# Carver County Bacterial TMDL Report

# Final

Prepared by:

**WENCK ASSOCIATES, INC.**
1800 Pioneer Creek Center
P.O. Box 249
Maple Plain, Minnesota 55359-0249
(763) 479-4200

In Cooperation with**:**

**Carver County Land and Water Services**
Government Center, Administration Building
600 East Fourth Street
**(952) 361-1820**

March 2007

wq-iw7-04e

# Table of Contents

# Table of Contents (con't.)

# Table of Contents (con't.)



**TABLES**

# Table of Contents (con't.)



**FIGURES**



**APPENDICES**

# 1.0 Introduction

## 1.1 PURPOSE

Section 303(d) of the Clean Water Act establishes a directive for developing Total Maximum Daily Loads (TMDLs) to achieve Minnesota water quality standards established for designated uses of State waterbodies. Under this directive, the State of Minnesota has directed Carver County to develop a TMDL for fecal coliform exceedances in the Carver, Bevens, and Silver Creek Watersheds.

A TMDL is defined as the maximum quantity of a pollutant that a water body can receive and continue to meet water quality standards for designated beneficial uses. Thus, a TMDL is simply the sum of point sources and nonpoint sources in a watershed. A TMDL can be represented in a simple equation as follows:

TMDL = Σ Wasteload Allocation (WLA; Point Sources) + Σ Load Allocation (LA; nonpoint sources) + Margin of Safety (MOS)

The wasteload allocation is the sum of all point sources and the load allocation is the sum of all nonpoint sources. The Margin of Safety represents a load allocation to account for variability in environmental data sets. Other factors that must be addressed in a TMDL include seasonal variation, future growth, critical conditions, and stakeholder participation.

The goal of this TMDL is to quantify the pollutant reductions needed to meet the water quality standards for fecal coliform in Carver, Bevens, and Silver Creeks. Ultimately, this TMDL will result in an implementation plan to achieve the identified load reductions needed to achieve the State Standard for fecal coliform.

## 1.2 PROBLEM IDENTIFICATION

As a result of water quality evaluations, the State of Minnesota has determined that waters in the Bevens, Carver, and Silver Creek Watersheds exceed the State established standards for fecal coliform (see Section 2.2 for standards). A map of the three watersheds is presented in Figure 1.1.

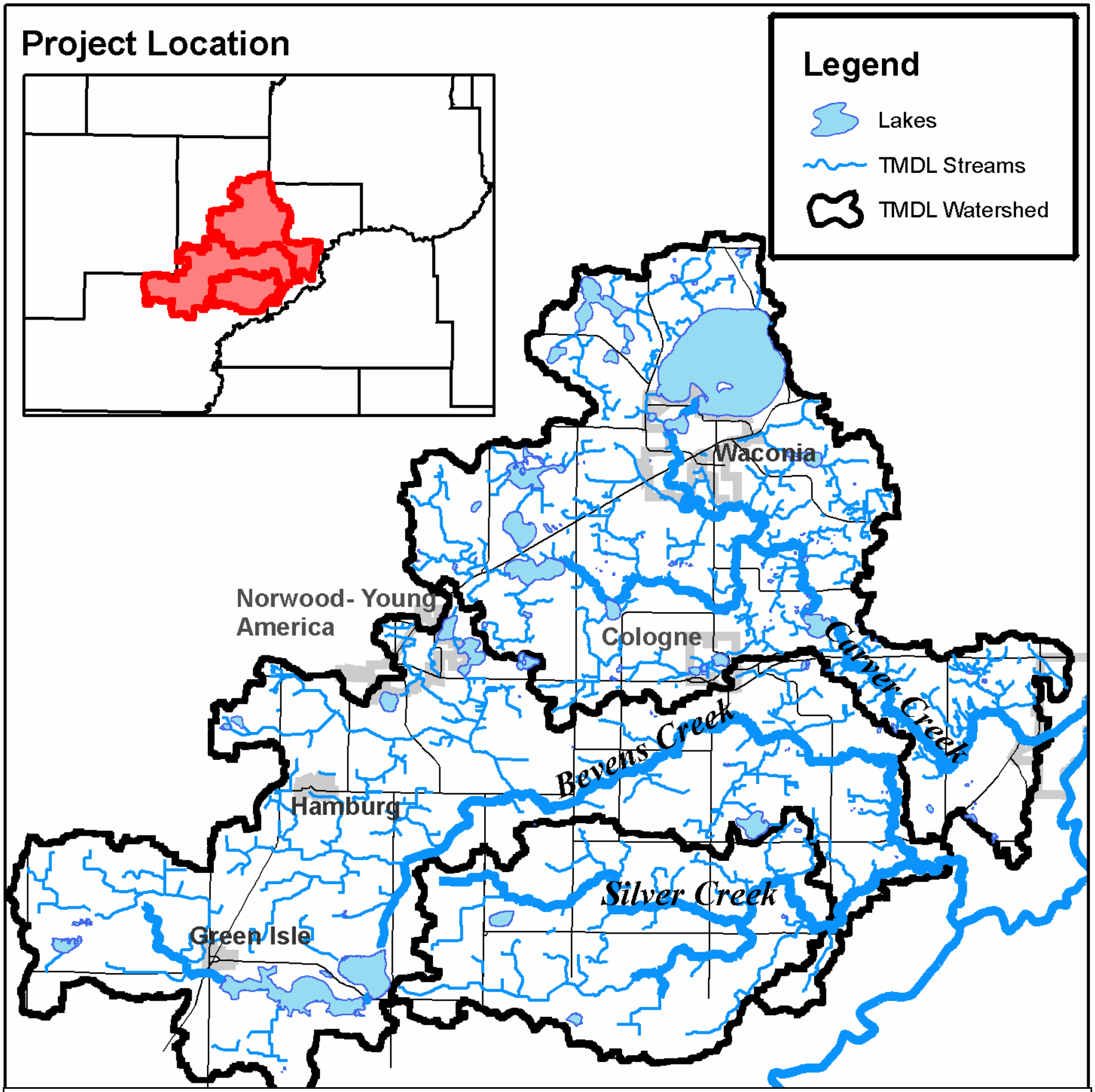



**Figure 1.1. Fecal Coliform Impaired Watersheds in Carver County.**

# 2.0 Target Identification and Determination of Endpoints

## 2.1 IMPAIRED REACHES

This TMDL addresses fecal coliform impairments in four listed reaches in Carver and Sibley Counties (Table 2.1). The Carver and Silver Creek reaches are treated and presented individually. The two Bevens Creek reaches are evaluated and presented together in this TMDL, however the approach and governance remains the same for each watershed. Consequently, discussions of methods, implementation, and reasonable assurance may include all four basins.

**Table 2.1. Reaches Impaired for Fecal Coliform in Carver County.**

| Stream Name | Reach Number | Reach Description | Beneficial Use |
|---|---|---|---|
| Carver Creek | 07020012-516 | Headwaters to Minnesota R | Aquatic recreation |
| Bevens Creek | 07020012-514 | Silver Cr to Minnesota R | Aquatic recreation |
| Bevens Creek | 07020012-515 | Headwaters (Washinton Lake) to Silver Cr | Aquatic recreation |
| Silver Creek | 07020012-523 | CD 32 to Bevens Cr | Aquatic recreation |

## 2.2 APPLICABLE MINNESOTA WATER QUALITY STANDARDS AND ENDPOINTS

Carver, Bevens, and Silver Creeks are classified as 2B waters. Class 2B refers to those State waters identified to support aquatic life (warm and cool water fisheries and associated biota) and recreation (all water recreation activities including bathing). The Minnesota standard for class 2B waters is as follows:

Minn. R. ch. 7050.0222 subp. 4 and 5, fecal coliform water quality standard for class 2B and 2C waters states that fecal coliforms shall not exceed 200 organisms per 100 milliliters as a geometric mean of not less than five samples in any calendar month, nor shall more than ten percent of all samples taken during any calendar month individually exceed 2,000 organisms per 100 milliliters. The standard applies only between April 1 and October 31.

Endpoint fecal coliform concentrations were determined to be the State water quality standard of a monthly geometric mean of 200 cfu/ 100 ml and no value exceeding 2,000 cfu/ 100 ml for the period of April 1 through October 31. However, the focus of this TMDL is on the “chronic” standard of 200 cfu/ 100 ml. It is believed that achieving the necessary reductions to meet the chronic standard will also reduce the exceedances of the acute standard (MPCA 2006).

### 2.3 MPCA NON-DEGRADATION POLICY

An important aspect of water quality standards in Minnesota is the non-degradation policy. The fundamental concept of non-degradation is the protection of water bodies already meeting State water quality standards. MPCA policy distinguishes non-degradation as follows:

Minn. R. ch. 7050.0185, subp. 1, Non-degradation for All Waters. The potential capacity of the water to assimilate additional wastes and the beneficial uses inherent in water resources are valuable public resources. It is the policy of the state of Minnesota to protect all waters from significant degradation from point and nonpoint sources and wetland alterations, and to maintain existing water uses, aquatic and wetland habitats, and the level of water quality necessary to protect these uses.

Minn. R. ch. 7050.0180, subp. 1-2. The agency recognizes that the maintenance of existing high quality in some waters of outstanding resource value to the state is essential to their function as exceptional recreational, cultural aesthetic, or scientific resources. To preserve the value of these special waters, the agency will prohibit or stringently control new or expanded discharges from either point or nonpoint sources to outstanding resource value waters.

# 3.0 Watershed Characterization

## 3.1 WATERSHED DESCRIPTION

### 3.1.1 Bevens and Silver Creek Watersheds

Water samples were collected and analysis performed for fecal Coliform bacteria has been collected throughout Carver County since 1997 in some locations. Data collected at these locations is difficult to compare on a yearly basis due to weather variations, laboratory variability, and sampling constraints. However, the Fecal Coliform levels in Carver County routinely exceed the state standard of 200 Colony Forming Units per 100mL (CFU/100mL).

- There are 12 lakes in the portion of the watershed in Carver County.
- There are approximately 97 miles of streams in the portion of the watershed in Carver County. There are 7 active stream sampling stations within the watershed.

The Bevens Creek watershed is located in the southeastern and south-central portion of Carver County with approximately 30 percent of the watershed located in Sibley County. The Silver Creek watershed, a tributary of Bevens Creek, is located along the southeastern portion of the Bevens Creek watershed. The Bevens Creek watershed covers approximately 59,844 acres and contains the cities of Norwood Young America, Hamburg, Green Isle, and a portion of Cologne. Silver Creek covers an additional 22,920 acres. The dominant land use within the Bevens Creek watershed is tilled agriculture (77 percent). Projected land use in 2020 shows tilled agriculture declining to 70 percent. The Silver Creek portion of the watershed in also dominated by tilled agriculture (87 percent). Projected land use in 2020 indicates that tilled agriculture will remain stable at 86 percent.

