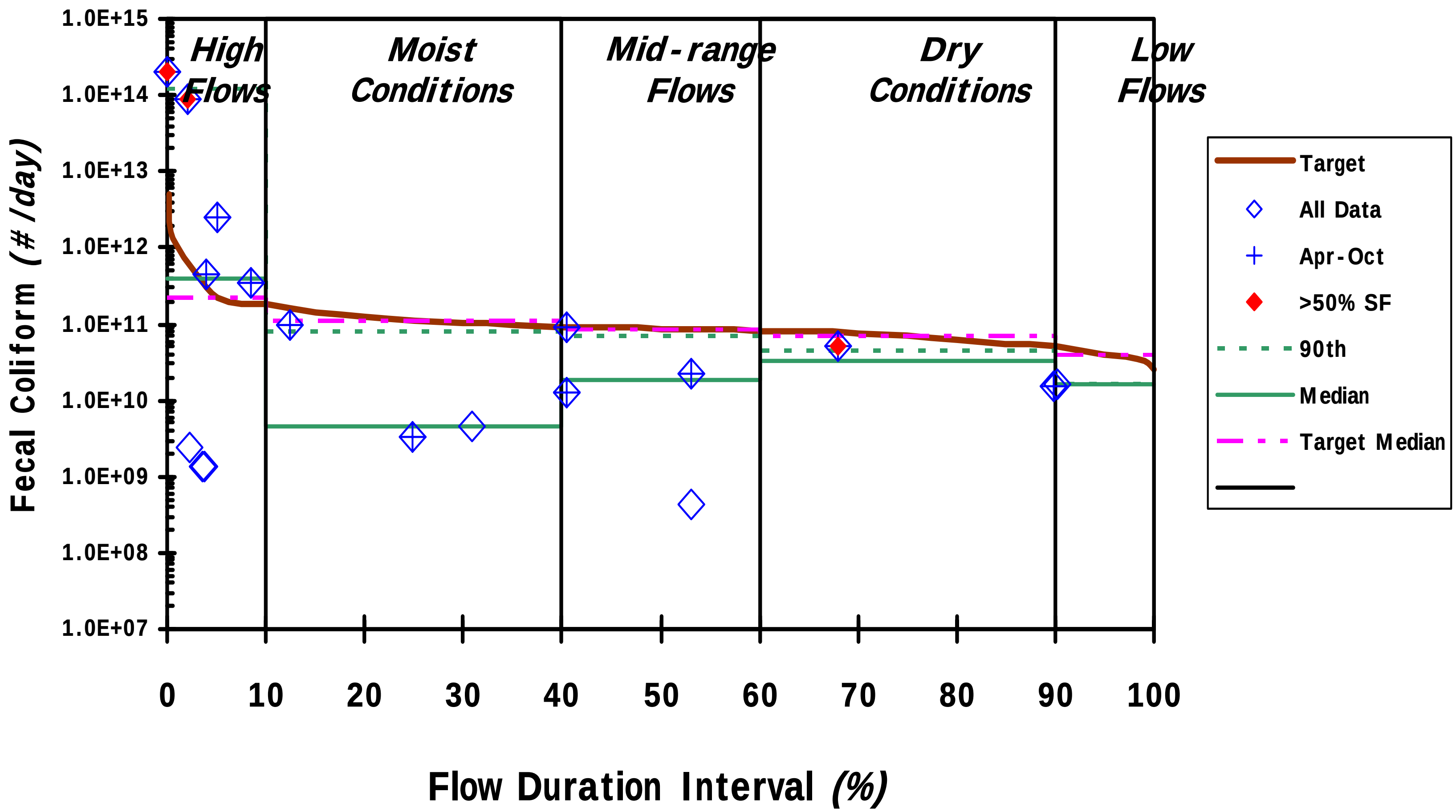



*SDDENR Data & Gage Duration Interval* *11.9 square miles*

# Turkey Ridge Creek near Turkey Ridge, SD

## Load Duration Curve *(2002-03 Monitoring Data)*

## *Site: TRC02*

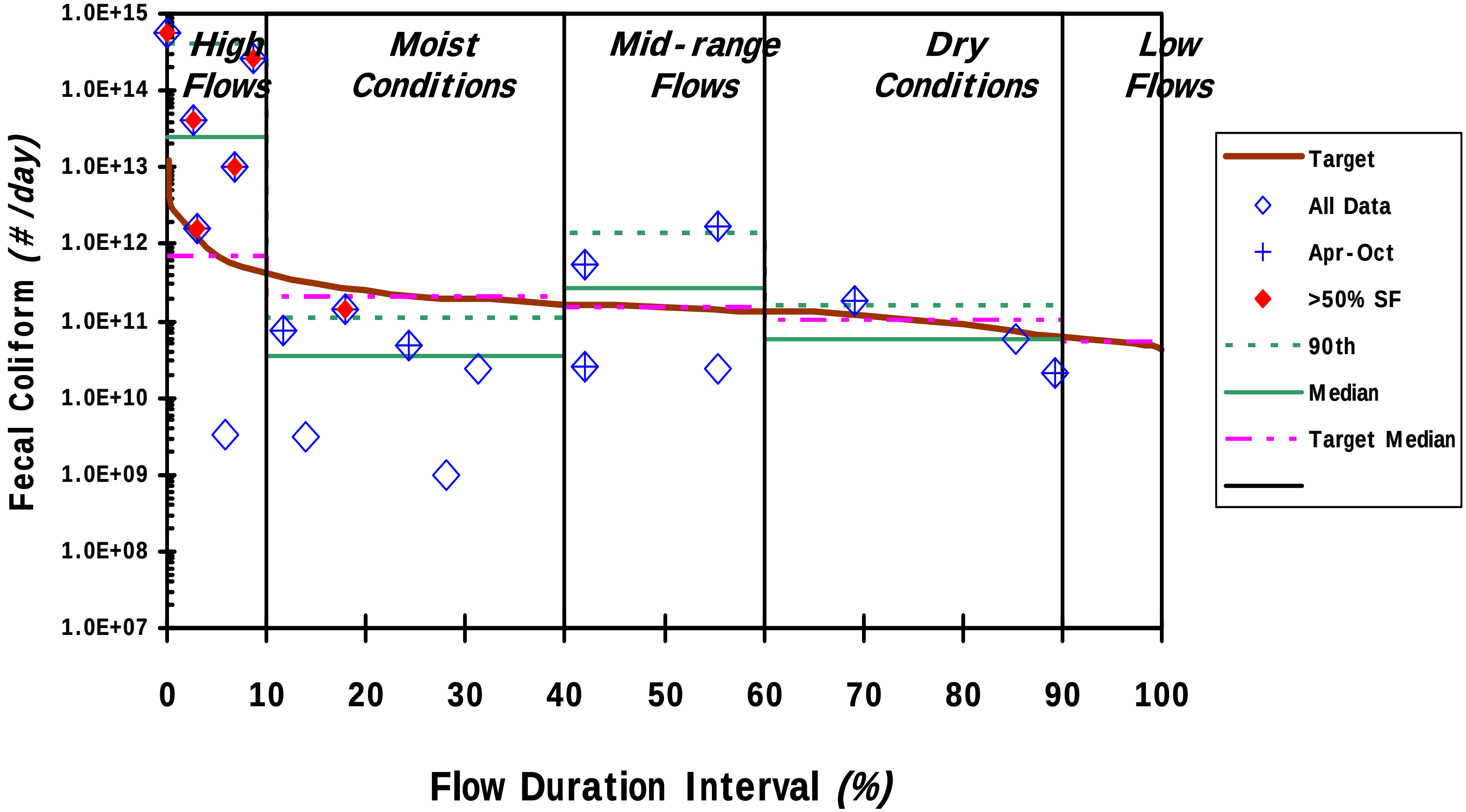



*SDDENR Data & Gage Duration Interval* *30.8 square miles*

# Turkey Ridge Creek

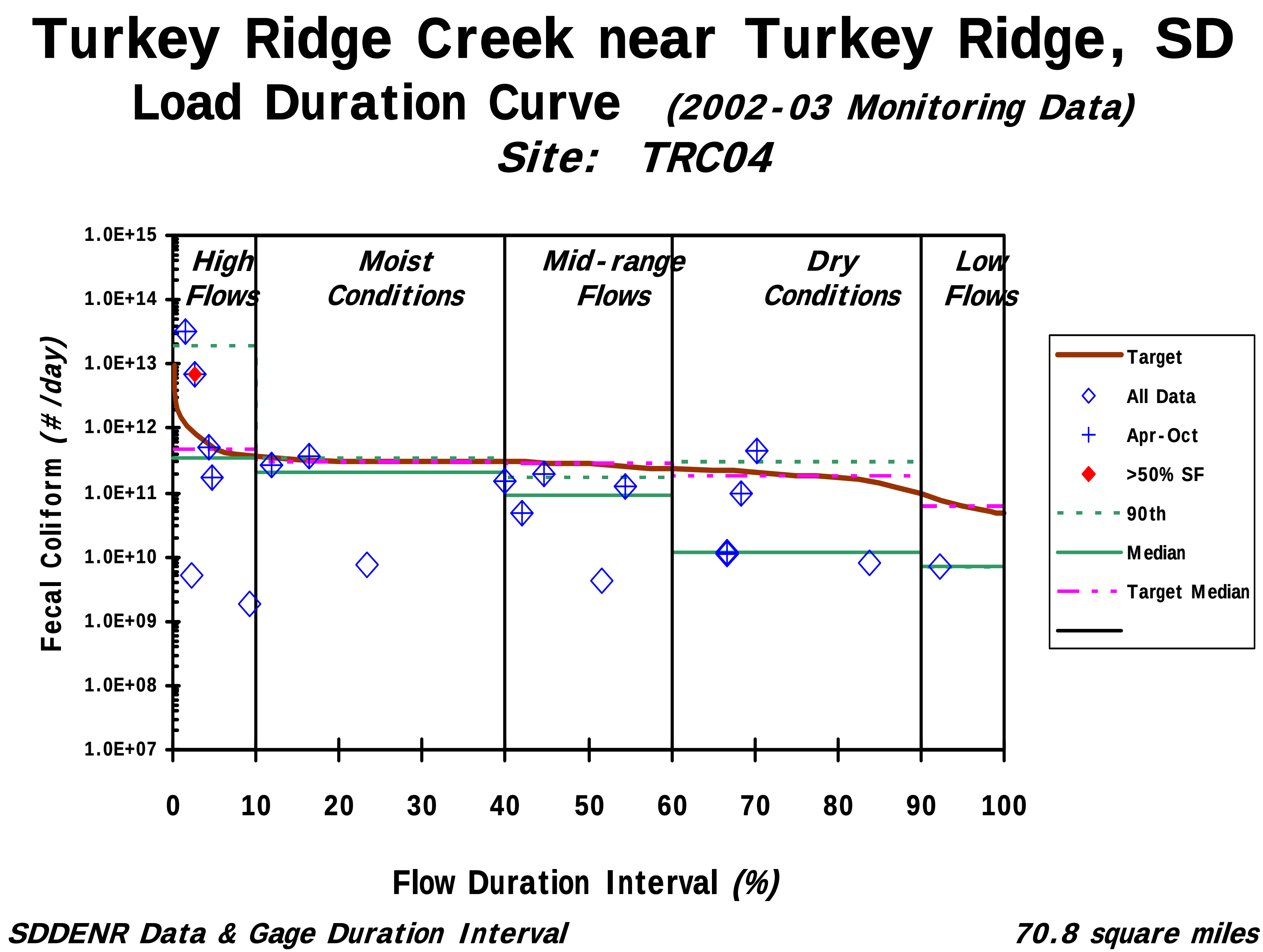
## Load Duration Curve *(2002-03 Monitoring Data)*

### *Site: TRC03*




*SDDENR Data & Gage Duration Interval*

*55.8 square miles*

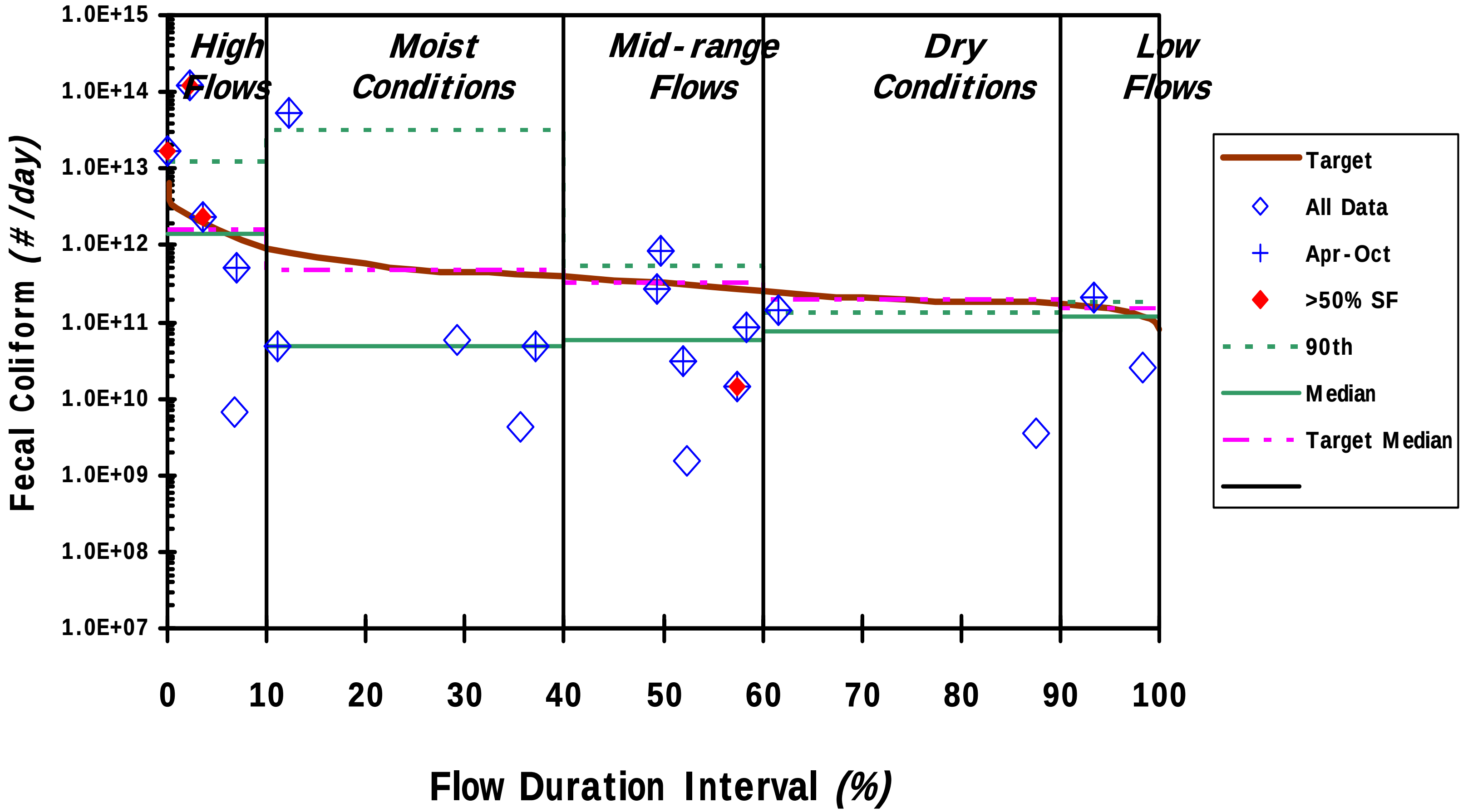


Turkey Ridge Creek near Turkey Ridge, SD
Load Duration Curve (2002-03 Monitoring Data)
Site: TRC04
High Flows
Moist Conditions
Mid-range Flows
Dry Conditions
Low Flows
1.0E+15
1.0E+14
1.0E+13
1.0E+12
1.0E+11
1.0E+10
1.0E+09
1.0E+08
1.0E+07
Fecal Coliform (# /day)
0
10
20
30
40
50
60
70
80
90
100
Flow Duration Interval (%)
Target
All Data
Apr-Oct
>50% SF
90th
Median
Target Median
SDDENR Data & Gage Duration Interval
70.8 square miles

# Turkey Ridge Creek near Viborg, SD

## Load Duration Curve *(2002-03 Monitoring Data)*

### *Site: TRC05*



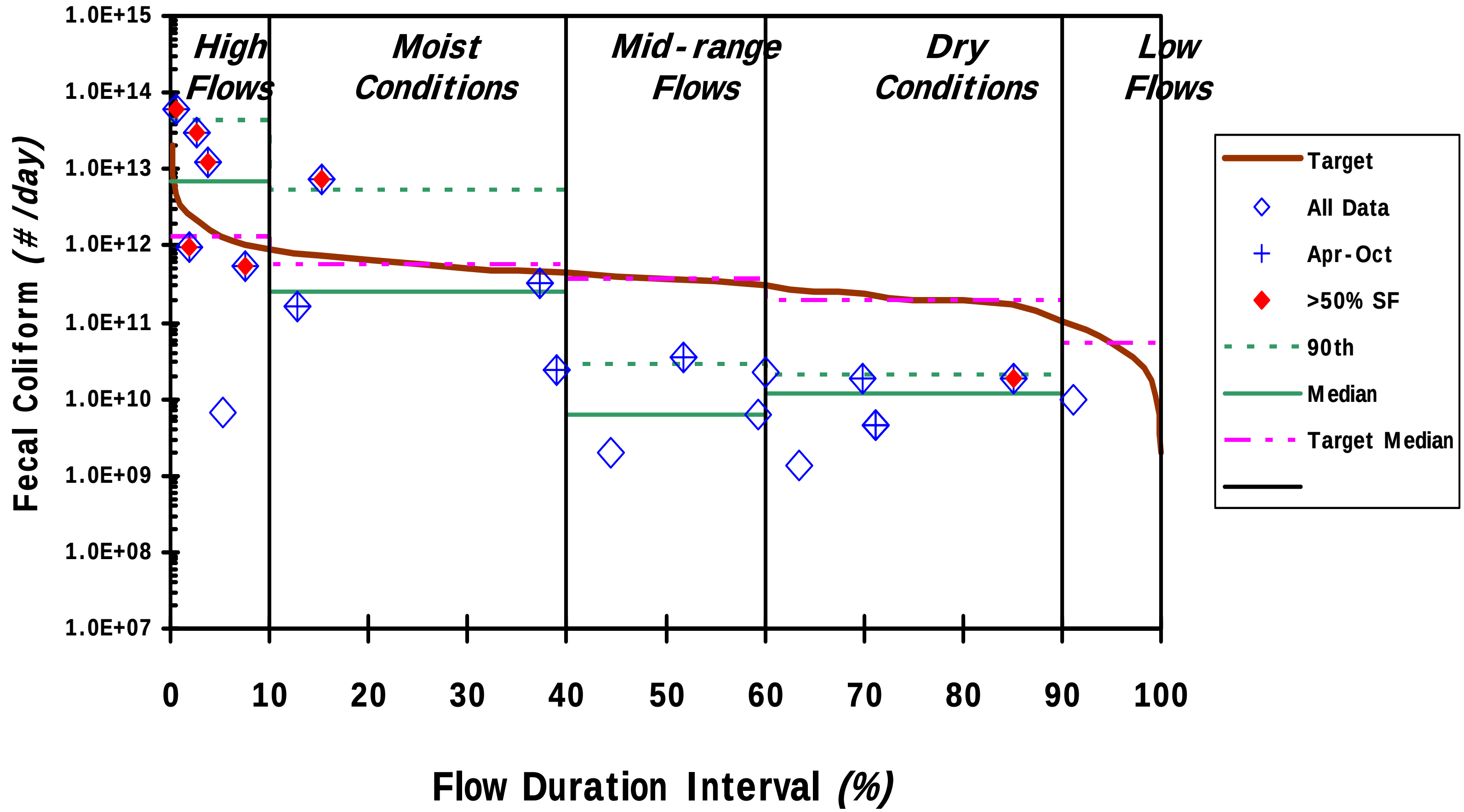

*SDDENR Data & Gage Duration Interval*

*121.8 square miles*

# Turkey Ridge Creek near Viborg, SD

## Load Duration Curve *(2002-03 Monitoring Data)*

## *Site: TRC07*

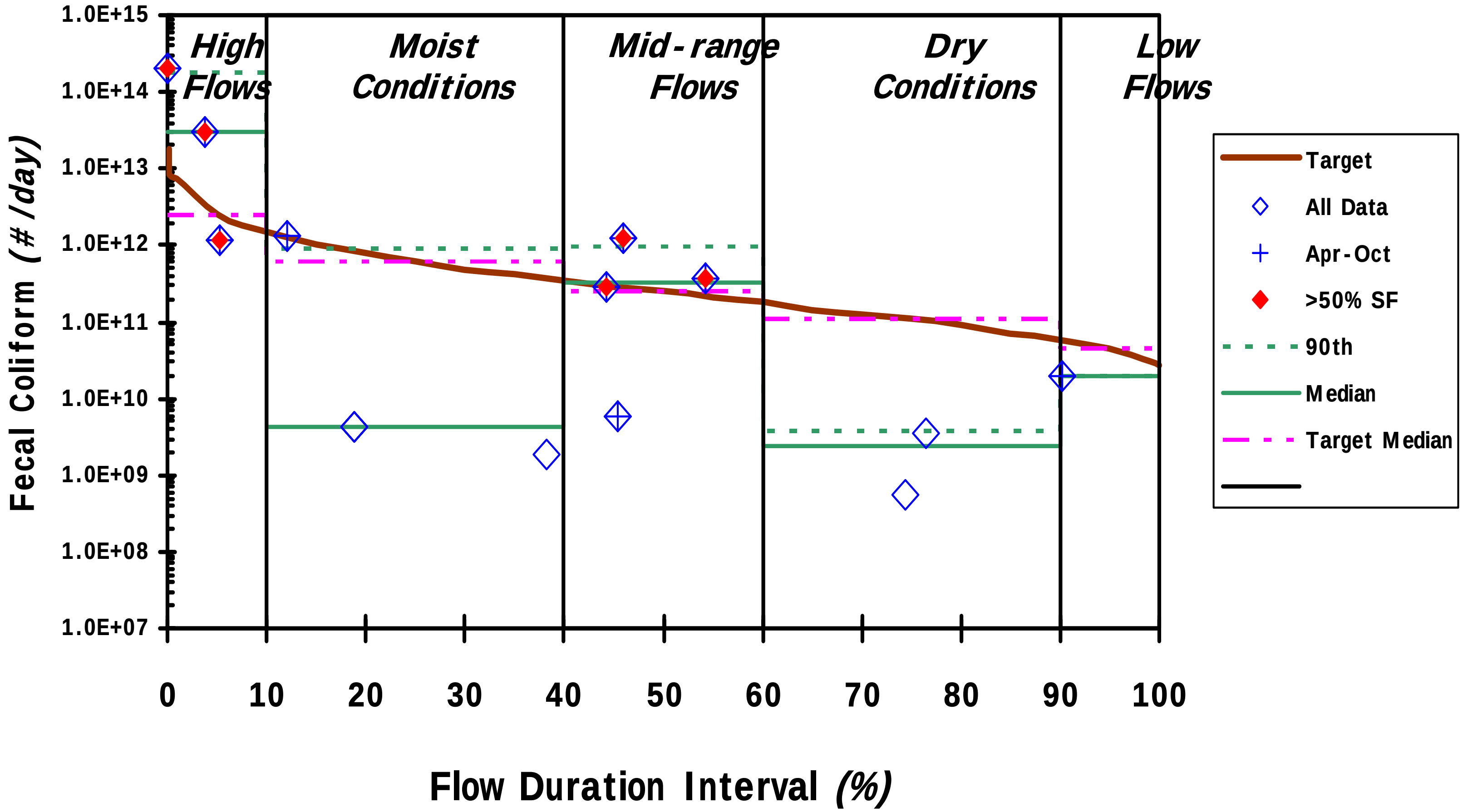



*SDDENR Data & Gage Duration Interval* *127 square miles*

# Turkey Ridge Creek near Viborg, SD

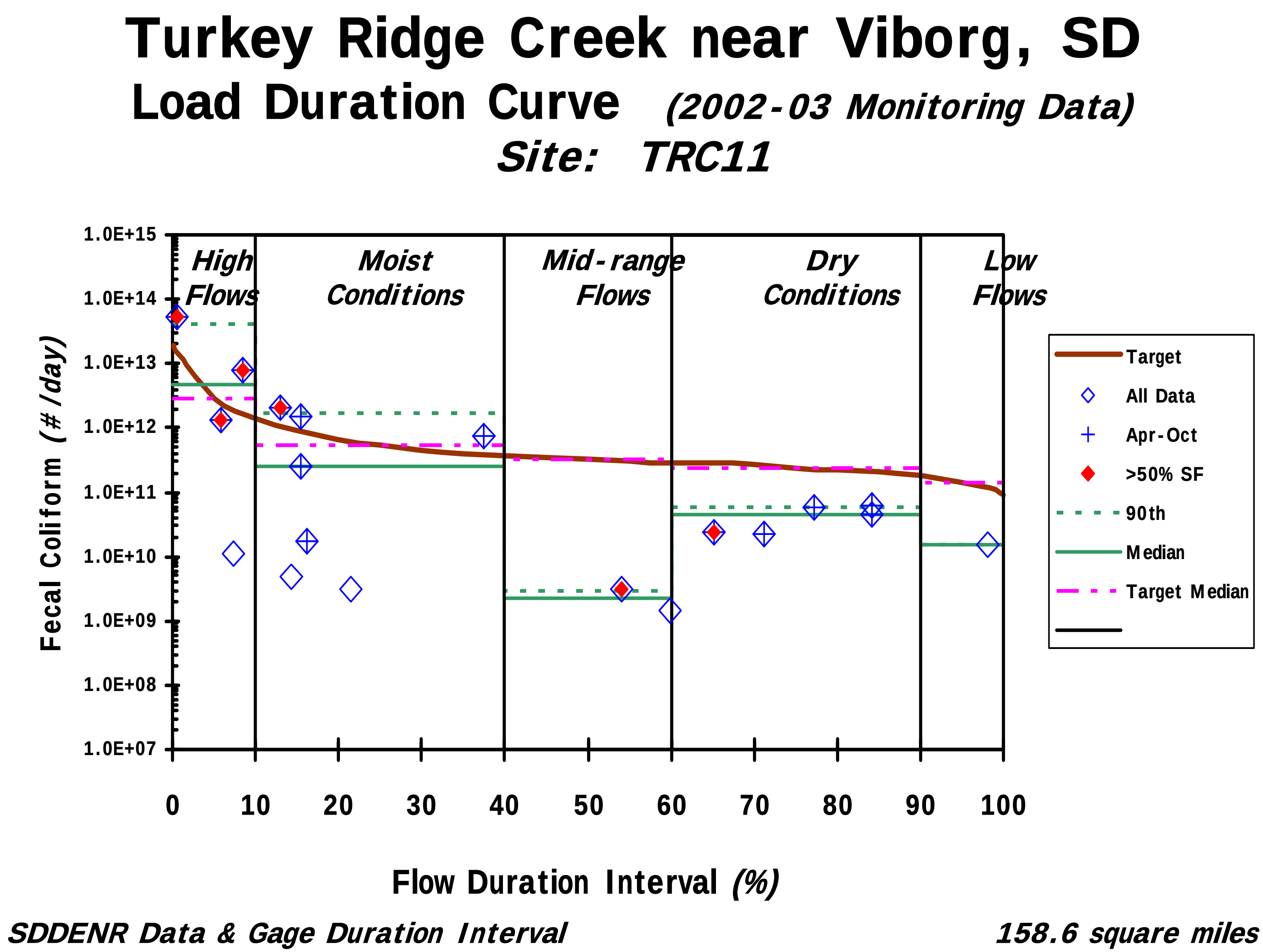
## Load Duration Curve *(2002-03 Monitoring Data)*

### *Site: TRC10*




*SDDENR Data & Gage Duration Interval*

*144.7 square miles*

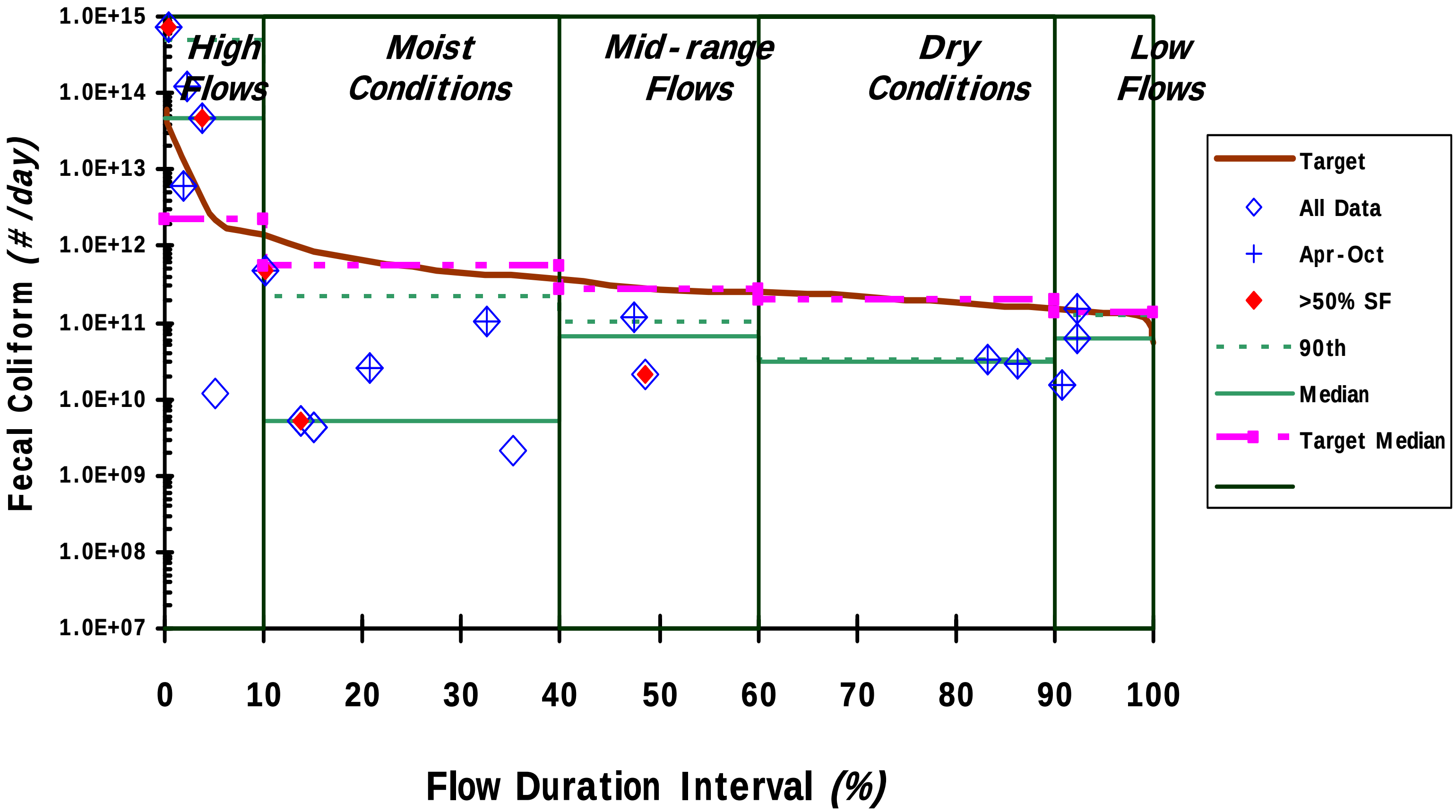


Turkey Ridge Creek near Viborg, SD
Load Duration Curve (2002-03 Monitoring Data)
Site: TRC11
1.0E+15
1.0E+14
1.0E+13
1.0E+12
1.0E+11
1.0E+10
1.0E+09
1.0E+08
1.0E+07
Fecal Coliform (# /day)
High Flows
Moist Conditions
Mid-range Flows
Dry Conditions
Low Flows
Target
All Data
Apr-Oct
>50% SF
90th
Median
Target Median
0
10
20
30
40
50
60
70
80
90
100
Flow Duration Interval (%)
SDDENR Data & Gage Duration Interval
158.6 square miles

# Turkey Ridge Creek near Centerville, SD

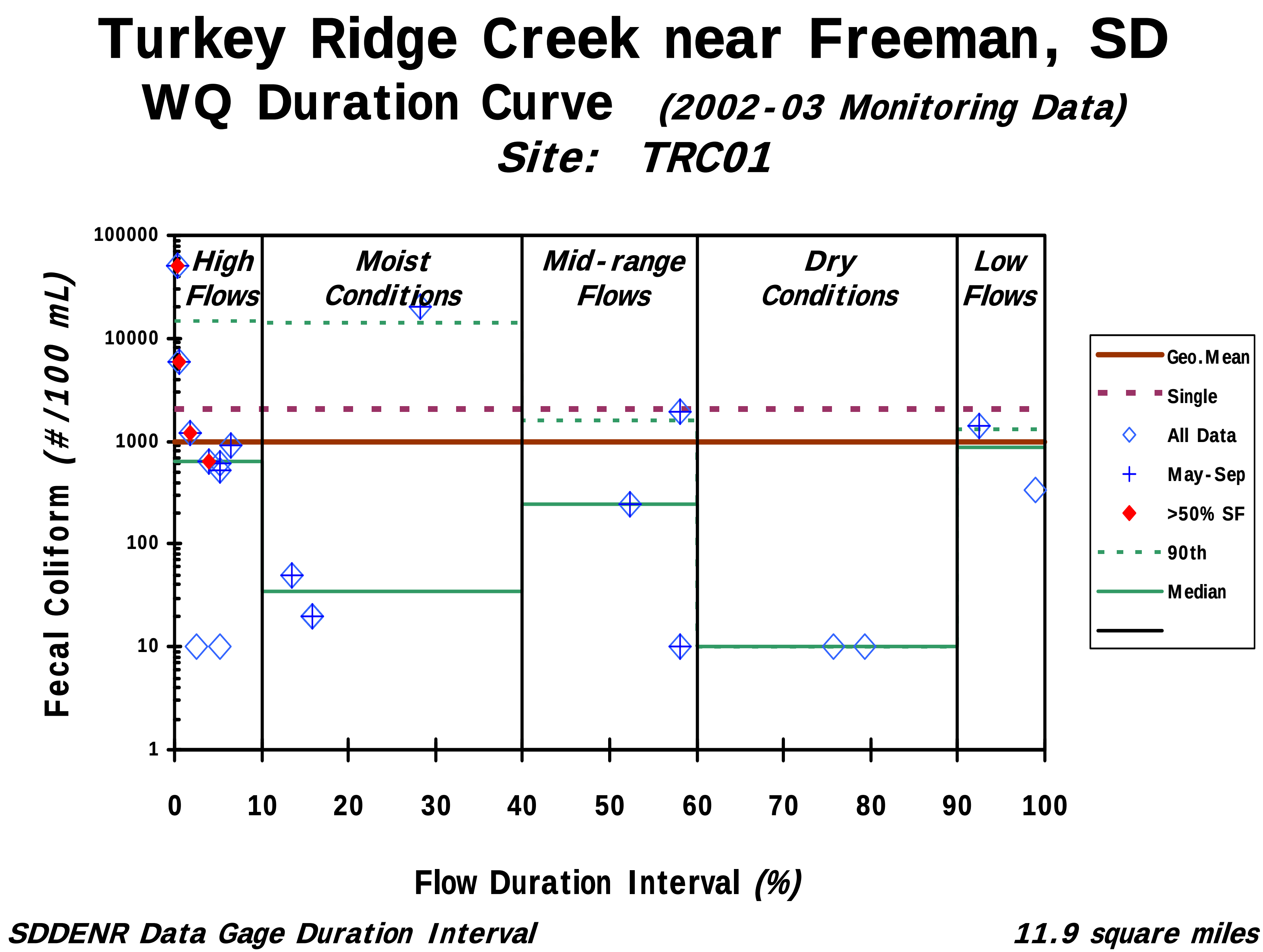
## Load Duration Curve *(2002-03 Monitoring Data)*

### *Site: TRC12*



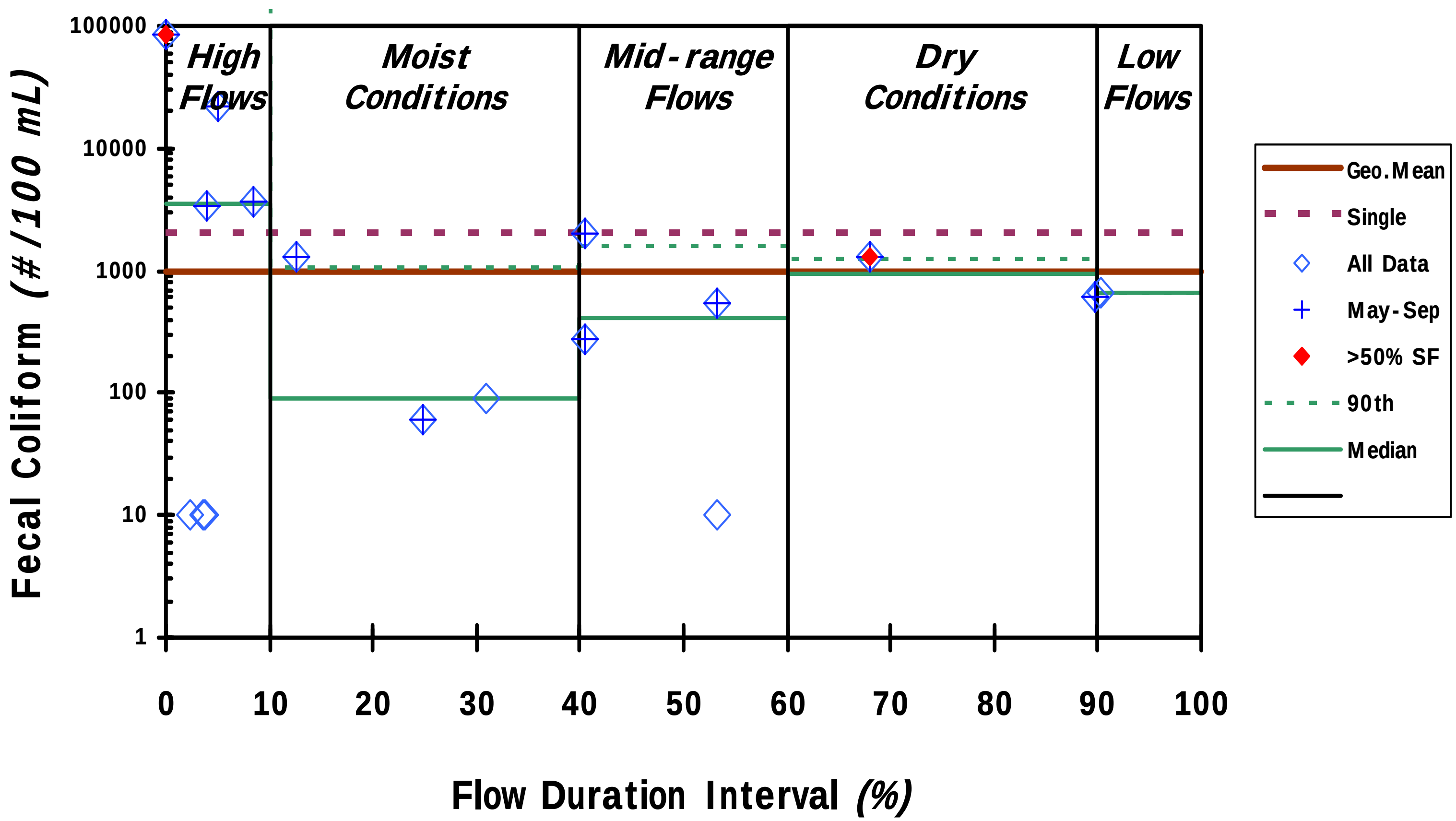

*SDDENR Data & Gage Duration Interval*

*174.5 square miles*



Turkey Ridge Creek near Freeman, SD
WQ Duration Curve (2002-03 Monitoring Data)
Site: TRC01
Fecal Coliform (#/100 mL)
100000
10000
1000
100
10
1
High Flows
Moist Conditions
Mid-range Flows
Dry Conditions
Low Flows
0
10
20
30
40
50
60
70
80
90
100
Flow Duration Interval (%)
Geo.Mean
Single
All Data
May-Sep
>50% SF
90th
Median
SDDENR Data Gage Duration Interval
11.9 square miles