### 3.1.2 Carver Creek Watershed

The watershed is entirely within Carver County, covers 54,220 acres and contains the cities of Cologne, Carver, and Waconia. The current land use is tilled agriculture (62 percent) and the 2020 projected land use shows tilled agriculture dropping to 57 percent and developed land increasing from 9 to 13 percent. The remaining land use is open space (including surface water) and developed areas.

- There are 15 lakes in the watershed.
- There are approximately 106 miles of streams within the watershed. There are four active stream sampling stations within the watershed.

Fecal Coliform bacteria has been collected throughout Carver County since 1997 in some locations. Data collected at these locations is difficult to compare on a yearly basis due to weather variations, laboratory variability, and sampling constraints. However, the Fecal Coliform levels in Carver County routinely exceed the state standard of 200 Colony Forming Units per 100mL (CFU/100mL).

## 3.2 SOILS

The Carver County Soil Survey provides detailed maps of the soils in Carver County along with descriptions. The following is a list of interpreted classifications of soil that can be found in the survey: Land capability classification, erodability, building site development, sanitary facility capability, and construction material suitability. Maps of overall soils in the county can be found in the Carver County Water Management Plan (http://www.co.carver.mn.us/water). The soil survey also describes technical soil characteristics including physical and chemical properties. Due to the heavy soils that exist in Carver County, much of the agriculture land is drained by subsurface agriculture drain tile. Many of these drain tile have open surface intakes that aide in removing excess surface water. The following soil associations can be found within the watersheds:

- The **Cordova-Webster-LeSueur association** is primarily composed of fine textured black clay loams. These deep soils are poor to moderately well drained and have a high moisture storage capacity. This soil pattern is generally associated with nearly level broad upland flats.

- The **Lester-LeSueur-Peat association** is primarily composed of medium to fine textured clay loams. These deep soils are moderately to well drained and have a high moisture storage capacity. This soil pattern is generally associated with gently rolling slopes and broad upland flats.

- The **Lester-Hayden-Peat association** is primarily composed of medium to fine textured loams with a subsoil of clay loam. These deep soils are well drained and have a moderately high moisture capacity. This soil pattern is generally associated with rolling slopes in the upland areas.

- The **Hayden-Lester-Peat association** is primarily composed of medium to fine textured loams with a subsoil of clay loam. These deep soils are well drained and have a moderately high moisture capacity. This soil pattern is generally associated with irregular strongly rolling slopes and hills in the upland areas.

- The **Mayer-Estherville-Talcot association** is primarily composed of medium texture loams with a subsoil of loams or sandy clay loams and a gravelly substratum. These moderately deep to shallow soils are poorly drained and tend to have a lower moisture storage capacity. This soil pattern is generally associated with broad flats and drainage ways.

- The **Fairhaven-Kasota-Estherville association** is primarily composed of medium textured loams or silt loams with a clayey subsoil. These moderately deep to shallow soils are well drained and have a moderately high storage capacity. This soil pattern is generally associated with broad flats and rolling outwash terraces.

- The **Salida-Hayden association** is primarily composed of coarse to medium textured soils over sand and gravel. These thin soils tend to have a poor moisture storage capacity. This soil pattern is generally associated with steep hills and bluffs.

- The **Alluvial Land-Chaska-Oshawa association** is primarily composed of medium to fine textured loamy soils and silty clay loams. These soils are poorly drained. This soil pattern is generally associated with flood plains.

## 3.3 GEOLOGY AND GEOMORPHOLOGY

Carver County is part of a geologic structure called the Hollandale Embayment, which formed as a result of erosion, sedimentation, and the rise and fall of ancient seas. In brief, these actions resulted in a sedimentary deposition of rock over 1,000 feet deep which covers older sedimentary and igneous rocks. The significance of this formation for groundwater planning is that, along with the glacial drift, it makes up the groundwater system in Carver County. Figure 3.1 illustrates the vertical geologic structure of the formation and gives a brief description of the water bearing characteristics of each layer.

The first layer (uppermost) in the system is the glacial drift, which covers the entire County at depths from 100 to over 500 feet. Repeated advances and declines of glaciers over the last two million years, and as recently as 14,000 years ago, deposited the drift which consists of two types of sediment: till and outwash.

Till is unconsolidated (mixed) material consisting of varying portions of clay, silt, sand, gravel, and boulders. The composition of the mixture can affect the transmission of the groundwater through the system. Till that tends to be clayey will transmit water more slowly than till with high percentages of sand and gravel. In some areas of Carver County, very heavy deposits of clay occur which severely limit the transmissivity of water. While till in an area may be clayey, there will typically be sand and gravel lenses which can greatly affect the flow of water through the drift layer making localized groundwater flow extremely variable. Figure 3.2 illustrates the composition of an area characterized as having clayey drift. The shaded areas represent sand and gravel lenses, which can occur randomly within the drift layer.

Outwash is sand and gravel material which has been deposited by a stream or river. Outwash is highly permeable and will transmit water at a high rate. Areas closer to the Minnesota River show large amounts of outwash deposited from the ancient glacial River Warren. A graphic from the MPCA showing average sand content in the Quaternary deposits can be found in the inventory appendix.

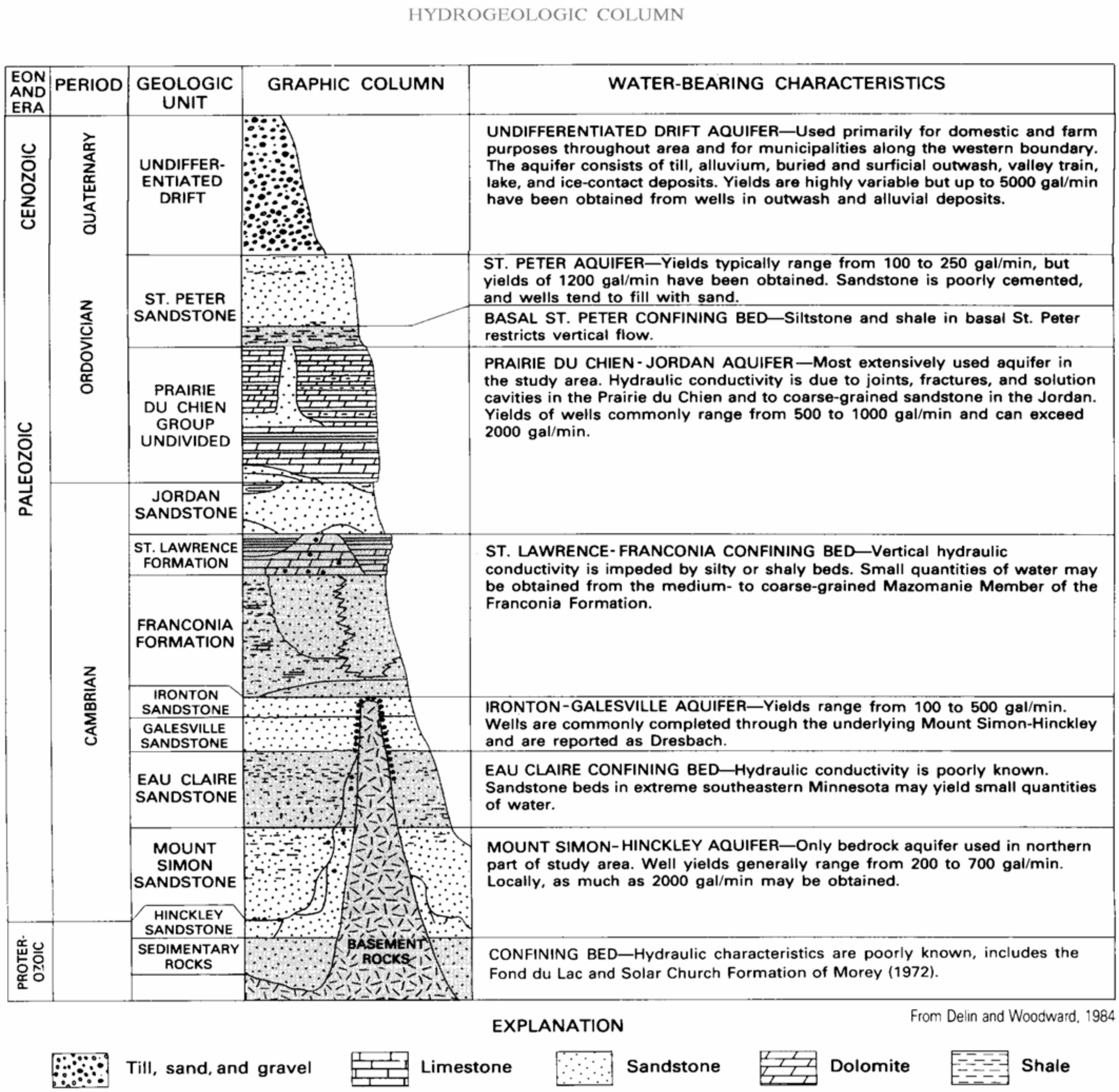



**Figure 3.1. Hydrogeologic Column of Hollandale Embayment.**
From D.G. Woodard, 1986, Hydrogeologic Framework and Properties of regional aquifers in the Hollandale Embayment, SE MN USGS HA-677

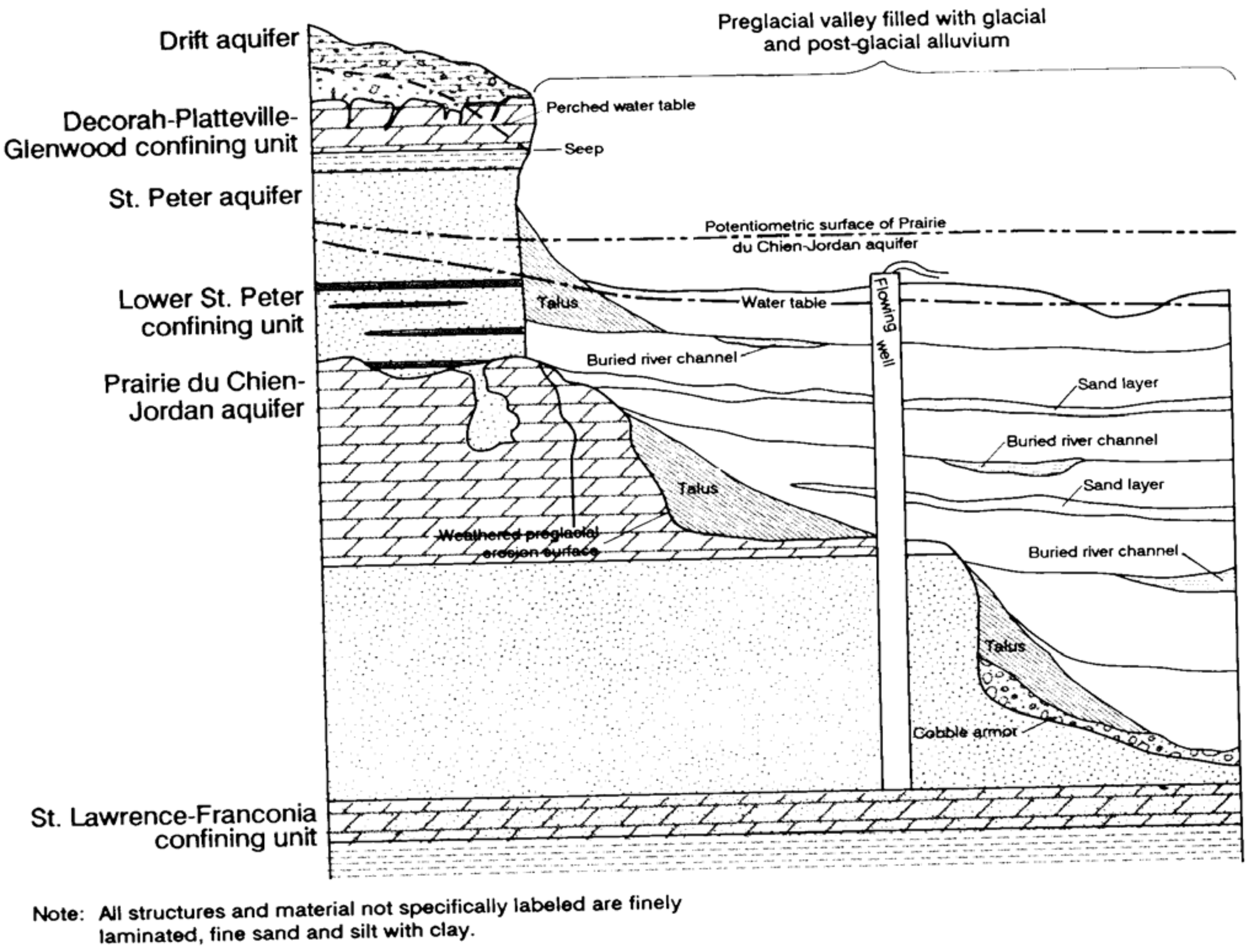



**Figure 3.2. Typical Composition of Area with Clayey Drift.**
From Effects of Present and Projected Ground-water Withdrawals on the Twin Cities Aquifer System Minnesota, U.S. Geological Survey Water Resources Investigations Report 90-4001

# 4.0 Assessment of Water Quality Data

## 4.1 STREAM SAMPLING LOCATIONS

### 4.1.1 Carver County Environmental Services

Carver County Environmental Services currently operates automatic and grab sampling sites in Bevens Creek, Carver Creek, Silver Creek, East Chaska Creek, West Chaska Creek and the Crow River Watersheds. Environmental Services operates 9 automatic sampling sites within six watersheds, approximately 20 fecal coliform grab sampling sites and 9 bio-monitoring sampling sites.

The ramped up effort that was undertaken by Carver County Environmental Services has done a great deal to develop a solid baseline network of water quality data for lakes and streams within the County. This monitoring network is recognized by state agencies and is one of the main reasons the County has been able to secure outside funding recently and in the past. Even with the amount of the monitoring that is performed, there are still some data gaps throughout the Carver County Water Management Resource Area (CCWMRA). Many of these gaps will be filled with short term data collection over the next two years, made possible by a grant from the MPCA to develop six written TMDLs in Carver and Bevens Creeks.

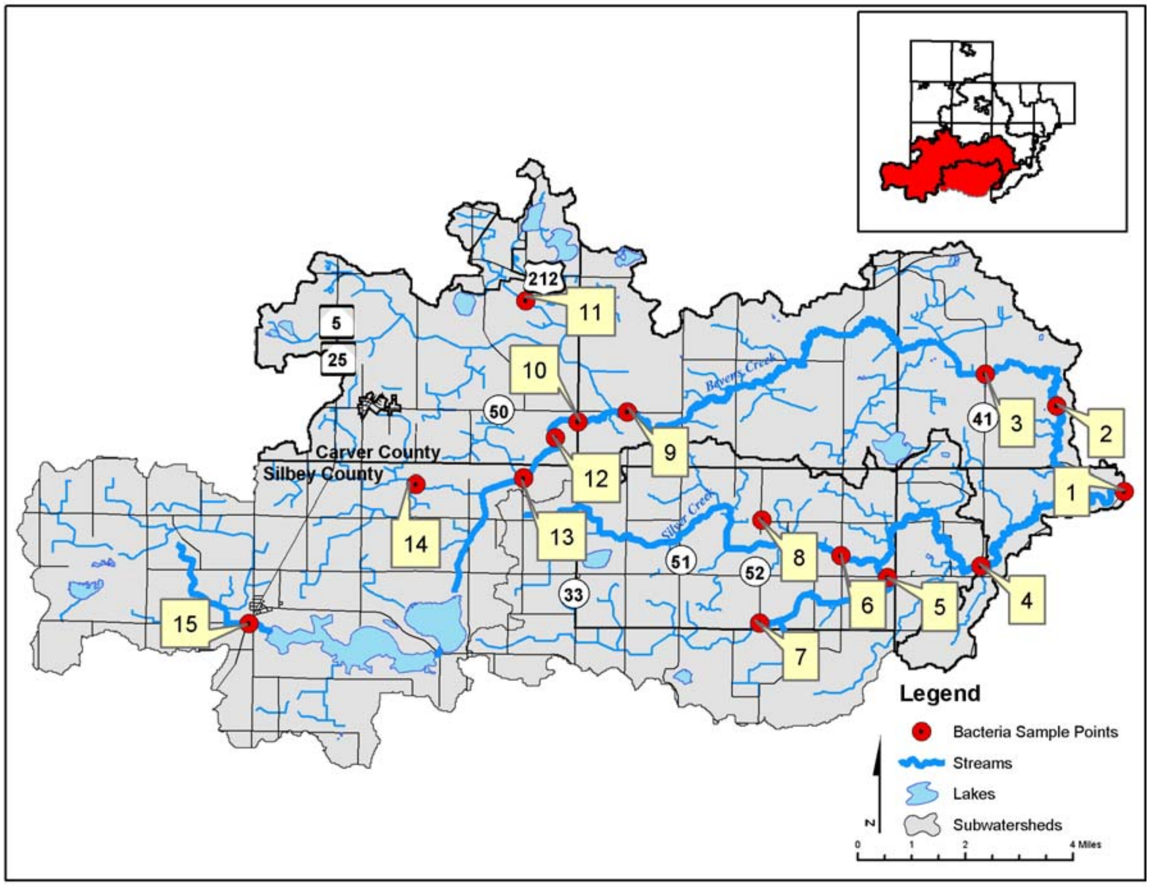
### 4.1.2 Metropolitan Council Environmental Services

In 1989 Metropolitan Council Environmental Services (at that time the Metropolitan Waste Control Commission) initiated a five-year non-point source pollution monitoring program for the seven tributaries of the Minnesota River. Initially, automatic sampling stations were set up at or near the mouths of Bevens Creek and Carver Creek in Carver County. Although the program was intended to last five years, it is still in place providing valuable data on concentration and load data for pollutants in two of Carver County's largest watersheds.

## 4.2 GRAB SAMPLES

Fecal Coliform Sampling occurred in September and October 2003, and April through October 2004. Because of the complexity of the watersheds and the need to pinpoint tributaries and sub-watersheds that need to be targeted for implementation, approximately 30 sites were sampled (Figures 4.1 and 4.2.).

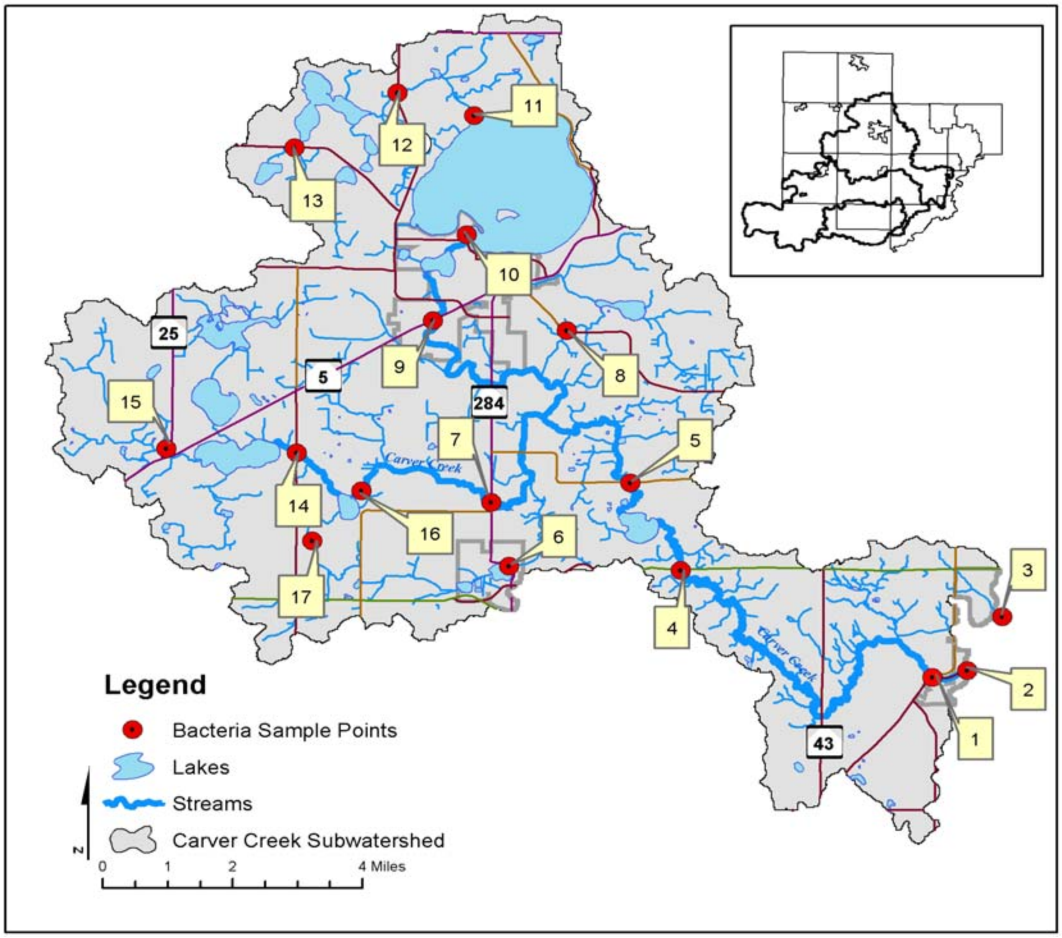
**Figure 4.1. Bevens and Silver Creek Fecal Coliform Sample Sites**