# Turkey Ridge Creek near Turkey Ridge, SD
## WQ Duration Curve *(2002-03 Monitoring Data)*
### *Site: TRC02*

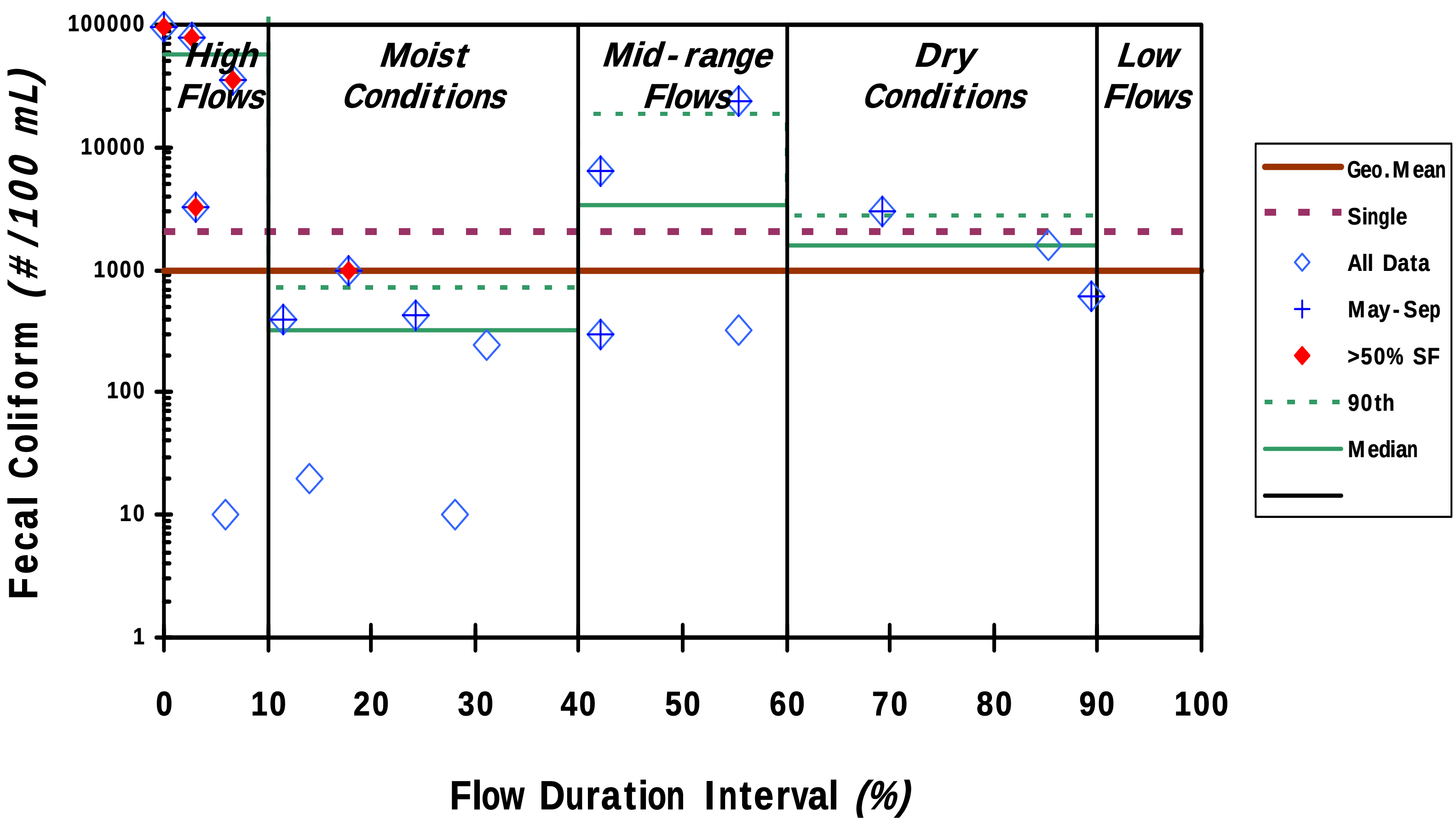



*SDDENR Data Gage Duration Interval* *30.8 square miles*

# Turkey Ridge Creek

## WQ Duration Curve *(2002-03 Monitoring Data)*

### *Site: TRC03*

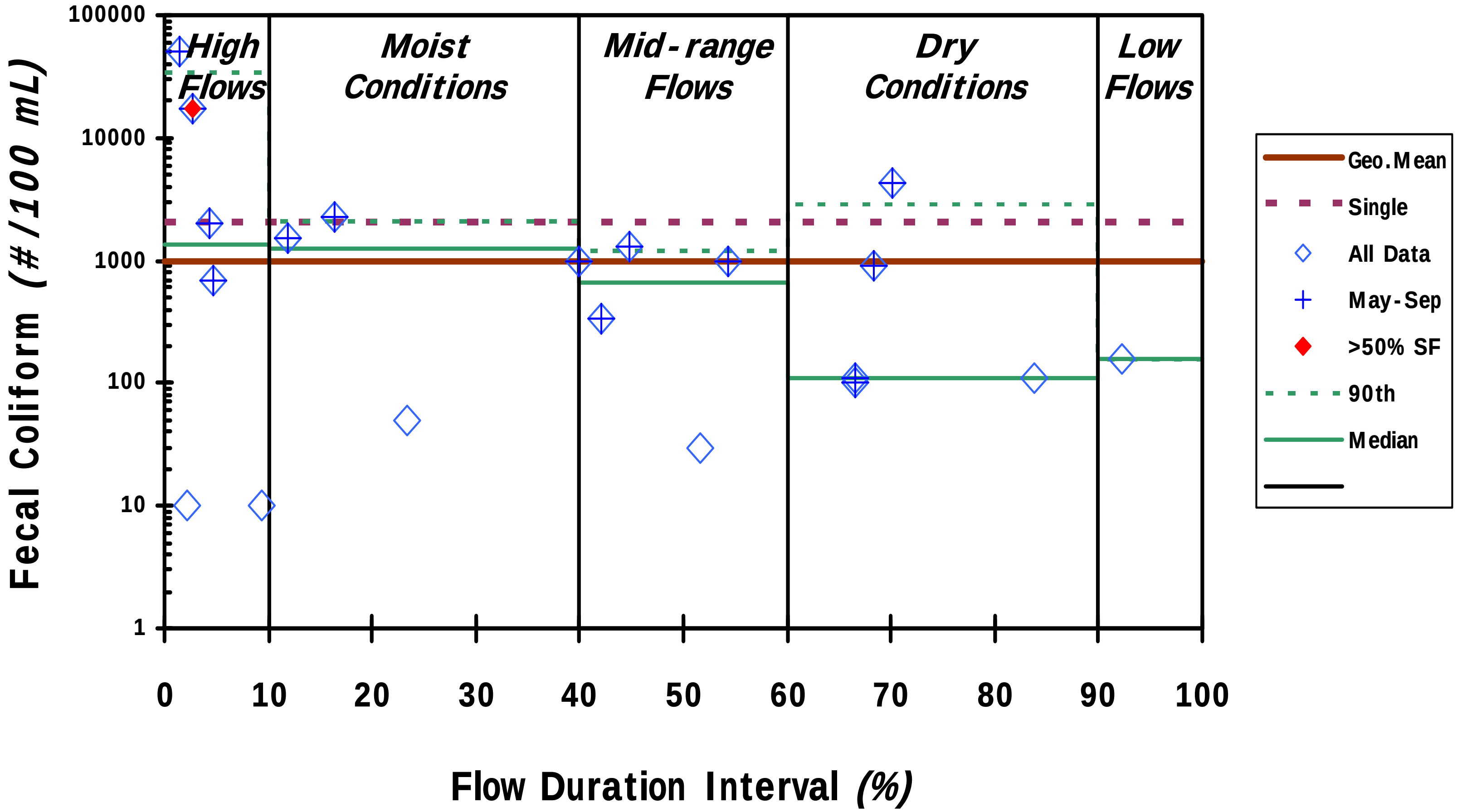



*SDDENR Data Gage Duration Interval* *55.8 square miles*

# Turkey Ridge Creek

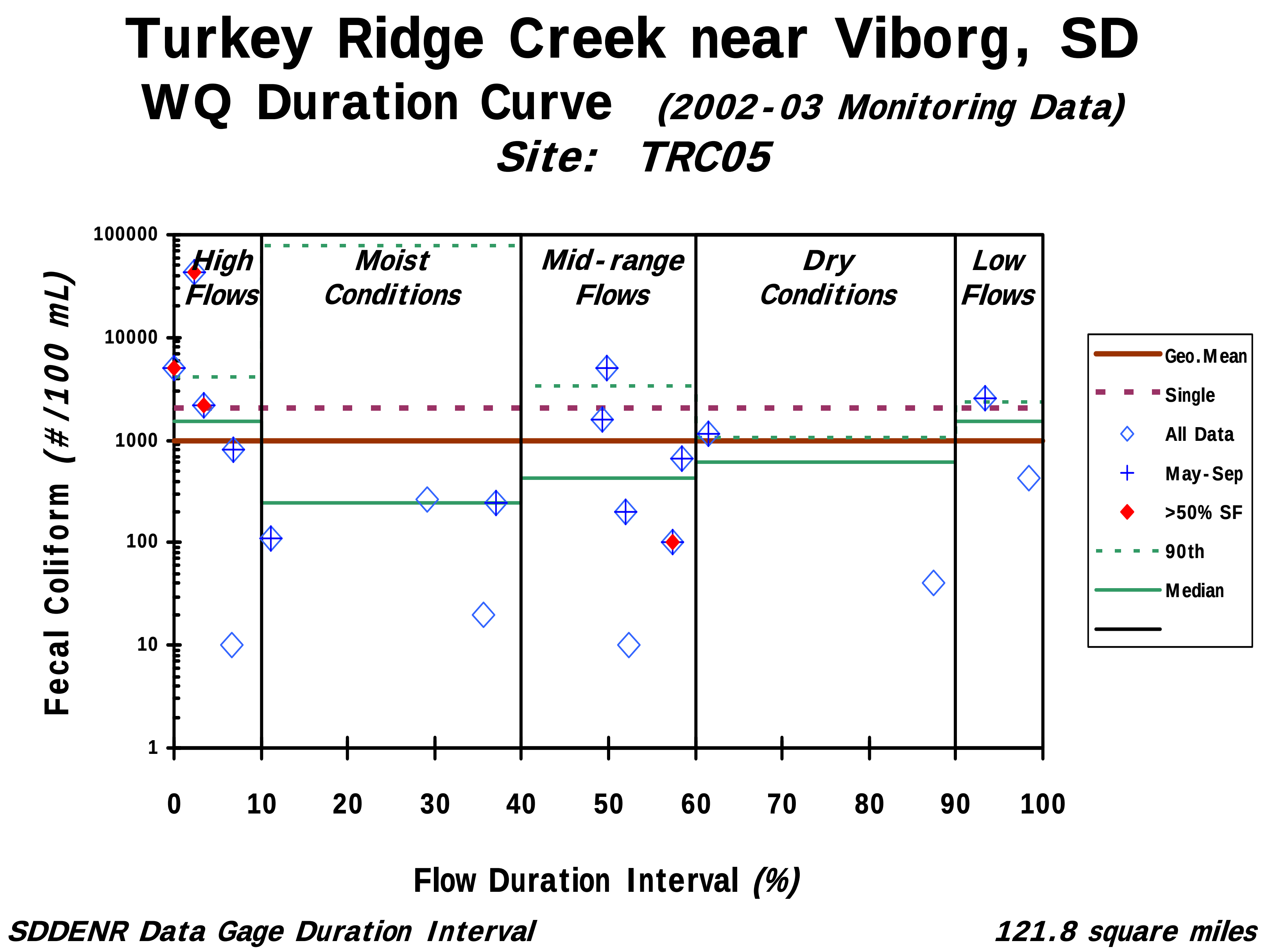
## WQ Duration Curve *(2002-03 Monitoring Data)*

### *Site: TRC04*




*SDDENR Data Gage Duration Interval*

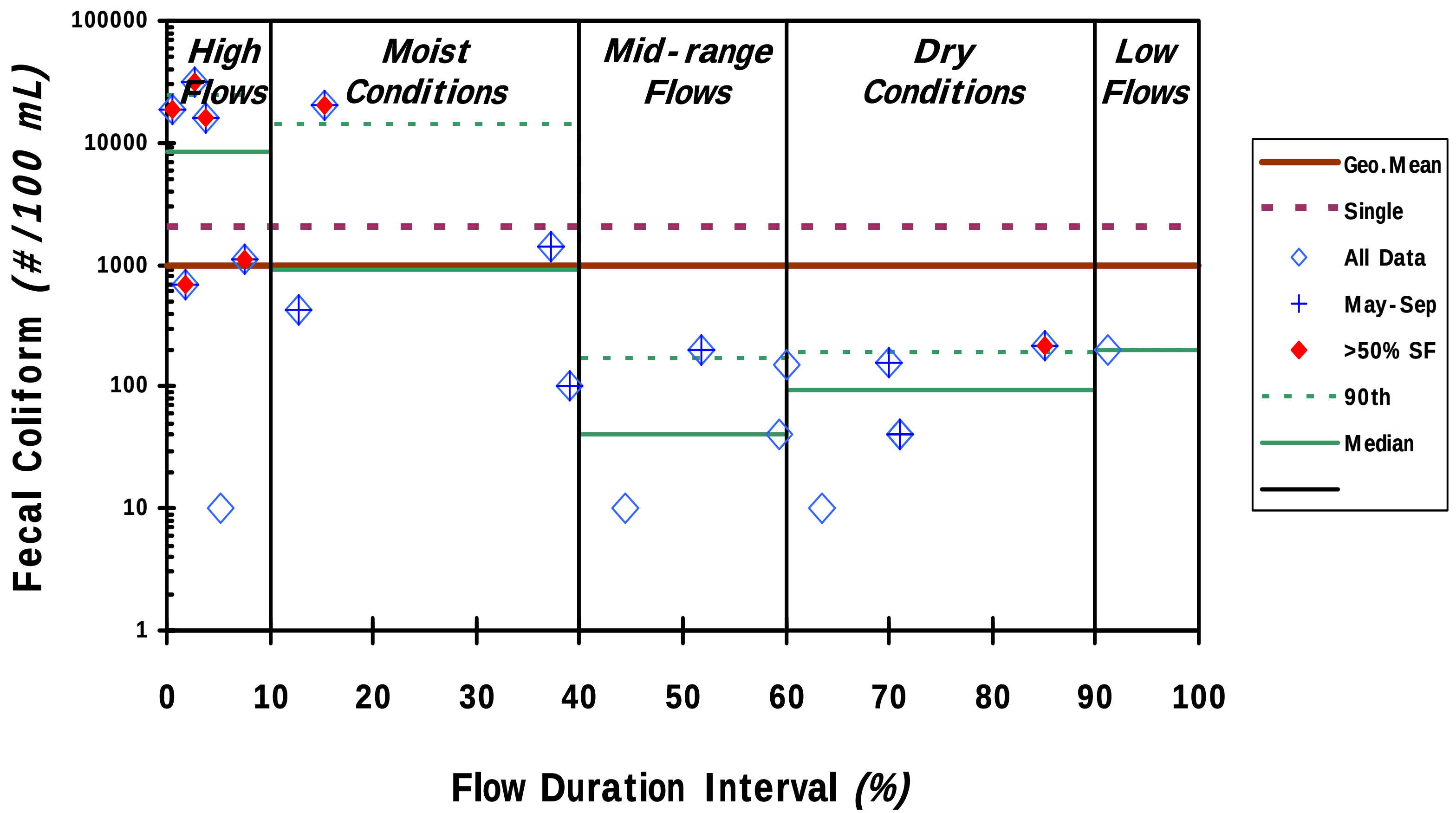
*70.8 square miles*


Turkey Ridge Creek near Viborg, SD
WQ Duration Curve (2002-03 Monitoring Data)
Site: TRC05
Fecal Coliform (#/100 mL)
100000
10000
1000
100
10
1
High Flows
Moist Conditions
Mid-range Flows
Dry Conditions
Low Flows
0
10
20
30
40
50
60
70
80
90
100
Flow Duration Interval (%)
Geo. Mean
Single
All Data
May-Sep
>50% SF
90th
Median
SDDENR Data Gage Duration Interval
121.8 square miles

# Turkey Ridge Creek near Viborg, SD

## WQ Duration Curve *(2002-03 Monitoring Data)*

### *Site: TRC07*



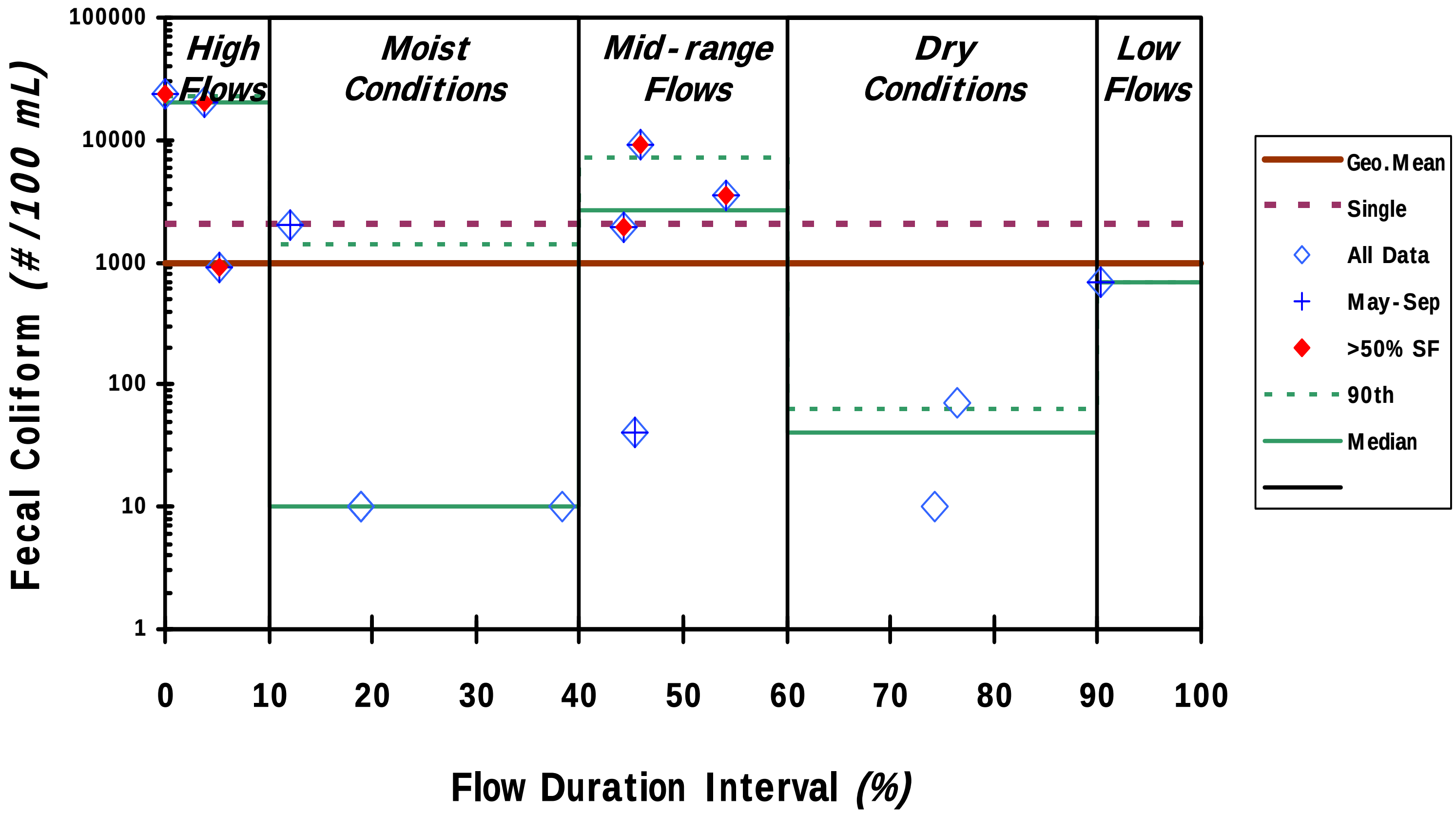

*SDDENR Data Gage Duration Interval*

*127 square miles*

# Turkey Ridge Creek near Viborg, SD

## WQ Duration Curve *(2002-03 Monitoring Data)*

### *Site: TRC10*



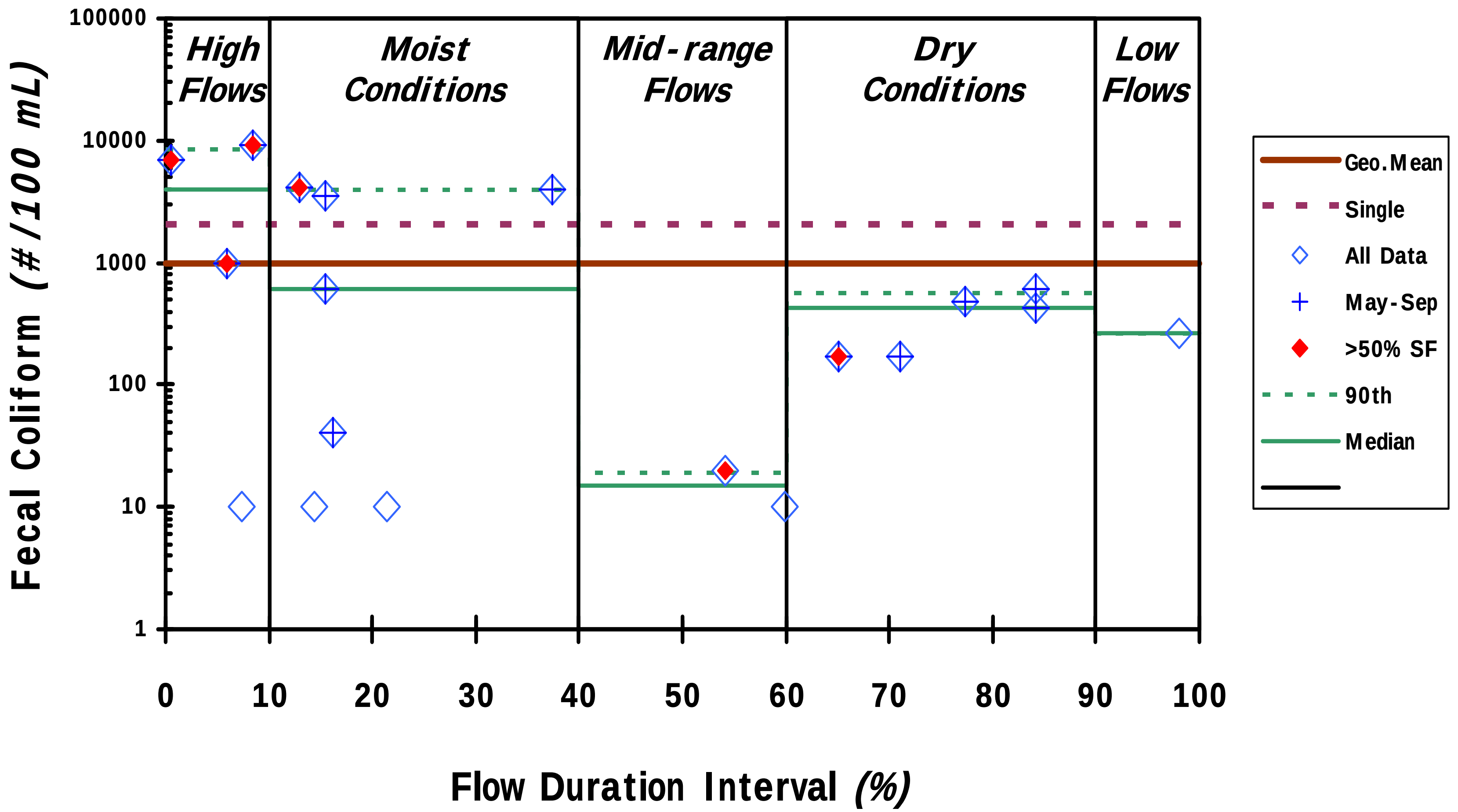

*SDDENR Data Gage Duration Interval*

*144.7 square miles*

# Turkey Ridge Creek near Viborg, SD

## WQ Duration Curve *(2002-03 Monitoring Data)*

### *Site: TRC11*

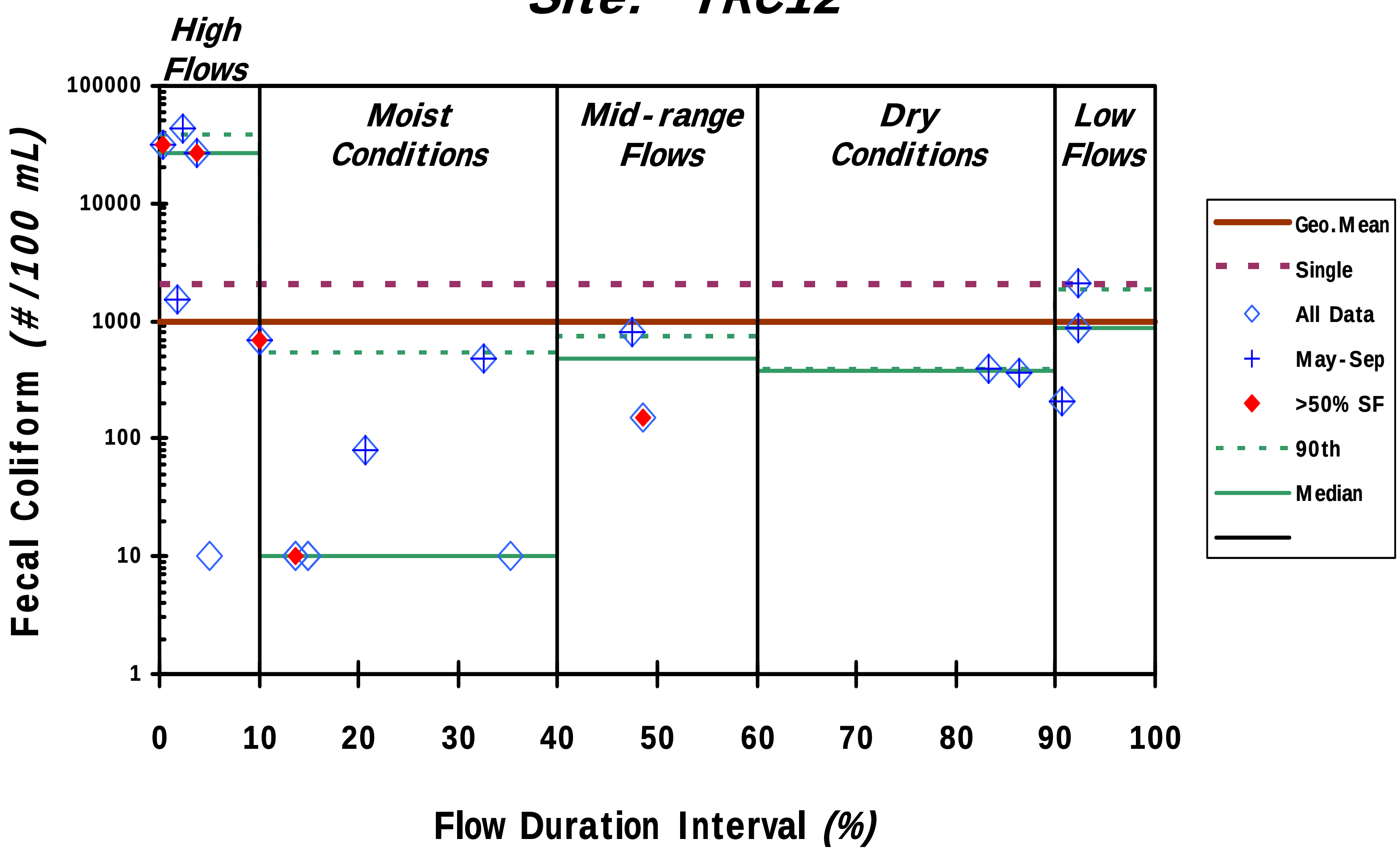



*SDDENR Data Gage Duration Interval* *158.6 square miles*

# Turkey Ridge Creek near Centerville, SD

## WQ Duration Curve *(2002-03 Monitoring Data)*

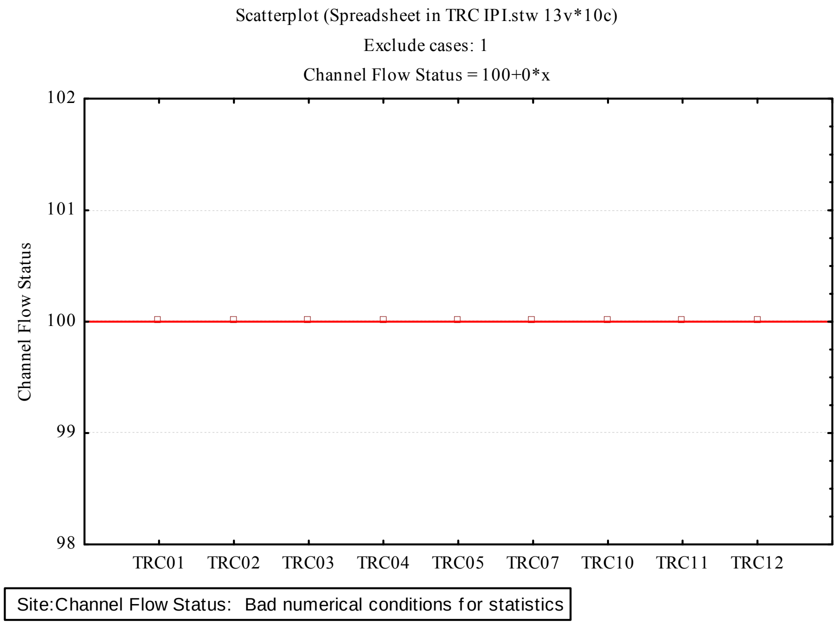
## *Site: TRC12*

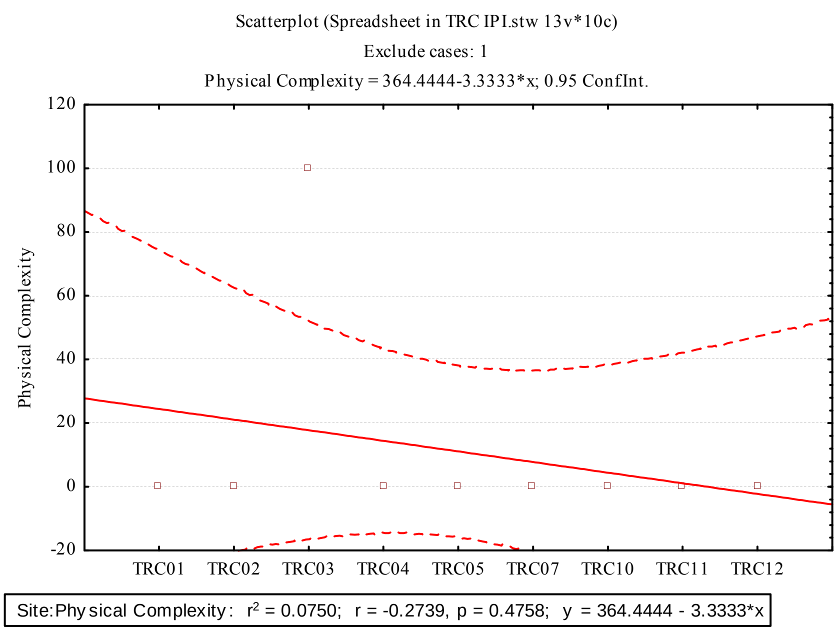


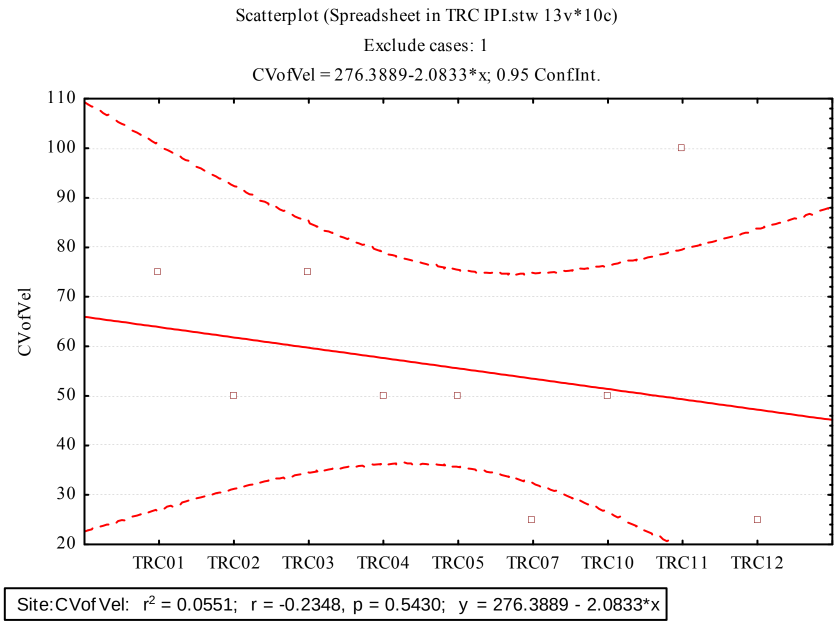

*SDDENR Data Gage Duration Interval*

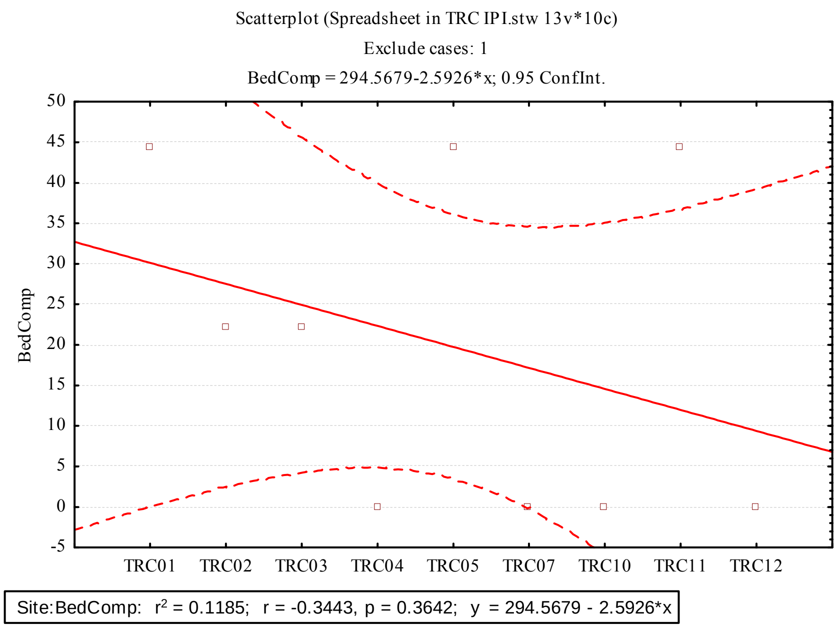
*174.5 square miles*

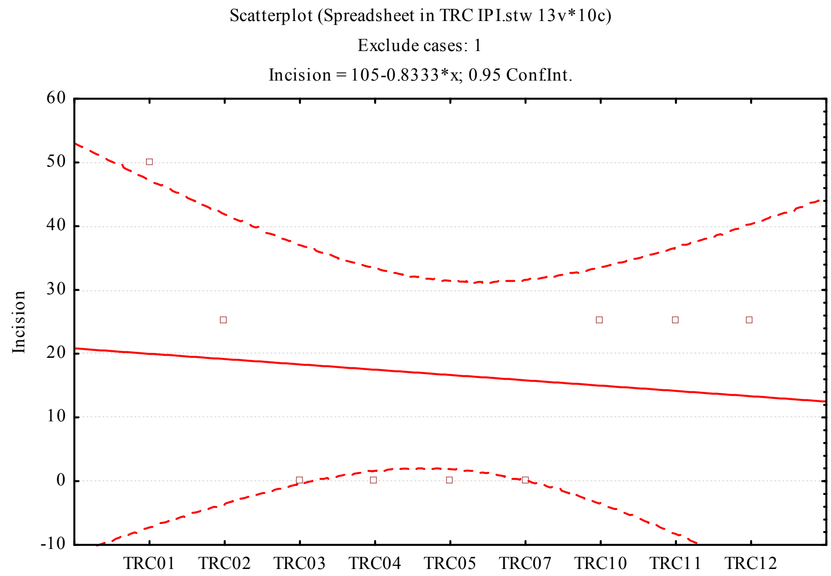
## 13.0 APPENDIX H – PHYSICAL HABITAT SCATTERPLOTS


Scatterplot (Spreadsheet in TRC IPI.stw 13v*10c)
Exclude cases: 1
Channel Flow Status = 100+0*x
Channel Flow Status
102
101
100
99
98
TRC01
TRC02
TRC03
TRC04
TRC05
TRC07
TRC10
TRC11
TRC12
Site:Channel Flow Status: Bad numerical conditions for statistics

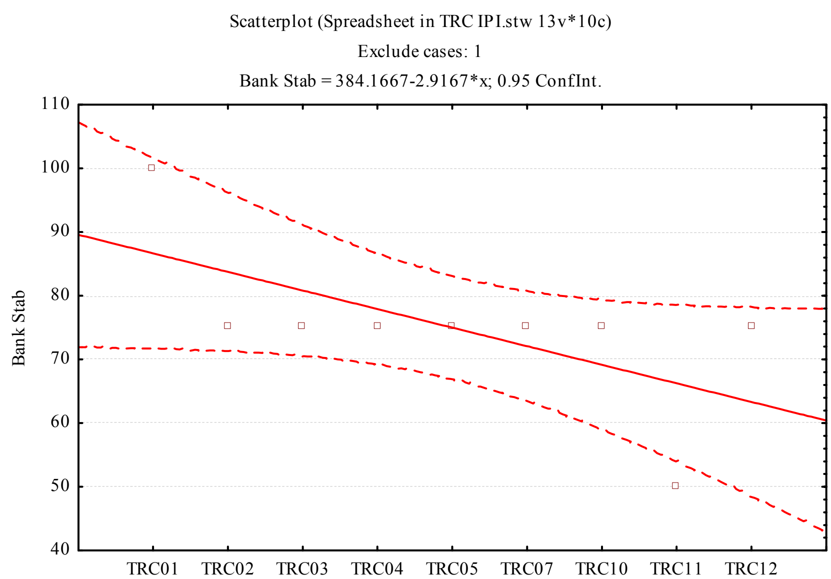

Scatterplot (Spreadsheet in TRC IPI.stw 13v*10c)
Exclude cases: 1
Physical Complexity = 364.4444-3.3333*x; 0.95 Conf.Int.
Physical Complexity
120
100
80
60
40
20
0
-20
TRC01
TRC02
TRC03
TRC04
TRC05
TRC07
TRC10
TRC11
TRC12
Site:Physical Complexity: r2 = 0.0750; r = -0.2739, p = 0.4758; y = 364.4444 - 3.3333*x


Scatterplot (Spreadsheet in TRC IPI.stw 13v*10c)
Exclude cases: 1
CVofVel = 276.3889-2.0833*x; 0.95 Conf.Int.
CVofVel
110
100
90
80
70
60
50
40
30
20
TRC01
TRC02
TRC03
TRC04
TRC05
TRC07
TRC10
TRC11
TRC12
Site:CVofVel: r2 = 0.0551; r = -0.2348, p = 0.5430; y = 276.3889 - 2.0833*x

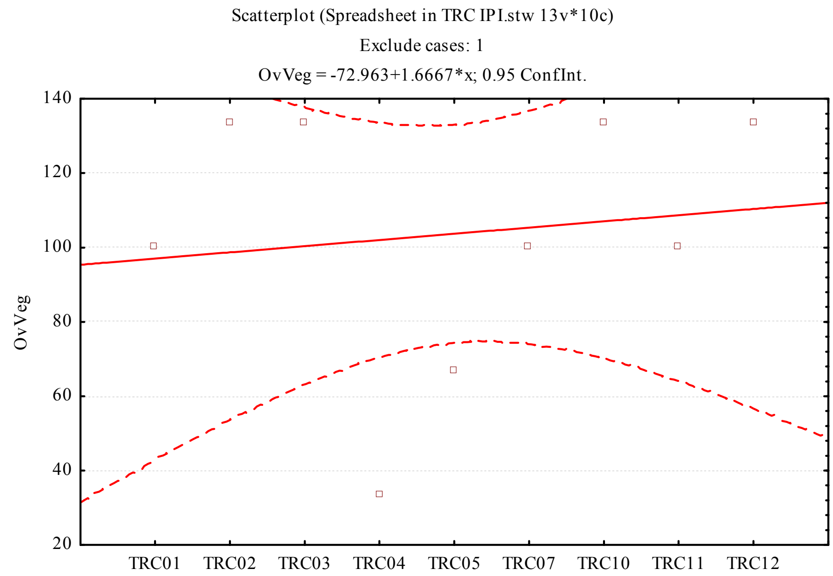

Scatterplot (Spreadsheet in TRC IPI.stw 13v*10c)
Exclude cases: 1
BedComp = 294.5679-2.5926*x; 0.95 Conf.Int.
BedComp
50
45
40
35
30
25
20
15
10
5
0
-5
TRC01
TRC02
TRC03
TRC04
TRC05
TRC07
TRC10
TRC11
TRC12
Site:BedComp: r2 = 0.1185; r = -0.3443, p = 0.3642; y = 294.5679 - 2.5926*x



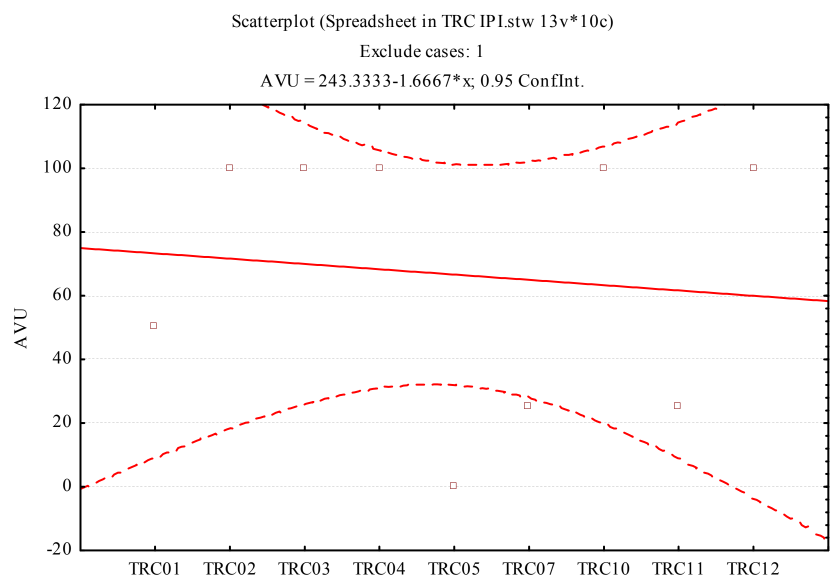

Site:Incision: $r^2$ = 0.0167; r = -0.1291, p = 0.7406; y = 105 - 0.8333*x



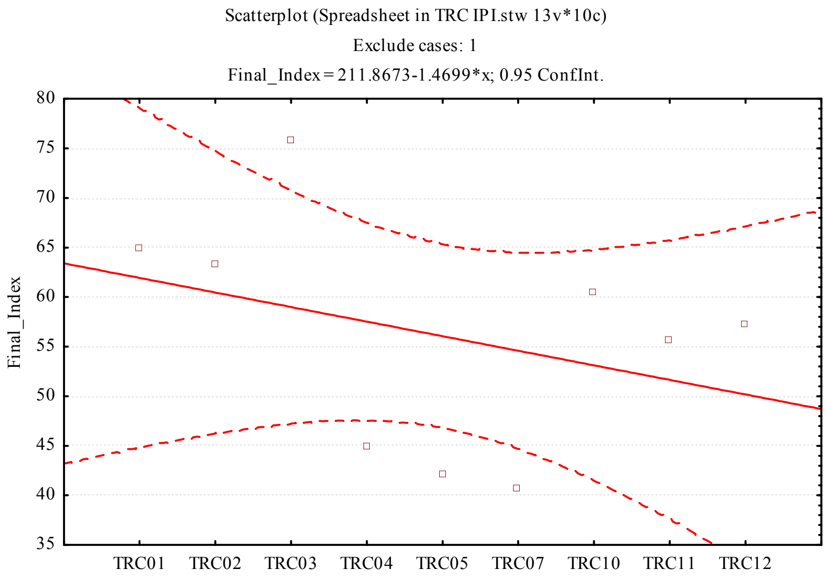

Site:Bank Stab: $r^2$ = 0.4083; r = -0.6390, p = 0.0639; y = 384.1667 - 2.9167*x



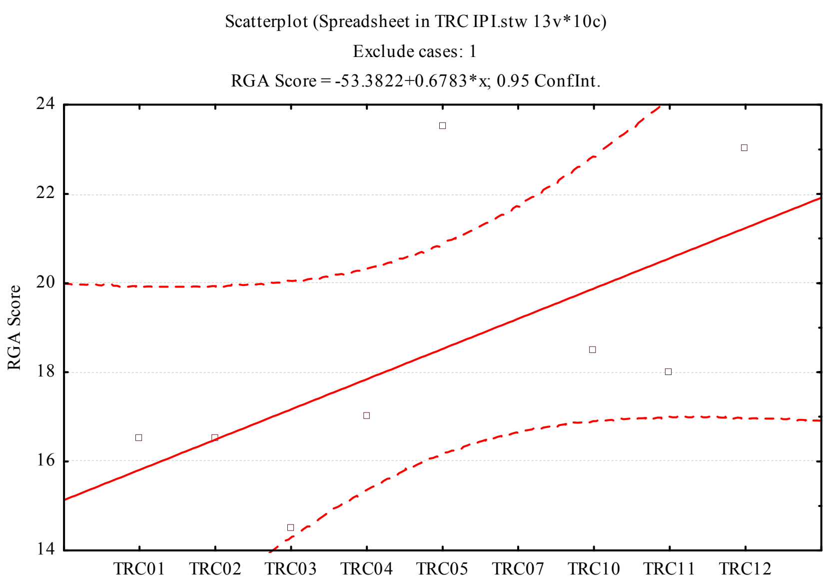

Site:OvVeg: $r^2 = 0.0169$; $r = 0.1299$, $p = 0.7391$; $y = -72.963 + 1.6667*x$



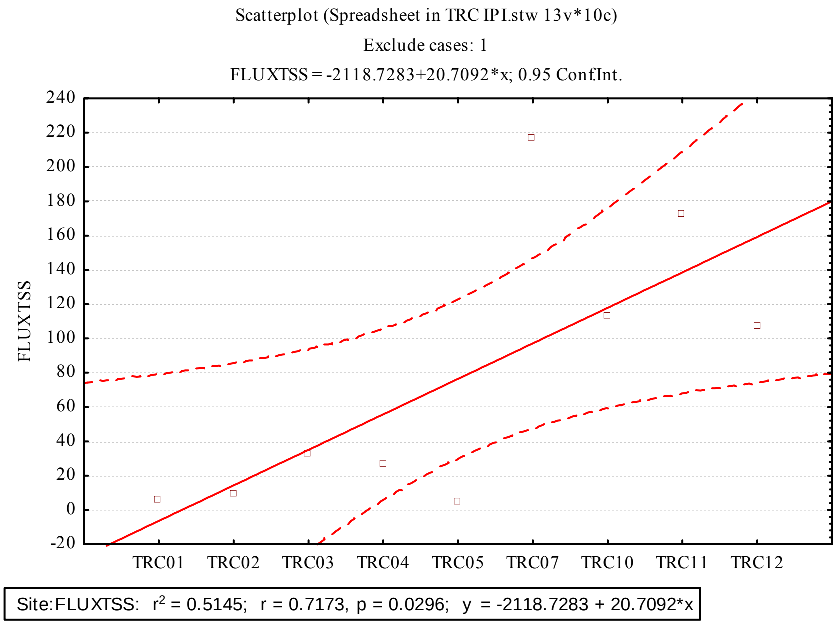

Site:AVU: $r^2 = 0.0121$; $r = -0.1101$, $p = 0.7780$; $y = 243.3333 - 1.6667*x$

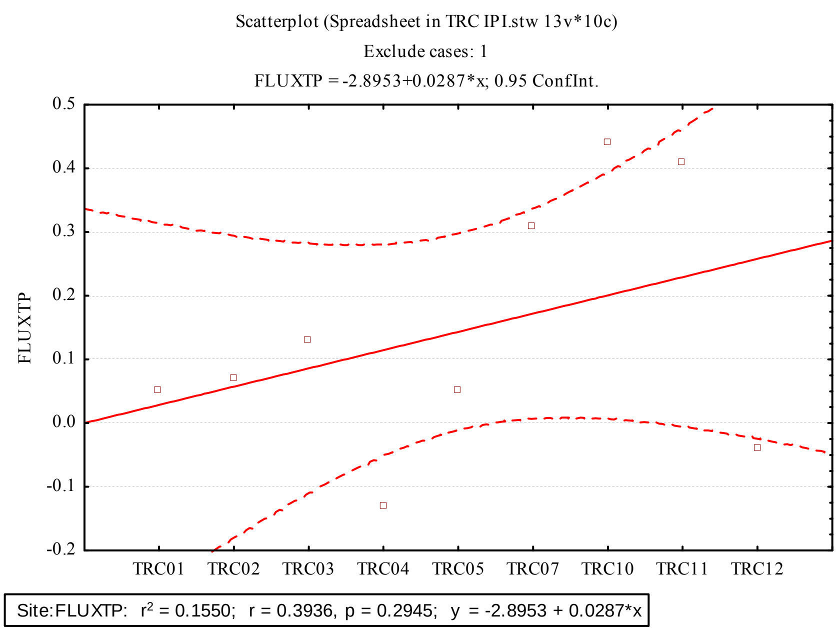



Site:Final_Index: $r^2 = 0.1180$; $r = -0.3436$, $p = 0.3654$; $y = 211.8673 - 1.4699*x$




Site:RGA Score: $r^2 = 0.3777$; $r = 0.6146$, $p = 0.1049$; $y = -53.3822 + 0.6783*x$


Scatterplot (Spreadsheet in TRC IP1.stw 13v*10c)
Exclude cases: 1
FLUXTSS = -2118.7283+20.7092*x; 0.95 Conf.Int.
FLUXTSS
240
220
200
180
160
140
120
100
80
60
40
20
0
-20
TRC01
TRC02
TRC03
TRC04
TRC05
TRC07
TRC10
TRC11
TRC12
Site:FLUXTSS: r2 = 0.5145; r = 0.7173, p = 0.0296; y = -2118.7283 + 20.7092*x


Scatterplot (Spreadsheet in TRC IP1.stw 13v*10c)
Exclude cases: 1
FLUXTP = -2.8953+0.0287*x; 0.95 Conf.Int.
FLUXTP
0.5
0.4
0.3
0.2
0.1
0.0
-0.1
-0.2
TRC01
TRC02
TRC03
TRC04
TRC05
TRC07
TRC10
TRC11
TRC12
Site:FLUXTP: r2 = 0.1550; r = 0.3936, p = 0.2945; y = -2.8953 + 0.0287*x

## 14.0 APPENDIX I – FECAL COLIFORM SPREADSHEETS USED FOR DEVELOPING TARGET LINES WITH LOAD DURATION CURVES

Site TRC12 as example only (Dr. Bruce Cleland's Load Duration Workshop, 2004.