## Stream Sampling Stations

| Site Number | I.D. | Agency | Parameter | Site Description/Notes: |
|---|---|---|---|---|
| 1 | BE 2_0 | CCES, Met Council | Fecal Coliform, Flow | Site is located on Bevens Creek South of East Union on CR 40 at the bridge crossing. |
| 2 | BE5_0 | CCES, Met Council | Fecal Coliform, Flow | Site is located on Bevens Creek at the culvert on the intersection of Maplewood Rd and Maplewood Ln. |
| 3 | BE 9_0 | CCES | Fecal Coliform, Flow | Site is located on Bevens Creek at the bridge crossing on CR 41. |
| 4 | SI 2_0 | CCES | Fecal Coliform, Flow | Site is located at the bridge crossing on CR 41 and Silver Creek. |
| 5 | SI 4_0 | CCES | Fecal Coliform | This site is located at the bridge crossing on the South fork of Silver Creek at CR 52. |
| 6 | SI 3_0 | CCES | Fecal Coliform | Site is located on the North fork of Silver Creek at the culvert on CR 53. |
| 7 | HA 15 | CCES | Fecal Coliform (1998-2000) | Site was located at the culvert on Ohio Ave. and Silver Creek. |
| 8 | HA 3 | CCES | Fecal Coliform (limited data) | Site was located on at tributary to Silver Creek at the culvert on 166th St. |
| 9 | BE 21_0 | CCES | Fecal Coliform, Flow | Site is located on Rice Ave. at the Bevens Creek bridge crossing. |
| 10 | CO. Rd 33 | CCES | Fecal Coliform | Site is located at the Bevens Creek bridge crossing on CR 33. |
| 11 | Tacoma | CCES | Fecal Coliform, Flow | Site is located on County Ditch 4a just outside NYA on Tacoma Ave. |
| 12 | YA 36 | CCSWCD | Fecal Coliform (1997-1998) | Site is located on Bevens Creek at the bridge crossing on 154th St. |
| 13 | Sibley | CCES | Fecal Coliform, Flow | Located in on Bevens Creek at 321st. St. bridge crossing in Sibley County. |
| 14 | Sibley 3 | CCES | Fecal Coliform | Located on Bevens Creek at the culvert on Hwy. 16 in Sibley County. |
| 15 | Sibley 2 | CCES | Fecal Coliform | Site is located on Bevens Creek at the culvert on Hwy. 25 in Green Isle which is located in Sibley County. |

**Figure 4.2. Carver Creek Watershed Fecal Coliform Sample Sites.**




## Stream Sampling Stations

| Site Number | I.D. | Agency | Parameters | Site Description/ Notes |
|---|---|---|---|---|
| 1 | CA 1_7 | CCES, Met Council | Fecal Coliform, Flow | Site is located on Carver Creek just South of Carver on CR 40 at the bridge crossing. |
| 2 | CA 1_1 | CCES, Met Council | Fecal Coliform, Flow (data consolidated w/ CA 1_7) | Location of this site is .6 miles downstream of CA 1.7. Site was relocated due to stream problems. |
| 3 | CR 19 | CCES | Fecal Coliform, | This site is located on Spring Creek at the culvert off Broadway St. N in Carver. |
| 4 | CA 8_7 | CCES | Fecal Coliform, Flow | Site is located on Carver Creek at the outlet of Miller Lake off Hwy. 212. |
| 5 | CA 10_4 | CCES | Fecal Coliform, Flow | Site is located on Carver Creek at the inlet to Miller Lake at the bridge crossing off CR 140. |
| 6 | B 1 | CCES | Fecal Coliform | This site is located at the outlet of Benton Lake in Cologne off Hwy284. |
| 7 | CC 10 | CCES | Fecal Coliform | Site is located on Carver Creek at the bridge crossing off Hwy 284 North of Cologne. |
| 8 | CC 7 | CCES | Fecal Coliform | Site is located at the culvert on the outlet of Reitz Lake off CR 10. |
| 9 | Bent Cr. | CCES, MDA | Fecal Coliform, Flow | Site is situated on Carver Creek at the outlet of Burandt Lake located at the culvert off Hwy 5 in Waconia. |
| 10 | W 10 | CCES | Fecal Coliform | This site is located on Carver Creek at the outlet of Lake Waconia off Lakeview Terrace Blvd. in Waconia. |
| 11 | W 11 | CCES | Fecal Coliform, | Located at the inlet of Lake Waconia under the bridge crossing off North Shore Dr. |
| 12 | CC 1 | CCES | Fecal Coliform | This site is located North of Waconia at the outlet of Goose Lake off CR 10 at the culvert. |
| 13 | G 1 | CCES | Fecal Coliform | Site is located on the inlet of Goose Lake off CR 30 at the culvert. |
| 14 | CC 8 | CCES | Fecal Coliform | Located on Carver Creek at the outlet of Rice Lake at the CR 51 culvert. |
| 15 | CC 12 | CCES | Fecal Coliform | Site is located on Carver Creek at the inlet to Rice Lake off Hwy. 25. |
| 16 | CC 11 | CCES | Fecal Coliform | Site is positioned at the outlet of Winkler Lake at the culvert off Knauer Ln. |
| 17 | CC 9 | CCES | Fecal Coliform | Located at the inlet to Winkler Lake off 122nd St. at the culvert. |

# 5.0 Historic Data and Cause for Listing

The outlets from Carver, Bevens, and Silver Creeks were monitored by the Metropolitan Council Environmental Services (MCES) as part of their Watershed Outlet Monitoring Program (WOMP) from 1998 through 2003. Monthly geometric averages across all years are presented in Figure 5.1. All sites demonstrated exceedances in May through October.