**LOAD DURATION SUMMARY**

| ***Peak to Low*** | ***cfs*** | ***mm*** | ***Load*** |
|---|---|---|---|
| **0.245%** | **1233.98** | 6.679 | 6.04E+13 |
| **0.100%** | **1111.10** | 6.014 | 5.44E+13 |
| **0.274%** | **904.51** | 4.896 | 4.43E+13 |
| **1%** | **523.28** | 2.832 | 2.56E+13 |
| **5%** | **46.33** | 0.251 | 2.27E+12 |
| **10%** | **28.28** | 0.153 | 1.38E+12 |
| **15%** | **17.73** | 0.096 | 8.68E+11 |
| **20%** | **13.03** | 0.071 | 6.38E+11 |
| **25%** | **10.75** | 0.058 | 5.26E+11 |
| **30%** | **9.33** | 0.050 | 4.56E+11 |
| **35%** | **8.39** | 0.045 | 4.10E+11 |
| **40%** | **7.38** | 0.040 | 3.61E+11 |
| **45%** | **6.33** | 0.034 | 3.10E+11 |
| **50%** | **5.64** | 0.031 | 2.76E+11 |
| **55%** | **5.31** | 0.029 | 2.60E+11 |
| **60%** | **5.21** | 0.028 | 2.55E+11 |
| **65%** | **4.90** | 0.027 | 2.40E+11 |
| **70%** | **4.51** | 0.024 | 2.20E+11 |
| **75%** | **4.05** | 0.022 | 1.98E+11 |
| **80%** | **3.71** | 0.020 | 1.81E+11 |
| **85%** | **3.31** | 0.018 | 1.62E+11 |
| **90%** | **3.01** | 0.016 | 1.47E+11 |
| **95%** | **2.68** | 0.015 | 1.31E+11 |
| **99%** | **2.43** | 0.013 | 1.19E+11 |
| **100%** | **1.10** | 0.006 | 5.39E+10 |

**Station ID:** **TRC12**

**Station name:** **Turkey Ridge Creek near Centerville, SD**

**174.52** **= Drainage Area** ***(square miles)***

| **High** | **Moist** | **Mid** | **Dry** | **Low** |
|---|---|---|---|---|
| 46.33 | 10.75 | 5.64 | 4.05 | 2.68 |
| 0.251 | 0.058 | 0.031 | 0.022 | 0.015 |
| 2.27E+12 | 5.26E+11 | 2.76E+11 | 1.98E+11 | 1.31E+11 |
| 4002924.356 | | | | |

***Criteria***

| | |
|---|---|
| **2000** | ***WQ Target Daily Maximum*** |
| **150** | ***WQ Target Geo Mean*** |

**Key Loading Equations**

***Load (lb/day) = Criteria * Flow * (5.38)***

***TSS Load (tons/day)***

***= Criteria * Flow * (5.38/2000)***

Used TSS Load in Load duration graph.

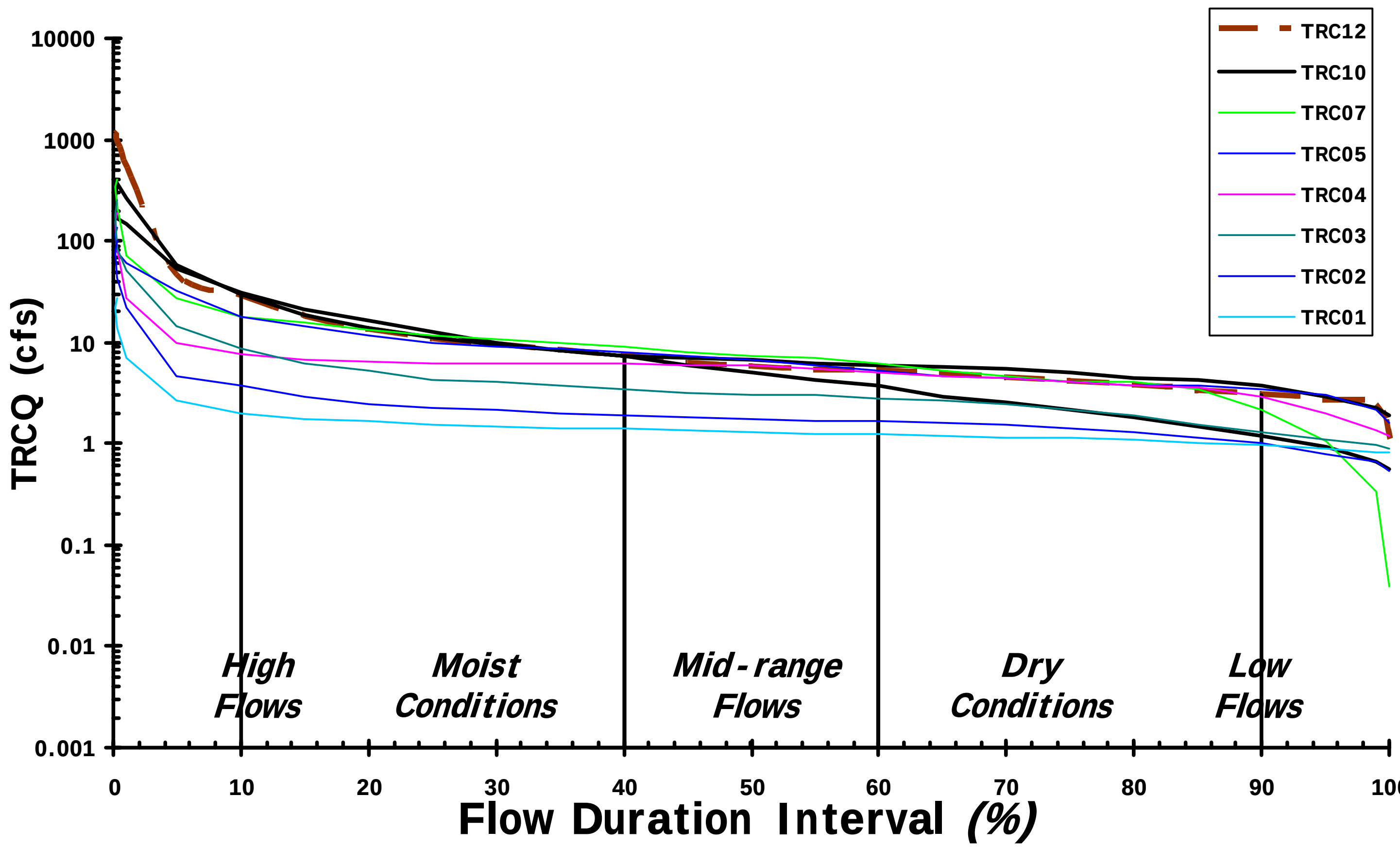
***Bacteria Load (counts/day)***

***= Criteria * Flow * ((28317/100)*60*60*24)***

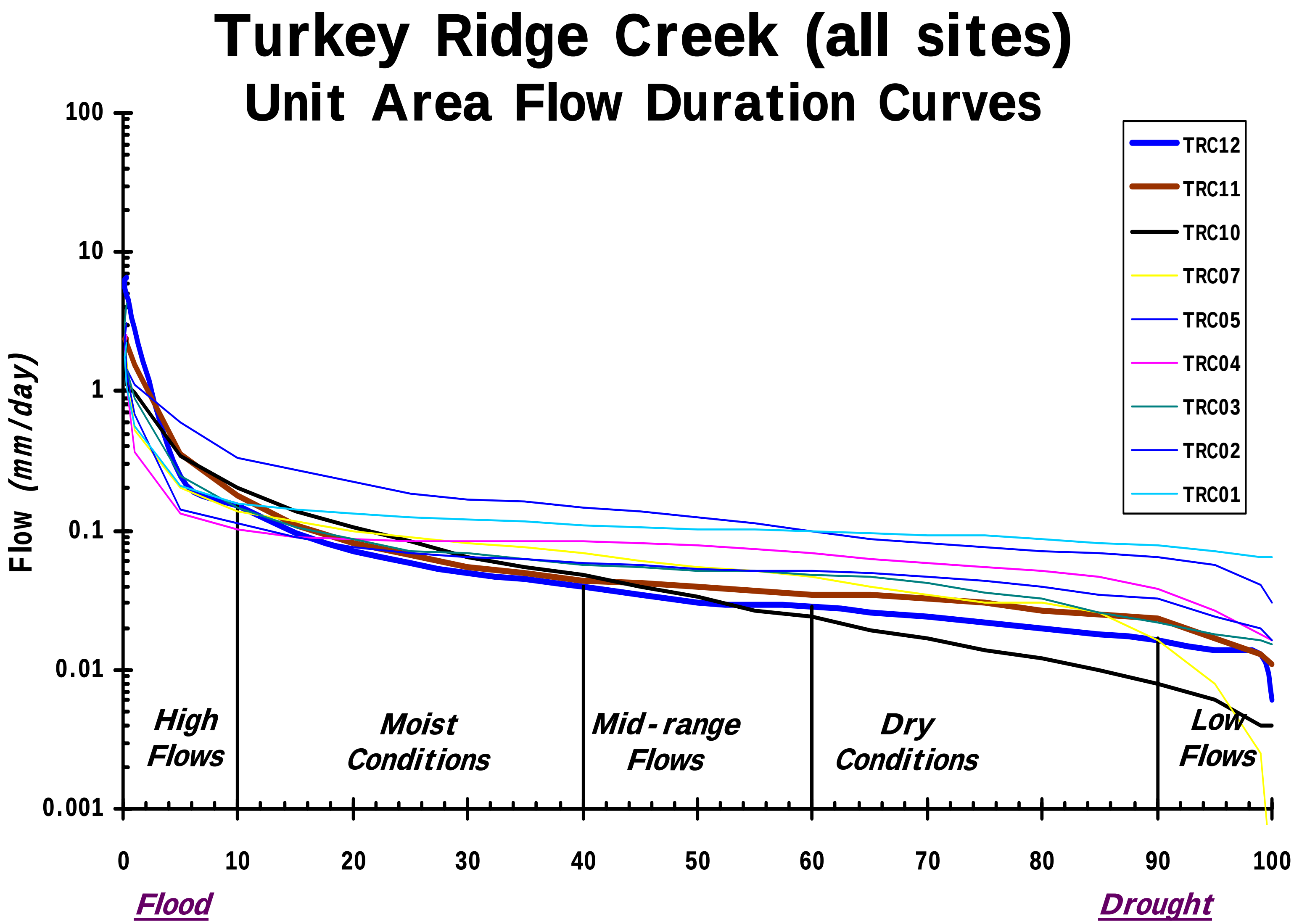
***Note:* 1 ft^3 = 28,317 mL**

# 15.0 APPENDIX J – TOTAL SUSPENDED SOLIDS LOAD DURATION CURVES

# Turkey Ridge Creek *(All Sites)*
## Flow Duration Curve

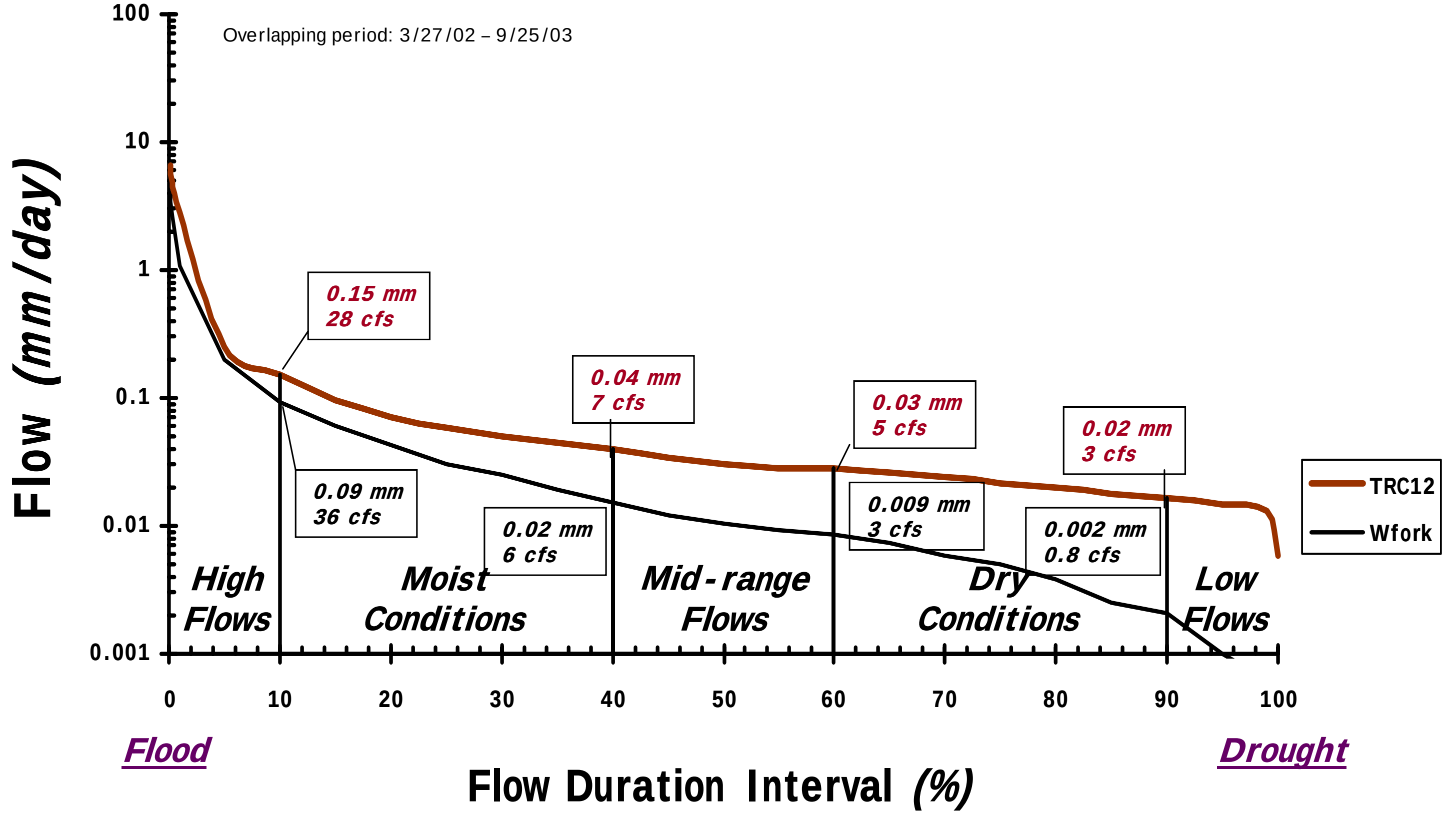



*SDDENR Flow Data* *175 square miles*



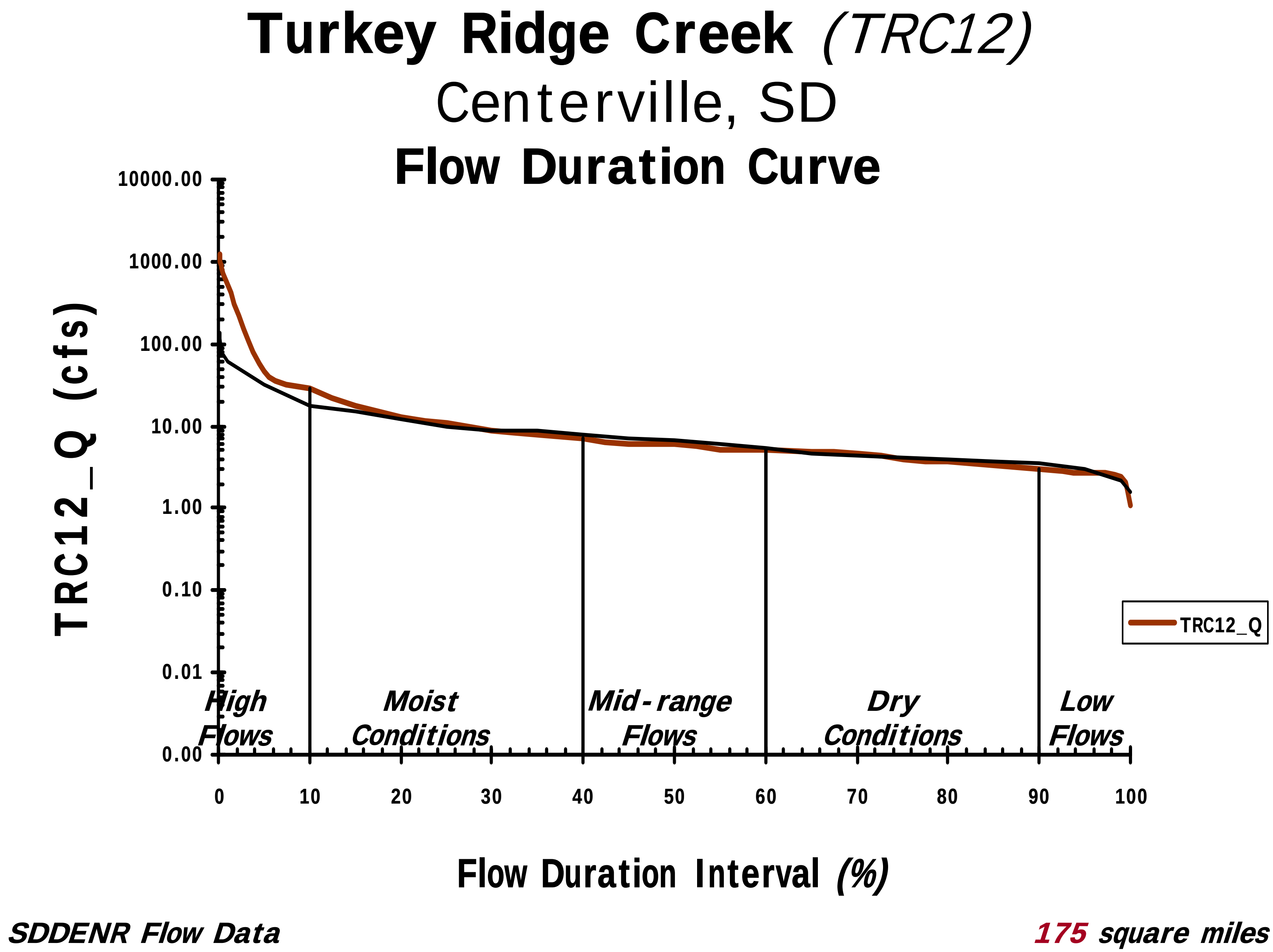

*SDDENR Flow Data*

# Turkey Ridge Creek *(TRC12)* Flow Comparison to the West Fork of the Vermillion River *(USGS Gage: 06478690)*




*USGS and SDDENR Flow Data*

*175, 388 square miles*

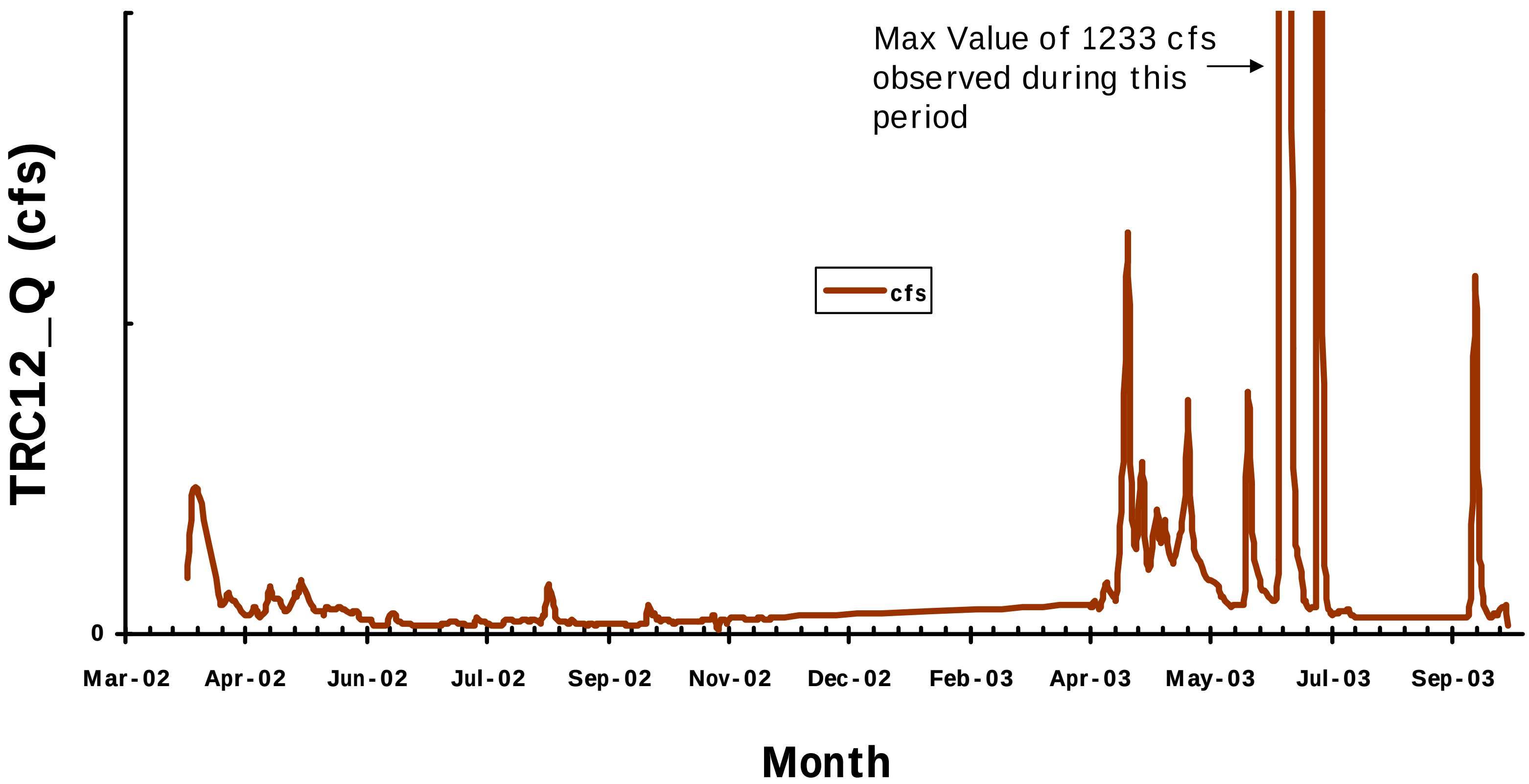


Turkey Ridge Creek (TRC12)
Centerville, SD
Flow Duration Curve
TRC12_Q (cfs)
10000.00
1000.00
100.00
10.00
1.00
0.10
0.01
0.00
High Flows
Moist Conditions
Mid-range Flows
Dry Conditions
Low Flows
0
10
20
30
40
50
60
70
80
90
100
TRC12_Q
Flow Duration Interval (%)
SDDENR Flow Data
175 square miles

# Turkey Ridge Creek *(TRC12)*

## Centerville, SD

## Seasonal Flow Pattern

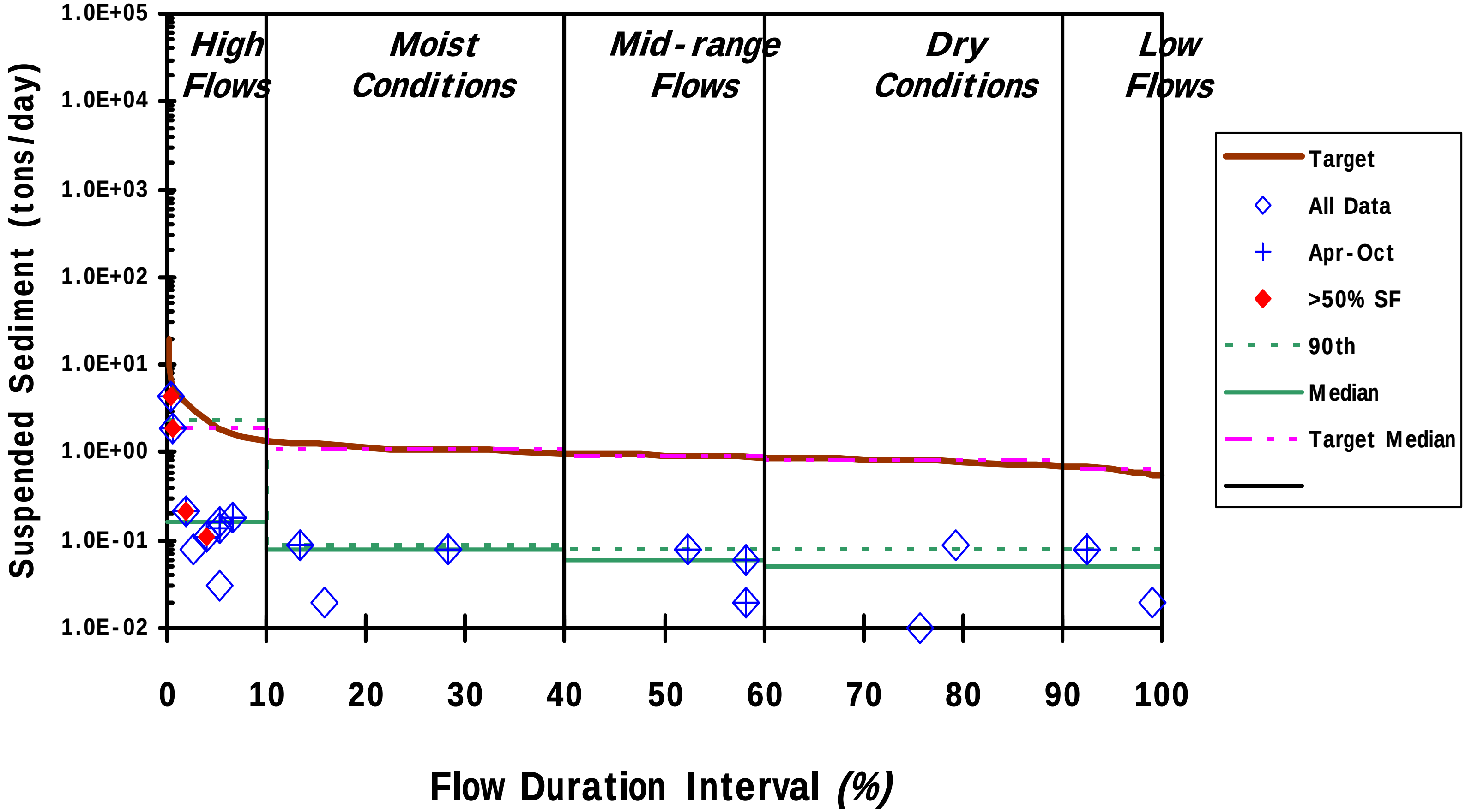



***SDDENR Flow Data*** ***175 square miles***

# Turkey Ridge Creek near Freeman, SD

## Load Duration Curve *(2002-03 Monitoring Data)*

## *Site: TRC01*



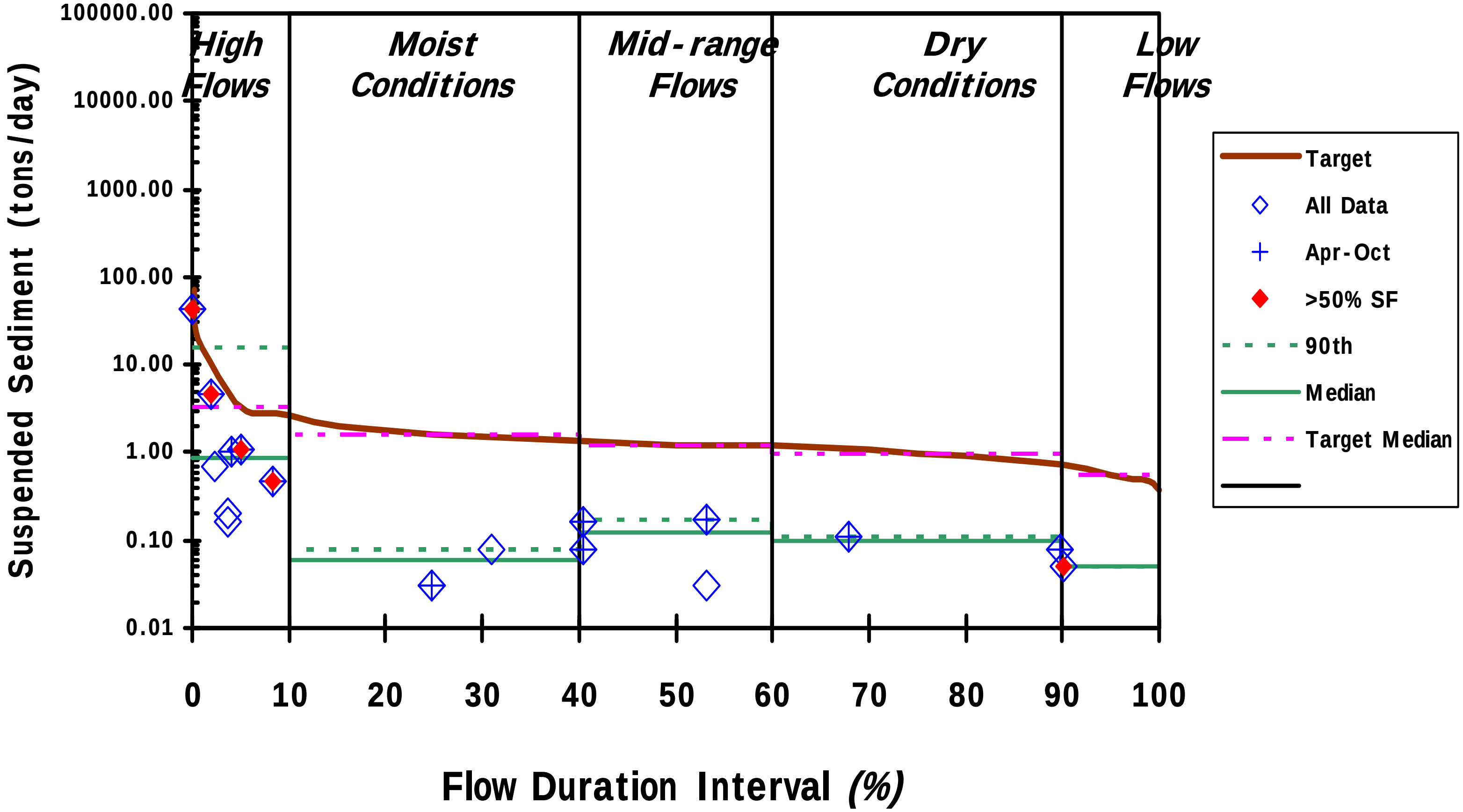

*SDDENR Data & Gage Duration Interval*

*11.9 square miles*

# Turkey Ridge Creek near Turkey Ridge, SD

## Load Duration Curve *(2002-03 Monitoring Data)*

## *Site: TRC02*



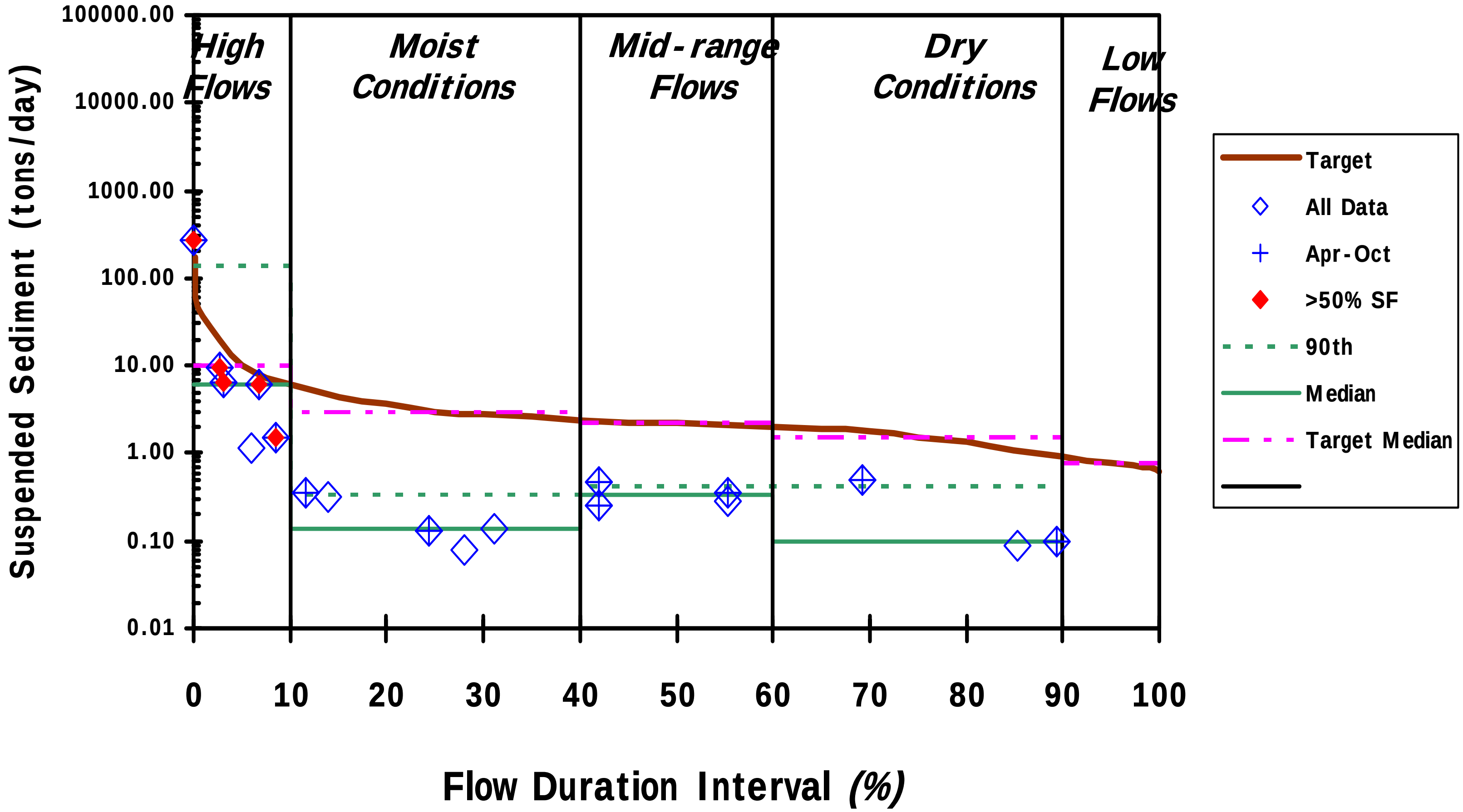

*SDDENR Data & Gage Duration Interval*

*30.8 square miles*

# Turkey Ridge Creek

## Load Duration Curve *(2002-03 Monitoring Data)*

## *Site: TRC03*

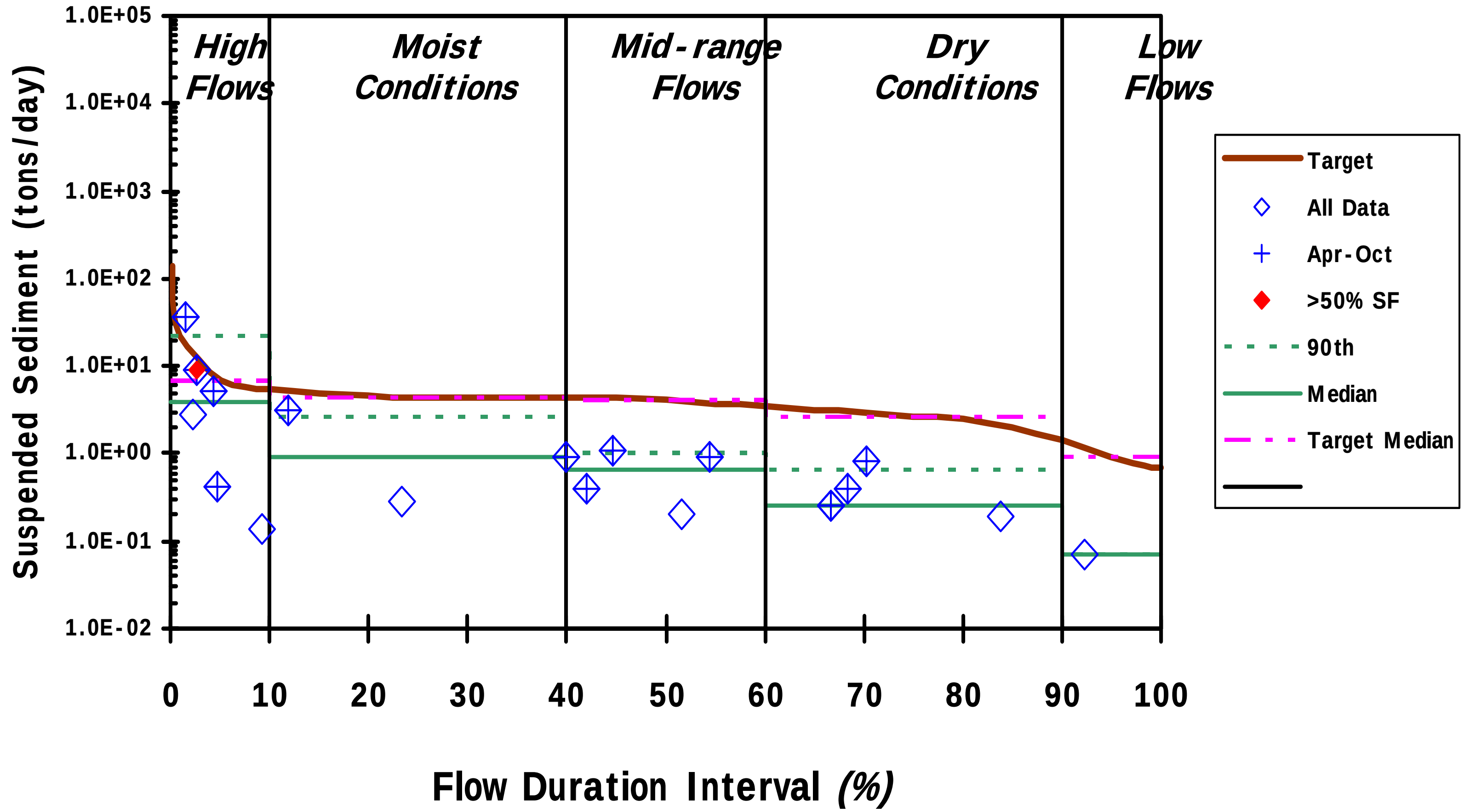



*SDDENR Data & Gage Duration Interval* *55.8 square miles*

# Turkey Ridge Creek near Turkey Ridge, SD

## Load Duration Curve *(2002-03 Monitoring Data)*

### *Site: TRC04*

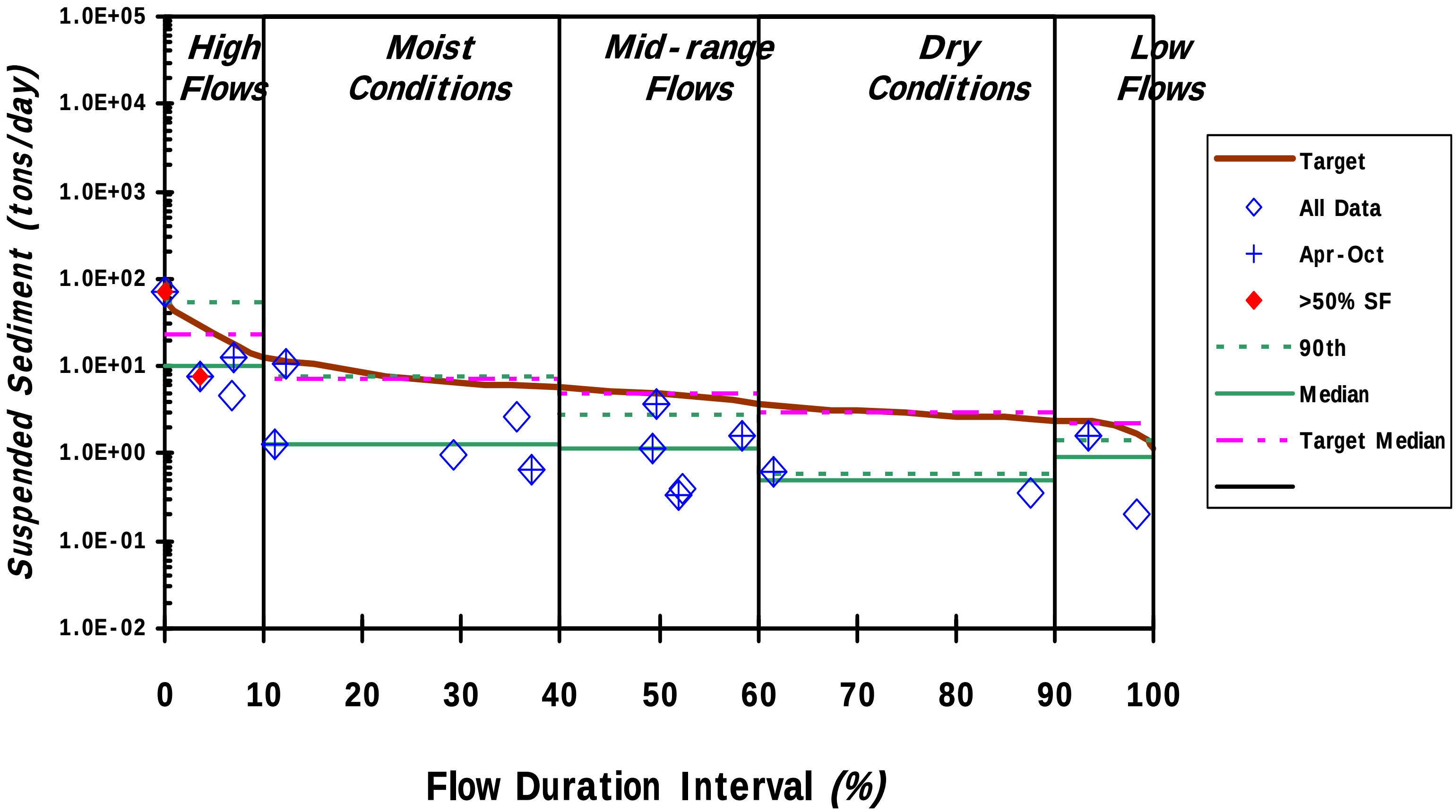



*SDDENR Data & Gage Duration Interval* *70.8 square miles*

# Turkey Ridge Creek near Viborg, SD

## Load Duration Curve *(2002-03 Monitoring Data)*

### *Site: TRC05*

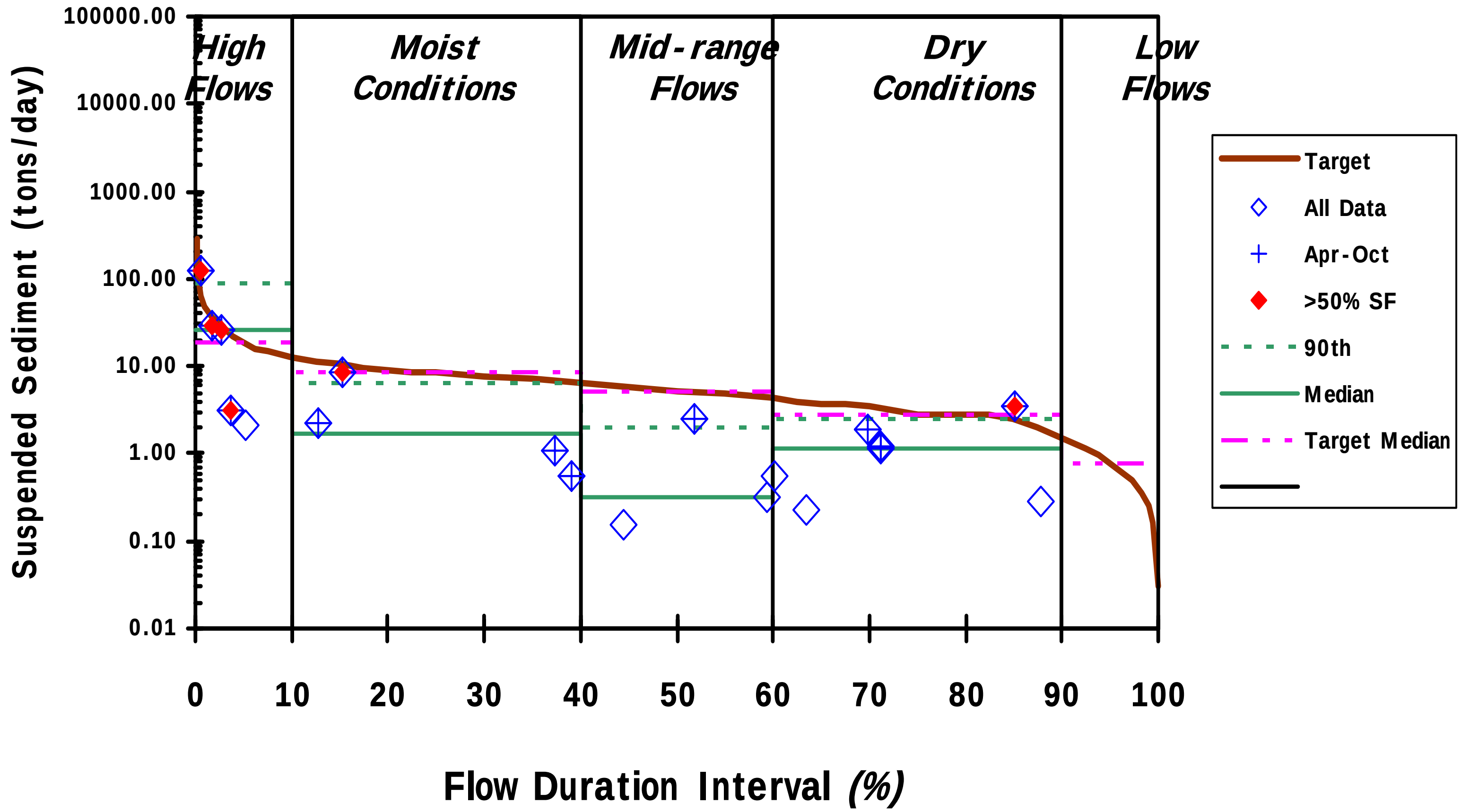



*SDDENR Data & Gage Duration Interval* *121.8 square miles*

# Turkey Ridge Creek near Viborg, SD

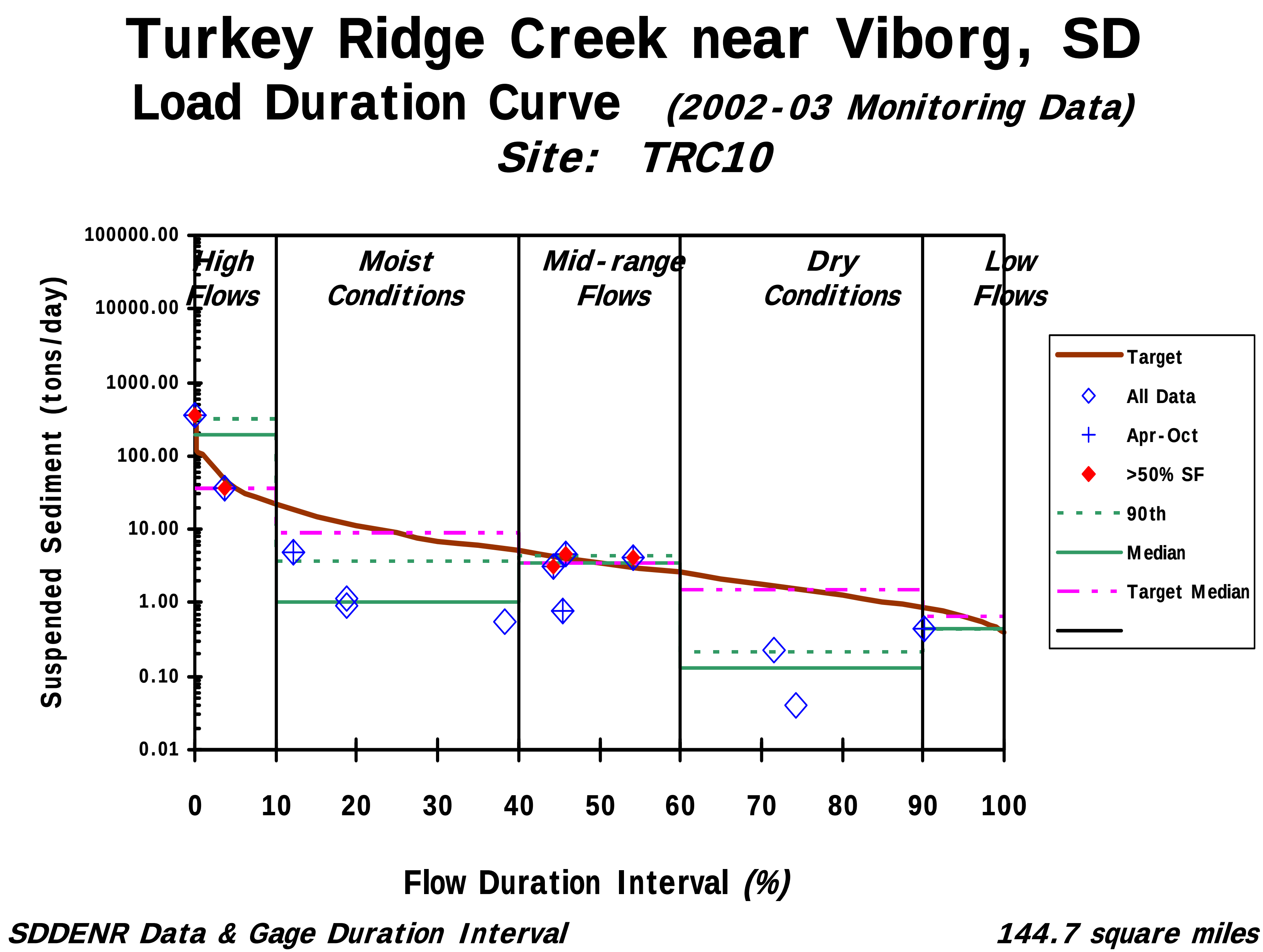
## Load Duration Curve *(2002-03 Monitoring Data)*