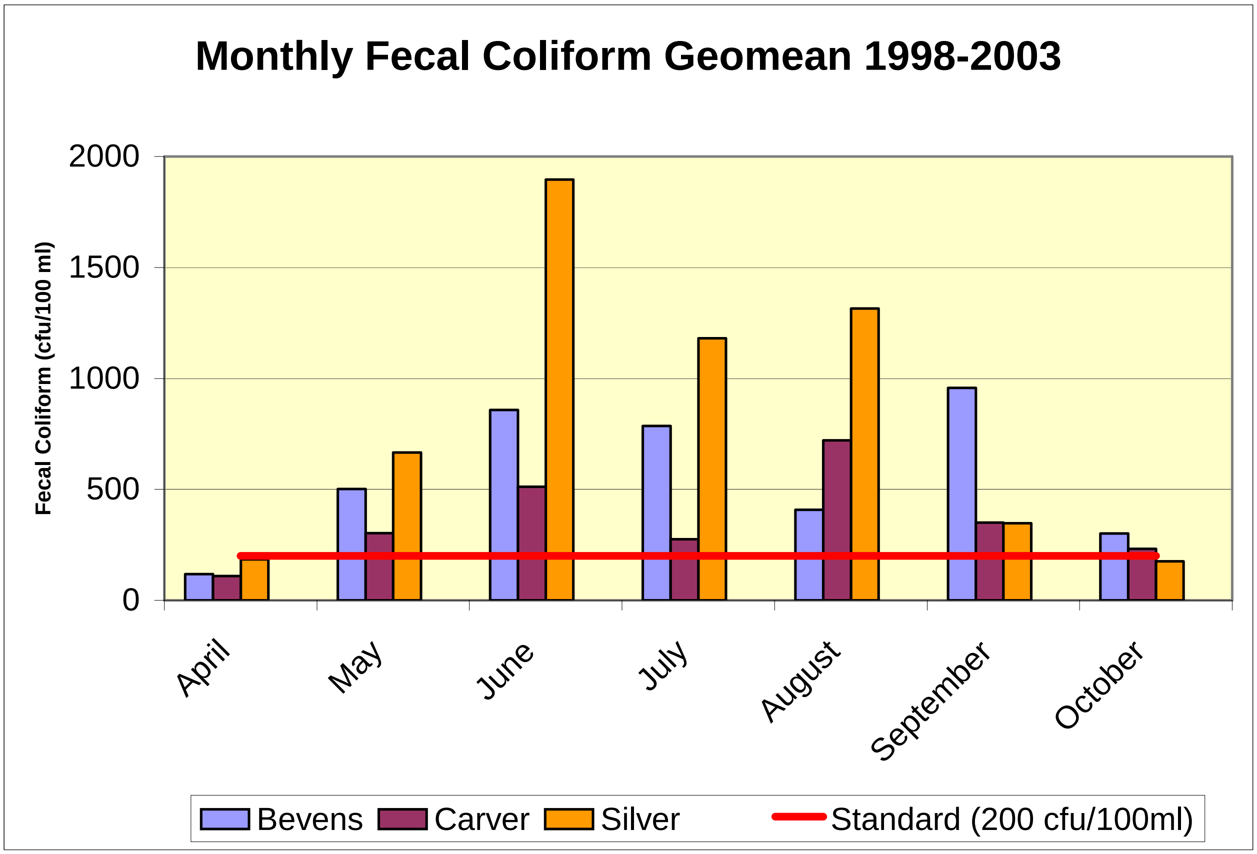


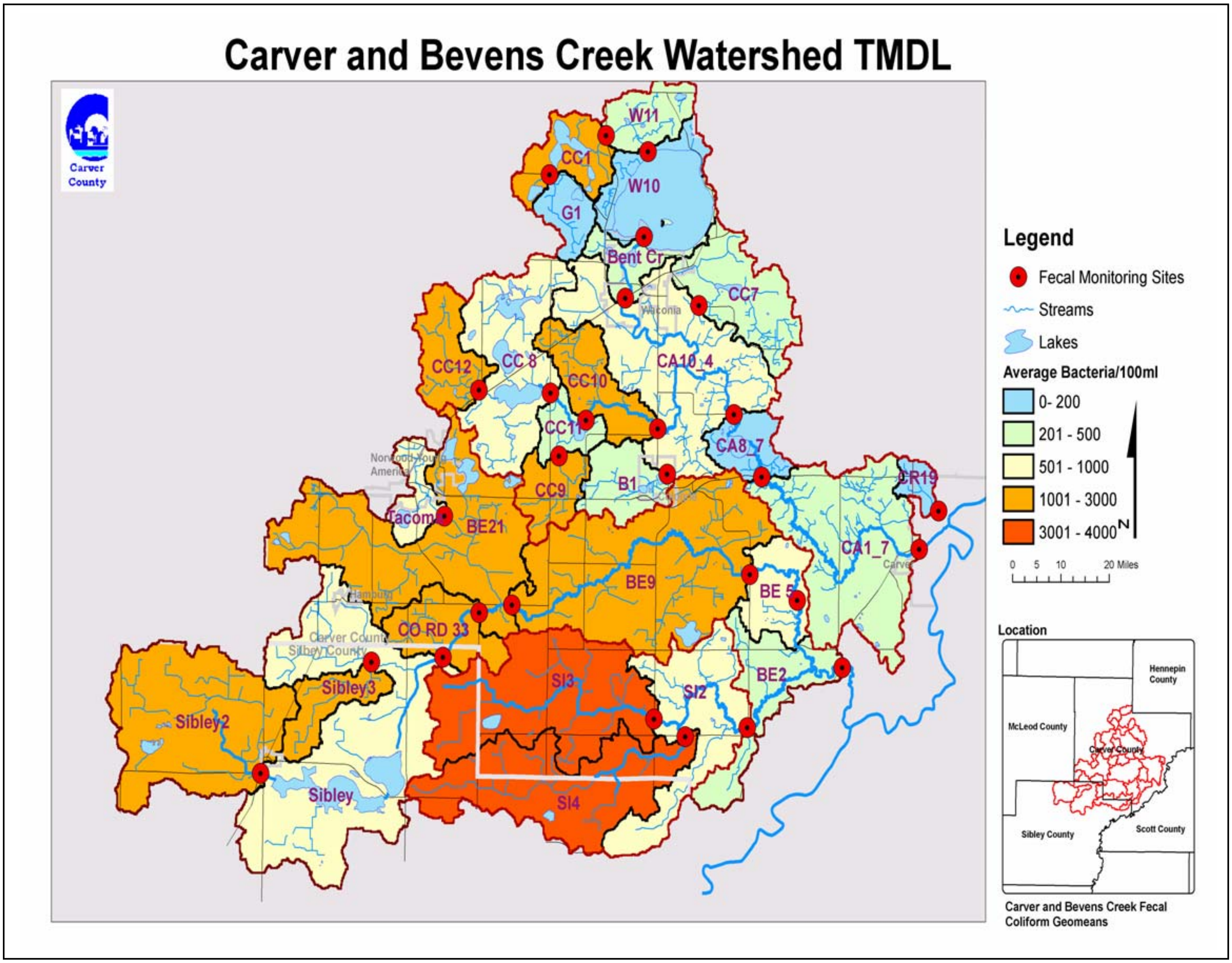

**Figure 5.1. Monthly Fecal Coliform Geometric Averages for Carver, Bevens, and Silver Creeks (1998-2003).**

### 5.1 EXTENT OF BACTERIA EXCEEDANCES

Data utilized for the development of this TMDL were collected between May of 1997 through September 2004. Although data prior to these dates may exist, the more recent data were believed to better represent current conditions in the watershed. Figure 5.2 presents the spatial extent of exceedances across the three watersheds.

Seasonal geomeans were calculated for each of the sampling subwatersheds. This analysis was applied seasonally to reflect differences in runoff, weather, and fecal coliform sources. These analyses provide a spatial and temporal description of fecal coliform concentrations in the respective watersheds to better demonstrate an overview of reductions needed in the watershed. The spatial data will be utilized during implementation to target watersheds that need a higher or lower reduction. The overview provides a picture of the reductions needed basin wide to meet the State standards for fecal coliform concentrations.

**Figure 5.2**


Carver and Bevens Creek Watershed TMDL
Carver County
W11
CC1
W10
G1
Bent Cr
CC7
Waconia
CC12
CC 8
CC10
CA10_4
CC11
CA8_7
CC9
B1
CR19
Tacoma
BE21
CA1_7
BE9
BE 5
CO RD 33
Carver County
Sibley County
SI3
SI2
BE2
Sibley3
Sibley2
Sibley
SI4
Legend
Fecal Monitoring Sites
Streams
Lakes
Average Bacteria/100ml
0- 200
201 - 500
501 - 1000
1001 - 3000
3001 - 4000
N
0 5 10 20 Miles
Location
Hennepin County
McLeod County
Carver County
Sibley County
Scott County
Carver and Bevens Creek Fecal Coliform Geomeans

### 5.1.1 Carver Creek

There were 354 samples collected from the Carver Creek watershed from 15 sites. Strong seasonal patterns exist for the Carver Creek watershed, with fall concentrations significantly higher than other seasons (Table 5.1). These differences are most likely a result of manure handling practices in the watershed with the largest amount of surface application occurring in the fall when manure pits are emptied.

**Table 5.1. Seasonal Fecal Coliform Concentrations in the Carver Creek Watershed.** Sites are listed moving from downstream to upstream.

| | Spring (March-May) | | Summer (June-Aug.) | | Fall (Sept.-Nov.) | | Total | |
|---|---|---|---|---|---|---|---|---|
| **Site Name** | N | Geomean | N | Geomean | N | Geomean | N | Geomean |
| CA 1.7 | 13 | 184 | 31 | 396 | 18 | 423 | 62 | 344 |
| CA 8_7 | 12 | 182 | 27 | 105 | 14 | 288 | 53 | 155 |
| CA 10_4 | 14 | 379 | 31 | 685 | 14 | 1,380 | 59 | 703 |
| B 1 | 3 | 124 | 5 | 296 | 2 | 4,095 | 10 | 385 |
| CC 10 | 4 | 289 | 6 | 553 | 5 | 5,751 | 15 | 1,014 |
| CC 7 | 3 | 55 | 5 | 461 | 1 | 2,200 | 9 | 269 |
| BENT | 13 | 200 | 27 | 174 | 14 | 638 | 54 | 252 |
| W 10 | 1 | 2,700 | 6 | 65 | 2 | 61 | 9 | 97 |
| W 11 | 3 | 278 | 6 | 407 | 5 | 517 | 14 | 409 |
| CC 1 | 2 | 480 | 6 | 672 | 2 | 9,423 | 10 | 1,065 |
| G 1 | 3 | 50 | 5 | 188 | 1 | 2,600 | 9 | 162 |
| CC 8 | 3 | 369 | 6 | 593 | 3 | 2,260 | 12 | 736 |
| CC 12 | | | 6 | 740 | 2 | 7,348 | 8 | 1,313 |
| CC 11 | 3 | 163 | 6 | 220 | 6 | 670 | 15 | 324 |
| CC 9 | 3 | 2,170 | 6 | 919 | 6 | 6,698 | 15 | 2,416 |
| All Sites | 84 | 290 | 192 | 335 | 94 | 906 | 370 | 418 |

### 5.1.2 Bevens Creek

There were 362 samples collected from the Bevens Creek watershed from 10 sites. Bevens Creek did not demonstrate the same seasonality as Carver Creek, with large reductions necessary across all three seasons (Table 5.2). The lack of differences in seasonal geomeans suggests a diversity of sources are contributing to the loads.

**Table 5.2. Seasonal Fecal Coliform Concentrations in the Bevens Creek Watershed.** Sites are listed moving from downstream to upstream.

| | Spring (March-May) | | Summer (June-Aug.) | | Fall (Sept.-Nov.) | | Total | |
|---|---|---|---|---|---|---|---|---|
| Site Name | N | Geomean | N | Geomean | N | Geomean | N | Geomean |
| BE 2 | 14 | 379 | 29 | 340 | 15 | 280 | 58 | 332 |
| BE 5 | 14 | 584 | 32 | 600 | 12 | 632 | 58 | 602 |
| BE 9 | 3 | 2,210 | 6 | 2,172 | 6 | 1,643 | 15 | 1,949 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| BE 24_0 | 6 | 300 | 11 | 1,182 | 8 | 1,459 | 25 | 910 |
| BE 21_0 | 16 | 1,158 | 38 | 3,065 | 17 | 5,023 | 71 | 2,771 |
| Co Rd 33 | 4 | 3,695 | 12 | 1,402 | 5 | 1,474 | 21 | 1,706 |
| TACOMA | 15 | 847 | 31 | 463 | 14 | 1,133 | 60 | 664 |
| Sibley | 9 | 457 | 17 | 974 | 5 | 1,064 | 31 | 793 |
| Sibley 2 | 3 | 759 | 6 | 946 | 2 | 4,000 | 11 | 1,158 |
| Sibley 3 | 3 | 366 | 6 | 1,641 | 3 | 3,049 | 12 | 1,317 |
| All Sites | 90 | 655 | 193 | 891 | 89 | 1,277 | 372 | 902 |

### 5.1.3 Silver Creek

There were 97 samples collected from the Silver Creek watershed from 4 sites. Silver Creek demonstrated the highest overall concentrations by far with all of the medians over 1,000 cfu/ 100 ml (Table 5.3). Fall concentrations were significantly higher reflecting the greater application of manure to the land surface during the fall season.

**Table 5.3. Seasonal Fecal Coliform Concentrations in the Silver Creek Watershed.** Sites are listed moving from downstream to upstream.

| | **Spring (March-May)** | | **Summer (June-Aug.)** | | **Fall (Sept.-Nov.)** | | **Total** | |
|---|---|---|---|---|---|---|---|---|
| **Site Name** | N | Geomean | N | Geomean | N | Geomean | N | Geomean |
| SI 2.0 | 11 | 838 | 26 | 1,093 | 10 | 376 | 47 | 818 |
| SI 4 | 4 | 1,634 | 5 | 2,342 | 2 | 56,391 | 11 | 3,664 |
| SI 3 | 2 | 5,639 | 6 | 1,876 | 2 | 8,390 | 10 | 3,154 |
| HA 15 | 7 | 507 | 16 | 877 | 7 | 553 | 30 | 693 |
| All Sites | 24 | 971 | 53 | 1,168 | 21 | 926 | 97 | 1,063 |

# 6.0 Source Assessment

## 6.1 SOURCE DESCRIPTIONS

### 6.1.1 Livestock

Livestock sources include several categories such as feedlots, overgrazed pastures, surface application of manure and incorporated manure. Following is a description of these sources.

### 6.1.2 Feedlots and Overgrazed Pastures Near Streams

An area is considered a feedlot if it is a lot or building or combination of lots and buildings intended for the confined feeding, breeding, raising or holding of animals and specifically designed as a confinement area in which manure may accumulate or where the concentration of animals is such that vegetative cover cannot be maintained within the enclosure. Open lots used for the feeding and rearing of poultry (poultry ranges) are considered animal feedlots. Note that Carver County does not have any Confined Animal Feeding Operations (CAFO) at this time. Pastures are not to be considered animal feedlots for purposes of these regulations (CCES 2002).

There are a total of 304 feedlots and 37,143 animal units in the three watersheds. The majority of the animal units are dairy (16,604 units) followed by beef (12,588 units) and swine (5,964 units). CAFOs are regulated under the NPDES permit system.

Feedlots were quantified utilizing Carver County's level 3 feedlot inventory data in GIS. Feedlot data included animal inventories that identified type (dairy, beef, swine, etc.) and size. These data were then used to calculate animal units in the watershed according to the County animal unit conversions (Minnesota Rules 7020). Sibley County has less information on feedlot sizes, animal numbers and types. They are currently updating their inventory from a level 2 to level 3, however those data were not available at the time this report was developed. To estimate animal units in Sibley County, we used 2000 feedlot census data for dairy, beef and swine animal units. For the rest, we calculated the average animal unit by type in Carver County and applied that rate to the Sibley County feedlots. For example, if there was an average of 50 poultry units per feedlot in Carver County, we multiplied the average of 50 poultry units by the number of feedlots in Sibley County to derive an estimate of total poultry units in the Sibley portions on the watershed.

GIS data for pastures in the watershed was limited, however all open lot cattle and dairy facilities within 300 ft of a stream would have a higher likelihood of animal access to the stream. To address overgrazed pastures, we utilized the assumptions made in the Southeast Minnesota Regional Fecal Coliform TMDL that 1% of dairy and beef cattle were in overgrazed pastures (MPCA April 5, 2006).

### 6.1.3 Surface Manure Application

Manure application rates were estimated for Carver County (Mike Wanous, Director – Carver SWCD). Approximately 1/3 of the cropland in Carver and Bevens Creek watersheds get some sort of manure application. The rates vary on the nutrient content but reasonable estimates would be 12,000 gallons per acre for liquid dairy manure, 3,000 – 4,000 gallons per acre for liquid swine manure and 15 tons per acre for solid manure.

Most hog manure is applied as a liquid. Most beef and poultry manure is applied as a solid. Dairy manure is applied as both liquid and solid manure. In most cases the larger dairy operations have liquid ag-waste pits, and the smaller dairies daily haul manure as a solid. A large portion of manure applications occur in the fall when animal waste pits are emptied out. However, some farmers (especially small dairy farmers) spread manure year round. To account for the varied application periods, it was assumed that 20% of surface applied manure occurred in the spring, 20% in the summer, and 60% in the fall (WENR Technical Sub-Committee, 2004).

### 6.1.4 Incorporated Manure

Liquid manure is often injected directly into the topsoil, or incorporated into the soil after surface spreading with agriculture tillage equipment. Application of incorporated manure typically occurs in the fall when waste pits are full and crops have been removed, however some pits will be emptied earlier in the year if needed. When this happens, it is often done before June 1 (before crops are planted in the spring). Most farmers find it difficult to rely on spring applications because the soil is often too wet in the spring months. To account for the varied application, it was assumed that 20% of incorporated manure spreading occurred in the spring with the remaining 80% occurring in the fall.

### 6.1.5 Industrial Facilities

There is one industrial discharger in the Carver Creek watershed, which is Bongards' Creameries, Inc. Bongards' Creamery has three discharges including two non-contact cooling water discharges (NPDES # MN0002135 – SD001 & SD003) and one wastewater pond discharge (NPDES # MN0002135 – SD002). Table 6.1 and Table 6.2 provide the fecal coliform data measured in the discharges in recent years. Non-contact cooling water discharges are not expected to contain fecal coliform bacteria; however, data from the facility's discharge monitoring reports (DMRs) indicated elevated levels of fecal coliform in recent years from one of the cooling water discharges (SD001). The source of the fecal coliform was isolated with additional monitoring and found to be from a combination of roof and upstream runoff rather than the facility's actual non-contact cooling water. Bongards' is correcting the connection problems via a stipulation agreement with the MPCA. With this correction, there will likely be no fecal coliform limit for the cooling water discharge in the NPDES permit that MPCA is developing for the facility; rather, the permit will require on-going monitoring to document that fecal coliform bacteria is not being discharged from the non-contact cooling water discharge. The fecal coliform data for the wastewater pond discharge (SD002) indicates that the discharge is within the fecal coliform discharge limit of the facility's NPDES permit.

Waste pond discharges (MN0002135-SD002) are regulated under NPDES and only occur for short durations during the year. Typically, the ponds would discharge about 6 inches a day from 11.5 acres for approximately 16 days (Enrique Gentzsch, pers. com.). Based on 2004 data, the wastewater pond loads could represent a significant portion of stream loads during the discharge period, especially if discharge occurs during summer low flows (Table 6.3). The ponds discharged well into the summer season, releasing water for 21 and 15 days respectively in May and June. Typically, discharging of the ponds should occur from April 1 through June 15 and September 15 through Dec 15.

**Table 6.1. Discharge Monitoring Data for Fecal Coliform Bacteria (#/100 ml)**
(MPCA WQDelta Database)

| Month-Year | SD001[1] | SD002[2] | SD003[1] |
|---|---|---|---|
| May-04 | 68 | 197 | 10 |
| Jun-04 | 3,448 | 67 | 10 |
| Jul-04 | 1,884 | | 10 |
| Aug-04 | 1,118 | | 10 |
| Sep-04 | 1,300 | | 10 |
| Oct-04 | 60 | 92 | 10 |
| May-05 | 498 | 14 | 10 |
| Jun-05 | 3,200 | 40 | 10 |
| Jul-05 | 198 | | 10 |
| Aug-05 | 3,404 | | 10 |
| Sep-05 | 693 | | 18 |
| Oct-05 | 158 | | 10 |
| May-06 | 148 | 10 | 10 |

[1] Calendar Month Average
[2] Calendar Month Geometric Mean

**Table 6.2. Load Calculations for Bongaards' Creamery Discharges**

(MPCA WQDelta Database)

| Facility | Year | Average[1] Flow (MGD) | Average[1] Fecal Coliform Concentration (CFU/ 100 ml) | Average Load (CFU/day x $10^9$) | Load at Standard (CFU/day x $10^9$) |
|---|---|---|---|---|---|
| Bongards' Creamery (MN0002135-SD001) | 2004 | 0.235 | 1,313 | 12 | 1.8 |
| | 2005 | 0.228 | 1,358 | 12 | 1.7 |

| | | | | | |
|---|---|---|---|---|---|
| Bongards' Creamery (MN0002135-SD002)[2] | 2004 | 0.855 | 119 | 3.8 | 6.5 |
| | 2005 | 0.758 | 27 | 0.78 | 5.7 |
| Bongards' Creamery (MN0002135-SD003) | 2004 | 0.045 | 10 | 0.017 | 0.34 |
| | 2005 | 0.125 | 11 | 0.054 | 0.95 |

[1]Averages are for actual discharges in May through October.
[2] The waste pond discharges only occur periodically to empty the ponds. These activities are regulated by the MPCA under NPDES.

**Table 6.3. Monthly Discharge Data for the Bongards' Creamery Waste water Pond Discharges during the Critical Season (April through October, 2004).**

| | May | June | July | Aug. | Sept. | Oct. |
|---|---|---|---|---|---|---|
| **# days of discharge** | 21 | 15 | 0 | 0 | 0 | 6 |
| **Ave. discharge/day (MGD)** | .87 | .91 | 0 | 0 | 0 | .78 |
| **Tot. Monthly Discharge (MG)** | 18.3 | 13.6 | 0 | 0 | 0 | 4.7 |
| **Ave. Fecal Conc. (CFU/100ml)** | 197 | 67 | -- | -- | -- | 92 |

### 6.1.6 Human Septic Systems (ISTS)

Failing or nonconforming septic systems can be an important source of fecal coliform bacteria especially during dry periods when these sources continue to discharge and runoff driven sources are not active. Following is an excerpt from the Carver County Water Management Plan that gives an overview of septic systems in Carver County (CCES 2001). Based on compliance reports submitted to Carver County, there is an average 43% failure rate of ISTS systems for the entire county (Mary West, pers. comm.). Past experience indicates that a significant number of failing septic systems are directly discharging to surface water. Systems directly discharging to surface water are considered crucial systems in terms of their impact on fecal coliform levels in surface waters and all reasonable, feasible means will be used to eliminate them.

Over 4200 households, encompassing about 20 percent of Carver County's population, dispose of wastewater through on-site disposal systems, also known as septic systems or individual sewage treatment systems (ISTS). Unless on-site disposal systems are functioning properly, groundwater and surface water contamination can occur. Wastewater from septic systems may include many types of contaminants such as nitrates, harmful bacteria and viruses, and other toxic substances, which can be hazardous to both groundwater and surface water. Properly sited, designed and operated, ISTS do not pose any risk of contamination to surface water or groundwater. Septic systems in the Carver, Bevens, and Silver Creek watersheds are presented in Table 6.4.

**Table 6.4. Septic Systems in the Carver, Bevens, and Silver Creek Watersheds.**

| Watershed | Number of Septic Systems | Number of Failing Septic Systems | Number of Septic Systems within 100 feet of a Stream | Number of Septic Systems within 300 feet of a Stream |
|---|---|---|---|---|
| Bevens | 618 | 266 | 2 | 58 |
| Carver | 1,150 | 495 | 20 | 195 |
| Silver | 308 | 132 | 3 | 52 |

**Municipal Wastewater Treatment Facilities**

The Carver Creek watershed has two wastewater treatment plants including the City of Cologne and the City of Carver (Table 6.5). These two WWTPs generate an average daily discharge of 0.39 MGD.

**Table 6.5. WWTP Loads for Dischargers in the Carver Creek Watershed.**

| WWTP | Average Flow (MGD) | Average Fecal Coliform Concentration (CFU/ 100 ml) | Average Load (CFU/day x $10^9$) | Load at Standard (CFU/day x $10^9$) |
|---|---|---|---|---|
| Cologne Wastewater Treatment Plant (MN0023108-SD001) | 0.25 | 11 | 0.10 | 1.89 |
| Carver Wastewater Treatment Plant (MN0053457-SD001 & SD002) | 0.14 | 36 | 0.19 | 1.06 |

There are two wastewater treatment plants in the Bevens Creek watershed including Norwood Young America and Hamburg (Table 6.6). Discharge from the City of Green Isle goes to Arlington.