### *Site: TRC07*




*SDDENR Data & Gage Duration Interval*

*127 square miles*

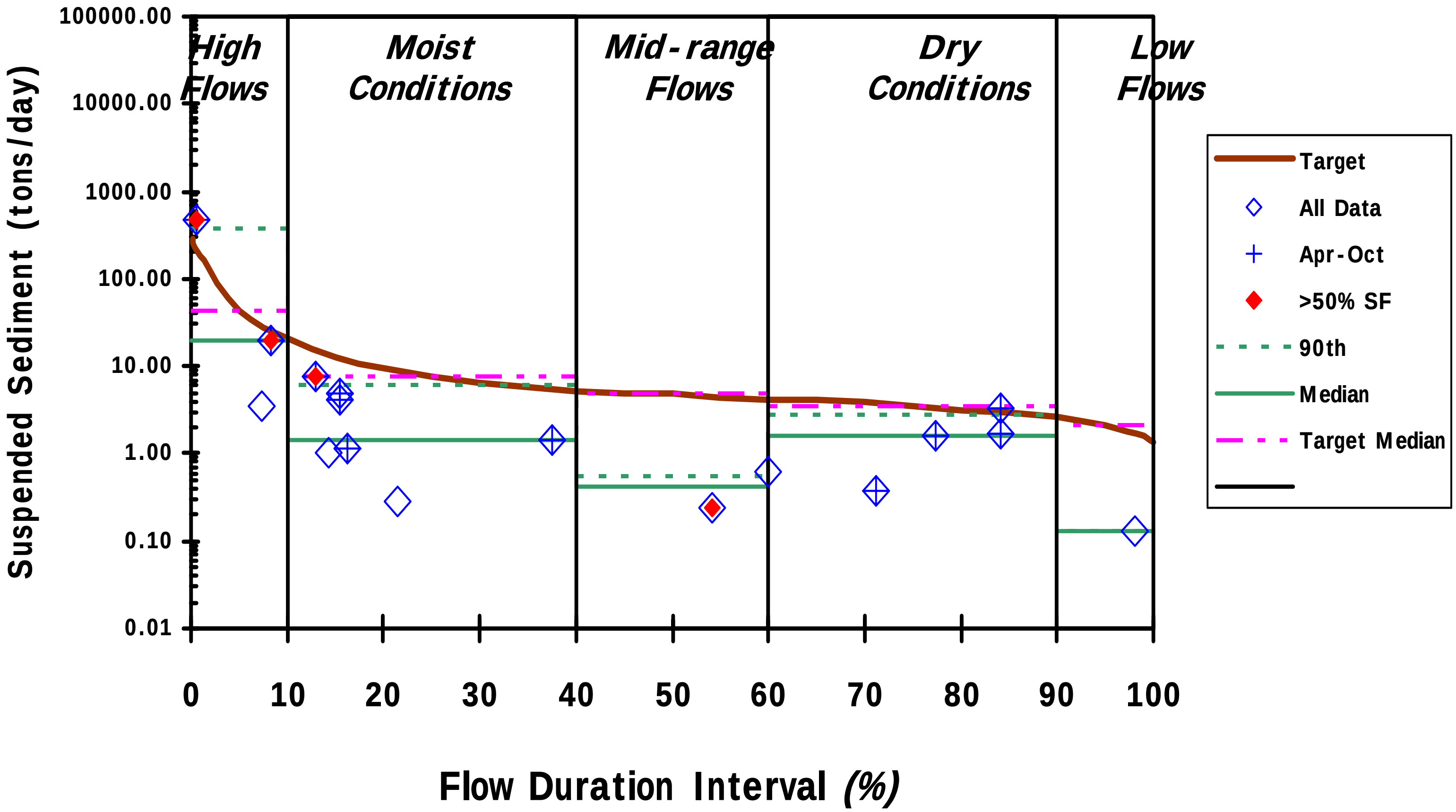


Turkey Ridge Creek near Viborg, SD
Load Duration Curve (2002-03 Monitoring Data)
Site: TRC10
100000.00
10000.00
1000.00
100.00
10.00
1.00
0.10
0.01
Suspended Sediment (tons/day)
High Flows
Moist Conditions
Mid-range Flows
Dry Conditions
Low Flows
Target
All Data
Apr-Oct
>50% SF
90th
Median
Target Median
0
10
20
30
40
50
60
70
80
90
100
Flow Duration Interval (%)
SDDENR Data & Gage Duration Interval
144.7 square miles

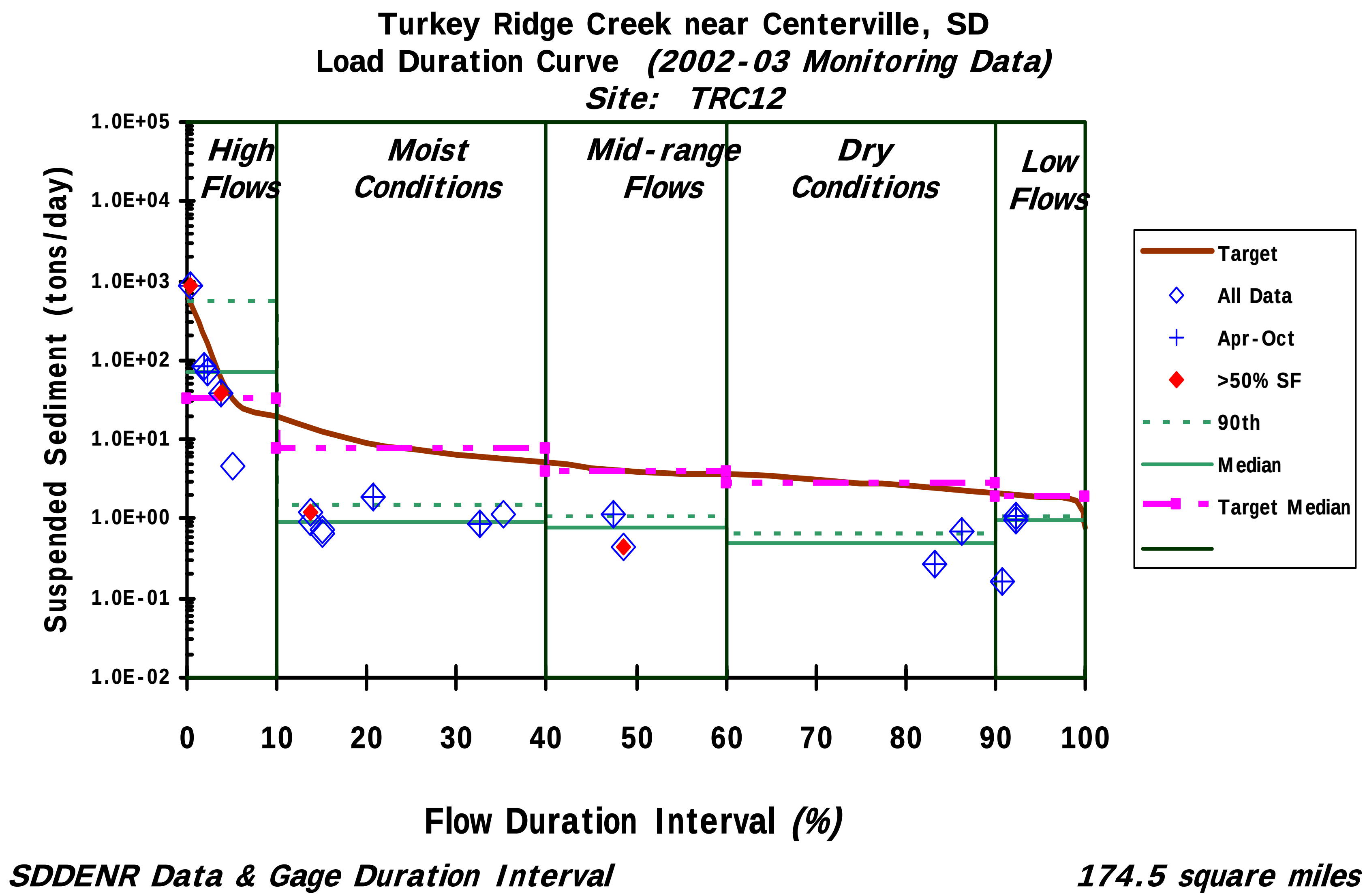
# Turkey Ridge Creek near Viborg, SD

## Load Duration Curve *(2002-03 Monitoring Data)*

## *Site: TRC11*



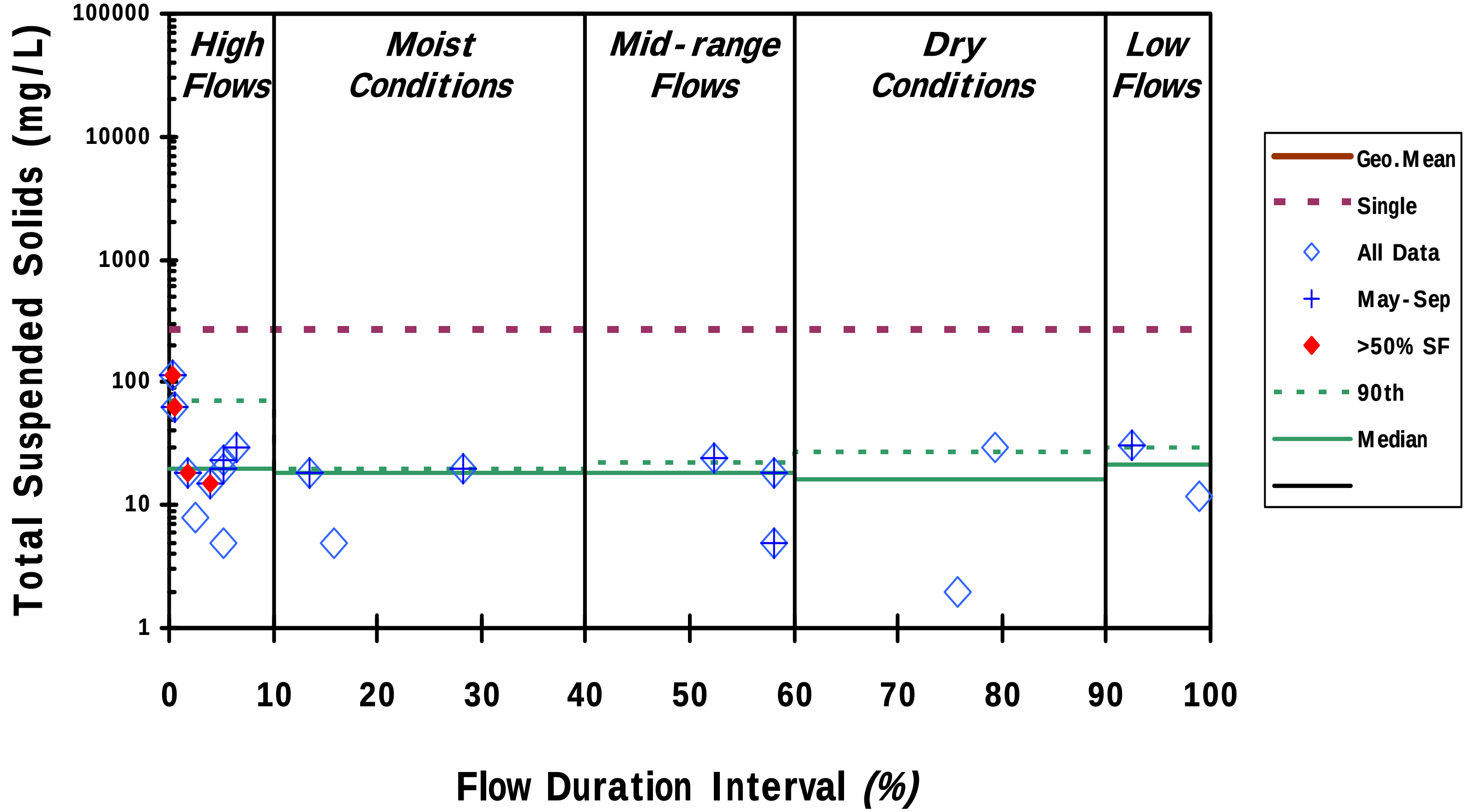

*SDDENR Data & Gage Duration Interval* *158.6 square miles*


Turkey Ridge Creek near Centerville, SD
Load Duration Curve (2002-03 Monitoring Data)
Site: TRC12
1.0E+05
1.0E+04
1.0E+03
1.0E+02
1.0E+01
1.0E+00
1.0E-01
1.0E-02
Suspended Sediment (tons/day)
High Flows
Moist Conditions
Mid-range Flows
Dry Conditions
Low Flows
0
10
20
30
40
50
60
70
80
90
100
Flow Duration Interval (%)
Target
All Data
Apr-Oct
>50% SF
90th
Median
Target Median
SDDENR Data & Gage Duration Interval
174.5 square miles

# Turkey Ridge Creek near Freeman, SD

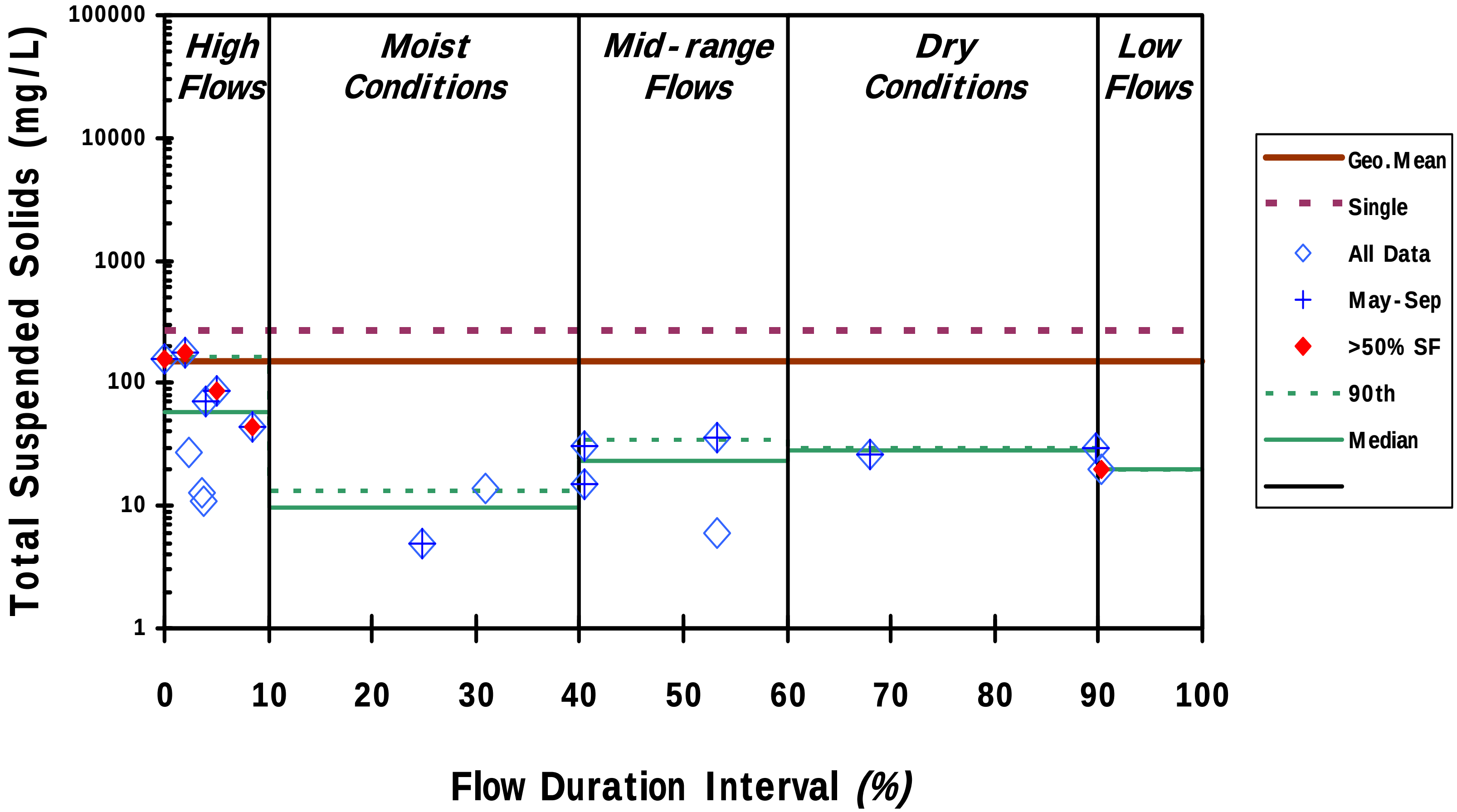
## WQ Duration Curve *(2002-03 Monitoring Data)*

### *Site: TRC01*




*SDDENR Data Gage Duration Interval* *11.9 square miles*

# Turkey Ridge Creek near Turkey Ridge, SD
## WQ Duration Curve *(2002-03 Monitoring Data)*
### *Site: TRC02*

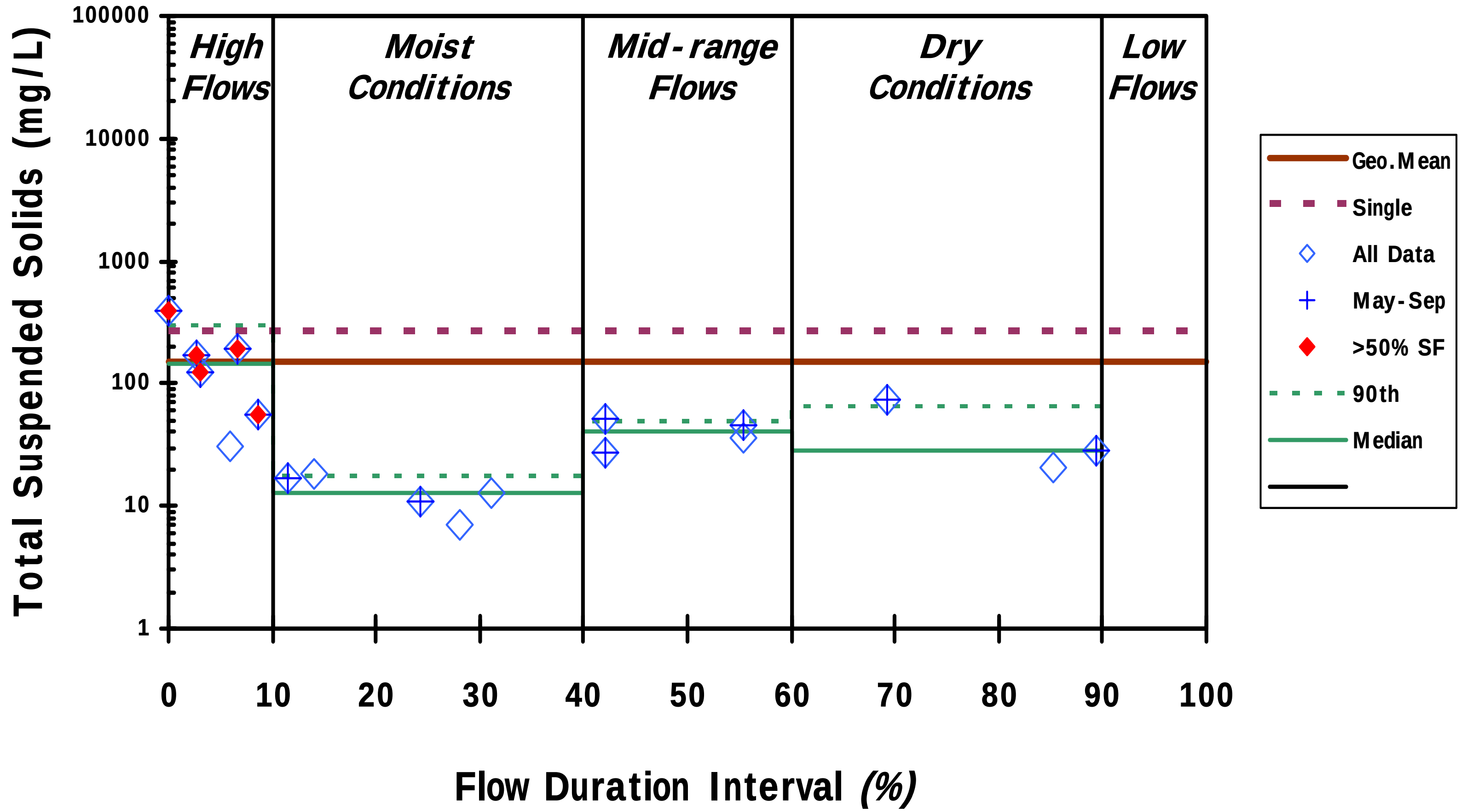



*SDDENR Data Gage Duration Interval* *30.8 square miles*

# Turkey Ridge Creek

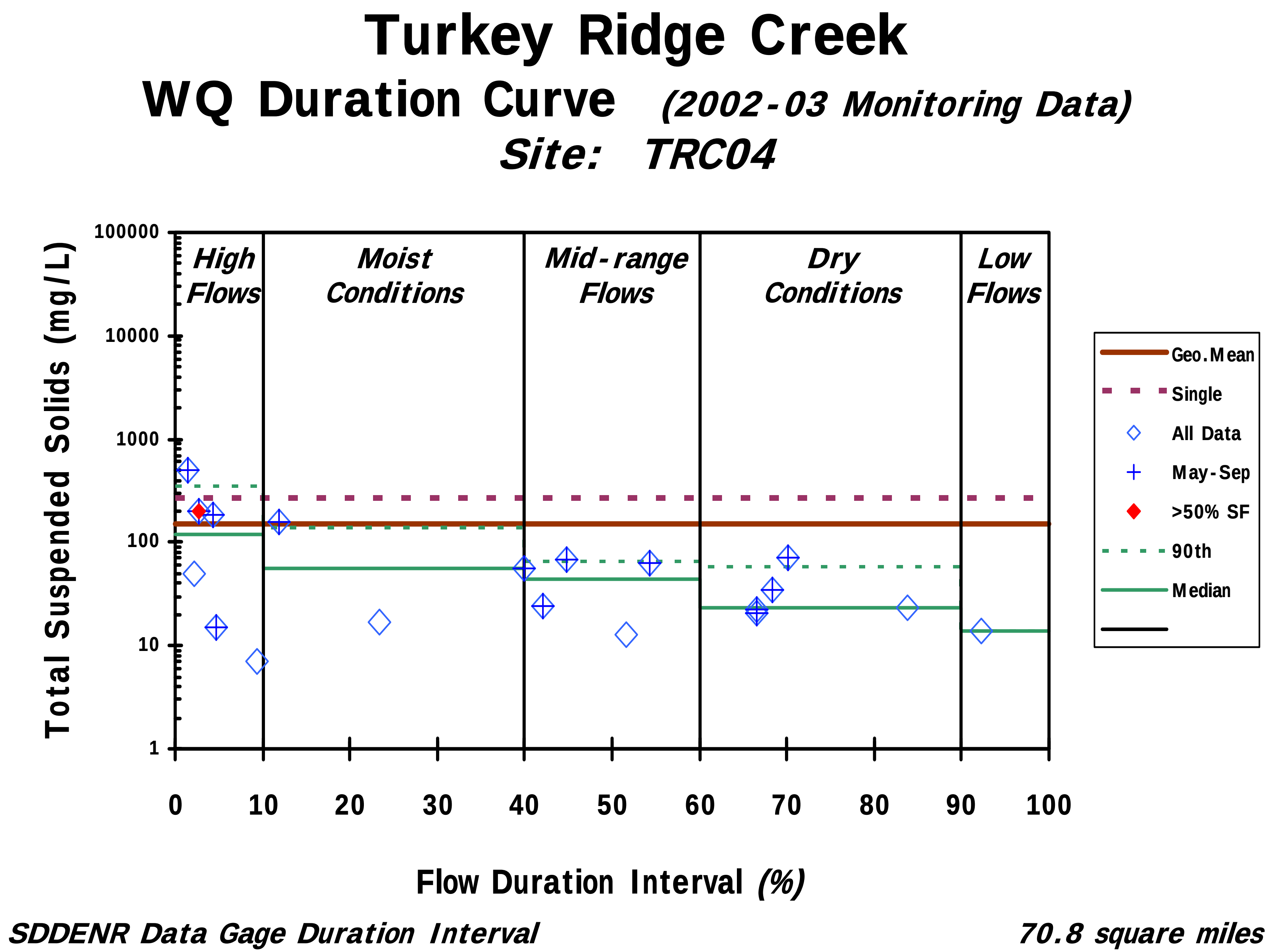
## WQ Duration Curve *(2002-03 Monitoring Data)*

## *Site: TRC03*




*SDDENR Data Gage Duration Interval*

*55.8 square miles*

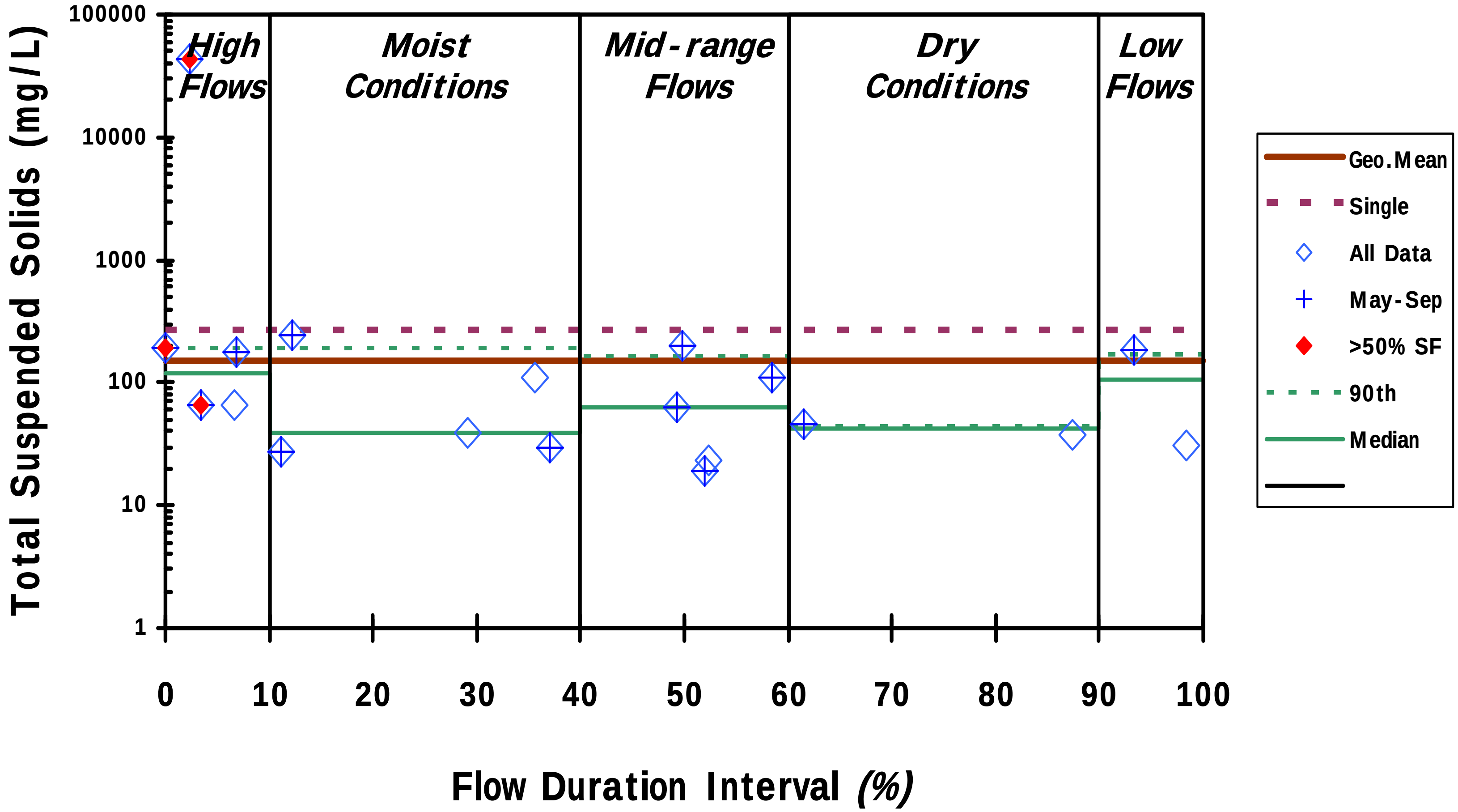


Turkey Ridge Creek
WQ Duration Curve (2002-03 Monitoring Data)
Site: TRC04
Total Suspended Solids (mg/L)
100000
10000
1000
100
10
1
High Flows
Moist Conditions
Mid-range Flows
Dry Conditions
Low Flows
0
10
20
30
40
50
60
70
80
90
100
Flow Duration Interval (%)
Geo. Mean
Single
All Data
May-Sep
>50% SF
90th
Median
SDDENR Data Gage Duration Interval
70.8 square miles

# Turkey Ridge Creek near Viborg, SD

## WQ Duration Curve *(2002-03 Monitoring Data)*

### *Site: TRC05*

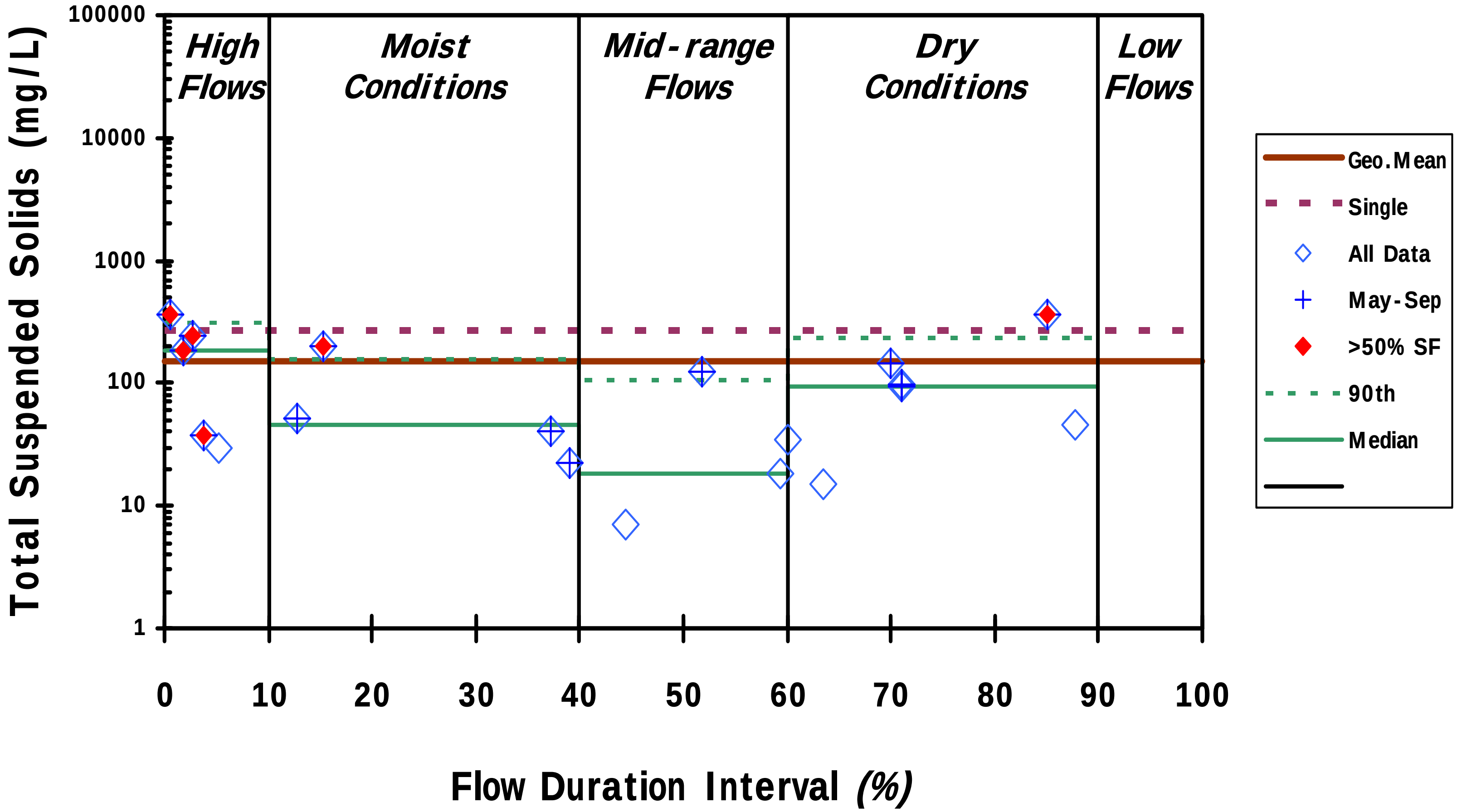



*SDDENR Data Gage Duration Interval* *121.8 square miles*

# Turkey Ridge Creek near Viborg, SD

## WQ Duration Curve *(2002-03 Monitoring Data)*

### *Site: TRC07*



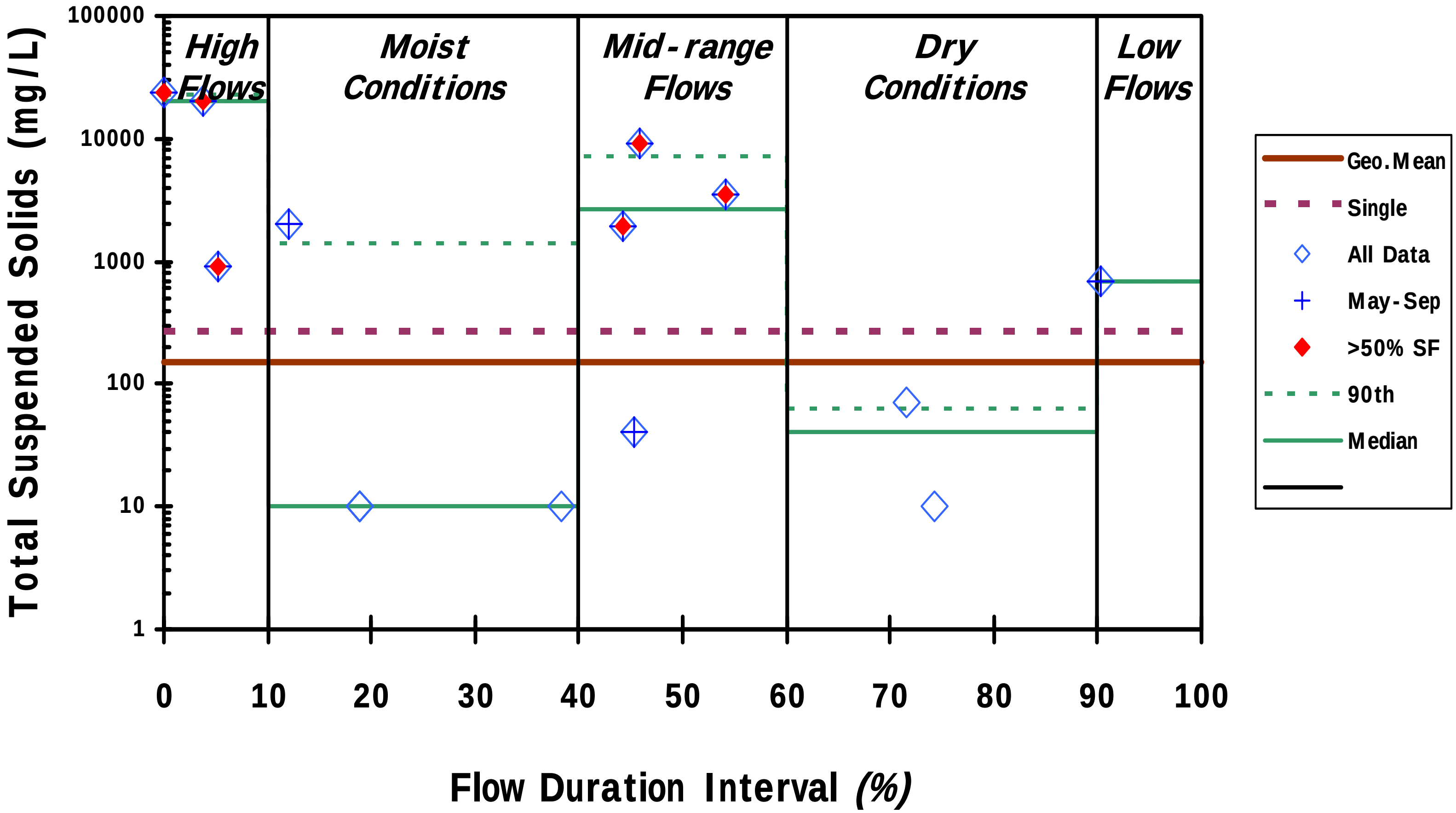

*SDDENR Data Gage Duration Interval*

*127 square miles*

# Turkey Ridge Creek near Viborg, SD

## WQ Duration Curve *(2002-03 Monitoring Data)*

### *Site: TRC10*

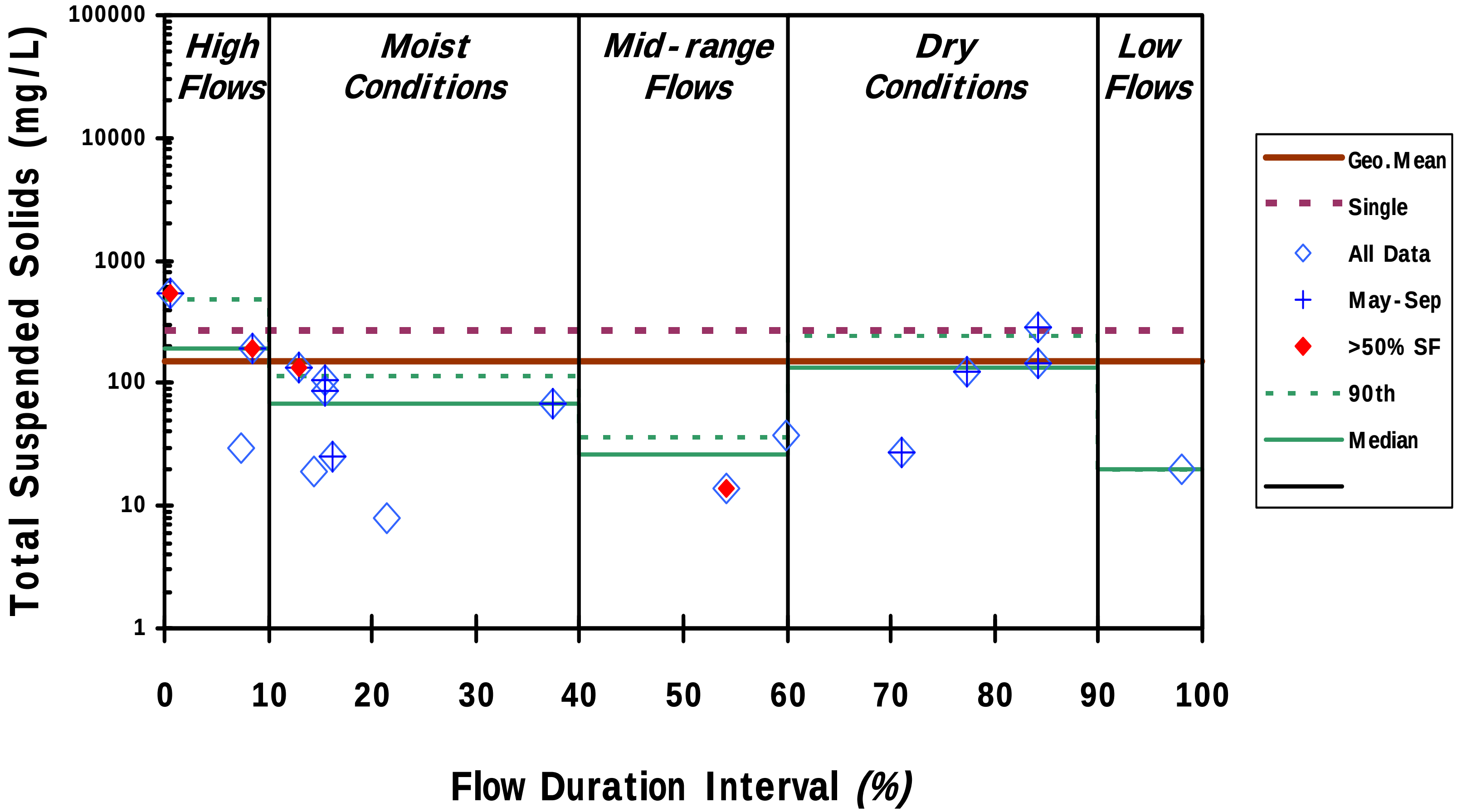



*SDDENR Data Gage Duration Interval* *144.7 square miles*

# Turkey Ridge Creek near Viborg, SD

## WQ Duration Curve *(2002-03 Monitoring Data)*

### *Site: TRC11*

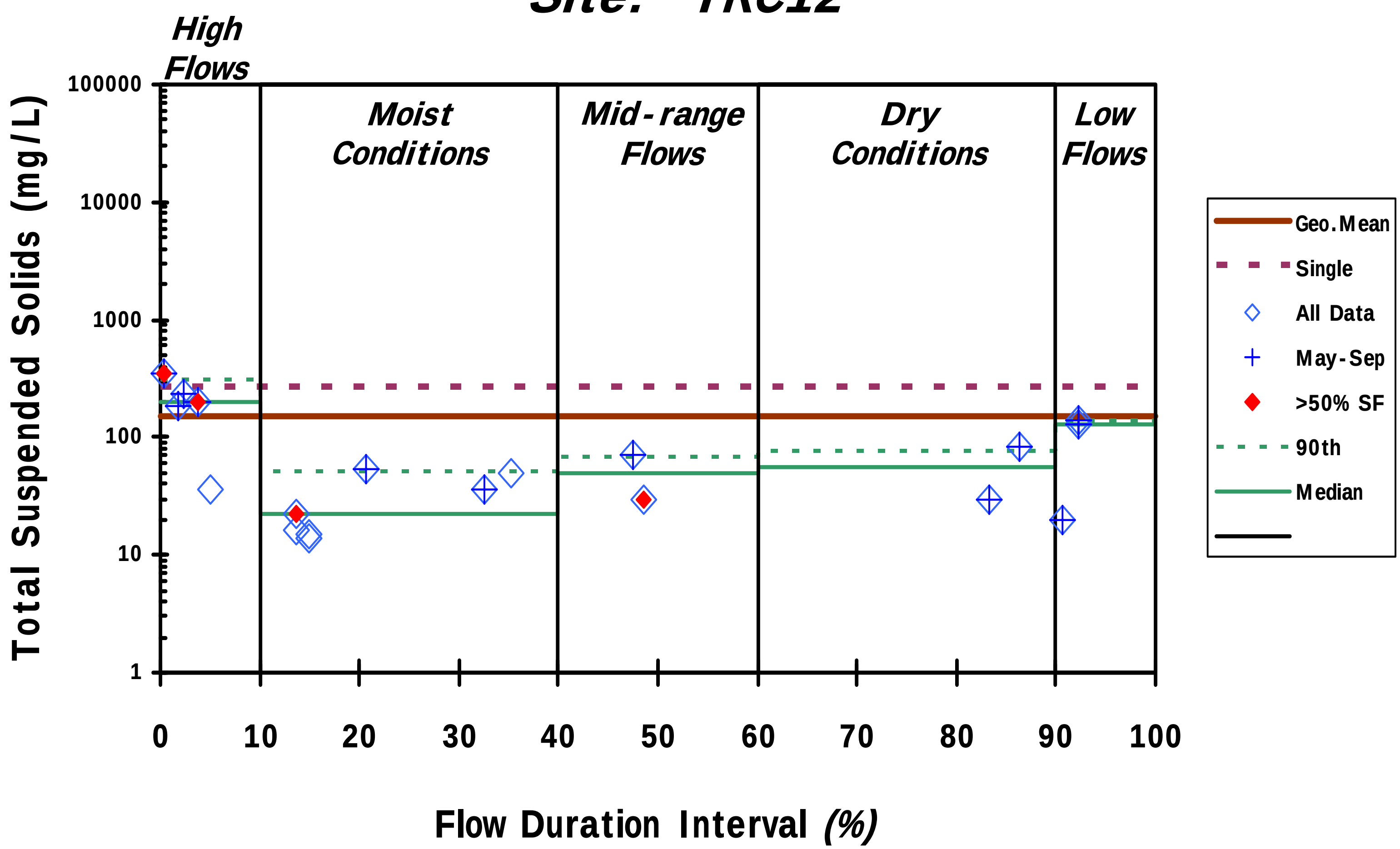



*SDDENR Data Gage Duration Interval* *158.6 square miles*

# Turkey Ridge Creek near Centerville, SD

## WQ Duration Curve *(2002-03 Monitoring Data)*

## *Site: TRC12*




*SDDENR Data Gage Duration Interval*

*174.5 square miles*

## 16.0 APPENDIX K – TOTAL SUSPENDED SOLIDS SPREADSHEET USED FOR TARGET IN LOAD DURATION CURVES

Site TRC12 as example only (Dr. Bruce Cleland's Load Duration Workshop, 2004.