**Table 6.6. WWTP Loads for Dischargers in the Bevens Creek Watershed.**

| WWTP | Average Flow (MGD) | Average Fecal Coliform Concentration (CFU/ 100 ml) | Average Load (CFU/day x $10^9$) | Load at Standard (CFU/day x $10^9$) |
|---|---|---|---|---|
| Norwood Young America[1] (MN 0024392-SD001 & SD002) | 0.42 | 20 | 0.32 | 3.18 |
| Hamburg WWTP (MN0025585-SD001) | * 0.83 | 4 | 0.13 | 6.28 |

[1] Not including bypass

* Permitted to only discharge between April 1st to June 15th and September 15th to December 15th. The facility may discharge at no more than 6 inches per day. But can discharge as often as needed during the discharge period and as

long as the permitted limits are met. There are no wastewater treatment plants in the Silver Creek watershed. By rule, these dischargers must maintain discharge fecal coliform concentrations below 200 cfu/100ml, which can be accomplished through additional treatment such as chlorination or ultraviolet light. Additionally, these dischargers must monitor effluent to ensure compliance with these rules

### 6.1.7 Wildlife

Wildlife in the watershed encompasses a broad group of animals. For the purposes of this assessment, we focused on deer and geese because they are known contributors of fecal coliform and considered good estimates of wildlife densities in general. Other wildlife were lumped into a single category.

The Deer Permit Areas that encompass Carver County are 337, 338, 427, and 428. The Minnesota Department of Natural Resources (MnDNR) modeled deer population densities for three of the four permit areas that fall in Carver County (Table 6.7). To be conservative, we assumed that the overall deer density was 6 deer per square mile.

**Table 6.7. Deer Population Estimates for Three Permit Areas in Carver County** (Bob Osborn, Minnesota DNR, pers. comm.).

| Deer Permit Area | Deer / square mile |
|---|---|
| PA – 338 | 6.0 |
| PA – 427 | 2.4 |
| PA – 428 | 5.5 |

Goose densities were estimated using the Southeast Minnesota Regional TMDL where they assumed a goose population of 20,000 individuals. Based on the land area in that watershed, the density would be approximately 2.8 geese per square mile. These estimates were reviewed by the MnDNR and thought to be a reasonable estimate (Eric Tobiasen pers. com.).

### 6.1.8 Urban Stormwater Runoff

Untreated urban stormwater has been shown to have fecal coliform concentrations as high or higher than grazed pasture runoff, cropland runoff, and feedlot runoff (USEPA 2001, Bannerman et al. 1993, 1996). There is relatively little urban area in the Carver and Bevens Creek watersheds (5 and 2% respectively) and no urban areas in the Silver Creek watershed. Consequently, urban stormwater is a relatively small portion of fecal coliform loads in these watersheds.

EPA guidance states that MS4 stormwater allocations in a TMDL must now be included in the TMDL as a wasteload allocation. The City of Waconia is the only municipality currently designated for NPDES Phase II MS4 permit coverage. Additionally, the Carver County Water Resource Management Rules, which regulate stormwater management and soil erosion on construction sites, apply throughout both watersheds.

The Carver County Rules are currently under revision to parallel the NPDES Phase II Construction permit, which applies to construction sites over one acre or less than an acre if part of a larger plan of development.  Therefore, any new development in Carver and Bevens watersheds will be subject to state and county requirements to address water quality issues associated with stormwater.

### 6.1.9 Carver Creek Fecal Coliform Producers

Table 6.8 summarizes the major sources of fecal coliform in the Carver Creek watershed.  It is important to note that there is some uncertainty associated with the estimates in the table. Estimates of the population with inadequate wastewater treatment are based on an assumed septic failure rate in the county.  Additionally, pet numbers are derived from a national survey and may not directly reflect conditions in Carver and Sibley Counties.  Deer populations are from model estimates and geese population estimates are based on densities used in the Southeast Minnesota Regional TMDL.  This summary does, however, provide a reasonable estimate of fecal coliform producers in the watershed as well as the comparative densities in each category.

There are 107 livestock facilities with a total of 10,000 animal units dominated by dairy and beef cattle.  Over half of the human population in the watershed discharges to a Municipal Wastewater Treatment Facility.

**Table 6.8.  Inventory of Fecal Coliform Producers in Carver Creek**

| Category | Sub-Category | | Animal Units or Individuals |
|---|---|---|---|
| Livestock | The Basin contains an estimated 107 livestock facilities ranging in size from a few animal units to several hundred | Dairy | 6,236 animal units |
| | | Beef | 2,747 animal units |
| | | Swine | 1,490 animal units |
| | | Poultry | 1 animal units |
| | | Other | 288 animal units |
| Human[1] | Rural Population with Inadequate Wastewater Treatment[2] | | 1,348 people |
| | Rural Population with Adequate Wastewater Treatment | | 1,787 people |
| | Municipal Wastewater Treatment Facilities | | 10,303 people |
| Wildlife | Deer (average 6 per square mile) | | 847 deer |
| | Geese[3] | | 237 geese |

**Table 6.8. Inventory of Fecal Coliform Producers in Carver Creek**

| Category | Sub-Category | | Animal Units or Individuals |
|---|---|---|---|
| | Other | | Other wildlife was assumed to be the equivalent of deer and geese combined in the watershed. |
| Pets | Dogs and Cats in Urban Areas[4] | | 4,820 dogs and cats |
| | Dogs and Cats in Rural Areas[4] | | 1,467 dogs and cats |

[1]Based on 2000 census data
[2]Assumes 65% failure rate for septic systems (65% of rural population with inadequate wastewater treatment)
[3]Rough estimate, likely representing maximum numbers; geese densities based on Southeastern Minnesota Regional Bacteria TMDL (MPCA 2002) densities (2.8 per square mile)
[4] People divided by 2.8 people/household multiplied by 0.58 dogs/household, 0.73 cats/household as used in the Southeast Minnesota Regional TMDL (MPCA 2002).

## 6.2 BEVENS CREEK FECAL COLIFORM PRODUCERS

Table 6.9 summarizes the major sources of fecal coliform in the Bevens Creek watershed. There are 144 livestock facilities with over 19,000 animal units dominated by dairy and beef cattle. Over half of the human population in the watershed discharges to a Municipal Wastewater Treatment Facility.

**Table 6.9. Inventory of Fecal Coliform Producers in Bevens Creek**

| Category | Sub-Category | | Animal Units or Individuals |
|---|---|---|---|
| Livestock[1] | The Basin contains an estimated 144 livestock facilities ranging in size from a few animal units to several hundred | Dairy | 7,638 animal units |
| | | Beef | 7,400 animal units |
| | | Swine | 3,321 animal units |
| | | Poultry | No known commercial scale production |
| | | Other | 495 animal units |
| Human[2] | Rural Population with Inadequate Wastewater Treatment[3] | | 1,524 people |
| | Rural Population with Adequate Wastewater Treatment | | 2,020 people |
| | Municipal Wastewater Treatment Facilities | | 4,036 people |
| Wildlife | Deer (average 6 per square mile) | | 935 deer |
| | Geese[4] | | 262 geese |
| | Other | | Other wildlife was assumed to be the equivalent of deer and geese combined in the watershed. |

**Table 6.9. Inventory of Fecal Coliform Producers in Bevens Creek**

| Category | Sub-Category | Animal Units or Individuals |
|---|---|---|
| Pets | Dogs and Cats in Urban Areas[5] | 1,888 dogs and cats |
| | Dogs and Cats in Rural Areas[5] | 1,658 dogs and cats |

[1]Sibley Animal units were estimated by multiplying the average # units per feedlot in Carver County by the number of feedlots in Sibley County
[2]Based on 2000 census data
[3]Assumes 65% failure rate for septic systems (65% of rural population with inadequate wastewater treatment)
[4]Rough estimate, likely representing maximum numbers; geese densities based on Southeastern Minnesota Regional Bacteria TMDL (MPCA 2002) densities (2.8 per square mile)
[5]People divided by 2.8 people/household multiplied by 0.58 dogs/household, 0.73 cats/household as used in the Southeast Minnesota Regional TMDL (MPCA 2002).

## 6.3 SILVER CREEK FECAL COLIFORM PRODUCERS

Table 6.10 summarizes the major sources of fecal coliform in the Silver Creek watershed. There are 53 livestock facilities with over 6,000 animal units dominated by dairy and beef cattle. None of the human population discharges to a Municipal Wastewater Treatment Facility.

**Table 6.10. Inventory of Fecal Coliform Producers in Silver Creek**

| Category | Sub-Category | | Animal Units or Individuals |
|---|---|---|---|
| Livestock[1] | The Basin contains an estimated 53 livestock facilities ranging in size from a few animal units to several hundred | Dairy | 2,731 animal units |
| | | Beef | 2,441 animal units |
| | | Swine | 1,153 animal units |
| | | Poultry | 11 animal units |
| | | Other | 205 animal units |
| Human[2] | Rural Population with Inadequate Wastewater Treatment[3] | | 599 people |
| | Rural Population with Adequate Wastewater Treatment | | 795 people |
| | Municipal Wastewater Treatment Facilities | | 0 people |
| Wildlife | Deer (average 6 per square mile) | | 358 deer |
| | Geese (Average 2.8 per square mile) [4] | | 100 geese |
| | Other | | Other wildlife was assumed to be the equivalent of deer and geese combined in the watershed. |
| Pets | Dogs and Cats in Urban Areas[5] | | 0 dogs and cats |
| | Dogs and Cats in Rural Areas[5] | | 652 dogs and cats |

[1]Sibley Animal units were estimated by multiplying the average # units per feedlot in Carver County by the number of feedlots in Sibley County
[2] Based on 2000 census data
[3]Assumes 65% failure rate for septic systems (65% of rural population with inadequate wastewater treatment)
[4]Rough estimate, likely representing maximum numbers; geese densities based on Southeastern Minnesota Regional Bacteria TMDL (MPCA 2002) densities (2.8 per square mile)
[5]People divided by 2.8 people/household multiplied by 0.58 dogs/household, 0.73 cats/household as used in the Southeast Minnesota Regional TMDL (MPCA 2002).

# 7.0 Linking Water Quality Targets and Sources

## 7.1 INTRODUCTION

A key aspect of a TMDL is the linkage between the pollutant sources and the selected water quality target or instream loads. Establishment of this linkage provides for the quantification of the assimilative capacity of the stream while still supporting State water quality standards. This linkage allows for loads or load reductions to be allocated among the sources that will ultimately result in the water body meeting standards. The linkages can be obtained through intensive modeling or through the use of qualitative assumptions backed by a sound understanding of pollutant dynamics in the watershed. Both techniques require significant professional judgment and selection of terms based on assumptions. However, intensive modeling assumptions are often complex and difficult to explain to local stakeholders. Alternatively, the utilization of qualitative assumptions can be clearly explained to those who they may affect the most. The qualitative assumptions can be tested through statistical analysis of a rigorous data set and a thorough understanding of pollutant source practices and dynamics.