**LOAD DURATION SUMMARY**

| | Peak to Low cfs | mm | TSS Load |
|---|---|---|---|
| **0.245%** | **1233.98** | 6.679 | 873.00 |
| **0.100%** | **1111.10** | 6.014 | 786.07 |
| **0.274%** | **904.51** | 4.896 | 639.92 |
| **1%** | **523.28** | 2.832 | 370.21 |
| **5%** | **46.33** | 0.251 | 32.78 |
| **10%** | **28.28** | 0.153 | 20.01 |
| **15%** | **17.73** | 0.096 | 12.55 |
| **20%** | **13.03** | 0.071 | 9.22 |
| **25%** | **10.75** | 0.058 | 7.60 |
| **30%** | **9.33** | 0.050 | 6.60 |
| **35%** | **8.39** | 0.045 | 5.93 |
| **40%** | **7.38** | 0.040 | 5.22 |
| **45%** | **6.33** | 0.034 | 4.48 |
| **50%** | **5.64** | 0.031 | 3.99 |
| **55%** | **5.31** | 0.029 | 3.76 |
| **60%** | **5.21** | 0.028 | 3.68 |
| **65%** | **4.90** | 0.027 | 3.46 |
| **70%** | **4.51** | 0.024 | 3.19 |
| **75%** | **4.05** | 0.022 | 2.86 |
| **80%** | **3.71** | 0.020 | 2.62 |
| **85%** | **3.31** | 0.018 | 2.34 |
| **90%** | **3.01** | 0.016 | 2.13 |
| **95%** | **2.68** | 0.015 | 1.90 |
| **99%** | **2.43** | 0.013 | 1.72 |
| **100%** | **1.10** | 0.006 | 0.78 |

**Station ID:** TRC12

**Station name:** Turkey Ridge Creek near Centerville, SD

**174.52** = **Drainage Area** *(square miles)*

| High | Moist | Mid | Dry | Low |
|---|---|---|---|---|
| 46.33 | 10.75 | 5.64 | 4.05 | 2.68 |
| 0.251 | 0.058 | 0.031 | 0.022 | 0.015 |
| 32.78 | 7.60 | 3.99 | 2.86 | 1.90 |

4002924.356

***Criteria***

| | |
|---|---|
| **263** | ***WQ Target Daily Maximum*** |
| **150** | ***WQ Target Geo Mean*** |

**Key Loading Equations**

***Load (lb/day) = Criteria * Flow * (5.38)***

***TSS Load (tons/day)***

***= Criteria * Flow * (5.38/2000)***

Used TSS Load in Load duration graph.

***Bacteria Load (counts/day)***

***= Criteria * Flow * ((28317/100)*60*60*24)***

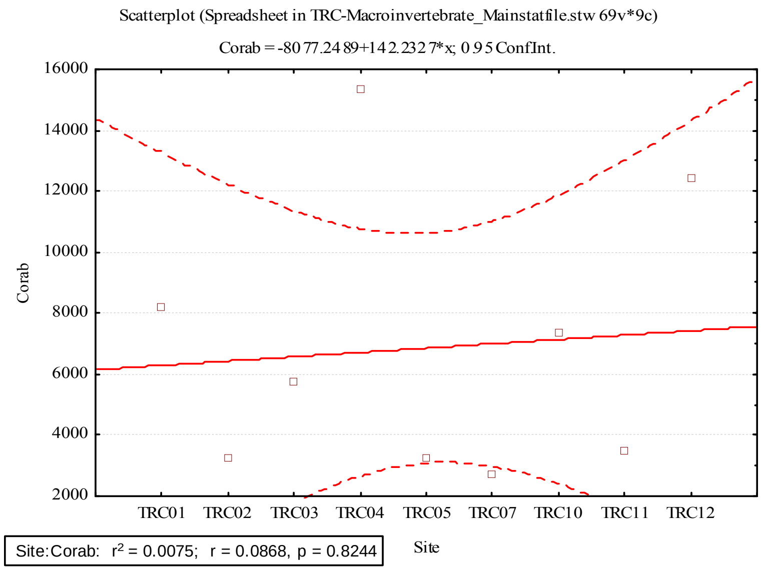
***Note:* 1 ft^3 = 28,317 mL**

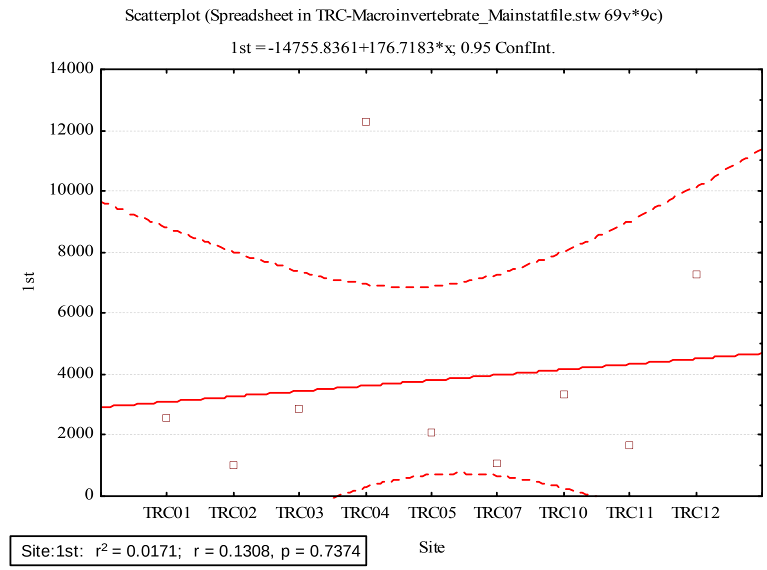
# 17.0 APPENDIX L – MACROINVERTEBRATE DATA AND METRICS WITH SCATTERPLOTS

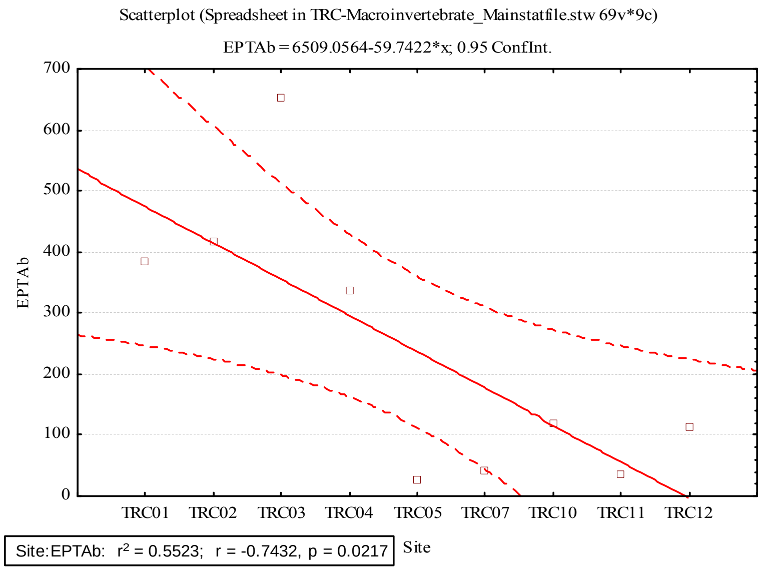
**Turner Conservation District**
**EcoAnalysts, Inc.**
***Data are adjusted for subsampling***

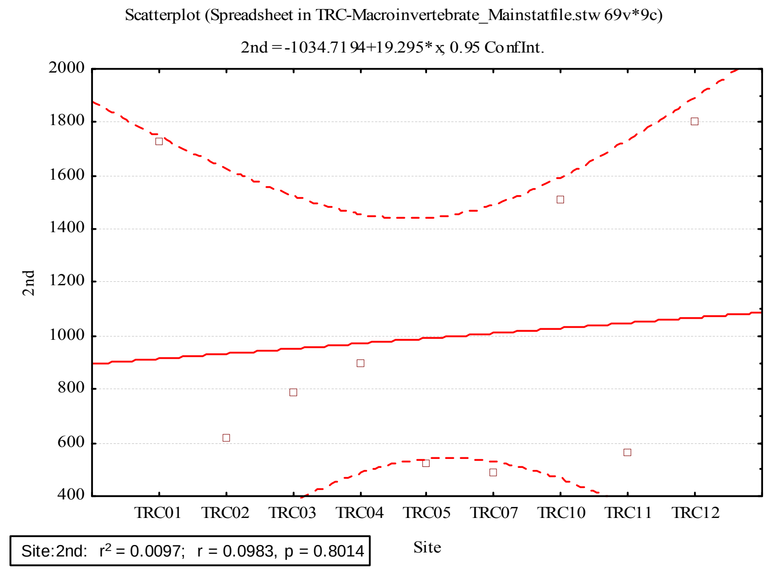
| Site | TRC01 | TRC02 | TRC03 | TRC04 | TRC05 | TRC07 | TRC10 | TRC11 | TRC12 |
|---|---|---|---|---|---|---|---|---|---|
| **Date** | **07-07-2002** | **07-10-2002** | **07-11-2002** | **07-11-2002** | **07-17-2002** | **07-18-2002** | **07-25-2002** | **08-07-2002** | **07-26-2002** |
| **Percent Subsampled** | **4.17** | **9.37** | **5.83** | **2.67** | **11.67** | **11.90** | **4.17** | **8.33** | **2.67** |
| **EcoAnalysts Sample ID** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** |
| **Abundance Measures** | | | | | | | | | |
| Corrected Abundance | 8184.00 | 3222.34 | 5724.76 | 15337.50 | 3248.03 | 2688.00 | 7344.00 | 3516.00 | 12450.00 |
| EPT Abundance | 384.00 | 416.13 | 651.32 | 337.50 | 25.71 | 42.00 | 120.00 | 36.00 | 112.50 |
| **Dominance Measures** | | | | | | | | | |
| 1st Dominant Taxon | Oligochaeta | Oligochaeta | Oligochaeta | Oligochaeta | Oligochaeta | Dubiraphia sp. | Oligochaeta | Oligochaeta | Oligochaeta |
| 1st Dominant Abundance | 2568.00 | 992.30 | 2880.00 | 12300.00 | 2065.00 | 1100.00 | 3336.00 | 1680.00 | 7275.00 |
| 2nd Dominant Taxon | Coenagrionidae | Physa (Physella) sp. | Physa (Physella) sp. | Physa (Physella) sp. | Dubiraphia sp. | Tanypus sp. | Corixidae | Tanypus sp. | Tanypus sp. |
| 2nd Dominant Abundance | 1728.00 | 618.90 | 788.40 | 900.00 | 522.80 | 487.20 | 1512.00 | 564.00 | 1800.00 |
| 3rd Dominant Taxon | Dicrotendipes sp. | Caenis diminuta gr. | Cheumatopsyche sp. | Dubiraphia sp. | Tanypus sp. | Oligochaeta | Dubiraphia sp. | Corixidae | Glyptotendipes sp. |
| 3rd Dominant Abundance | 1176.00 | 320.10 | 308.50 | 750.00 | 137.10 | 386.40 | 888.00 | 468.00 | 975.00 |
| % 1 Dominant Taxon | 31.38 | 30.79 | 50.30 | 80.20 | 63.59 | 40.94 | 45.42 | 47.78 | 58.43 |
| % 2 Dominant Taxa | 52.49 | 50.00 | 64.07 | 86.06 | 79.68 | 59.06 | 66.01 | 63.82 | 72.89 |
| % 3 Dominant Taxa | 66.86 | 59.93 | 69.46 | 90.95 | 83.91 | 73.44 | 78.10 | 77.13 | 80.72 |
| **Richness Measures** | | | | | | | | | |
| Species Richness | 27.00 | 25.00 | 26.00 | 20.00 | 22.00 | 24.00 | 18.00 | 11.00 | 18.00 |
| EPT Richness | 4.00 | 3.00 | 5.00 | 3.00 | 1.00 | 2.00 | 3.00 | 1.00 | 2.00 |
| Ephemeroptera Richness | 2.00 | 2.00 | 3.00 | 2.00 | 1.00 | 2.00 | 2.00 | 1.00 | 2.00 |
| Plecoptera Richness | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Trichoptera Richness | 2.00 | 1.00 | 2.00 | 1.00 | 0.00 | 0.00 | 1.00 | 0.00 | 0.00 |
| Chironomidae Richness | 16.00 | 10.00 | 12.00 | 8.00 | 14.00 | 13.00 | 5.00 | 4.00 | 9.00 |
| Oligochaeta Richness | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Non-Chiro. Non-Olig. Richness | 10.00 | 14.00 | 13.00 | 11.00 | 7.00 | 10.00 | 12.00 | 6.00 | 8.00 |
| Rhyacophila Richness | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| **Community Composition** | | | | | | | | | |
| % Ephemeroptera | 2.93 | 12.58 | 5.69 | 1.96 | 0.79 | 1.56 | 1.31 | 1.02 | 0.90 |
| % Plecoptera | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| % Trichoptera | 1.76 | 0.33 | 5.69 | 0.24 | 0.00 | 0.00 | 0.33 | 0.00 | 0.00 |
| % EPT | 4.69 | 12.91 | 11.38 | 2.20 | 0.79 | 1.56 | 1.63 | 1.02 | 0.90 |
| % Coleoptera | 1.47 | 9.93 | 5.09 | 4.89 | 16.09 | 40.94 | 13.73 | 11.60 | 1.51 |
| % Diptera | 34.31 | 14.57 | 13.47 | 5.13 | 16.09 | 33.13 | 15.03 | 25.60 | 32.23 |
| % Oligochaeta | 31.38 | 30.79 | 50.30 | 80.20 | 63.59 | 14.38 | 45.42 | 47.78 | 58.43 |
| % Baetidae | 2.35 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| % Brachycentridae | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| % Chironomidae | 34.31 | 13.58 | 12.28 | 4.16 | 13.98 | 30.94 | 12.09 | 24.91 | 31.33 |
| % Ephemerellidae | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| % Hydropsychidae | 1.76 | 0.00 | 5.69 | 0.24 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| % Odonata | 21.11 | 0.99 | 0.00 | 0.24 | 0.00 | 0.00 | 0.33 | 0.00 | 2.11 |
| % Perlidae | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| % Pteronarcyidae | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| % Simuliidae | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| **Functional Group Composition** | | | | | | | | | |
| % Filterers | 2.05 | 6.62 | 6.89 | 0.24 | 1.32 | 0.94 | 1.31 | 0.34 | 0.00 |

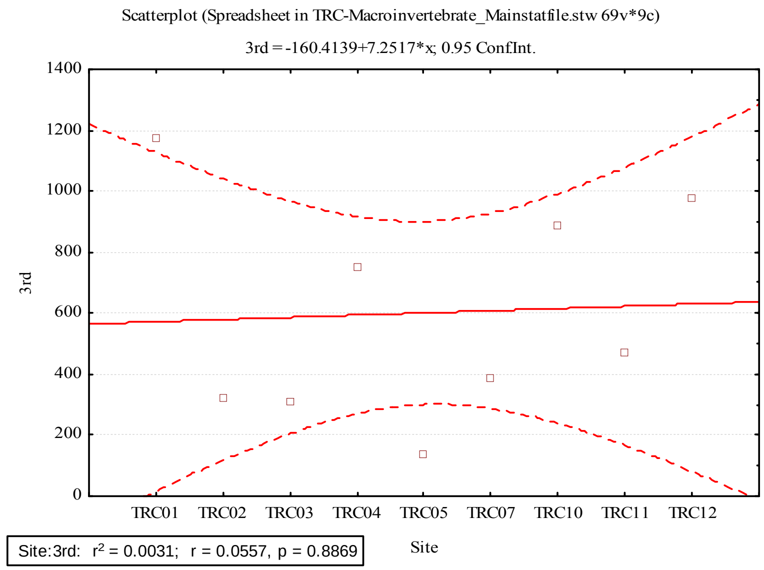
| Site | TRC01 | TRC02 | TRC03 | TRC04 | TRC05 | TRC07 | TRC10 | TRC11 | TRC12 |
|---|---|---|---|---|---|---|---|---|---|
| **Date** | **07-07-2002** | **07-10-2002** | **07-11-2002** | **07-11-2002** | **07-17-2002** | **07-18-2002** | **07-25-2002** | **08-07-2002** | **07-26-2002** |
| **Percent Subsampled** | **4.17** | **9.37** | **5.83** | **2.67** | **11.67** | **11.90** | **4.17** | **8.33** | **2.67** |
| **EcoAnalysts Sample ID** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** |
| % Gatherers | 72.43 | 57.28 | 66.77 | 88.51 | 84.96 | 60.94 | 61.11 | 67.92 | 77.11 |
| % Predators | 22.87 | 4.64 | 5.09 | 4.16 | 6.60 | 28.44 | 13.07 | 17.06 | 17.47 |
| % Scrapers | 0.59 | 19.21 | 13.77 | 6.11 | 1.58 | 2.50 | 2.61 | 0.00 | 2.71 |
| % Shredders | 2.05 | 2.32 | 3.29 | 0.73 | 4.75 | 6.56 | 21.57 | 13.65 | 2.41 |
| % Piercer-Herbivores | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| % Unclassified | 0.00 | 9.93 | 4.19 | 0.24 | 0.79 | 0.62 | 0.33 | 1.02 | 0.30 |
| Filterer Richness | 3.00 | 4.00 | 4.00 | 1.00 | 3.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| Gatherer Richness | 14.00 | 9.00 | 12.00 | 7.00 | 9.00 | 10.00 | 5.00 | 4.00 | 9.00 |
| Predator Richness | 6.00 | 7.00 | 5.00 | 7.00 | 3.00 | 8.00 | 7.00 | 3.00 | 3.00 |
| Scraper Richness | 1.00 | 1.00 | 1.00 | 2.00 | 2.00 | 2.00 | 2.00 | 0.00 | 2.00 |
| Shredder Richness | 3.00 | 3.00 | 3.00 | 2.00 | 4.00 | 2.00 | 2.00 | 2.00 | 3.00 |
| Piercer-Herbivore Richness | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Unclassified | 0.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| **Diversity/Evenness Measures** | | | | | | | | | |
| Shannon-Weaver H' (log 10) | 0.94 | 1.00 | 0.85 | 0.41 | 0.63 | 0.86 | 0.77 | 0.67 | 0.68 |
| Shannon-Weaver H' (log 2) | 3.12 | 3.33 | 2.83 | 1.36 | 2.08 | 2.87 | 2.55 | 2.22 | 2.24 |
| Shannon-Weaver H' (log e) | 2.16 | 2.31 | 1.96 | 0.94 | 1.45 | 1.99 | 1.77 | 1.54 | 1.55 |
| Margalef's Richness | 2.89 | 2.97 | 2.89 | 1.97 | 2.60 | 2.91 | 1.91 | 1.22 | 1.80 |
| Pielou's J' | 0.66 | 0.72 | 0.60 | 0.31 | 0.47 | 0.63 | 0.61 | 0.64 | 0.54 |
| Simpson's Heterogeneity | 0.82 | 0.84 | 0.72 | 0.35 | 0.57 | 0.77 | 0.73 | 0.71 | 0.63 |
| **Biotic Indices** | | | | | | | | | |
| Hilsenhoff Biotic Index | 7.84 | 6.75 | 7.26 | 7.83 | 7.58 | 7.33 | 7.67 | 8.13 | 8.37 |
| Metals Tolerance Index | 2.02 | 1.60 | 1.35 | 0.70 | 1.20 | 2.57 | 1.89 | 1.50 | 0.72 |
| Fine Sediment Biotic Index | 2.00 | 1.00 | 11.00 | 3.00 | -99.00 | -99.00 | -99.00 | -99.00 | -99.00 |
| FSBI - average | 0.07 | 0.04 | 0.42 | 0.15 | -99.00 | -99.00 | -99.00 | -99.00 | -99.00 |
| FSBI - weighted average | 0.03 | 0.01 | 0.16 | 0.01 | -99.00 | -99.00 | -99.00 | -99.00 | -99.00 |
| Temp. Pref. Metric - average | 0.78 | 0.44 | 0.42 | 0.55 | 0.59 | 0.25 | 0.33 | 0.36 | 0.33 |
| TPM - weighted average | 0.24 | 0.22 | 0.27 | 0.08 | 0.28 | 0.50 | 0.37 | 0.26 | 0.05 |
| DEQ MBI | 2.38 | 2.79 | 2.39 | 1.31 | 1.61 | 2.15 | 1.91 | 1.53 | 1.59 |
| **Karr BIBI Metrics** | | | | | | | | | |
| Long-Lived Taxa Richness | 1.00 | 6.00 | 2.00 | 2.00 | 3.00 | 1.00 | 4.00 | 2.00 | 2.00 |
| Clinger Richness | 10.00 | 8.00 | 6.00 | 5.00 | 7.00 | 4.00 | 5.00 | 2.00 | 5.00 |
| % Clingers | 12.02 | 14.90 | 15.57 | 6.36 | 21.64 | 44.69 | 16.67 | 11.95 | 10.24 |
| Intolerant Taxa Richness | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| % Tolerant taxa | 2.54 | 5.18 | 4.04 | 2.31 | 7.70 | 2.46 | 2.85 | 5.09 | 1.74 |

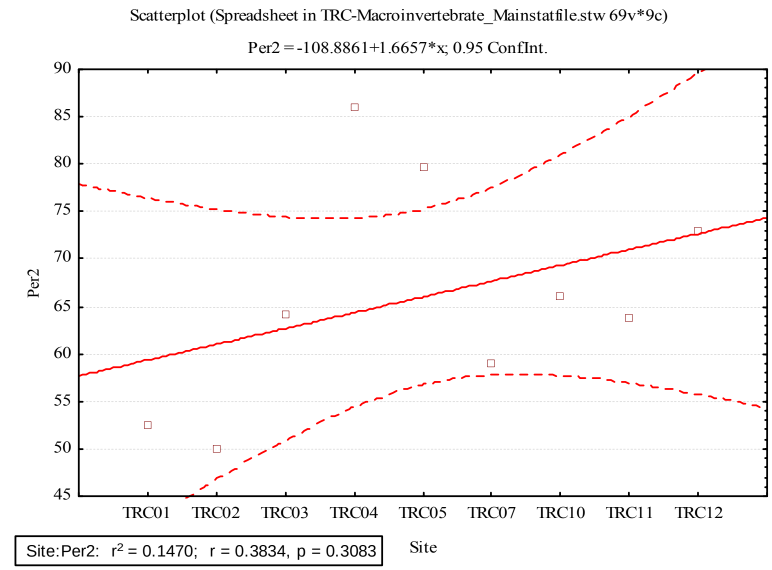

Scatterplot (Spreadsheet in TRC-Macroinvertebrate_Mainstatfile.stw 69v*9c)
Corab = -8077.2489+142.2327*x; 0.95 Conf.Int.
Corab
Site
TRC01 TRC02 TRC03 TRC04 TRC05 TRC07 TRC10 TRC11 TRC12
Site:Corab: r² = 0.0075; r = 0.0868, p = 0.8244

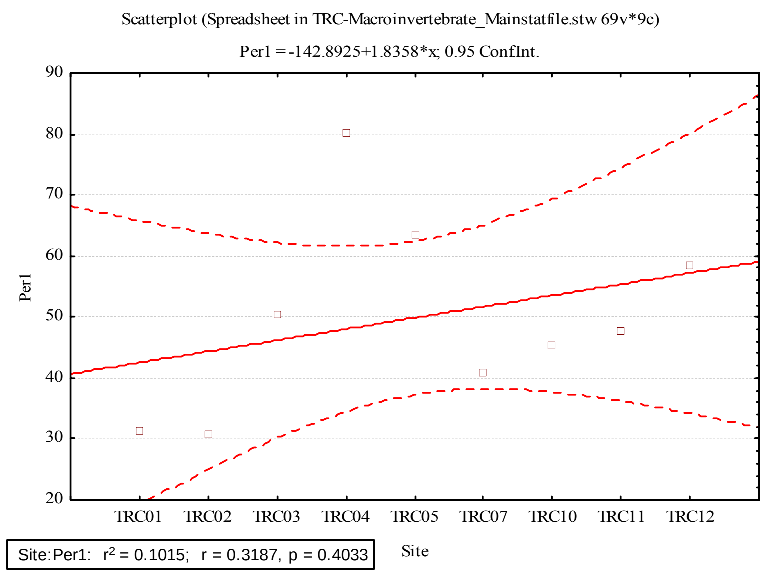

Scatterplot (Spreadsheet in TRC-Macroinvertebrate_Mainstatfile.stw 69v*9c)
1st = -14755.8361+176.7183*x; 0.95 Conf.Int.
1st
Site
TRC01 TRC02 TRC03 TRC04 TRC05 TRC07 TRC10 TRC11 TRC12
Site:1st: r² = 0.0171; r = 0.1308, p = 0.7374

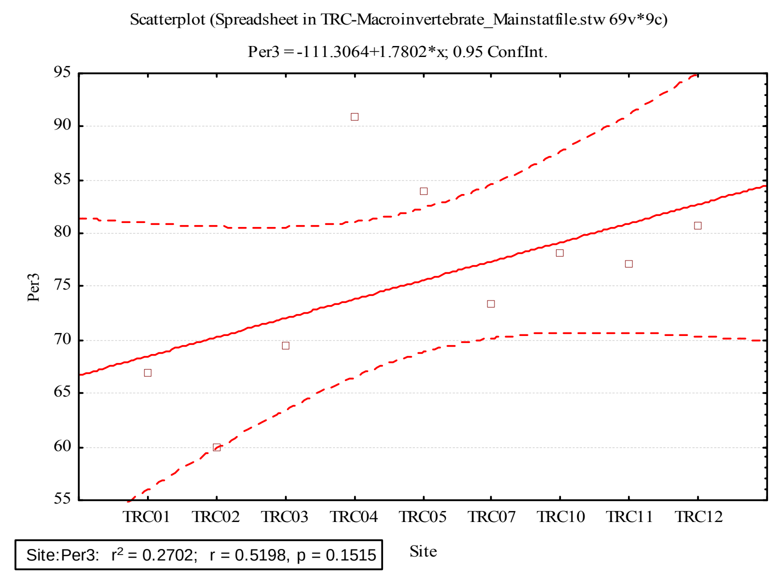

Scatterplot (Spreadsheet in TRC-Macroinvertebrate_Mainstatfile.stw 69v*9c)
EPTAb = 6509.0564-59.7422*x; 0.95 Conf.Int.
EPTAb
Site
TRC01 TRC02 TRC03 TRC04 TRC05 TRC07 TRC10 TRC11 TRC12
Site:EPTAb: r² = 0.5523; r = -0.7432, p = 0.0217

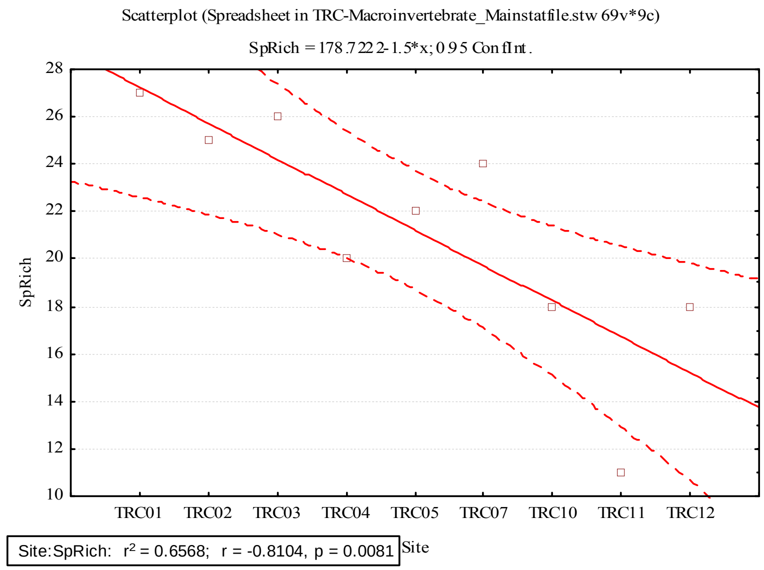

Scatterplot (Spreadsheet in TRC-Macroinvertebrate_Mainstatfile.stw 69v*9c)
2nd = -1034.7194+19.295*x; 0.95 Conf.Int.
2nd
Site
TRC01 TRC02 TRC03 TRC04 TRC05 TRC07 TRC10 TRC11 TRC12
Site:2nd: r² = 0.0097; r = 0.0983, p = 0.8014

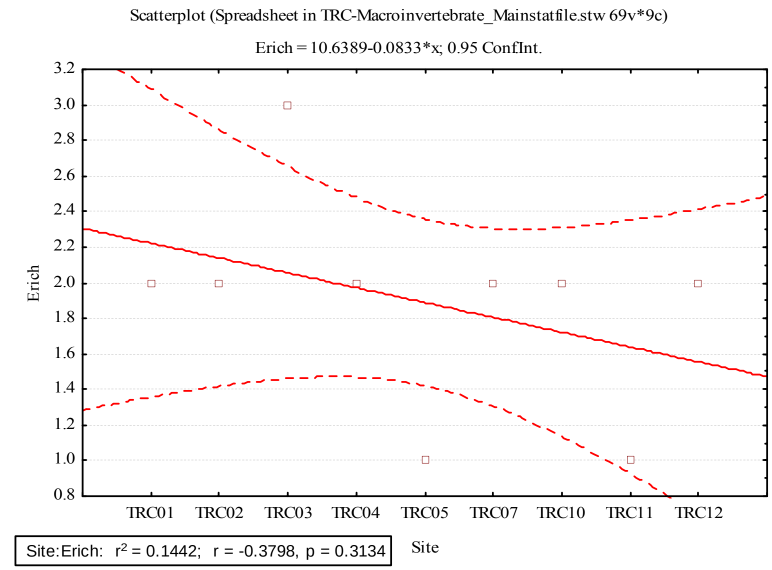

Scatterplot (Spreadsheet in TRC-Macroinvertebrate_Mainstatfile.stw 69v*9c)
3rd = -160.4139+7.2517*x; 0.95 Conf.Int.
1400
1200
1000
800
600
400
200
0
3rd
TRC01 TRC02 TRC03 TRC04 TRC05 TRC07 TRC10 TRC11 TRC12
Site
Site:3rd: r2 = 0.0031; r = 0.0557, p = 0.8869

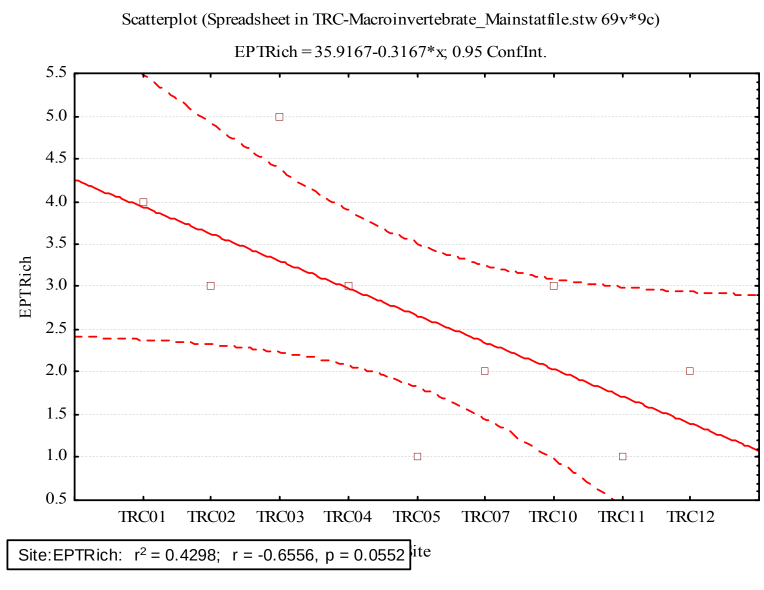

Scatterplot (Spreadsheet in TRC-Macroinvertebrate_Mainstatfile.stw 69v*9c)
Per2 = -108.8861+1.6657*x; 0.95 Conf.Int.
90
85
80
75
70
65
60
55
50
45
Per2
TRC01 TRC02 TRC03 TRC04 TRC05 TRC07 TRC10 TRC11 TRC12
Site
Site:Per2: r2 = 0.1470; r = 0.3834, p = 0.3083

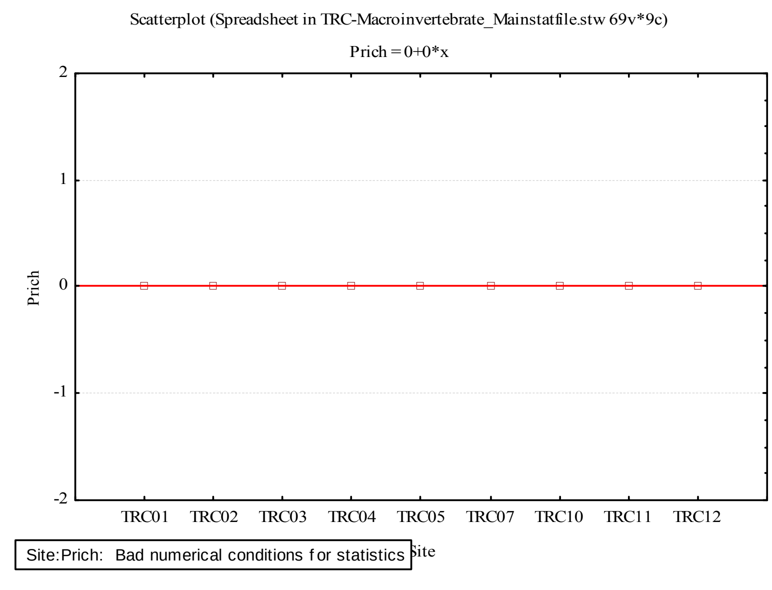

Scatterplot (Spreadsheet in TRC-Macroinvertebrate_Mainstatfile.stw 69v*9c)
Per1 = -142.8925+1.8358*x; 0.95 Conf.Int.
90
80
70
60
50
40
30
20
Per1
TRC01 TRC02 TRC03 TRC04 TRC05 TRC07 TRC10 TRC11 TRC12
Site
Site:Per1: r2 = 0.1015; r = 0.3187, p = 0.4033

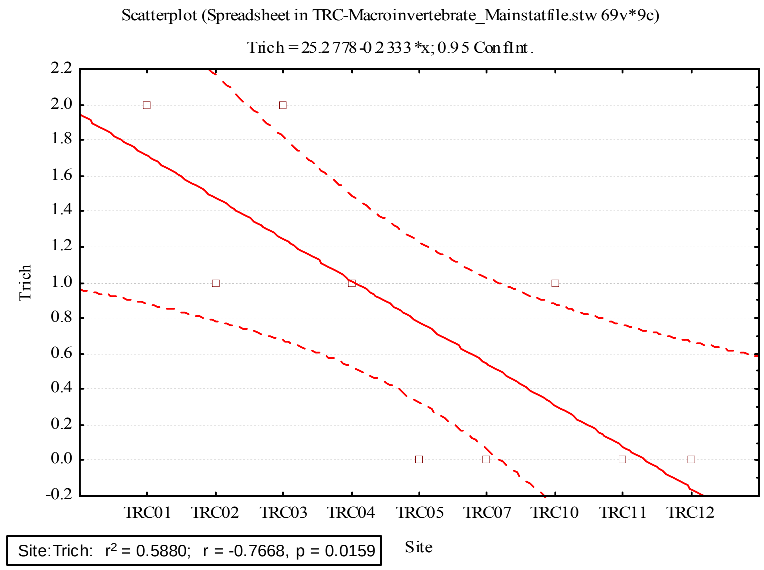

Scatterplot (Spreadsheet in TRC-Macroinvertebrate_Mainstatfile.stw 69v*9c)
Per3 = -111.3064+1.7802*x; 0.95 Conf.Int.
95
90
85
80
75
70
65
60
55
Per3
TRC01 TRC02 TRC03 TRC04 TRC05 TRC07 TRC10 TRC11 TRC12
Site
Site:Per3: r2 = 0.2702; r = 0.5198, p = 0.1515

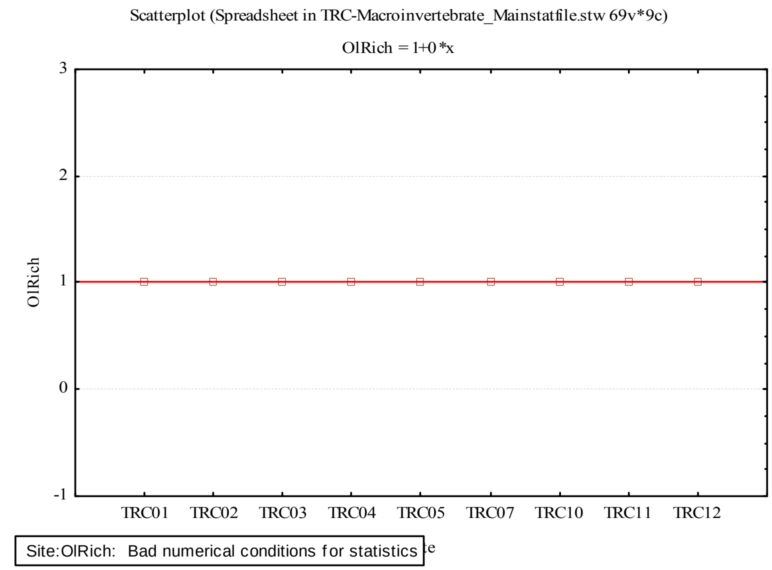

Scatterplot (Spreadsheet in TRC-Macroinvertebrate_Mainstatfile.stw 69v*9c)
SpRich = 178.7222-1.5*x; 0.95 Conf.Int.
SpRich
Site
TRC01 TRC02 TRC03 TRC04 TRC05 TRC07 TRC10 TRC11 TRC12
Site:SpRich: r² = 0.6568; r = -0.8104, p = 0.0081

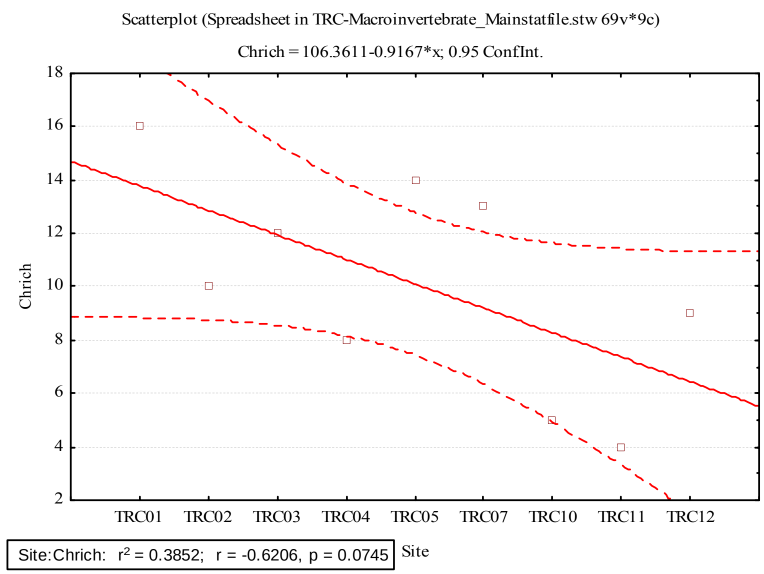

Scatterplot (Spreadsheet in TRC-Macroinvertebrate_Mainstatfile.stw 69v*9c)
Erich = 10.6389-0.0833*x; 0.95 Conf.Int.
Erich
Site
TRC01 TRC02 TRC03 TRC04 TRC05 TRC07 TRC10 TRC11 TRC12
Site:Erich: r² = 0.1442; r = -0.3798, p = 0.3134

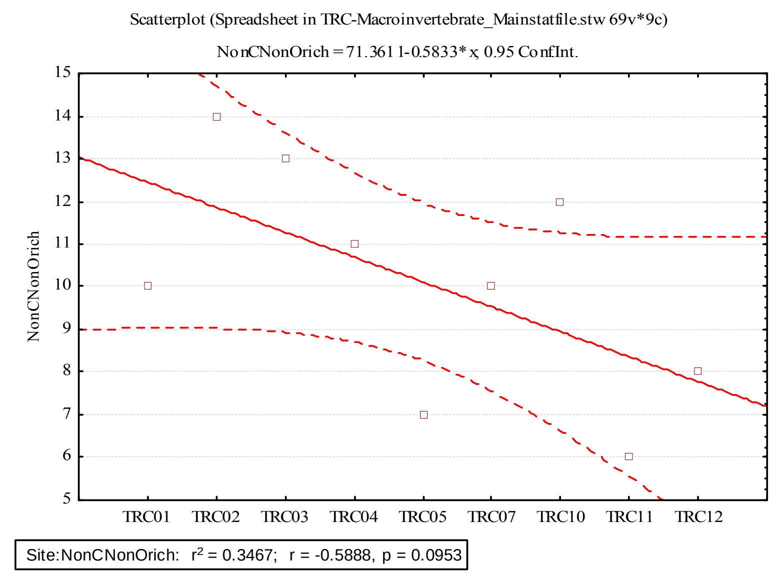

Scatterplot (Spreadsheet in TRC-Macroinvertebrate_Mainstatfile.stw 69v*9c)
EPTRich = 35.9167-0.3167*x; 0.95 Conf.Int.
EPTRich
TRC01 TRC02 TRC03 TRC04 TRC05 TRC07 TRC10 TRC11 TRC12
Site:EPTRich: r² = 0.4298; r = -0.6556, p = 0.0552

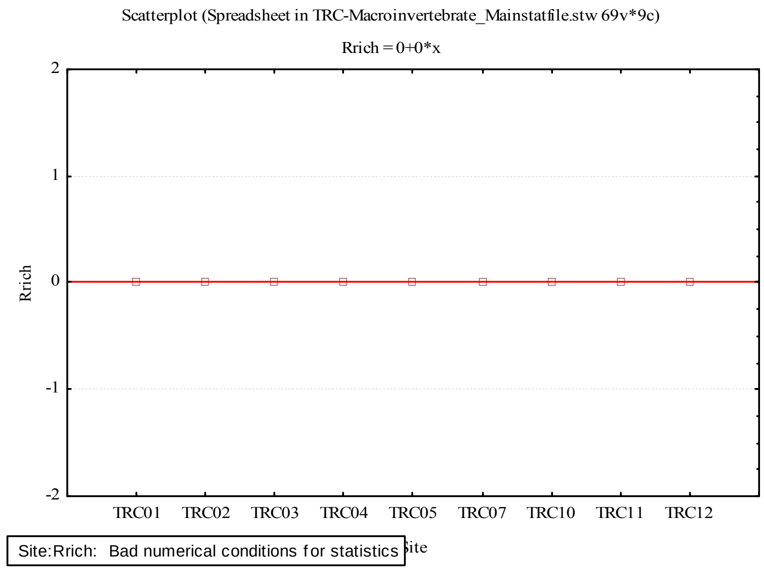

Scatterplot (Spreadsheet in TRC-Macroinvertebrate_Mainstatfile.stw 69v*9c)
Prich = 0+0*x
Prich
TRC01 TRC02 TRC03 TRC04 TRC05 TRC07 TRC10 TRC11 TRC12
Site:Prich: Bad numerical conditions for statistics

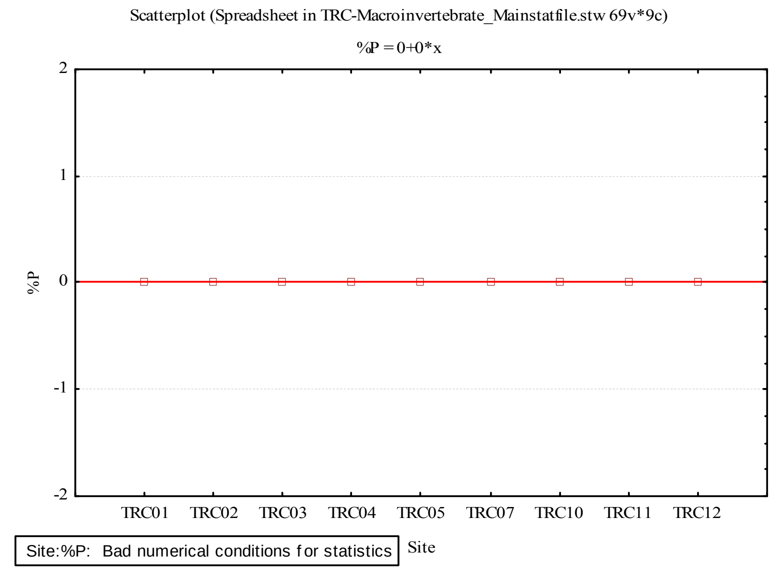

Scatterplot (Spreadsheet in TRC-Macroinvertebrate_Mainstatfile.stw 69v*9c)
Trich = 25.2778-0.2333*x; 0.95 Conf.Int.
Trich
Site
TRC01 TRC02 TRC03 TRC04 TRC05 TRC07 TRC10 TRC11 TRC12
Site:Trich: r² = 0.5880; r = -0.7668, p = 0.0159

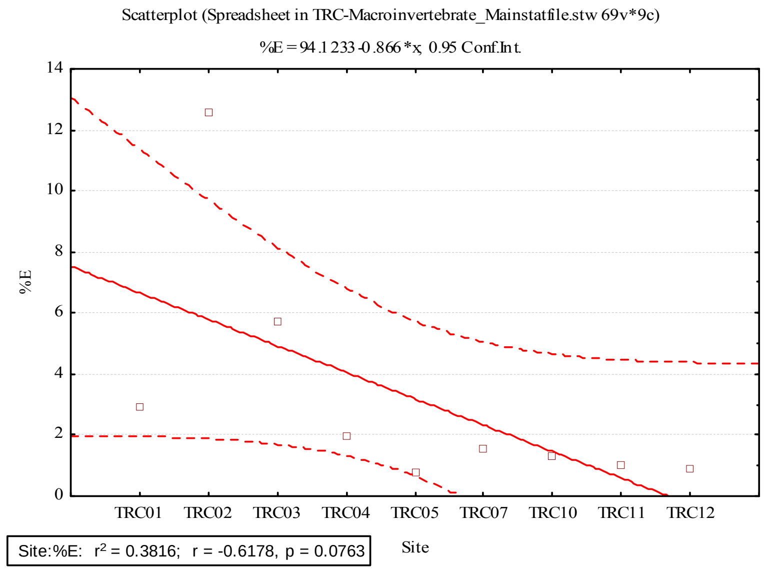

Scatterplot (Spreadsheet in TRC-Macroinvertebrate_Mainstatfile.stw 69v*9c)
OIRich = 1+0*x
OIRich
TRC01 TRC02 TRC03 TRC04 TRC05 TRC07 TRC10 TRC11 TRC12
Site:OIRich: Bad numerical conditions for statistics

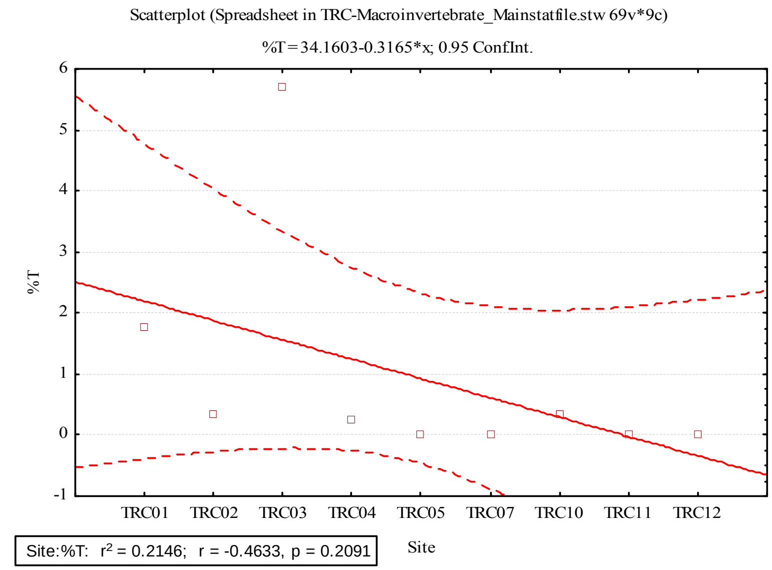

Scatterplot (Spreadsheet in TRC-Macroinvertebrate_Mainstatfile.stw 69v*9c)
Chrich = 106.3611-0.9167*x; 0.95 Conf.Int.
Chrich
Site
TRC01 TRC02 TRC03 TRC04 TRC05 TRC07 TRC10 TRC11 TRC12
Site:Chrich: r² = 0.3852; r = -0.6206, p = 0.0745

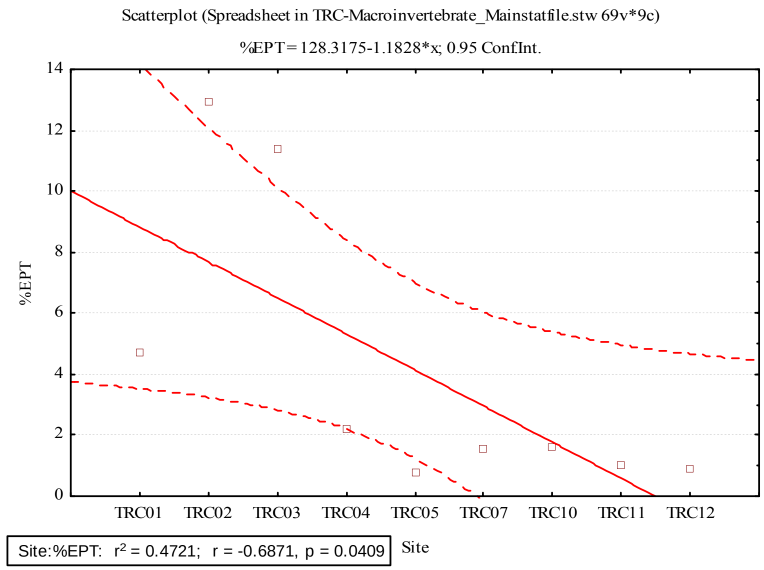

Scatterplot (Spreadsheet in TRC-Macroinvertebrate_Mainstatfile.stw 69v*9c)
NonCNonOrich = 71.3611-0.5833*x; 0.95 Conf.Int.
NonCNonOrich
TRC01 TRC02 TRC03 TRC04 TRC05 TRC07 TRC10 TRC11 TRC12
Site:NonCNonOrich: r² = 0.3467; r = -0.5888, p = 0.0953

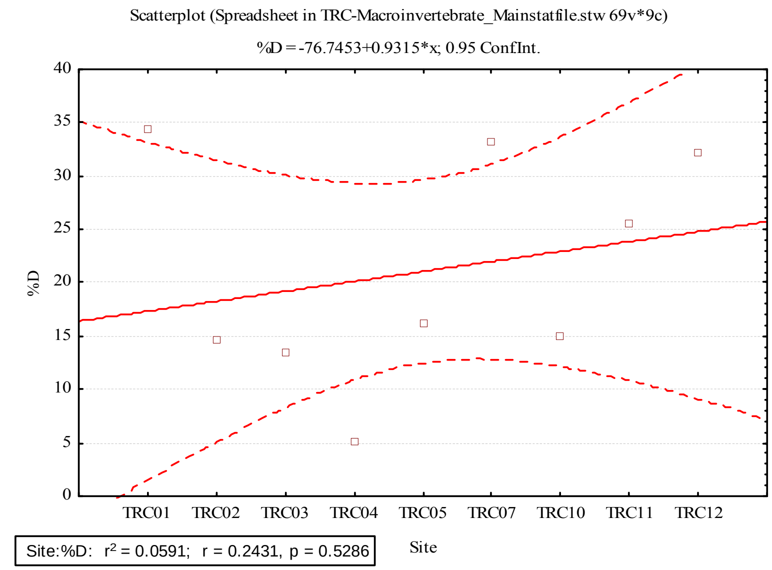

Scatterplot (Spreadsheet in TRC-Macroinvertebrate_Mainstatfile.stw 69v*9c)
Rrich = 0+0*x
Rrich
2
1
0
-1
-2
TRC01 TRC02 TRC03 TRC04 TRC05 TRC07 TRC10 TRC11 TRC12
Site
Site:Rrich: Bad numerical conditions for statistics

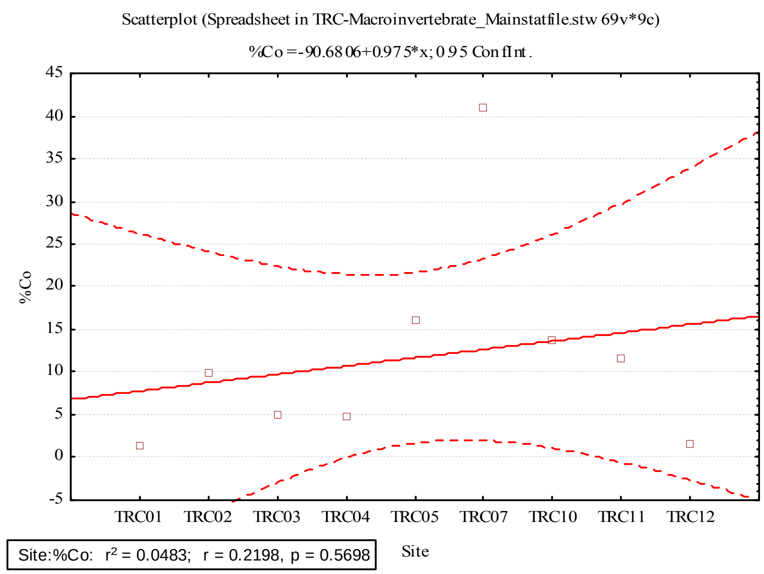

Scatterplot (Spreadsheet in TRC-Macroinvertebrate_Mainstatfile.stw 69v*9c)
%P = 0+0*x
%P
2
1
0
-1
-2
TRC01 TRC02 TRC03 TRC04 TRC05 TRC07 TRC10 TRC11 TRC12
Site
Site:%P: Bad numerical conditions for statistics

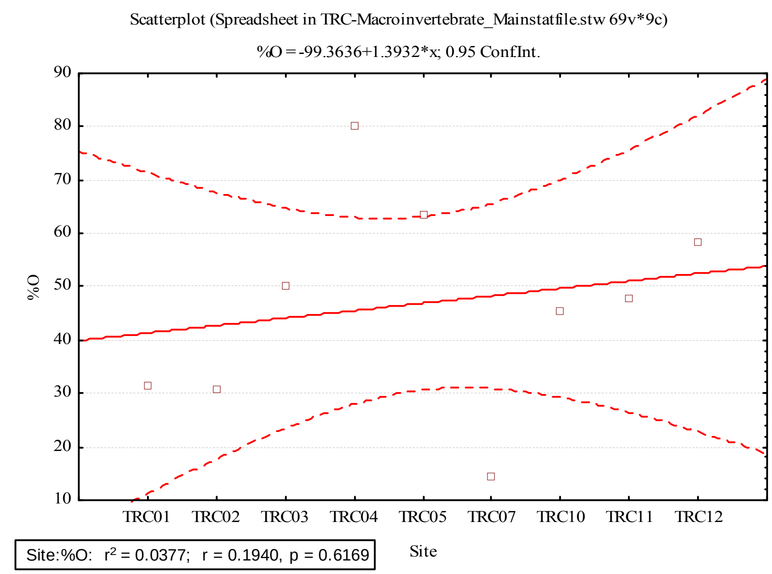

Scatterplot (Spreadsheet in TRC-Macroinvertebrate_Mainstatfile.stw 69v*9c)
%E = 94.1233-0.866*x; 0.95 Conf.Int.
%E
14
12
10
8
6
4
2
0
TRC01 TRC02 TRC03 TRC04 TRC05 TRC07 TRC10 TRC11 TRC12
Site
Site:%E: $r^2$ = 0.3816; r = -0.6178, p = 0.0763

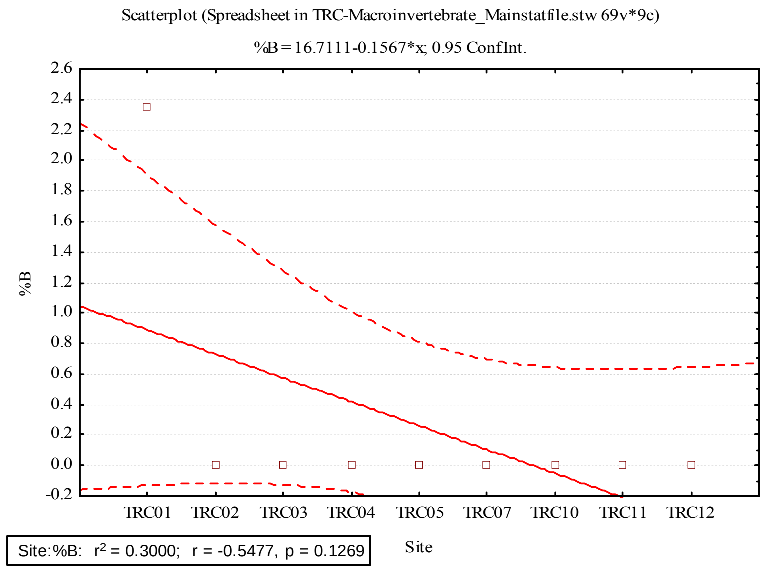

Scatterplot (Spreadsheet in TRC-Macroinvertebrate_Mainstatfile.stw 69v*9c)
%T = 34.1603-0.3165*x; 0.95 Conf.Int.
%T
6
5
4
3
2
1
0
-1
TRC01 TRC02 TRC03 TRC04 TRC05 TRC07 TRC10 TRC11 TRC12
Site
Site:%T: $r^2$ = 0.2146; r = -0.4633, p = 0.2091

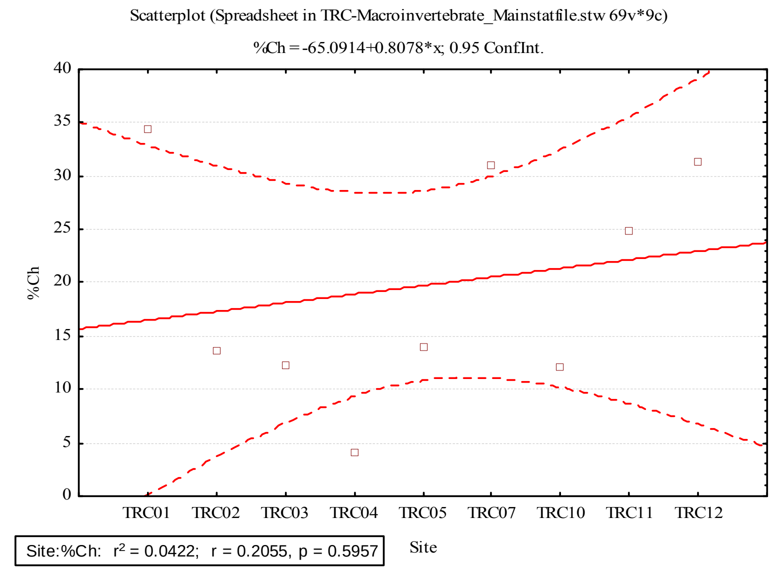

Scatterplot (Spreadsheet in TRC-Macroinvertebrate_Mainstatfile.stw 69v*9c)
%EPT = 128.3175-1.1828*x; 0.95 Conf.Int.
%EPT
TRC01 TRC02 TRC03 TRC04 TRC05 TRC07 TRC10 TRC11 TRC12
Site
Site:%EPT: r² = 0.4721; r = -0.6871, p = 0.0409

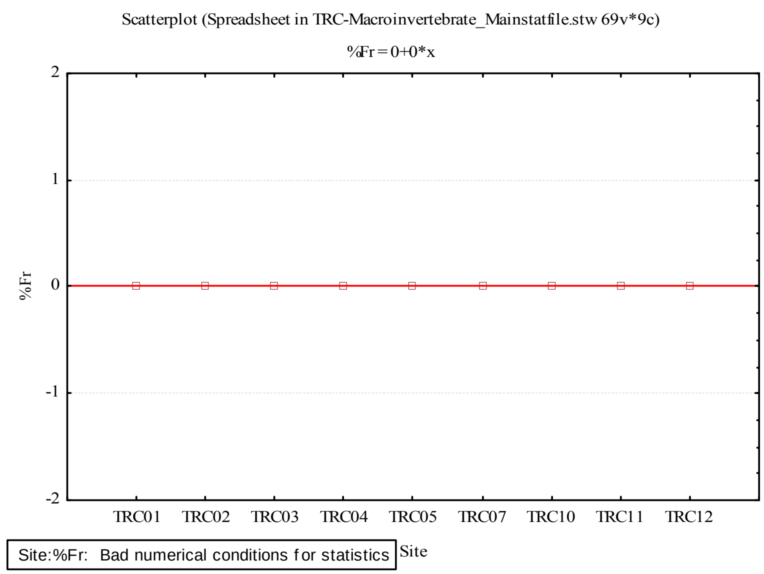

Scatterplot (Spreadsheet in TRC-Macroinvertebrate_Mainstatfile.stw 69v*9c)
%D = -76.7453+0.9315*x; 0.95 Conf.Int.
%D
TRC01 TRC02 TRC03 TRC04 TRC05 TRC07 TRC10 TRC11 TRC12
Site
Site:%D: r² = 0.0591; r = 0.2431, p = 0.5286

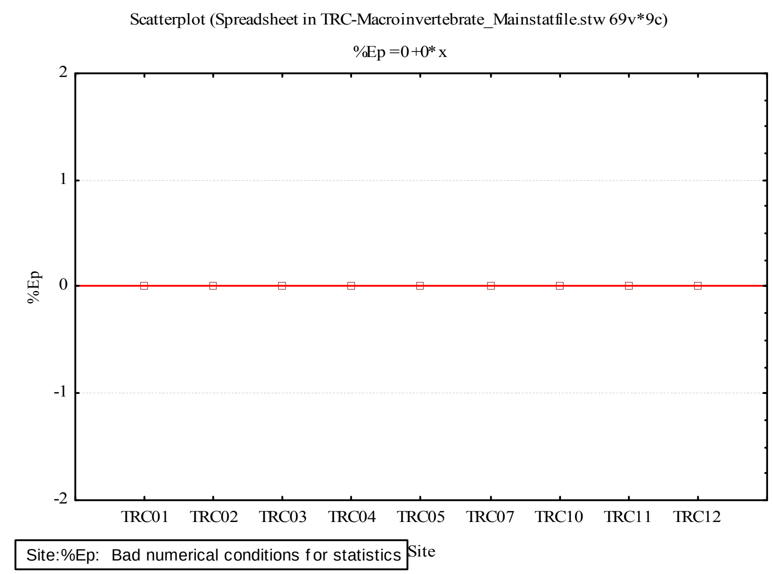

Scatterplot (Spreadsheet in TRC-Macroinvertebrate_Mainstatfile.stw 69v*9c)
%Co = -90.6806+0.975*x; 0.95 Conf.Int.
%Co
TRC01 TRC02 TRC03 TRC04 TRC05 TRC07 TRC10 TRC11 TRC12
Site
Site:%Co: r² = 0.0483; r = 0.2198, p = 0.5698

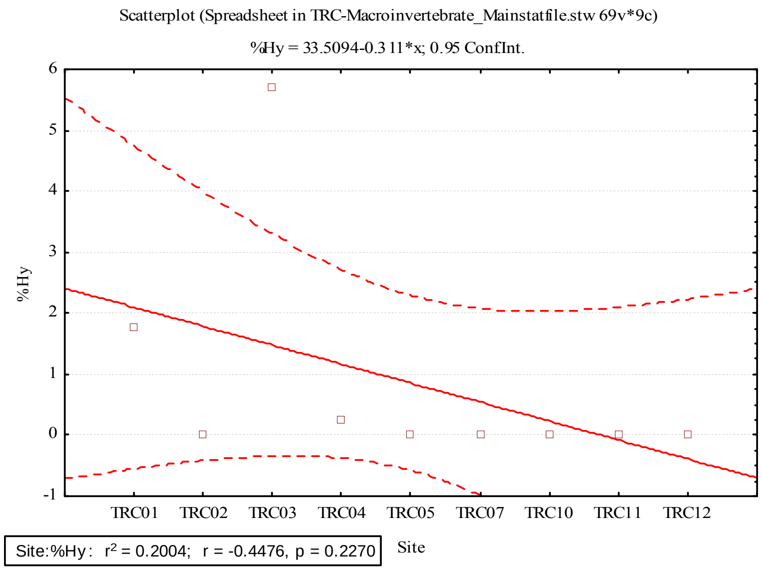

Scatterplot (Spreadsheet in TRC-Macroinvertebrate_Mainstatfile.stw 69v*9c)
%O = -99.3636+1.3932*x; 0.95 Conf.Int.
%O
TRC01 TRC02 TRC03 TRC04 TRC05 TRC07 TRC10 TRC11 TRC12
Site
Site:%O: r² = 0.0377; r = 0.1940, p = 0.6169

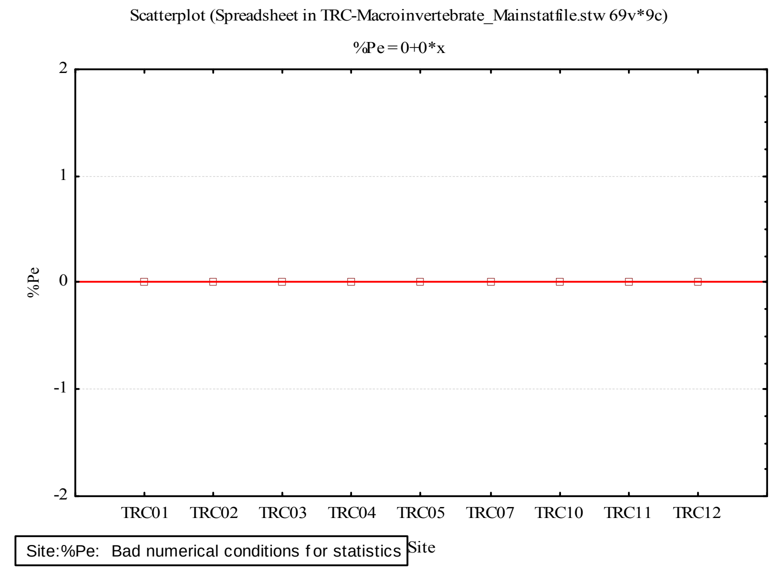

Scatterplot (Spreadsheet in TRC-Macroinvertebrate_Mainstatfile.stw 69v*9c)
%B = 16.7111-0.1567*x; 0.95 Conf.Int.
%B
Site
TRC01 TRC02 TRC03 TRC04 TRC05 TRC07 TRC10 TRC11 TRC12
Site:%B: r² = 0.3000; r = -0.5477, p = 0.1269

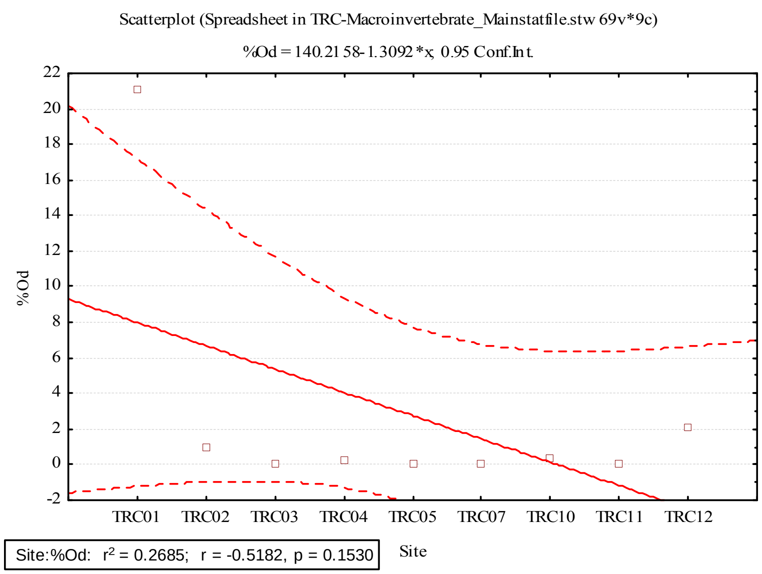

Scatterplot (Spreadsheet in TRC-Macroinvertebrate_Mainstatfile.stw 69v*9c)
%Ch = -65.0914+0.8078*x; 0.95 Conf.Int.
%Ch
Site
TRC01 TRC02 TRC03 TRC04 TRC05 TRC07 TRC10 TRC11 TRC12
Site:%Ch: r² = 0.0422; r = 0.2055, p = 0.5957

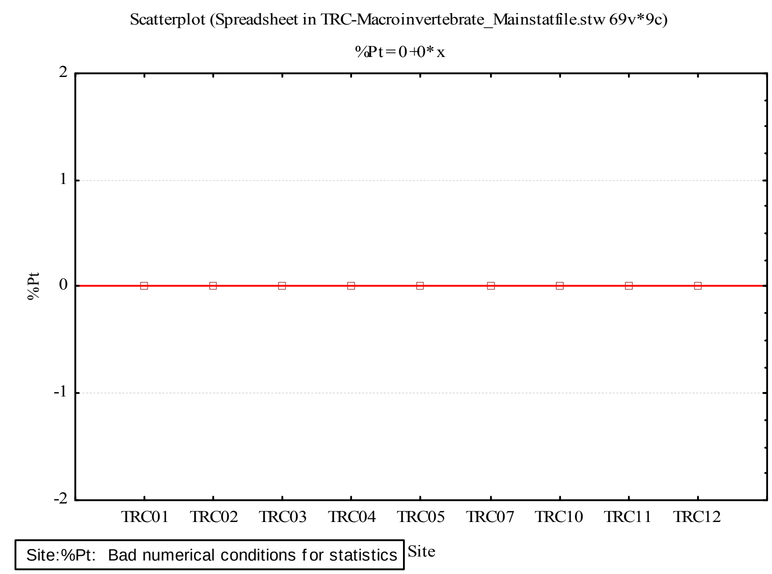

Scatterplot (Spreadsheet in TRC-Macroinvertebrate_Mainstatfile.stw 69v*9c)
%Fr = 0+0*x
%Fr
Site
TRC01 TRC02 TRC03 TRC04 TRC05 TRC07 TRC10 TRC11 TRC12
Site:%Fr: Bad numerical conditions for statistics

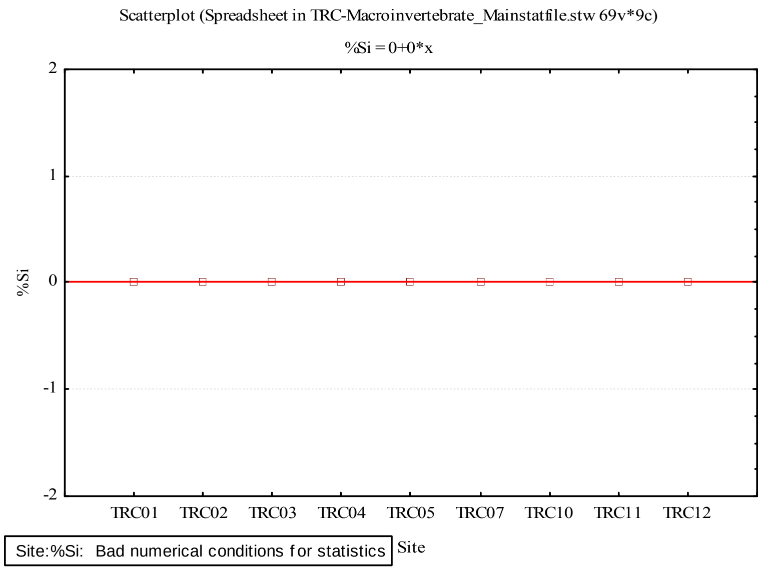

Scatterplot (Spreadsheet in TRC-Macroinvertebrate_Mainstatfile.stw 69v*9c)
%Ep = 0+0*x
%Ep
Site
TRC01 TRC02 TRC03 TRC04 TRC05 TRC07 TRC10 TRC11 TRC12
Site:%Ep: Bad numerical conditions for statistics

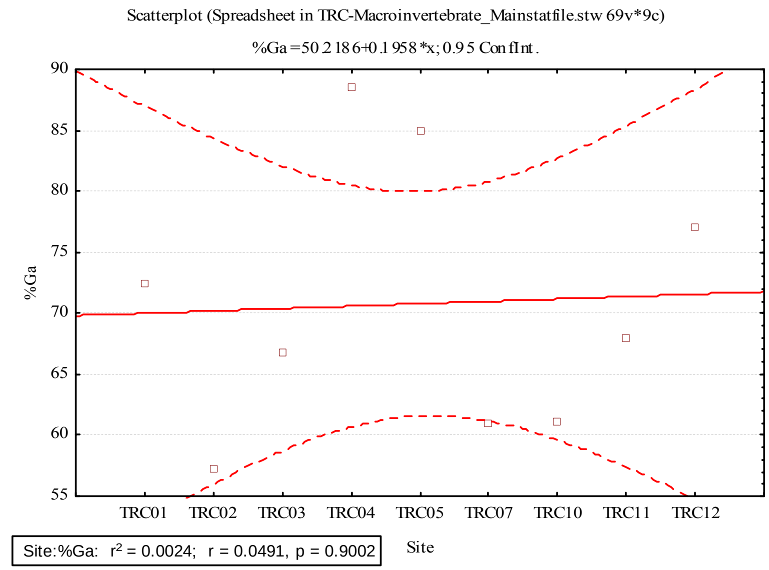

Scatterplot (Spreadsheet in TRC-Macroinvertebrate_Mainstatfile.stw 69v*9c)
%Hy = 33.5094-0.311*x; 0.95 Conf.Int.
%Hy
Site
TRC01 TRC02 TRC03 TRC04 TRC05 TRC07 TRC10 TRC11 TRC12
Site:%Hy: r² = 0.2004; r = -0.4476, p = 0.2270

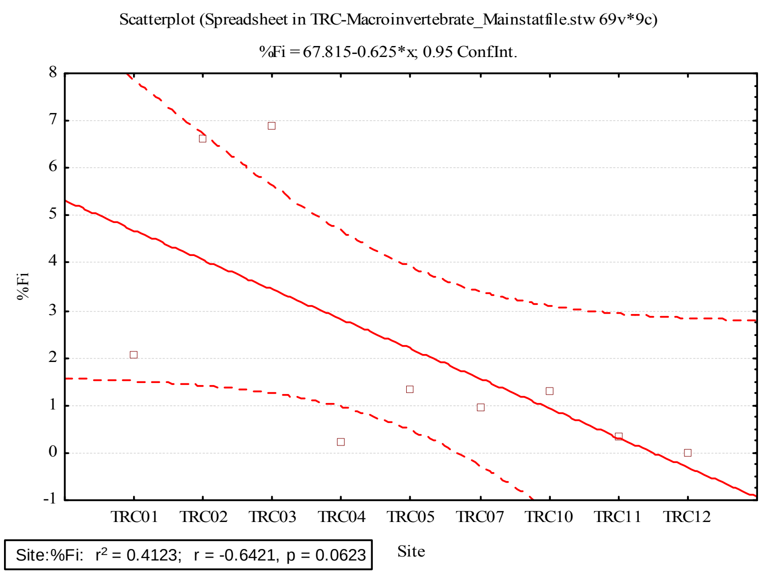

Scatterplot (Spreadsheet in TRC-Macroinvertebrate_Mainstatfile.stw 69v*9c)
%Pe = 0+0*x
%Pe
Site
TRC01 TRC02 TRC03 TRC04 TRC05 TRC07 TRC10 TRC11 TRC12
Site:%Pe: Bad numerical conditions for statistics

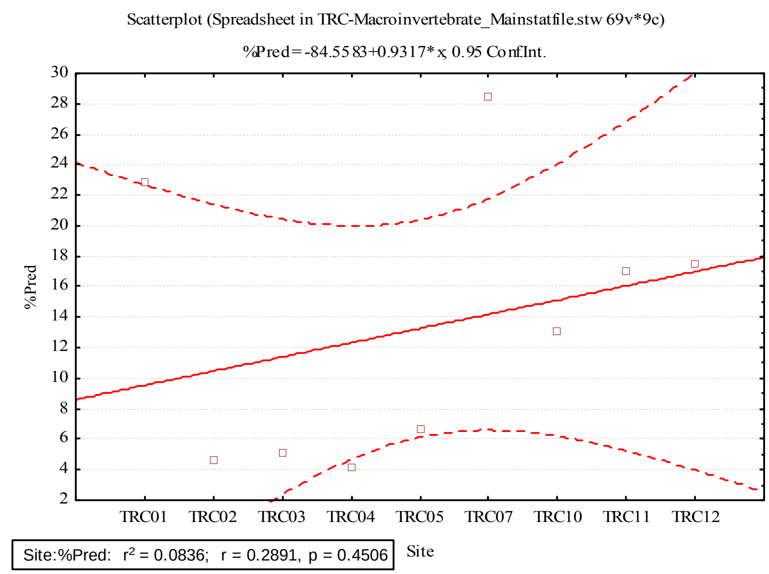

Scatterplot (Spreadsheet in TRC-Macroinvertebrate_Mainstatfile.stw 69v*9c)
%Od = 140.2158-1.3092*x; 0.95 Conf.Int.
%Od
Site
TRC01 TRC02 TRC03 TRC04 TRC05 TRC07 TRC10 TRC11 TRC12
Site:%Od: r² = 0.2685; r = -0.5182, p = 0.1530

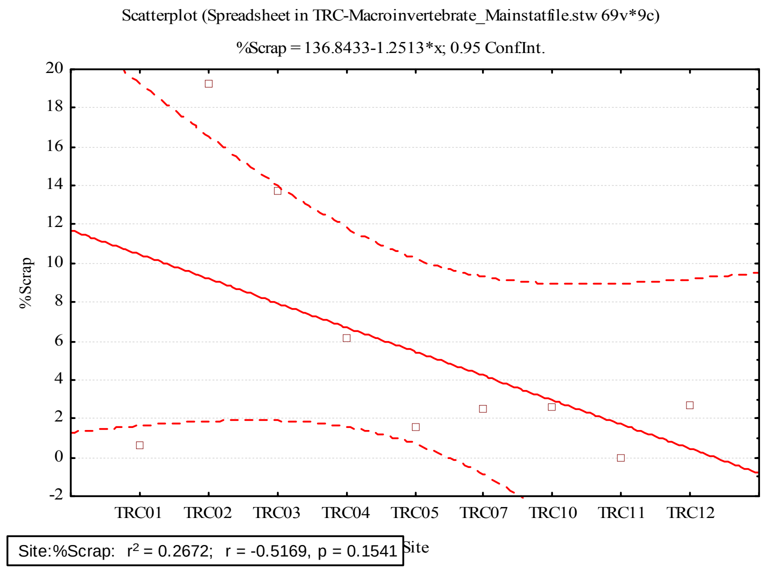

Scatterplot (Spreadsheet in TRC-Macroinvertebrate_Mainstatfile.stw 69v*9c)
%Pt = 0+0*x
%Pt
Site
TRC01 TRC02 TRC03 TRC04 TRC05 TRC07 TRC10 TRC11 TRC12
Site:%Pt: Bad numerical conditions for statistics

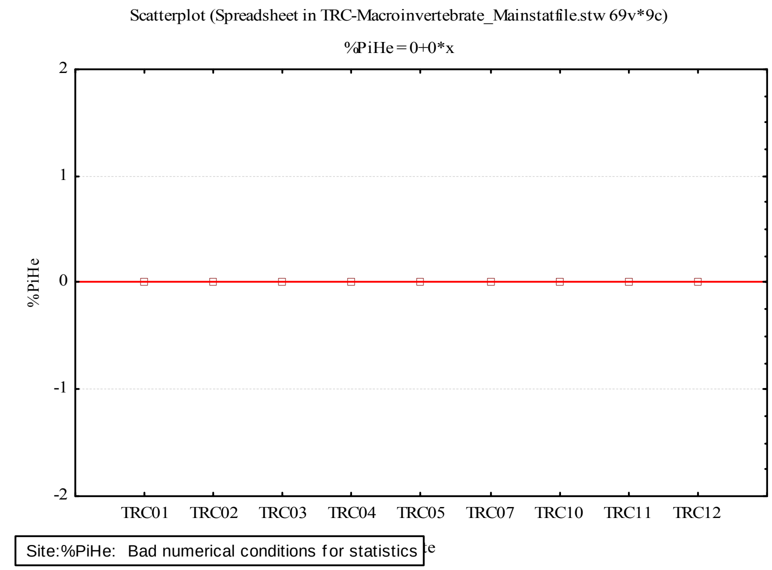

Scatterplot (Spreadsheet in TRC-Macroinvertebrate_Mainstatfile.stw 69v*9c)
%Si = 0+0*x
%Si
Site
TRC01 TRC02 TRC03 TRC04 TRC05 TRC07 TRC10 TRC11 TRC12
Site:%Si: Bad numerical conditions for statistics

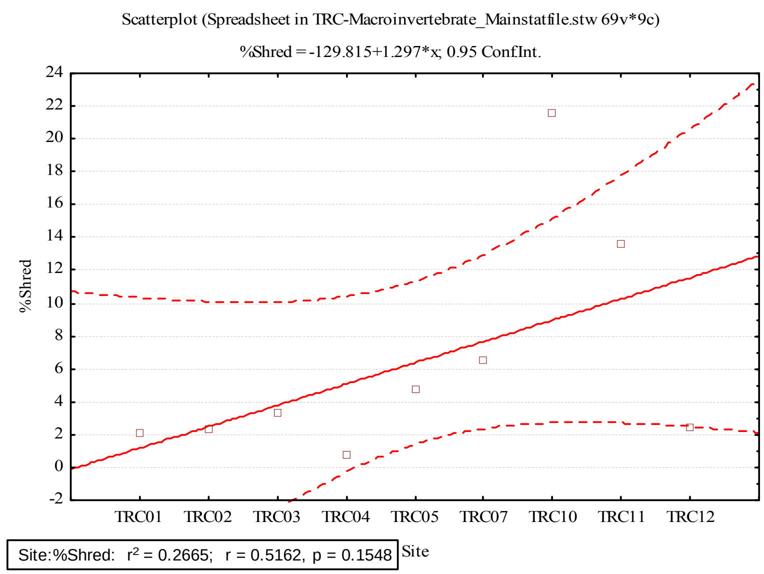

Scatterplot (Spreadsheet in TRC-Macroinvertebrate_Mainstatfile.stw 69v*9c)
%Ga = 50.2186+0.1958*x; 0.95 Conf.Int.
%Ga
Site
TRC01 TRC02 TRC03 TRC04 TRC05 TRC07 TRC10 TRC11 TRC12
Site:%Ga: r² = 0.0024; r = 0.0491, p = 0.9002

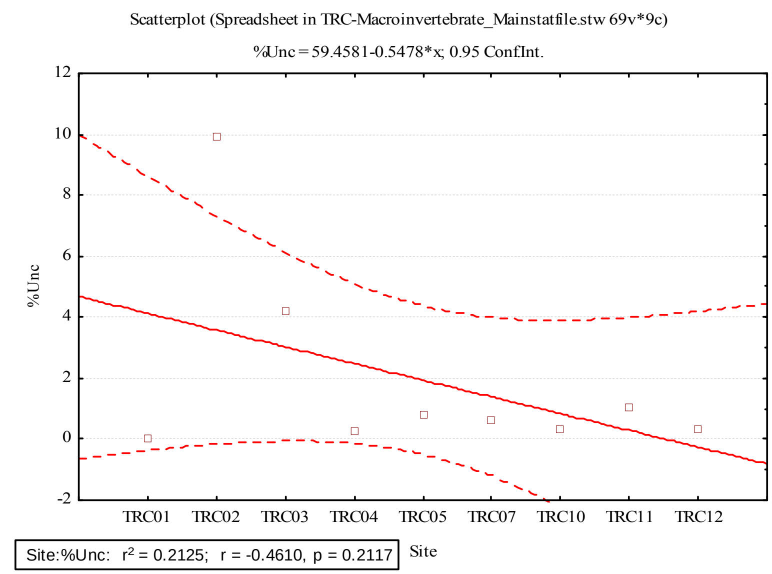

Scatterplot (Spreadsheet in TRC-Macroinvertebrate_Mainstatfile.stw 69v*9c)
%Fi = 67.815-0.625*x; 0.95 Conf.Int.
%Fi
Site
TRC01 TRC02 TRC03 TRC04 TRC05 TRC07 TRC10 TRC11 TRC12
Site:%Fi: r² = 0.4123; r = -0.6421, p = 0.0623

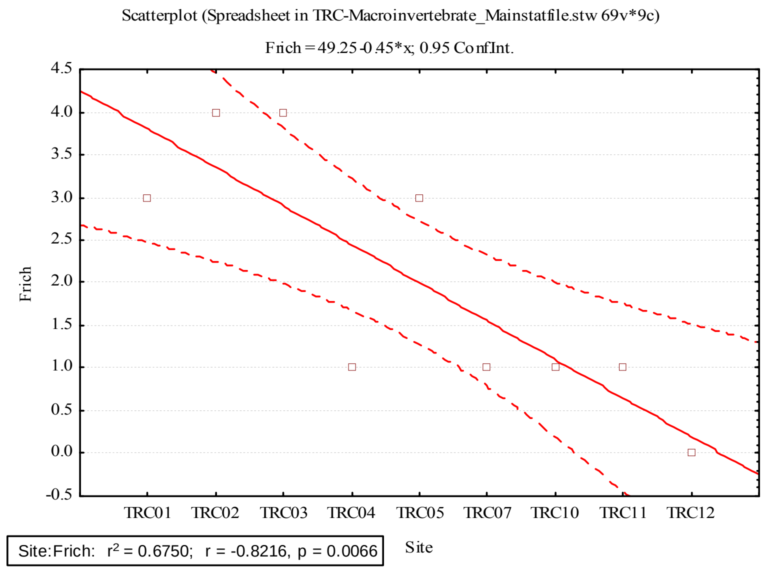

Scatterplot (Spreadsheet in TRC-Macroinvertebrate_Mainstatfile.stw 69v*9c)
%Pred = -84.5583+0.9317*x; 0.95 Conf.Int.
%Pred
Site
TRC01 TRC02 TRC03 TRC04 TRC05 TRC07 TRC10 TRC11 TRC12
Site:%Pred: r² = 0.0836; r = 0.2891, p = 0.4506

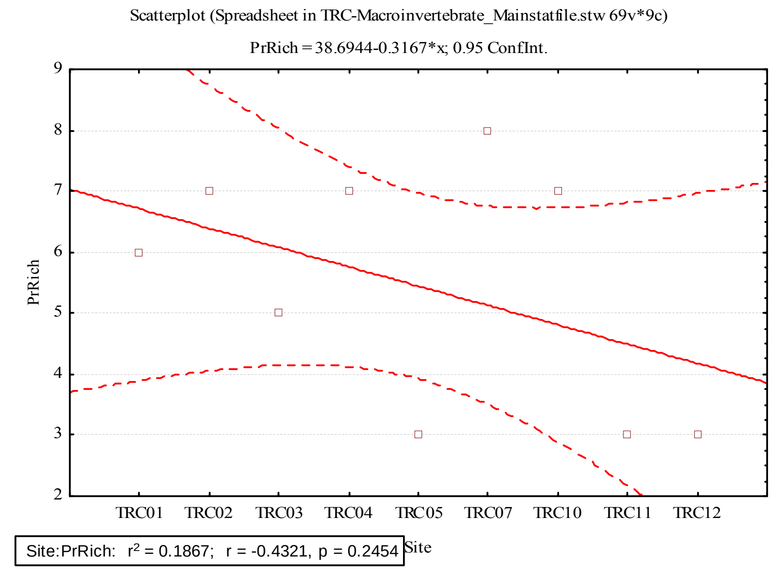

Scatterplot (Spreadsheet in TRC-Macroinvertebrate_Mainstatfile.stw 69v*9c)
%Scrap = 136.8433-1.2513*x; 0.95 Conf.Int.
%Scrap
Site
TRC01 TRC02 TRC03 TRC04 TRC05 TRC07 TRC10 TRC11 TRC12
Site:%Scrap: r2 = 0.2672; r = -0.5169, p = 0.1541

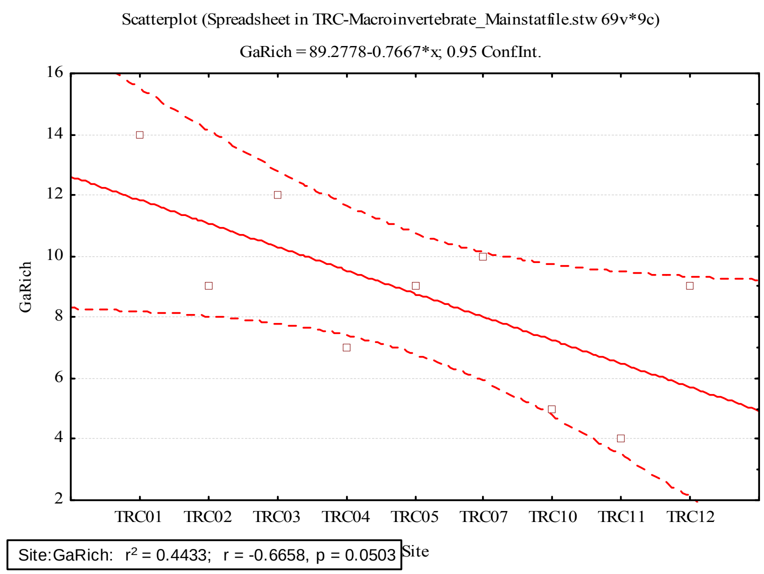

Scatterplot (Spreadsheet in TRC-Macroinvertebrate_Mainstatfile.stw 69v*9c)
%PiHe = 0+0*x
%PiHe
TRC01 TRC02 TRC03 TRC04 TRC05 TRC07 TRC10 TRC11 TRC12
Site:%PiHe: Bad numerical conditions for statistics

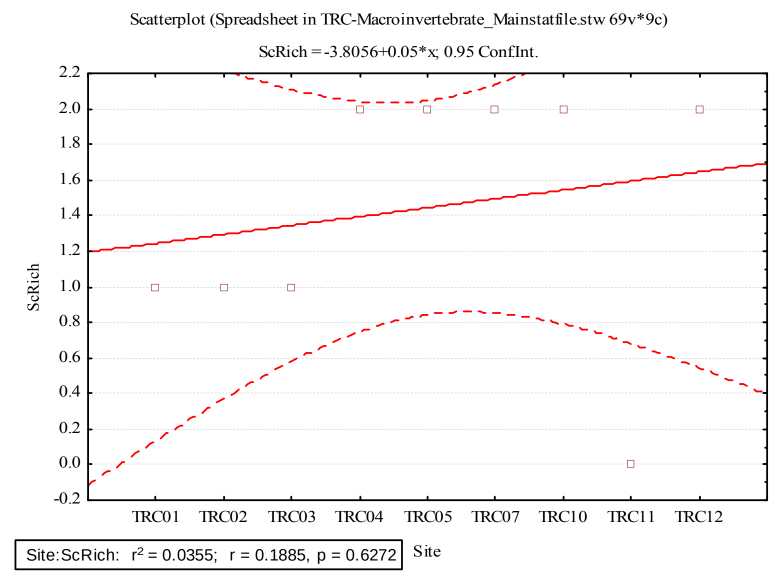

Scatterplot (Spreadsheet in TRC-Macroinvertebrate_Mainstatfile.stw 69v*9c)
%Shred = -129.815+1.297*x; 0.95 Conf.Int.
%Shred
Site
TRC01 TRC02 TRC03 TRC04 TRC05 TRC07 TRC10 TRC11 TRC12
Site:%Shred: r2 = 0.2665; r = 0.5162, p = 0.1548

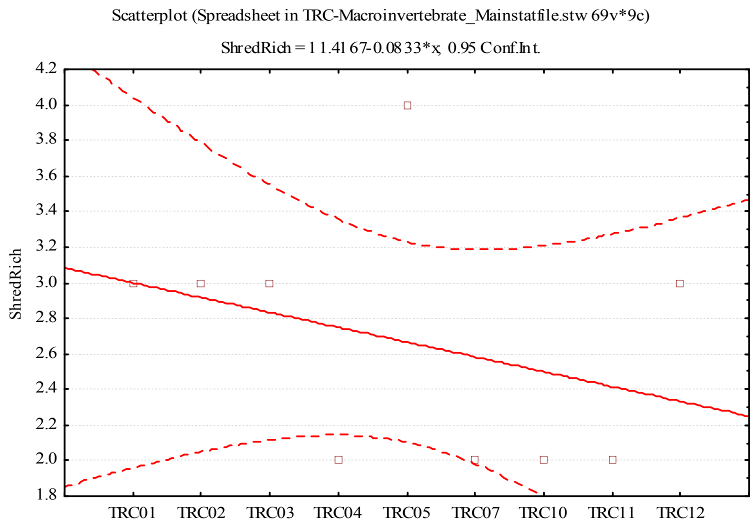

Scatterplot (Spreadsheet in TRC-Macroinvertebrate_Mainstatfile.stw 69v*9c)
%Unc = 59.4581-0.5478*x; 0.95 Conf.Int.
%Unc
Site
TRC01 TRC02 TRC03 TRC04 TRC05 TRC07 TRC10 TRC11 TRC12
Site:%Unc: r2 = 0.2125; r = -0.4610, p = 0.2117


Scatterplot (Spreadsheet in TRC-Macroinvertebrate_Mainstatfile.stw 69v*9c)
Frich = 49.25-0.45*x; 0.95 Conf.Int.
Frich
TRC01 TRC02 TRC03 TRC04 TRC05 TRC07 TRC10 TRC11 TRC12
Site
Site:Frich: r2 = 0.6750; r = -0.8216, p = 0.0066

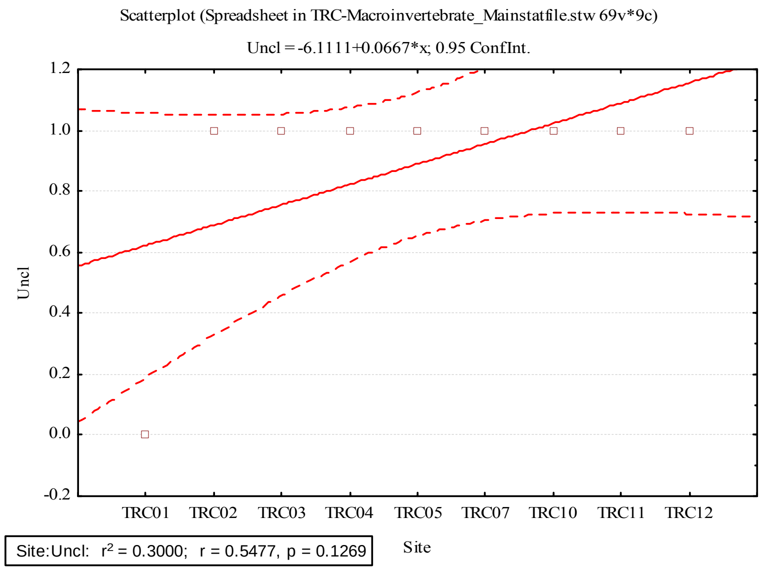

Scatterplot (Spreadsheet in TRC-Macroinvertebrate_Mainstatfile.stw 69v*9c)
PrRich = 38.6944-0.3167*x; 0.95 Conf.Int.
PrRich
TRC01 TRC02 TRC03 TRC04 TRC05 TRC07 TRC10 TRC11 TRC12
Site
Site:PrRich: r2 = 0.1867; r = -0.4321, p = 0.2454


Scatterplot (Spreadsheet in TRC-Macroinvertebrate_Mainstatfile.stw 69v*9c)
GaRich = 89.2778-0.7667*x; 0.95 Conf.Int.
GaRich
TRC01 TRC02 TRC03 TRC04 TRC05 TRC07 TRC10 TRC11 TRC12
Site
Site:GaRich: r2 = 0.4433; r = -0.6658, p = 0.0503

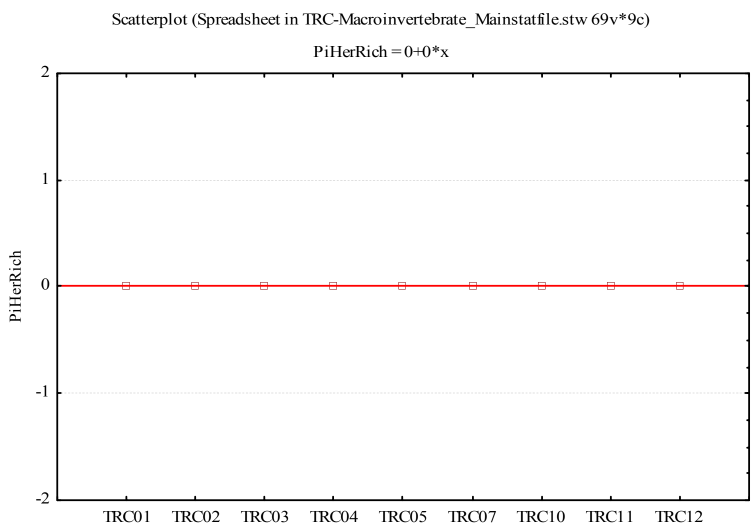

Scatterplot (Spreadsheet in TRC-Macroinvertebrate_Mainstatfile.stw 69v*9c)
ScRich = -3.8056+0.05*x; 0.95 Conf.Int.
ScRich
TRC01 TRC02 TRC03 TRC04 TRC05 TRC07 TRC10 TRC11 TRC12
Site
Site:ScRich: r2 = 0.0355; r = 0.1885, p = 0.6272



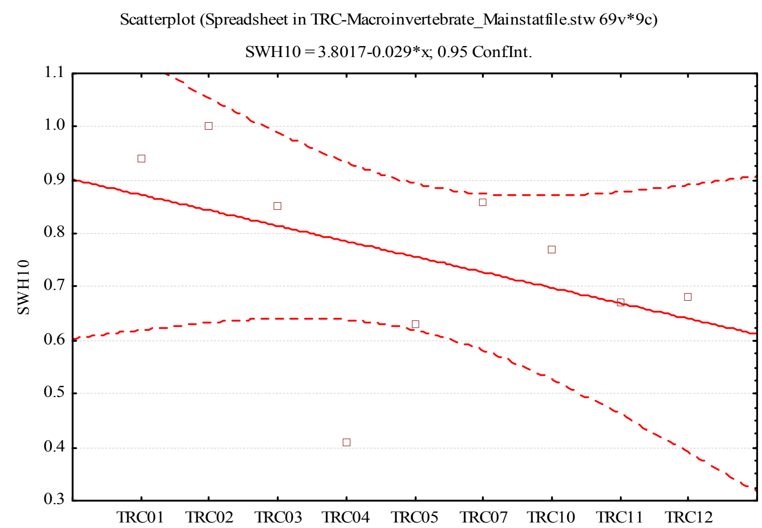

Site:ShredRich: $r^2 = 0.1042$; $r = -0.3227$, $p = 0.3969$



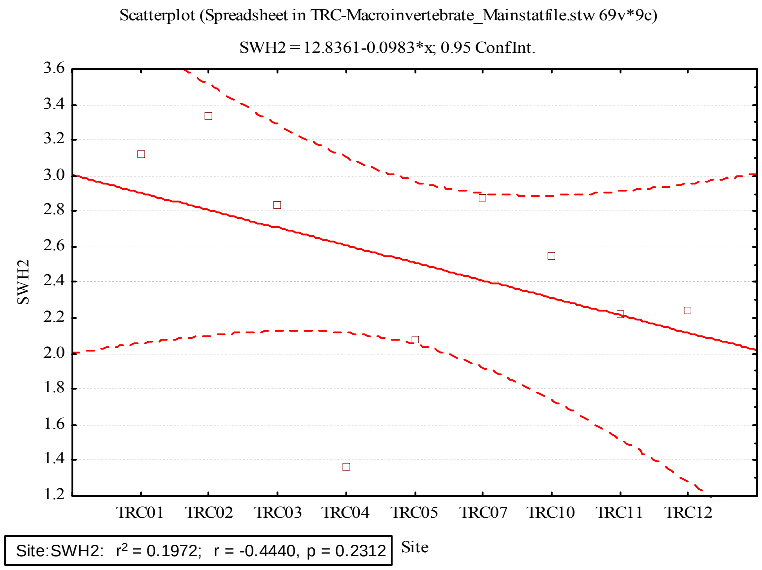

Site:Uncl: $r^2 = 0.3000$; $r = 0.5477$, $p = 0.1269$

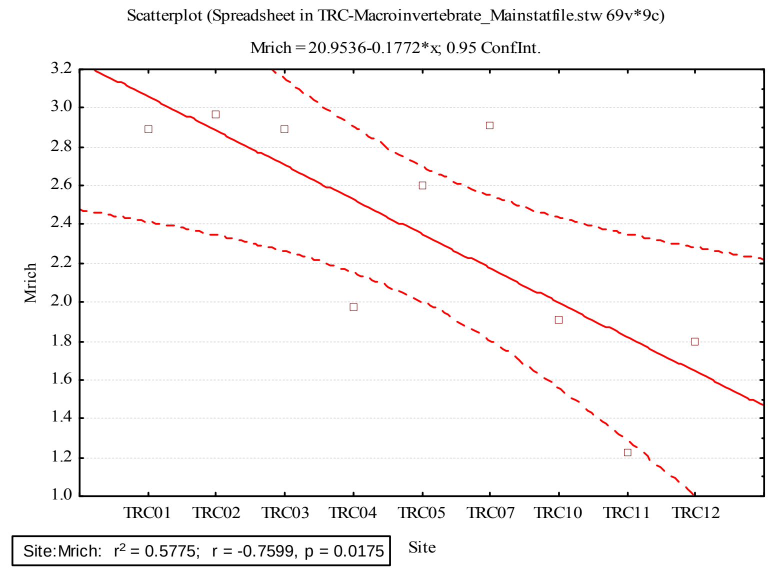


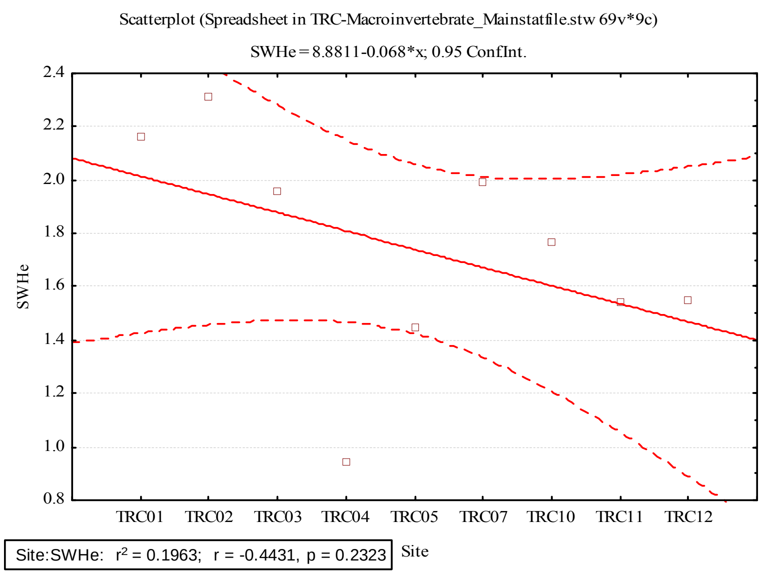

Site:PiHerRich: Bad numerical conditions for statistics

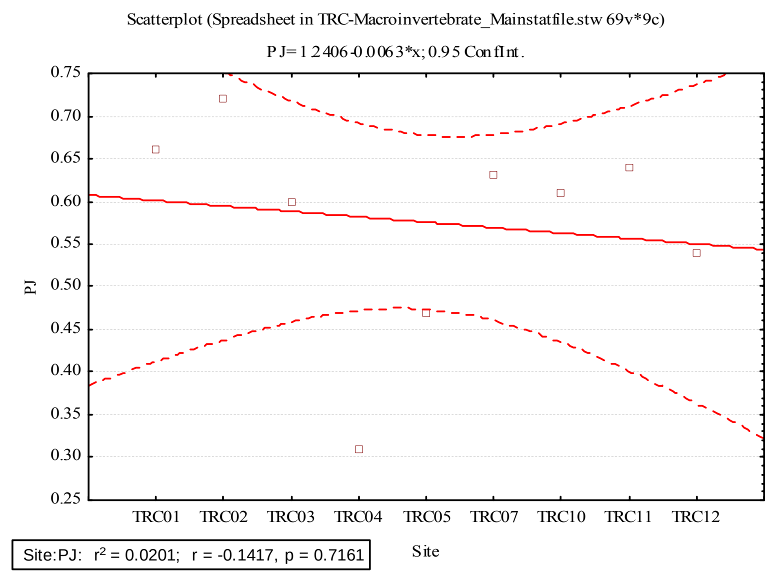


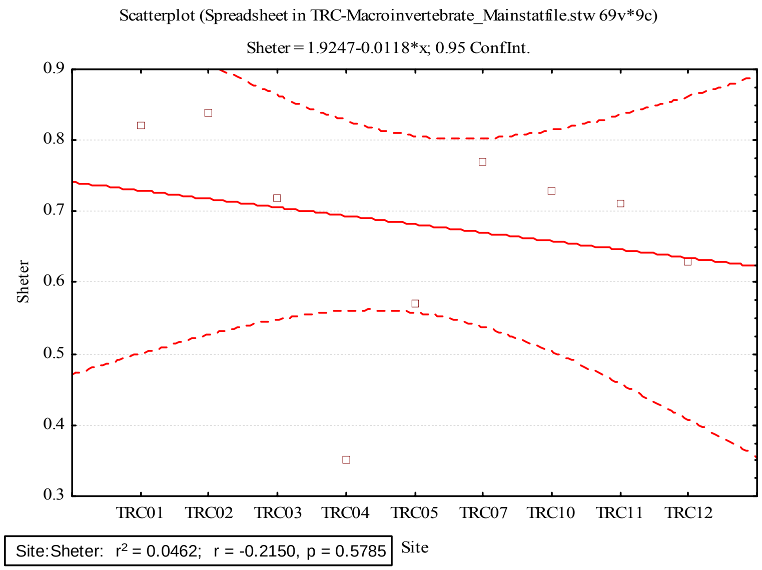

Site:SWH10: $r^2 = 0.1926$; $r = -0.4389$, $p = 0.2373$

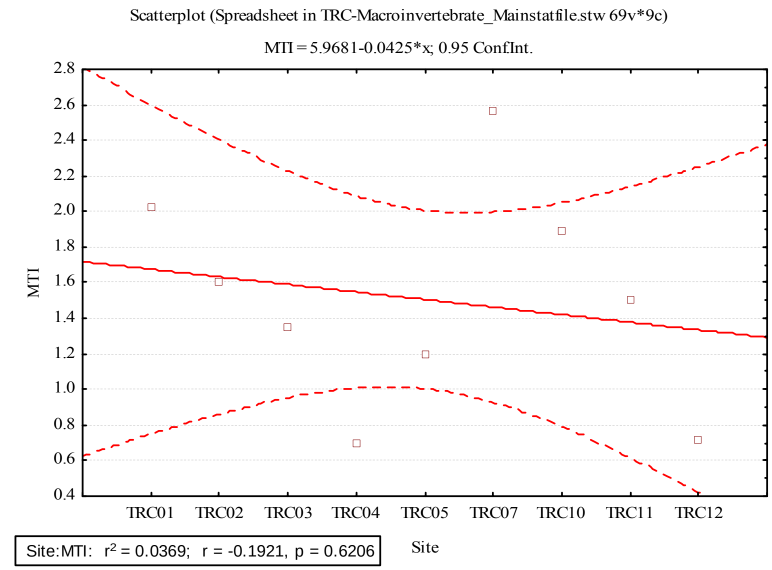

Scatterplot (Spreadsheet in TRC-Macroinvertebrate_Mainstatfile.stw 69v*9c)
SWH2 = 12.8361-0.0983*x; 0.95 Conf.Int.
SWH2
TRC01 TRC02 TRC03 TRC04 TRC05 TRC07 TRC10 TRC11 TRC12
Site
Site:SWH2: r² = 0.1972; r = -0.4440, p = 0.2312

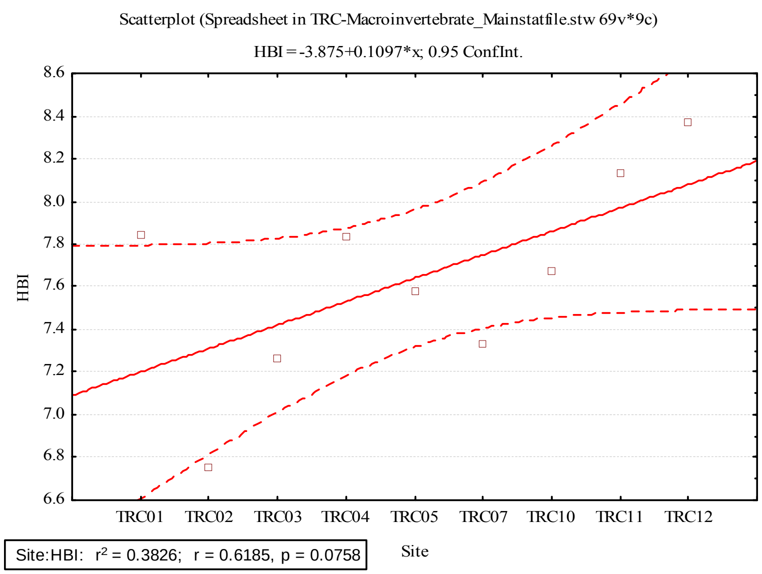

Scatterplot (Spreadsheet in TRC-Macroinvertebrate_Mainstatfile.stw 69v*9c)
Mrich = 20.9536-0.1772*x; 0.95 Conf.Int.
Mrich
TRC01 TRC02 TRC03 TRC04 TRC05 TRC07 TRC10 TRC11 TRC12
Site
Site:Mrich: r² = 0.5775; r = -0.7599, p = 0.0175

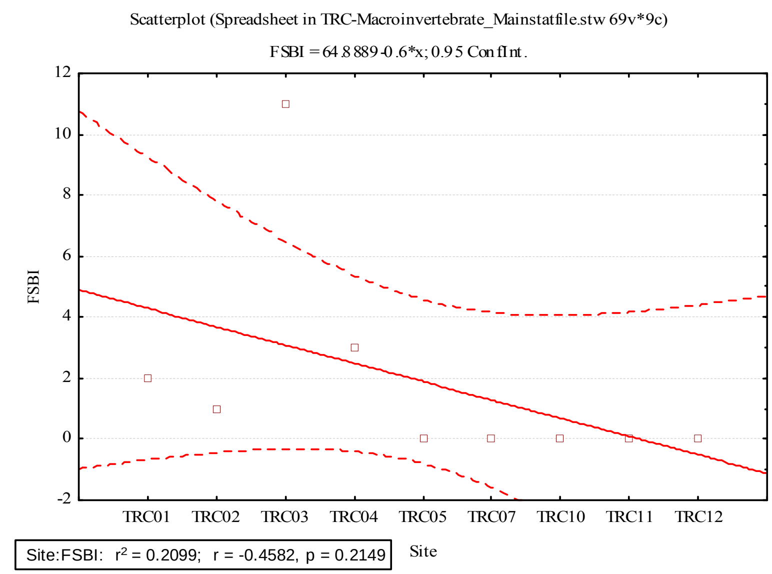

Scatterplot (Spreadsheet in TRC-Macroinvertebrate_Mainstatfile.stw 69v*9c)
SWHe = 8.8811-0.068*x; 0.95 Conf.Int.
SWHe
TRC01 TRC02 TRC03 TRC04 TRC05 TRC07 TRC10 TRC11 TRC12
Site
Site:SWHe: r² = 0.1963; r = -0.4431, p = 0.2323

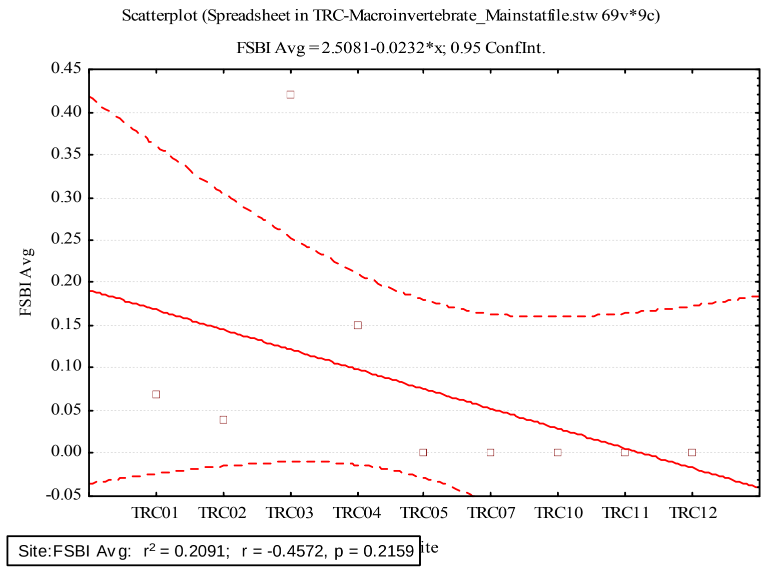

Scatterplot (Spreadsheet in TRC-Macroinvertebrate_Mainstatfile.stw 69v*9c)
PJ = 1.2406-0.0063*x; 0.95 Conf.Int.
PJ
TRC01 TRC02 TRC03 TRC04 TRC05 TRC07 TRC10 TRC11 TRC12
Site
Site:PJ: r² = 0.0201; r = -0.1417, p = 0.7161

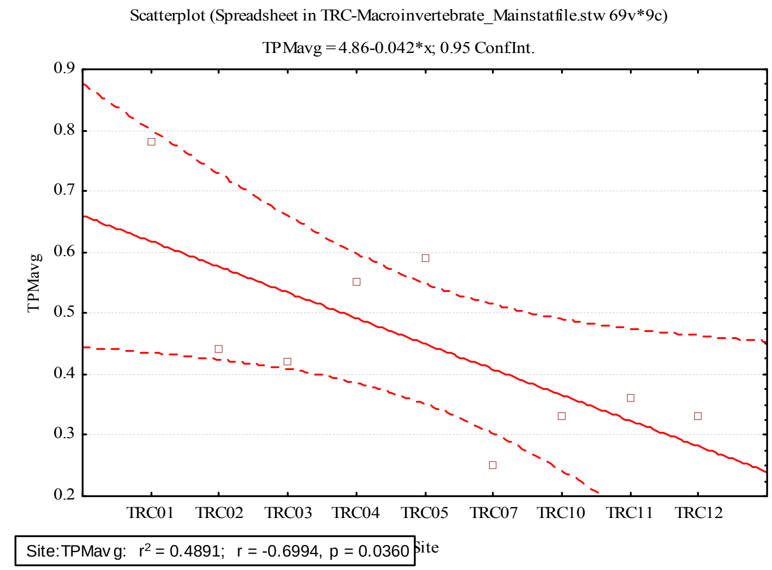

Scatterplot (Spreadsheet in TRC-Macroinvertebrate_Mainstatfile.stw 69v*9c)
Sheter = 1.9247-0.0118*x; 0.95 Conf.Int.
Sheter
TRC01 TRC02 TRC03 TRC04 TRC05 TRC07 TRC10 TRC11 TRC12
Site
Site:Sheter: r2 = 0.0462; r = -0.2150, p = 0.5785

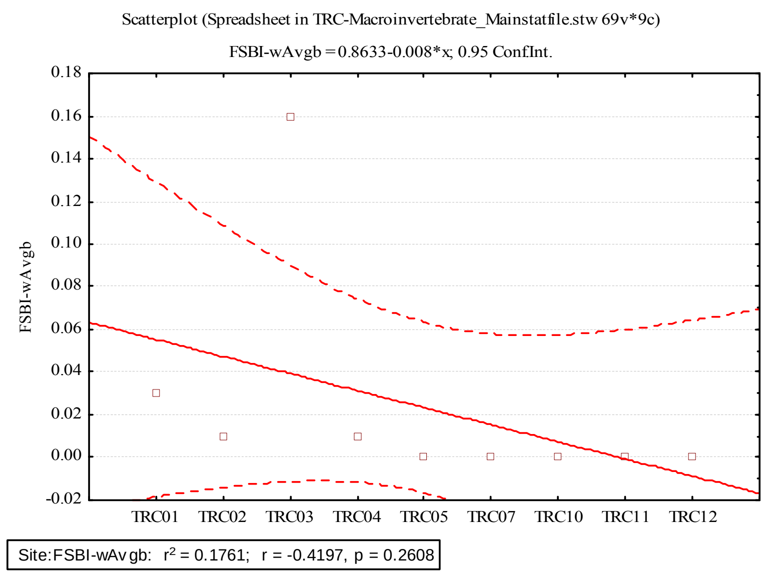

Scatterplot (Spreadsheet in TRC-Macroinvertebrate_Mainstatfile.stw 69v*9c)
MTI = 5.9681-0.0425*x; 0.95 Conf.Int.
MTI
TRC01 TRC02 TRC03 TRC04 TRC05 TRC07 TRC10 TRC11 TRC12
Site
Site:MTI: r2 = 0.0369; r = -0.1921, p = 0.6206

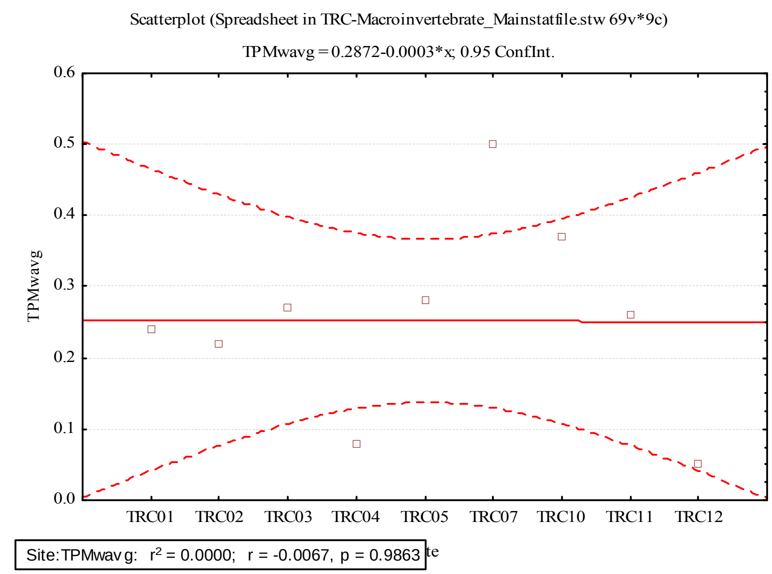

Scatterplot (Spreadsheet in TRC-Macroinvertebrate_Mainstatfile.stw 69v*9c)
HBI = -3.875+0.1097*x; 0.95 Conf.Int.
HBI
TRC01 TRC02 TRC03 TRC04 TRC05 TRC07 TRC10 TRC11 TRC12
Site
Site:HBI: r2 = 0.3826; r = 0.6185, p = 0.0758

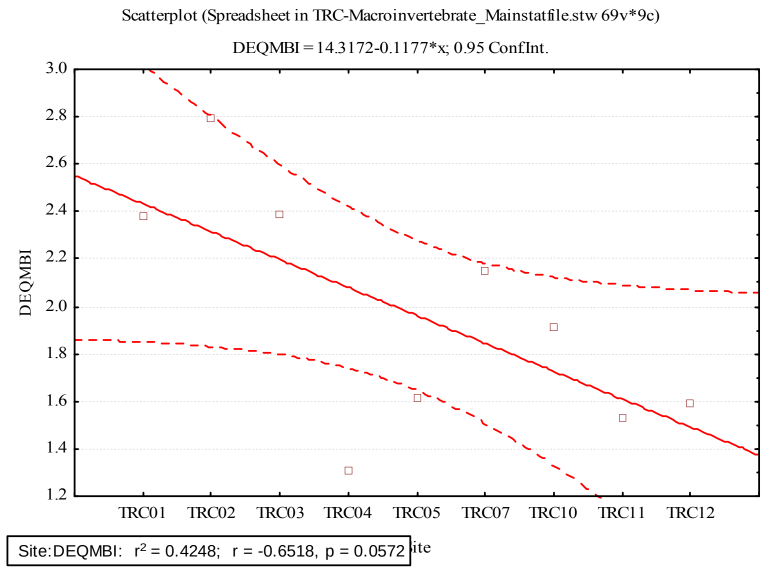

Scatterplot (Spreadsheet in TRC-Macroinvertebrate_Mainstatfile.stw 69v*9c)
FSBI = 64.8889-0.6*x; 0.95 Conf.Int.
FSBI
TRC01 TRC02 TRC03 TRC04 TRC05 TRC07 TRC10 TRC11 TRC12
Site
Site:FSBI: r2 = 0.2099; r = -0.4582, p = 0.2149

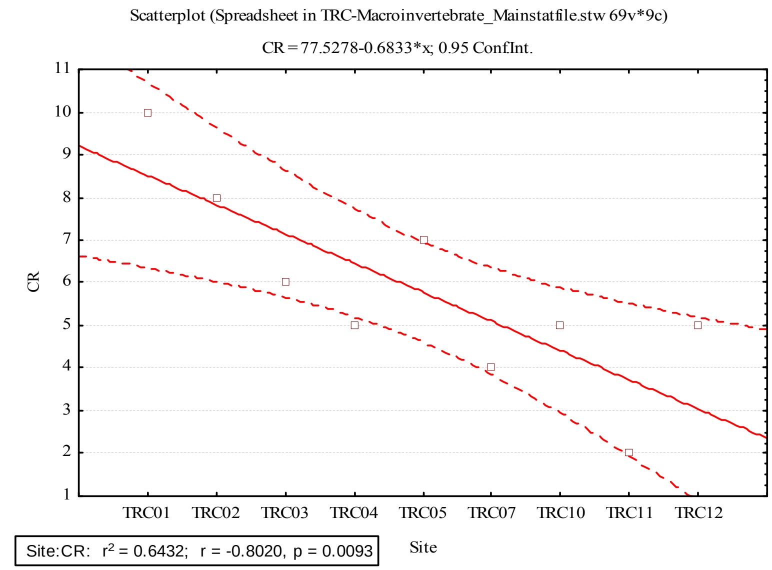

Scatterplot (Spreadsheet in TRC-Macroinvertebrate_Mainstatfile.stw 69v*9c)
FSBI Avg = 2.5081-0.0232*x; 0.95 Conf.Int.
FSBI Avg
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
-0.05
TRC01
TRC02
TRC03
TRC04
TRC05
TRC07
TRC10
TRC11
TRC12
ite
Site:FSBI Avg: r2 = 0.2091; r = -0.4572, p = 0.2159

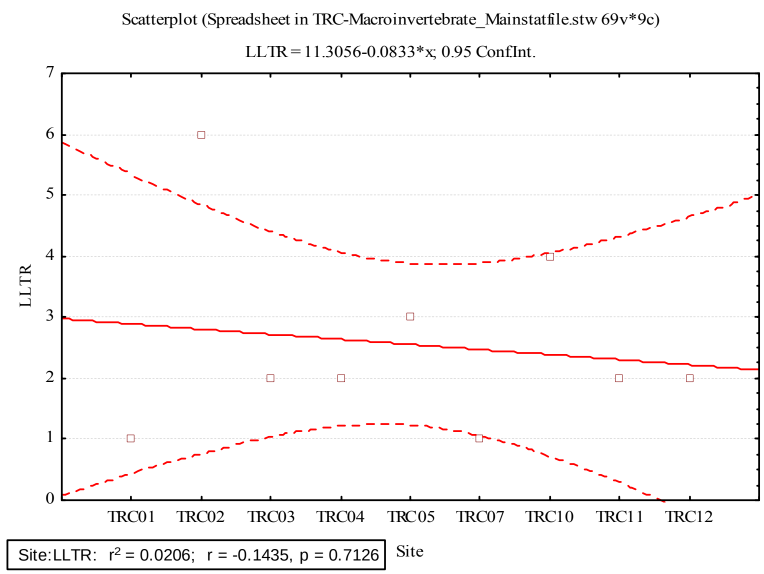

Scatterplot (Spreadsheet in TRC-Macroinvertebrate_Mainstatfile.stw 69v*9c)
TPMavg = 4.86-0.042*x; 0.95 Conf.Int.
TPMavg
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
TRC01
TRC02
TRC03
TRC04
TRC05
TRC07
TRC10
TRC11
TRC12
Site
Site:TPMavg: r2 = 0.4891; r = -0.6994, p = 0.0360

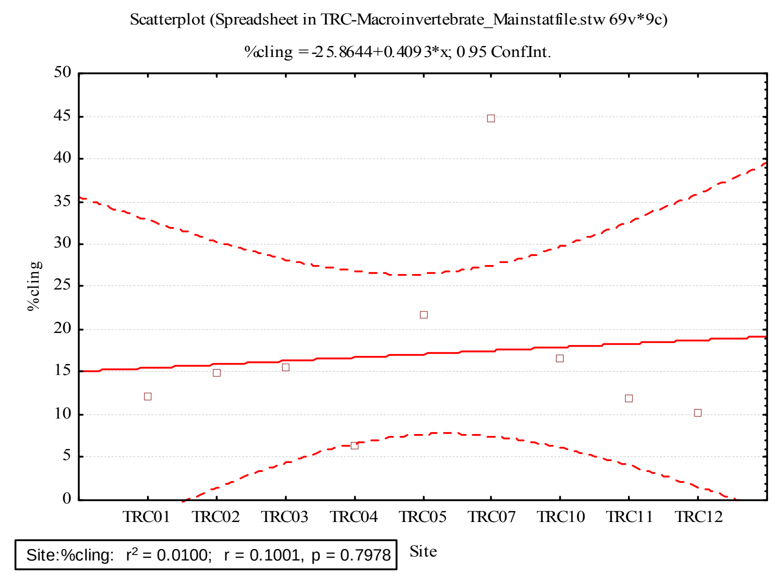

Scatterplot (Spreadsheet in TRC-Macroinvertebrate_Mainstatfile.stw 69v*9c)
FSBI-wAvgb = 0.8633-0.008*x; 0.95 Conf.Int.
FSBI-wAvgb
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
-0.02
TRC01
TRC02
TRC03
TRC04
TRC05
TRC07
TRC10
TRC11
TRC12
Site:FSBI-wAvgb: r2 = 0.1761; r = -0.4197, p = 0.2608

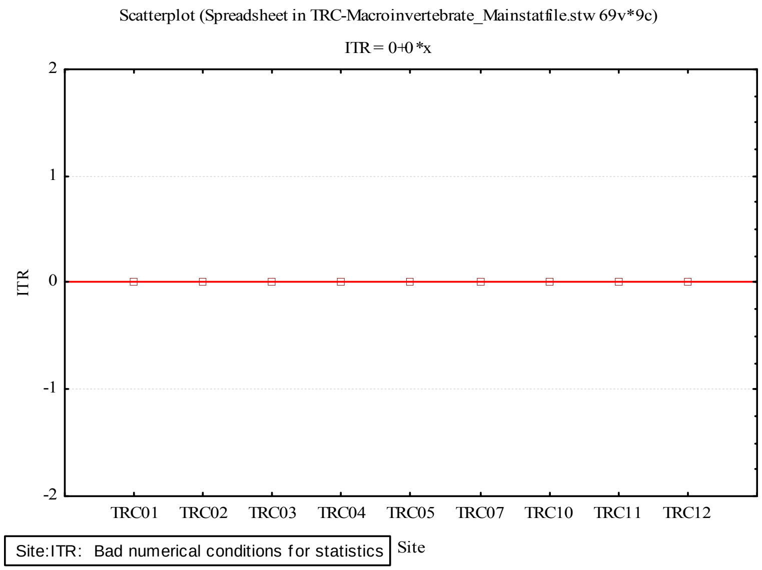

Scatterplot (Spreadsheet in TRC-Macroinvertebrate_Mainstatfile.stw 69v*9c)
TPMwavg = 0.2872-0.0003*x; 0.95 Conf.Int.
TPMwavg
0.6
0.5
0.4
0.3
0.2
0.1
0.0
TRC01
TRC02
TRC03
TRC04
TRC05
TRC07
TRC10
TRC11
TRC12
te
Site:TPMwavg: r2 = 0.0000; r = -0.0067, p = 0.9863

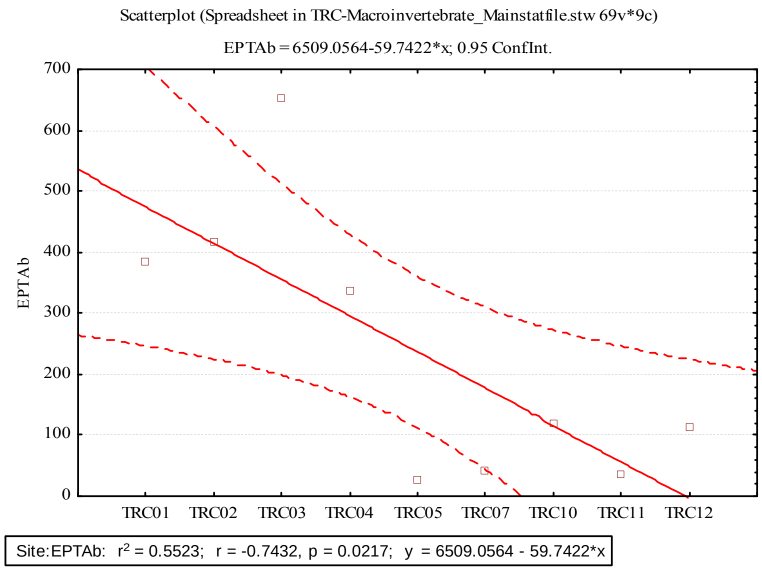

Scatterplot (Spreadsheet in TRC-Macroinvertebrate_Mainstatfile.stw 69v*9c)
DEQMBI = 14.3172-0.1177*x; 0.95 Conf.Int.
DEQMBI
3.0
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
TRC01 TRC02 TRC03 TRC04 TRC05 TRC07 TRC10 TRC11 TRC12
Site:DEQMBI: $r^2$ = 0.4248; r = -0.6518, p = 0.0572
Site

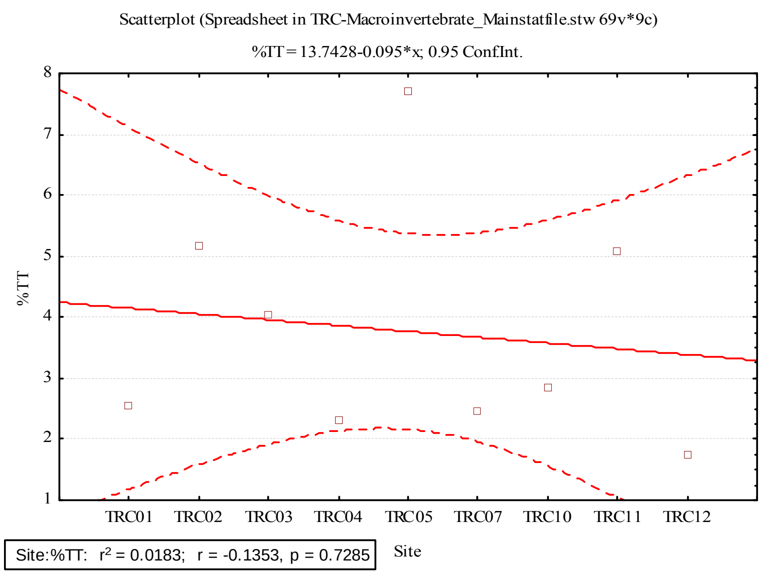

Scatterplot (Spreadsheet in TRC-Macroinvertebrate_Mainstatfile.stw 69v*9c)
CR = 77.5278-0.6833*x; 0.95 Conf.Int.
CR
11
10
9
8
7
6
5
4
3
2
1
TRC01 TRC02 TRC03 TRC04 TRC05 TRC07 TRC10 TRC11 TRC12
Site:CR: $r^2$ = 0.6432; r = -0.8020, p = 0.0093
Site


Scatterplot (Spreadsheet in TRC-Macroinvertebrate_Mainstatfile.stw 69v*9c)
LLTR = 11.3056-0.0833*x; 0.95 Conf.Int.
LLTR
7
6
5
4
3
2
1
0
TRC01 TRC02 TRC03 TRC04 TRC05 TRC07 TRC10 TRC11 TRC12
Site:LLTR: $r^2$ = 0.0206; r = -0.1435, p = 0.7126
Site

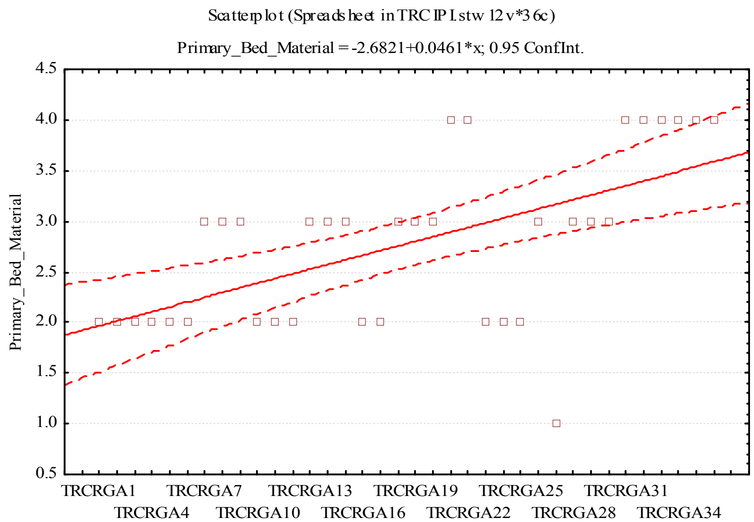

Scatterplot (Spreadsheet in TRC-Macroinvertebrate_Mainstatfile.stw 69v*9c)
%cling = -25.8644+0.4093*x; 0.95 Conf.Int.
%cling
50
45
40
35
30
25
20
15
10
5
0
TRC01 TRC02 TRC03 TRC04 TRC05 TRC07 TRC10 TRC11 TRC12
Site:%cling: $r^2$ = 0.0100; r = 0.1001, p = 0.7978
Site


Scatterplot (Spreadsheet in TRC-Macroinvertebrate_Mainstatfile.stw 69v*9c)
ITR = 0+0*x
ITR
2
1
0
-1
-2
TRC01
TRC02
TRC03
TRC04
TRC05
TRC07
TRC10
TRC11
TRC12
Site:ITR: Bad numerical conditions for statistics
Site

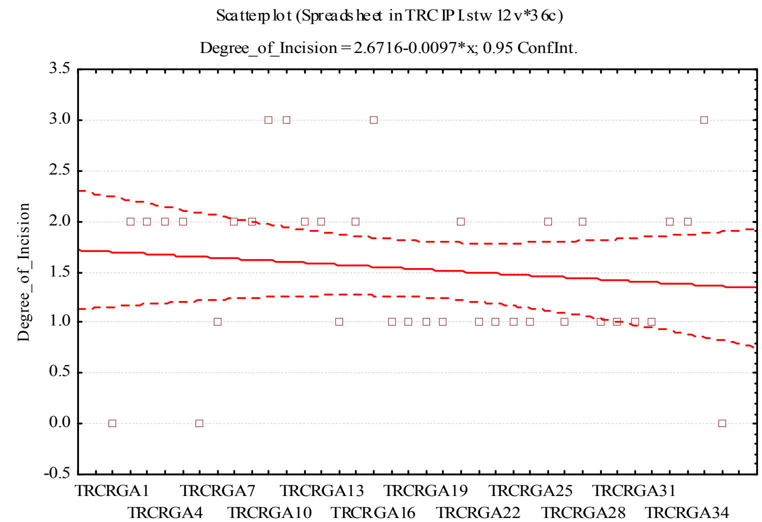

Scatterplot (Spreadsheet in TRC-Macroinvertebrate_Mainstatfile.stw 69v*9c)
EPTAb = 6509.0564-59.7422*x; 0.95 Conf.Int.
EPTAb
700
600
500
400
300
200
100
0
TRC01
TRC02
TRC03
TRC04
TRC05
TRC07
TRC10
TRC11
TRC12
Site:EPTAb: r2 = 0.5523; r = -0.7432, p = 0.0217; y = 6509.0564 - 59.7422*x


Scatterplot (Spreadsheet in TRC-Macroinvertebrate_Mainstatfile.stw 69v*9c)
%TT = 13.7428-0.095*x; 0.95 Conf.Int.
%TT
8
7
6
5
4
3
2
1
TRC01
TRC02
TRC03
TRC04
TRC05
TRC07
TRC10
TRC11
TRC12
Site:%TT: r2 = 0.0183; r = -0.1353, p = 0.7285
Site

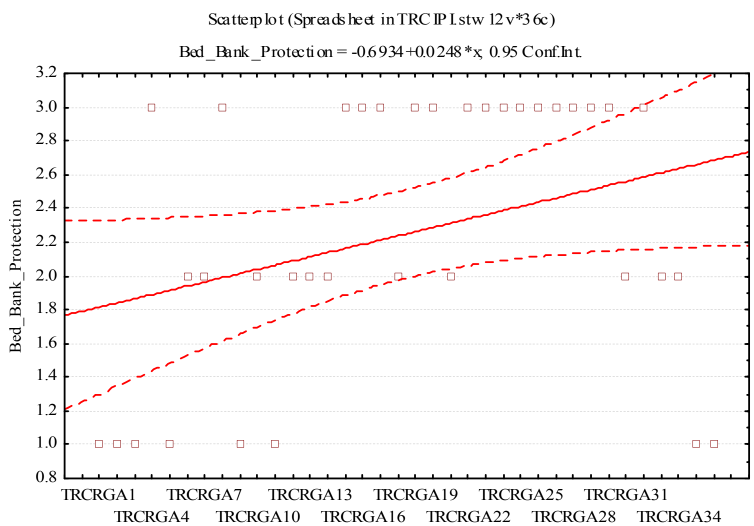
# 18.0 APPENDIX M – Rapid Geomorphic Assessment Scatterplots for Individual Variables



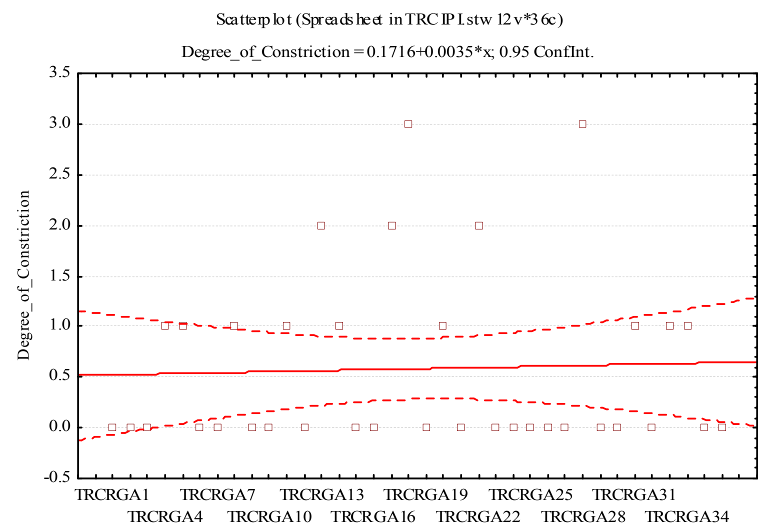

Station:Primary_Bed_Material: $r^2 = 0.3405$; $r = 0.5835$, $p = 0.0002$; $y = -2.6821 + 0.0461*x$



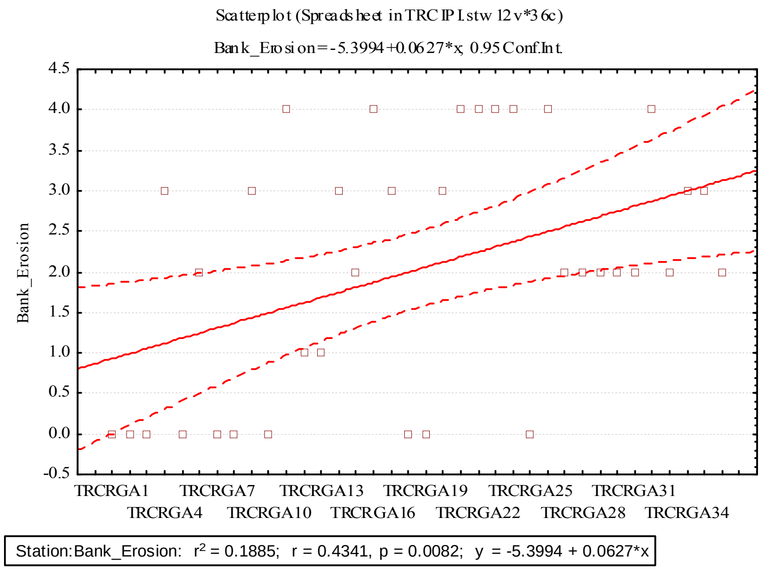

Station:Degree_of_Incision: $r^2 = 0.0158$; $r = -0.1255$, $p = 0.4657$; $y = 2.6716 - 0.0097*x$

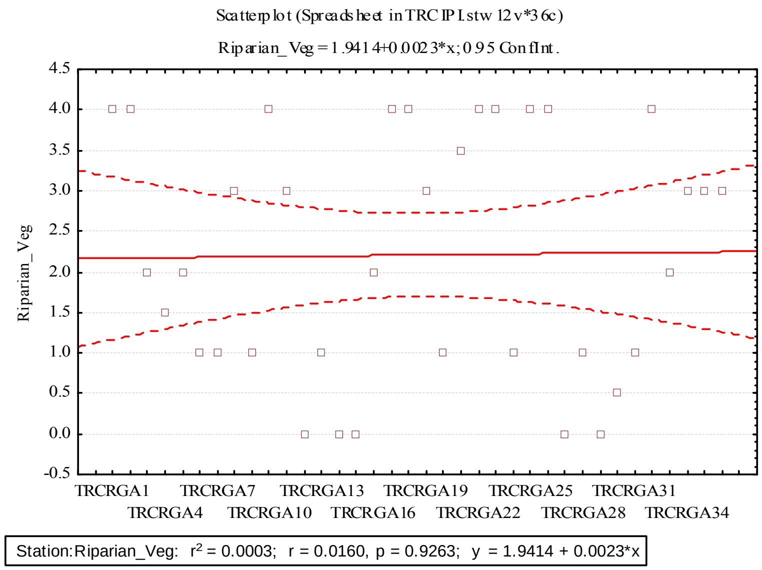


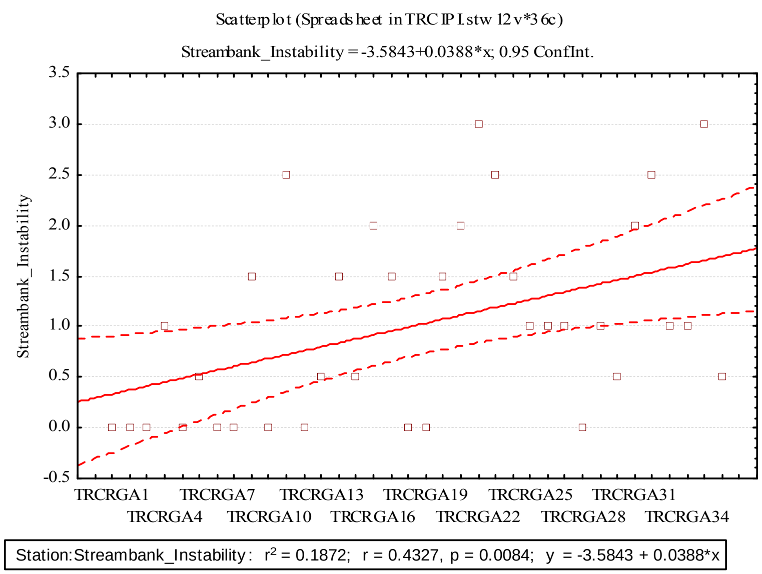

Station:Bed_Bank_Protection: $r^2 = 0.1054$; $r = 0.3246$, $p = 0.0534$; $y = -0.6934 + 0.0248*x$

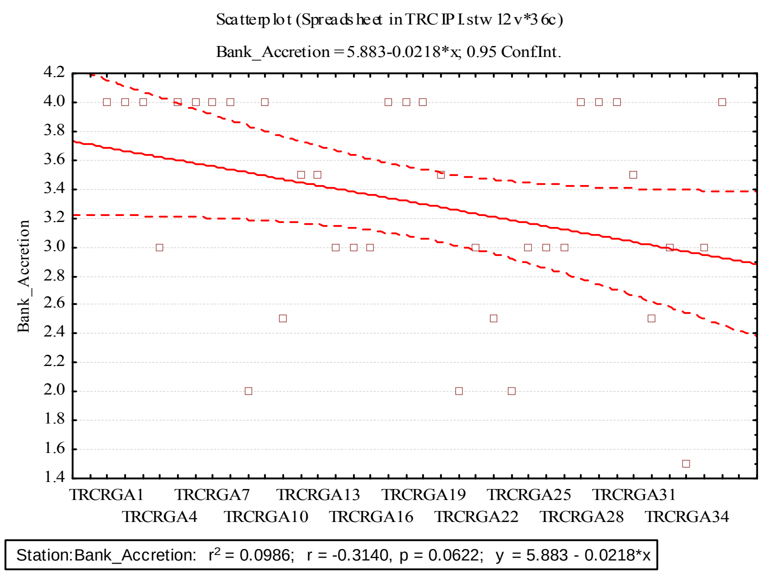


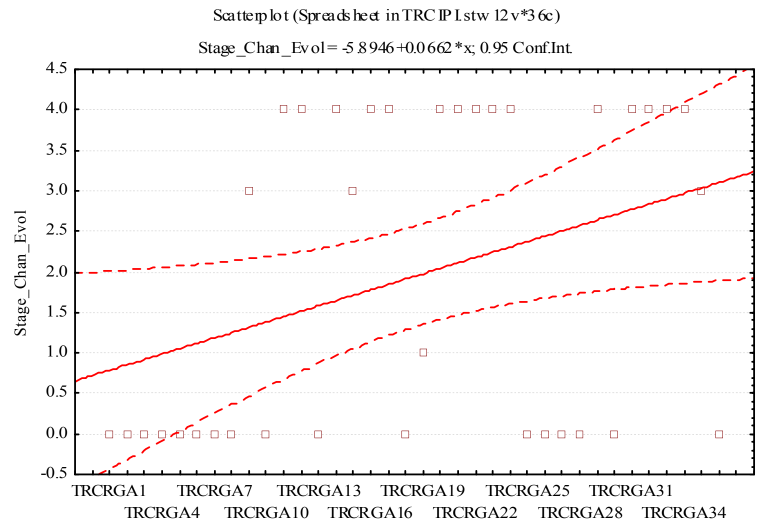

Station:Degree_of_Constriction: $r^2 = 0.0018$; $r = 0.0419$, $p = 0.8084$; $y = 0.1716 + 0.0035*x$


Scatterplot (Spreadsheet in TRC IPI.stw 12v*36c)
Bank_Erosion = -5.3994+0.0627*x; 0.95 Conf.Int.
Bank_Erosion
TRCRGA1
TRCRGA4
TRCRGA7
TRCRGA10
TRCRGA13
TRCRGA16
TRCRGA19
TRCRGA22
TRCRGA25
TRCRGA28
TRCRGA31
TRCRGA34
Station:Bank_Erosion: r2 = 0.1885; r = 0.4341, p = 0.0082; y = -5.3994 + 0.0627*x

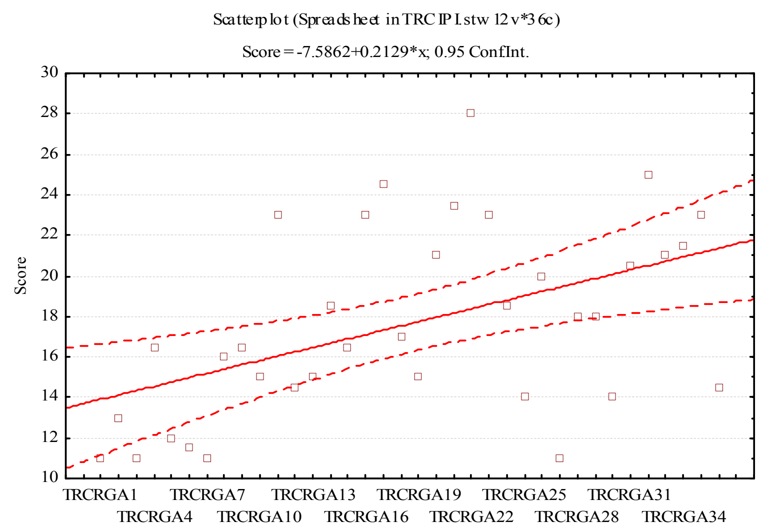

Scatterplot (Spreadsheet in TRC IPI.stw 12v*36c)
Riparian_Veg = 1.9414+0.0023*x; 0.95 Conf.Int.
Riparian_Veg
TRCRGA1
TRCRGA4
TRCRGA7
TRCRGA10
TRCRGA13
TRCRGA16
TRCRGA19
TRCRGA22
TRCRGA25
TRCRGA28
TRCRGA31
TRCRGA34
Station:Riparian_Veg: r2 = 0.0003; r = 0.0160, p = 0.9263; y = 1.9414 + 0.0023*x


Scatterplot (Spreadsheet in TRC IPI.stw 12v*36c)
Streambank_Instability = -3.5843+0.0388*x; 0.95 Conf.Int.
Streambank_Instability
TRCRGA1
TRCRGA4
TRCRGA7
TRCRGA10
TRCRGA13
TRCRGA16
TRCRGA19
TRCRGA22
TRCRGA25
TRCRGA28
TRCRGA31
TRCRGA34
Station:Streambank_Instability: r2 = 0.1872; r = 0.4327, p = 0.0084; y = -3.5843 + 0.0388*x


Scatterplot (Spreadsheet in TRC IPI.stw 12v*36c)
Bank_Accretion = 5.883-0.0218*x; 0.95 Conf.Int.
Bank_Accretion
TRCRGA1
TRCRGA4
TRCRGA7
TRCRGA10
TRCRGA13
TRCRGA16
TRCRGA19
TRCRGA22
TRCRGA25
TRCRGA28
TRCRGA31
TRCRGA34
Station:Bank_Accretion: r2 = 0.0986; r = -0.3140, p = 0.0622; y = 5.883 - 0.0218*x




Station:Stage_Chan_Evol: $r^2 = 0.1289$; $r = 0.3590$, $p = 0.0315$; $y = -5.8946 + 0.0662*x$




Station:Score: $r^2 = 0.2340$; $r = 0.4837$, $p = 0.0028$; $y = -7.5862 + 0.2129*x$

## 19.0 APPENDIX N – TURKEY RIDGE PRELIMINARY IMPLEMENATION PLAN

## 1.0 PROJECT SUMMARY SHEET

**PROJECT TITLE: Turkey Ridge Creek Watershed Project**

**NAME, ADDRESS, PHONE AND E-MAIL OF LEAD PROJECT SPONSOR/SUBGRANTEE:**

Turner County Conservation District
Dennis Johnson, Chairperson
Frances Ingalls District Secretary
655 East 4th Street, P.O. Box 416
Parker, South Dakota 57053-0416
Phone: 605- 297-5564 Email: francis-ingalls@sd.nacdnet.org

**STATE CONTACT PERSON:** Alan Wittmuss
**PHONE** (605) - 677-6163 **FAX** (605) – 677-5895 **E-MAIL** awittmus@usd.edu
**STATE** South Dakota **WATERSHED** Turkey Ridge Creek
HYDROLOGIC UNIT CODE 10170102130
HIGH PRIORITY WATERSHED (yes/no) Yes – 303 (d) list
**TMDL** Development X and/or Implementation X (Check any that apply)

**PROJECT TYPES**
**[ ] STAFFING & SUPPORT**
**[X] WATERSHED**
**[ ] GROUNDWATER**
**[ ] I&E**

**WATERBODY TYPES**
**[ ] GROUNDWATER**
**[ ] LAKES/RESERVOIRS**
**[X] RIVERS**
**[X] STREAMS**
**[ ] WETLANDS**
**[ ] OTHER**

**NPS CATEGORY**
**[X] AGRICULTURE**
**[ ] URBAN RUNOFF**
**[ ] SILVICULTURE**
**[ ] CONSTRUCTION**
**[ ] RESOURCE EXTRACTION**
**[ ] STOWAGE/LAND DISPOSAL**
**[ ] HYDRO MODIFICATION**
**[ ] OTHER**

PROJECT LOCATION: LATITUDE 43 MIN. 258818 LONGITUDE -97 MIN. 240050

**SUMMARIZATION OF MAJOR GOALS:**
The Turkey Ridge Creek Watershed Implementation Project is to restore the beneficial uses of Turkey Ridge Creek through the implementation of Best Management Practices (BMPS) in the watershed that target sources of fecal coli form bacteria. These BMPs will also reduce the fecal coli form and sediment contribution from Turkey Ridge Creek to the Vermillion River below the city of Centerville, SD. This project is the initial steps towards helping the two water bodies achieve full support status of all their beneficial uses.

**PROJECT DESCRIPTION**:
This proposed 18 month project is the first segment of the Turkey Ridge Creek Watershed TMDL Implementation Project. The project, over a 6-year span, will restore Turkey Ridge Creek water quality to meet the limited contact recreation designated beneficial use. Preliminary results from the Turkey Ridge Creek Watershed Assessment rated Turkey Ridge Creek high in fecal coliform bacteria from runoff from animal feeding areas and animals having direct access to the creek. As part of the overall project an informational and educational campaign will be conducted to keep the public and stakeholders informed on project progress and to provide technical information on BMPs and water quality.

**319 funds requested: $ 130,440.00**
**Other Federal Funds: $ 28,610.00**
**319 Funded Part Time Personnel: 0.5**

**Other Funds: $ 22,000.00**
**Local Match: $ 82,950.00**
**Total Project Cost: $ 264,000**

# 20.0 APPENDIX O – ANN-AGNPS HYDROLOGIC SPREADSHEETS FOR TURKEY RIDGE CREEK FECAL COLIFORM TMDL

Hydrologic Output from ANN-AGNPS Turkey Ridge Creek

| | Receiving | | | Channel | | | Valley | | | | Total | Distance | Velocity | Delivery |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Reach ID | R Reach ID | Mannings | Slope | Length | Depth | Width | Width | Travel Time | Upstream | Downstream | Travel Time | to Outlet | | |
| | | n | m/m | m | m | m | m | hr | hr | hr | hr | miles | m/Day | % |
| Reach | Receiving | Mannings | Slope | C_Length | C_Depth | C_Width | V_Width | TravelTime | Upstream | Downstream | TotalTime | Distance | Velocity | Delivery |
| 1 | | | | | | | | | | | | | | |
| 2 | 1 | 0.04 | 0.00001 | 2605 | 2.026 | 31.97 | 32 | 6.191 | 67.98 | 74.17 | 6.191 | 1.618672 | 6.274936 | 0.876728 |
| 3 | 2 | 0.04 | 0.00001 | 1484 | 2.022 | 31.89 | 31.9 | 3.531 | 64.45 | 67.98 | 9.722 | 0.9231206 | 2.278841 | 0.813351 |
| 4 | 3 | 0.04 | 0.00369 | 542 | 0.475 | 4.24 | 4.2 | 0.186 | 14.23 | 14.41 | 9.908 | 0.3373568 | 0.817174 | 0.810143 |
| 5 | 4 | 0.04 | 0.05858 | 102 | 0.261 | 1.85 | 1.8 | 0.014 | 6.76 | 6.78 | 9.922 | 0.0635895 | 0.153815 | 0.809902 |
| 6 | 4 | 0.04 | 0.03048 | 230 | 0.454 | 3.98 | 4 | 0.028 | 14.20 | 14.23 | 9.936 | 0.143125 | 0.345713 | 0.809661 |
| 7 | 6 | 0.04 | 0.00001 | 422 | 0.264 | 1.88 | 1.9 | 4.247 | 7.41 | 11.66 | 14.183 | 0.2623076 | 0.443868 | 0.73979 |
| 8 | 6 | 0.04 | 0.00001 | 30 | 0.431 | 3.7 | 3.7 | 0.213 | 13.99 | 14.20 | 10.149 | 0.0187301 | 0.044292 | 0.806004 |
| 9 | 8 | 0.04 | 0.00001 | 655 | 0.268 | 1.91 | 1.9 | 6.528 | 7.46 | 13.99 | 16.677 | 0.4070098 | 0.585731 | 0.701604 |
| 10 | 8 | 0.04 | 0.001 | 1012 | 0.358 | 2.86 | 2.9 | 0.819 | 7.02 | 7.84 | 10.968 | 0.6288393 | 1.376016 | 0.792098 |
| 11 | 10 | 0.04 | 0.00461 | 217 | 0.267 | 1.9 | 1.9 | 0.101 | 0.59 | 0.69 | 11.069 | 0.1352283 | 0.293204 | 0.7904 |
| 12 | 10 | 0.04 | 0.00718 | 837 | 0.264 | 1.88 | 1.9 | 0.314 | 6.71 | 7.02 | 11.282 | 0.5204784 | 1.107205 | 0.78683 |
| 13 | 3 | 0.04 | 0.00201 | 2001 | 2.016 | 31.77 | 31.8 | 0.336 | 64.11 | 64.45 | 10.058 | 1.2439374 | 2.968234 | 0.807564 |
| 14 | 13 | 0.04 | 0.00001 | 132 | 1.986 | 31.1 | 31.1 | 0.318 | 63.80 | 64.11 | 10.376 | 0.0827939 | 0.191505 | 0.802126 |
| 15 | 14 | 0.04 | 0.01401 | 500 | 0.265 | 1.88 | 1.9 | 0.134 | 6.55 | 6.69 | 10.51 | 0.310737 | 0.70958 | 0.799845 |
| 16 | 14 | 0.04 | 0.00001 | 320 | 1.985 | 31.08 | 31.1 | 0.771 | 63.02 | 63.80 | 11.147 | 0.1988902 | 0.42822 | 0.789091 |
| 17 | 16 | 0.04 | 0.01005 | 1394 | 0.373 | 3.02 | 3 | 0.346 | 6.88 | 7.23 | 11.493 | 0.866315 | 1.809063 | 0.78331 |
| 18 | 17 | 0.04 | 0.00332 | 302 | 0.297 | 2.2 | 2.2 | 0.153 | 0.86 | 1.01 | 11.646 | 0.1881924 | 0.387826 | 0.780768 |
| 19 | 17 | 0.04 | 0.00295 | 339 | 0.286 | 2.09 | 2.1 | 0.188 | 6.69 | 6.88 | 11.681 | 0.2111831 | 0.433901 | 0.780187 |
| 20 | 16 | 0.04 | 0.0007 | 1443 | 1.981 | 31 | 31 | 0.416 | 62.61 | 63.02 | 11.563 | 0.8967622 | 1.861307 | 0.782146 |
| 21 | 20 | 0.04 | 0.00001 | 1608 | 1.978 | 30.93 | 30.9 | 3.885 | 58.72 | 62.61 | 15.448 | 0.9997221 | 1.553167 | 0.720169 |

Spreadsheet Setup for Fecal Coliform Calculation on Turkey Ridge Creek

| #/mile | #/acre | FC/Animal/Day | FC/Acre | Rangeland | Cropland | Urban | Water |
|---|---|---|---|---|---|---|---|
| 15.19 | 0.02 | 4.46E+10 | 1059055386 | 1059055386 | 32874777 | | |
| 1875.00 | 2.93 | 3.90E+10 | 114257812500 | 114257812500 | 387910714 | | |
| 117.04 | 0.18 | 1.08E+10 | 1975102669 | | 197510267 | | |
| 26.69 | 0.04 | 1.96E+10 | 817505133 | | 81750513 | | |
| 0.62 | 0.00 | 5.15E+10 | 49570427 | 49570427 | 4957043 | | |
| 102.67 | 0.16 | 1.36E+08 | 21817248 | | 2181725 | | |
| 300.00 | 0.47 | 1.85E+09 | 867187500 | | | 867187500 | |
| 0.41 | 0.00 | 9.30E+07 | 59578 | 59578 | 59578 | 59578 | 59578 |
| 0.81 | 0.00 | 7.99E+08 | 1011234 | 1011234 | 1011234 | 1011234 | 1011234 |
| 2.84 | 0.00 | 3.47E+08 | 1539813 | 1539813 | 1539813 | 1539813 | 1539813 |
| 1.78 | 0.00 | 2.00E+05 | 556 | 556 | 556 | 556 | 556 |
| 3.73 | 0.01 | 5.00E+09 | 29140625 | 29140625 | 29140625 | 29140625 | 29140625 |
| 0.81 | 0.00 | 1.85E+09 | 2341406 | 2341406 | 2341406 | 2341406 | 2341406 |
| 1.30 | 0.00 | 2.50E+07 | 50781 | 50781 | 50781 | 50781 | 50781 |
| | | | Total/Acre | 1.15401E+11 | 741329032.6 | 901331494 | 34143994 |

| GRIDCODE | RATING | Slaughter Steer | Young Beef | Mature Dairy | Young Dairy | Horse | Pig | Feeder Pig | Sheep | DELIVERY | Fecal Load |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 22 | 40 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.8770 | 1.71E+12 |
| 91 | 46 | 85 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.7020 | 2.33E+12 |
| 132 | 35 | 40 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.8080 | 1.26E+12 |
| 242 | 24 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 80 | 0.6980 | 1.09E+12 |
| 573 | 54 | 0 | 490 | 0 | 0 | 0 | 0 | 0 | 0 | 0.5040 | 9.63E+12 |
| 582 | 31 | 20 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.5040 | 3.93E+11 |
| 602 | 52 | 115 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.5010 | 2.25E+12 |
| 691 | 22 | 0 | 60 | 0 | 0 | 0 | 0 | 0 | 0 | 0.4970 | 1.16E+12 |
| 693 | 24 | 0 | 15 | 0 | 0 | 0 | 40 | 140 | 0 | 0.4750 | 1.20E+12 |
| 702 | 45 | 80 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0.4750 | 2.41E+12 |
| 712 | 53 | 80 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.4750 | 1.48E+12 |
| 743 | 51 | 0 | 200 | 0 | 0 | 0 | 0 | 0 | 0 | 0.4750 | 3.71E+12 |
| 761 | 41 | 60 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.4750 | 1.11E+12 |
| 803 | 53 | 0 | 250 | 0 | 0 | 0 | 0 | 0 | 0 | 0.4610 | 4.49E+12 |
| 813 | 59 | 0 | 900 | 0 | 0 | 0 | 0 | 0 | 0 | 0.4610 | 1.62E+13 |
| 842 | 38 | 0 | 150 | 0 | 0 | 0 | 0 | 0 | 0 | 0.4600 | 2.69E+12 |
| 953 | 27 | 0 | 0 | 0 | 0 | 0 | 70 | 0 | 0 | 0.4190 | 3.17E+11 |
| 1233 | 55 | 0 | 300 | 0 | 0 | 0 | 0 | 0 | 0 | 0.3780 | 4.42E+12 |

| FID_1 | ID | GRIDCODE | LANDOO | GROUP | REACH_1 | REACH | DELIVERY | NONPTFECAL | FECALSDELI | Acres | Area | Perimeter | Count_ | Max_ID | Max_GRIDCO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 12832 | 12833 | 22 | 103 | Cropland | 2 | 2.00 | 0.88 | 2994654931 | 0.0 | 0.0 | 0.0 | 0.0 | 5.0 | 9390.0 | 5.0 |
| 12954 | 12955 | 22 | 103 | Cropland | 2 | 2.00 | 0.88 | 2994654931 | 664107538699.0 | 252.9 | 1023316.1 | 6776.0 | 31.0 | 9471.0 | 5.0 |
| 12952 | 12953 | 23 | 103 | Cropland | 2 | 2.00 | 0.88 | 2994654931 | 599038161027.0 | 228.1 | 923051.4 | 6720.2 | 35.0 | 9472.0 | 5.0 |
| 12835 | 12836 | 24 | 103 | Cropland | | 0.00 | 0.00 | 2994654931 | 0.0 | 0.2 | 900.0 | 120.0 | 3.0 | 9412.0 | 5.0 |
| 12859 | 12860 | 24 | 103 | Cropland | | 0.00 | 0.00 | 2994654931 | 0.0 | 2.7 | 10800.0 | 780.0 | 2.0 | 9420.0 | 5.0 |
| 12871 | 12872 | 24 | 103 | Cropland | | 0.00 | 0.00 | 2994654931 | 0.0 | 0.7 | 2700.0 | 240.0 | 2.0 | 9423.0 | 5.0 |
| 12874 | 12875 | 24 | 103 | Cropland | | 0.00 | 0.00 | 2994654931 | 0.0 | 0.2 | 900.0 | 120.0 | 2.0 | 9430.0 | 5.0 |
| 12885 | 12886 | 24 | 103 | Cropland | | 0.00 | 0.00 | 2994654931 | 0.0 | 0.7 | 2700.0 | 240.0 | 2.0 | 9440.0 | 5.0 |
| 12905 | 12906 | 24 | 103 | Cropland | | 0.00 | 0.00 | 2994654931 | 0.0 | 0.7 | 2700.0 | 240.0 | 2.0 | 9444.0 | 5.0 |
| 12914 | 12915 | 24 | 103 | Cropland | | 0.00 | 0.00 | 2994654931 | 0.0 | 0.7 | 2700.0 | 240.0 | 2.0 | 9446.0 | 5.0 |
| 12917 | 12918 | 24 | 103 | Cropland | | 0.00 | 0.00 | 2994654931 | 0.0 | 0.4 | 1800.0 | 180.0 | 2.0 | 9448.0 | 5.0 |
| 12921 | 12922 | 24 | 103 | Cropland | | 0.00 | 0.00 | 2994654931 | 0.0 | 0.2 | 900.0 | 120.0 | 2.0 | 9450.0 | 5.0 |
| 12925 | 12926 | 24 | 103 | Cropland | | 0.00 | 0.00 | 2994654931 | 0.0 | 0.4 | 1800.0 | 180.0 | 2.0 | 9451.0 | 5.0 |
| 12927 | 12928 | 24 | 103 | Cropland | | 0.00 | 0.00 | 2994654931 | 0.0 | 0.2 | 900.0 | 120.0 | 2.0 | 9452.0 | 5.0 |
| 12928 | 12929 | 24 | 103 | Cropland | | 0.00 | 0.00 | 2994654931 | 0.0 | 0.2 | 900.0 | 120.0 | 2.0 | 9453.0 | 5.0 |
| 12929 | 12930 | 24 | 103 | Cropland | | 0.00 | 0.00 | 2994654931 | 0.0 | 0.2 | 900.0 | 120.0 | 2.0 | 9454.0 | 5.0 |

| Pature Number | 2 | 3 |
|---|---|---|
| | PastureGood | PastPoor |
| 22 | 0.911 | 0.911 |
| 23 | 0.272 | 0.272 |
| 32 | 0.387 | 1.442 |
| 33 | 1.366 | 1.366 |
| 42 | 1.366 | 1.366 |
| 43 | 0.373 | 0.373 |
| 51 | 1.537 | 1.537 |
| 53 | 1.537 | 1.537 |
| 62 | 1.537 | 1.537 |
| 63 | 1.537 | 1.537 |
| 71 | 1.538 | 1.538 |
| 72 | 1.537 | 1.537 |
| 73 | 2.162 | 2.162 |

| Copy the data from FecalOutput Sheet to Fill in the yellow Highlighted Sections | | | | | | | | | From Water Load | **Daily Loads** | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Grid code | Landuse | Acres | C Length | Total Time | Dist | Velocity | Delivery | Stream Order | In /Year | Fecal Concentration in Cell | Daily Feedlot Fecal Delivered | Growing Season Instream Fecal Delivered | Total Daily Fecal in Cell | Total Storm Event Fecal Delivered | Storm Event Fecal Per Acre | Storm Event Water Load |
| 22 | Crop | 313.58 | 2605 | 6.191 | 1.619 | 6.275 | 0.877 | 5 | 0.911 | 1.42E+10 | 1.7102E+12 | 0 | 3.91E+12 | 1.04E+13 | 3.32E+10 | 285.67138 |
| 23 | Crop | 229.96 | 2605 | 6.191 | 1.619 | 6.275 | 0.877 | 5 | 0.272 | 1.42E+10 | | 0 | 2.87E+12 | 7.80E+11 | 3.39E+09 | 62.54912 |
| 32 | Range | 124.1 | 1484 | 9.722 | 0.923 | 2.279 | 0.813 | 5 | 0.387 | 1.15E+11 | | 3.43E+10 | 1.16E+13 | 4.54E+12 | 3.66E+10 | 48.0267 |
| 33 | Crop | 167.91 | 1484 | 9.722 | 0.923 | 2.279 | 0.813 | 5 | 1.366 | 1.42E+10 | | 0 | 1.94E+12 | 2.65E+12 | 1.58E+10 | 229.36506 |
| 42 | Crop | 30.02 | 542 | 9.908 | 0.337 | 0.817 | 0.81 | 2 | 1.366 | 1.42E+10 | | 0 | 3.46E+11 | 4.72E+11 | 1.57E+10 | 41.00732 |
| 43 | Crop | 35.36 | 542 | 9.908 | 0.337 | 0.817 | 0.81 | 2 | 0.373 | 1.42E+10 | | 0 | 4.07E+11 | 1.52E+11 | 4.29E+09 | 13.18928 |
| 51 | Crop | 74.06 | 102 | 9.922 | 0.064 | 0.154 | 0.81 | 1 | 1.537 | 1.42E+10 | | 0 | 8.53E+11 | 1.31E+12 | 1.77E+10 | 113.83022 |
| 53 | Crop | 10.45 | 102 | 9.922 | 0.064 | 0.154 | 0.81 | 1 | 1.537 | 1.42E+10 | | 0 | 1.20E+11 | 1.85E+11 | 1.77E+10 | 16.06165 |
| 62 | Crop | 2 | 230 | 9.936 | 0.143 | 0.346 | 0.81 | 2 | 1.537 | 1.42E+10 | | 0 | 2.30E+10 | 3.54E+10 | 1.77E+10 | 3.074 |
| 63 | Crop | 6.67 | 230 | 9.936 | 0.143 | 0.346 | 0.81 | 2 | 1.537 | 1.42E+10 | | 0 | 7.68E+10 | 1.18E+11 | 1.77E+10 | 10.25179 |
| 71 | Crop | 77.17 | 422 | 14.183 | 0.262 | 0.444 | 0.74 | 1 | 1.538 | 1.42E+10 | | 0 | 8.12E+11 | 1.25E+12 | 1.62E+10 | 118.68746 |
| 72 | Crop | 9.56 | 422 | 14.183 | 0.262 | 0.444 | 0.74 | 1 | 1.537 | 1.42E+10 | | 0 | 1.01E+11 | 1.55E+11 | 1.62E+10 | 14.69372 |
| 73 | Crop | 4.23 | 422 | 14.183 | 0.262 | 0.444 | 0.74 | 1 | 2.162 | 1.42E+10 | | 0 | 4.45E+10 | 9.62E+10 | 2.27E+10 | 9.14526 |
| 91 | Crop | 80.95 | 655 | 16.677 | 0.407 | 0.586 | 0.702 | 1 | 1.539 | 1.42E+10 | 2.3271E+12 | 0 | 8.08E+11 | 1.06E+13 | 1.30E+11 | 124.58205 |
| 92 | Crop | 13.34 | 655 | 16.677 | 0.407 | 0.586 | 0.702 | 0 | 1.537 | 1.42E+10 | | 0 | 1.33E+11 | 2.05E+11 | 1.53E+10 | 20.50358 |
| 93 | Crop | 22.24 | 655 | 16.677 | 0.407 | 0.586 | 0.702 | 2 | 1.537 | 1.42E+10 | | 0 | 2.22E+11 | 3.41E+11 | 1.53E+10 | 34.18288 |
| 102 | Crop | 44.7 | 1012 | 10.968 | 0.629 | 1.376 | 0.792 | 2 | 1.367 | 1.42E+10 | | 0 | 5.03E+11 | 6.88E+11 | 1.54E+10 | 61.1049 |
| 103 | Crop | 51.37 | 1012 | 10.968 | 0.629 | 1.376 | 0.792 | 2 | 1.537 | 1.42E+10 | | 0 | 5.78E+11 | 8.89E+11 | 1.73E+10 | 78.95569 |
| 111 | Crop | 80.06 | 217 | 11.069 | 0.135 | 0.293 | 0.79 | 1 | 1.539 | 1.42E+10 | | 0 | 8.99E+11 | 1.38E+12 | 1.73E+10 | 123.21234 |
| 112 | Crop | 7.78 | 217 | 11.069 | 0.135 | 0.293 | 0.79 | 1 | 1.368 | 1.42E+10 | | 0 | 8.74E+10 | 1.20E+11 | 1.54E+10 | 10.64304 |

| Cell | DeliveryRatio | AnnualWater | FecalPerAcre | BaseflowFecal | StormDeliveryLoad | StormDelPerAcre |
|---|---|---|---|---|---|---|
| 22 | 0.877 | 0.911 | 14213932551 | 0 | 1.04E+13 | 3.32E+10 |
| 23 | 0.877 | 0.272 | 14213932551 | 0 | 7.80E+11 | 3.39E+09 |
| 32 | 0.813 | 0.387 | 1.15401E+11 | 34250892829 | 4.54E+12 | 3.66E+10 |
| 33 | 0.813 | 1.366 | 14213932551 | 0 | 2.65E+12 | 1.58E+10 |
| 42 | 0.81 | 1.366 | 14213932551 | 0 | 4.72E+11 | 1.57E+10 |
| 43 | 0.81 | 0.373 | 14213932551 | 0 | 1.52E+11 | 4.29E+09 |
| 51 | 0.81 | 1.537 | 14213932551 | 0 | 1.31E+12 | 1.77E+10 |
| 53 | 0.81 | 1.537 | 14213932551 | 0 | 1.85E+11 | 1.77E+10 |
| 62 | 0.81 | 1.537 | 14213932551 | 0 | 3.54E+10 | 1.77E+10 |
| 63 | 0.81 | 1.537 | 14213932551 | 0 | 1.18E+11 | 1.77E+10 |
| 71 | 0.74 | 1.538 | 14213932551 | 0 | 1.25E+12 | 1.62E+10 |
| 72 | 0.74 | 1.537 | 14213932551 | 0 | 1.55E+11 | 1.62E+10 |
| 73 | 0.74 | 2.162 | 14213932551 | 0 | 9.62E+10 | 2.27E+10 |
| 91 | 0.702 | 1.539 | 14213932551 | 0 | 1.06E+13 | 1.30E+11 |
| 92 | 0.702 | 1.537 | 14213932551 | 0 | 2.05E+11 | 1.53E+10 |
| 93 | 0.702 | 1.537 | 14213932551 | 0 | 3.41E+11 | 1.53E+10 |
| 102 | 0.792 | 1.367 | 14213932551 | 0 | 6.88E+11 | 1.54E+10 |
| 103 | 0.792 | 1.537 | 14213932551 | 0 | 8.89E+11 | 1.73E+10 |
| 111 | 0.79 | 1.539 | 14213932551 | 0 | 1.38E+12 | 1.73E+10 |
| 112 | 0.79 | 1.368 | 14213932551 | 0 | 1.20E+11 | 1.54E+10 |
| 113 | 0.79 | 1.368 | 14213932551 | 0 | 3.76E+10 | 1.54E+10 |
| 121 | 0.787 | 1.37 | 14213932551 | 0 | 1.18E+12 | 1.53E+10 |
| 122 | 0.787 | 1.539 | 14213932551 | 0 | 3.52E+11 | 1.72E+10 |
| 123 | 0.787 | 1.369 | 14213932551 | 0 | 6.06E+11 | 1.53E+10 |
| 132 | 0.808 | 1.368 | 14213932551 | 0 | 7.99E+12 | 4.26E+10 |

| | |
|---|---|
| Enter Stream Base Flow cfs | 10 |
| Stream Flow CF/Day | 864000 |
| # of 100 mL Samples | 244657554.6 |

| | | Base Flow Concentration |
|---|---|---|
| Daily Base Fecal Load | 7.91841E+11 | 3237 |

| | |
|---|---|
| Water Volume (acre inches) | 136181.0024 |
| Cubic Inches | 8.54214E+11 |
| # of 100 mL Samples | 1.39981E+11 |

| | | 4.34 Inch rain event Storm Event Concentration |
|---|---|---|
| Storm Fecal | 4.91E+15 | 35106 |

End of report