## 7. 2 SELECTION OF MODEL AND TOOLS

To develop the linkage between watershed sources and water quality targets, we utilized the approach developed for the Southeast Minnesota Regional Fecal Coliform TMDL (MPCA 2002). This approach entails a two-step process that identifies the amount of fecal coliform potentially available for runoff and links these quantified sources to the streams through a runoff potential. This approach is ultimately based on two sets of clearly defined assumptions: 1) The amount of fecal coliform available for runoff from each source and 2) the potential for that fecal coliform to reach surface waters under wet and dry conditions. These analyses will result in a partitioning of the stream load among the sources based on the proportions available for delivery from the watershed and the potential for that source to reach surface waters. The relationship between land use and fecal coliform concentrations found in streams is complex, involving both pollutant transport and rate of survival in different types of aquatic environments (MPCA 2002). Intensive sampling at several sites in southeastern Minnesota shows a strongly positive correlation between stream flow, precipitation, and fecal coliform bacteria concentrations.

A study of the Straight River watershed divided sources into continuous (failing individual sewage treatment systems, unsewered communities, industrial and institutional sources, wastewater treatment facilities) and weather-driven (feedlot runoff, manured fields, urban stormwater categories). The study hypothesized that when precipitation and stream flows are high, the influence of continuous sources is overshadowed by weather-driven sources, which generate extremely high fecal coliform concentrations. However, during drought, low-flow conditions, continuous sources can generate high concentrations of fecal coliform, the study indicated. Besides precipitation and flow, factors such as temperature, livestock management practices, wildlife activity, fecal deposit age, and channel and bank storage also affect bacterial concentrations in runoff (Baxter-Potter and Gilliland, 1988).

Several studies have found a strong correlation between livestock grazing and fecal coliform levels in streams running through pastures (MPCA 2002). Several samples taken in the Grindstone River in the St. Croix River Basin, downstream of cattle observed to be in the stream, were found to contain a geometric mean of 11,000 organisms/100ml, with individual samples ranging as high as 110,000/100ml. However, carefully managed grazing can be beneficial to stream water quality. A study of southeastern Minnesota streams by Sovell, et. al., found that fecal coliform, as well as turbidity, were consistently higher at continuously grazed sites than at rotationally grazed sites where cattle exposure to the stream corridor was greatly reduced. This study and several others indicate that sediment-embeddedness, turbidity, and fecal coliform concentrations are positively related. Fine sediment particles in the streambed can serve as a substrate harboring fecal coliform bacteria. "Extended survival of fecal bacteria in sediment can obscure the source and extent of fecal contamination in agricultural settings," (Howell et. al., 1996).

Hydrogeologic features may favor the survival of fecal coliform bacteria (MPCA 2002). Cold ground water, shaded streams, and sinkholes may protect fecal coliform from light, heat, drying, and predation (MPCA 1999). Sampling in the South Branch of the Root River watershed showed concentrations of up to 2,000 organisms/100 ml coming from springs, pointing to a strong connection between surface water and ground water. The presence of fecal coliform bacteria has been detected in private well water in southeastern Minnesota. However, many such detections have been traced to problems of well construction, wellhead management, or flooding, not from widespread contamination of the deeper aquifers used for drinking water. One study from Kentucky showed that rainfall on well-structured soil with a sod surface could generate fecal coliform contamination of the shallow ground water through preferential flow (McMurry et.al., 1998).

An MPCA evaluation for the Minnesota River Basin suggests that improper Individual Sewage Treatment Systems (ISTS) may be responsible for approximately 74 fecal coliform bacteria organisms per 100 milliliter sample within larger rivers.[1] However, transport and survival of fecal coliform bacteria are not well understood, particularly as they are affected by the interaction of surface and ground water flows in karst geology. Wastewater treatment facilities are required to conduct seasonal disinfection of their wastewater before it is discharged.

## 7.3 FECAL COLIFORM AVAILABLE FOR RUNOFF

The first set of assumptions divides the fecal coliform produced in the watershed into several source areas such as surface applied manure (Table 7.1). It is important to note that this process assumes that all fecal coliform produced in the watershed, remains in the watershed. For example, all dairy cow manure is potentially available for runoff. Only 1% is assumed to be in overgrazed pastures while 64% is assumed to be applied to the watershed surface. Additionally,

[1] David Morrison, "Contributions from Septic Systems and Undersewered Communities," presented at Bacteria in the Minnesota River, Mankato, Minnesota, Feb 16, 1999

the assumptions identify the proportion available seasonally and the quantity that may be available. For example, it was assumed that 10% of cat and dog waste in urban areas was improperly managed. These assumptions are gross and are intended to represent average conditions in the watershed (MPCA 2002).

The assumptions were first developed as a part of the Southeast Regional TMDL (MPCA 2002; Mulla et al 2001) and then adjusted by the Carver County Water Environment and Natural Resources Technical Sub-Committee and Policy Committee to reflect current practices and conditions in the three local watersheds.

**Table 7.1. Assumptions Used to Estimate the Amount of Daily Fecal Coliform** Production Available for Potential Runoff or Discharge into the Streams and Rivers of Carver and Sibley Counties

| **Category** | **Source** | **Assumption** |
|---|---|---|
| Livestock | Overgrazed Pasture near Streams or Waterways | 1% of Dairy Manure<br>1% of Beef Manure |
| | Feedlots or Stockpiles without Runoff Controls | 1% of Dairy<br>5% of Beef Manure<br>1% Poultry Manure |
| | Surface Applied Manure | 64% of Dairy Manure<br>94% of Beef Manure<br>99% of Poultry Manure<br>10% Swine Manure;<br>20% of this manure applied in Spring<br>20% of this manure applied in Summer<br>60% of this manure applied in Fall |
| | Incorporated Manure | 34% of Dairy Manure<br>90% of Swine Manure;<br>20% of this manure applied in the Spring<br>80% of this manure applied in Fall |
| Human | Failing Septic Systems and Unsewered Communities | All waste from failing septic systems and unsewered communities |
| | Municipal Wastewater Treatment Facilities (excluding bypasses) | Calculated directly from WWTP discharge (April through October) and the geometric mean fecal coliform concentration (2004 data) |
| Wildlife | Deer | All fecal matter produced by deer in basin |
| | Geese | All fecal matter produced by geese in basin |
| | Other Wildlife | The equivalent of all fecal matter produced by deer and geese in basin |
| Urban Stormwater Runoff | Improperly Managed Waste from Dogs and Cats | 10% of waste produced by estimated number of dogs and cats in basin |

Estimated Daily fecal coliform potentially available for runoff are shown in Tables 7.2, 7.3, and 7.4. The daily fecal coliform production estimates for each animal unit or individual were based on literature values (MPCA 2002). For the sake of consistency, we utilized the same values developed as a part of the Southeast Minnesota Regional Fecal Coliform TMDL (MPCA 2002). Some small differences may occur when fecal coliform production is estimated based on animal unit definitions. However, these differences would fall within the standard deviation of production numbers and would not increase the accuracy of the data. Consequently, the production numbers in the Southeast Minnesota Regional Fecal Coliform TMDL (MPCA 2002) are reasonably representative for individuals in Carver and Sibley Counties.

**Table 7.2. Estimated Daily Fecal Coliform Available for <u>Potential</u> Runoff or Discharge into Carver Creek**

| Category | Source | Animal Units or Individuals Derived from Tables and * | Fecal Coliform Organisms Produced Per Unit Per Day ($10^9$)** | Total Fecal Coliform Available ($10^9$) | Total Fecal Coliform Available by Source ($10^9$) |
|---|---|---|---|---|---|
| Livestock | Overgrazed Pasture near Streams or Waterways | 62 Dairy Animal Units | 58 | 3,629 | 6,077 |
| | | 27 Beef Animal Units | 89 | 2,448 | |
| | Feedlots or Stockpiles without Runoff Controls | 62 Dairy Animal Units | 58 | 3,629 | 15,869 |
| | | 137 Beef Animal Units | 89 | 12,240 | |
| | | 0 Poultry Animal Units | 21 | 0 | |
| | Surface Applied Manure*** | 3,991 Dairy Animal Units | 58 | 232,264 | 467,262 |
| | | 2,583 Beef Animal Units | 89 | 230,106 | |
| | | 149 Swine Units | 33 | 4,872 | |
| | | 1 Poultry Animal Units | 21 | 21 | |
| | Incorporated Manure | 2,120 Dairy Animal Units | 58 | 123,390 | 167,238 |
| | | 0 Beef Animal Units | 89 | 0 | |
| | | 1,341 Swine Units | 33 | 43,848 | |
| | | 0 Poultry Animal Units | 21 | 0 | |
| Human | Failing Septic Systems and Unsewered Communities | 1,616 People | 2.0 | 3,232 | 8,638 |
| | Municipal Wastewater Treatment Facilities | 2,703 People | 2.0 | 5,406 | |
| Wildlife | Deer | 508 Deer | 0.5 | 254 | 698 |
| | Geese | 237 Geese | 0.4 | 95 | |
| | Other Wildlife | Equivalent of deer and geese | | 349 | |
| Urban Stormwater | Improperly Managed Waste from Dogs and Cats | 126 Dogs and Cats | 4.5 | 569 | 569 |
| Total | | | | | 666,351 |

* Example –Dairy Animal Units in Basin x 1% on Overgrazed Pasture in Riparian Areas = Animal Units
** Derived from literature values in Mulla et. Al (2001), USEPA (2001), and Alderisio and DeLuca (1999)
*** Total fecal coliform available reduced by seasonal assumptions to reflect manure application practices. For example, 20% of surface applied manure was assumed to be available in the spring, 20% in the summer, and 60% in the fall.

**Table 7.3. Estimated Daily Fecal Coliform Available for <u>Potential</u> Runoff or Discharge into Bevens Creek**

| Category | Source | Animal Units or Individuals Derived from Tables 4.10 and 4.20* | Fecal Coliform Organisms Produced Per Unit Per Day ($10^9$)** | Total Fecal Coliform Available ($10^9$) | Total Fecal Coliform Available by Source ($10^9$) |
|---|---|---|---|---|---|
| Livestock | Overgrazed Pasture near Streams or Waterways | 76 Dairy Animal Units | 58 | 4,445 | 11,038 |
| | | 74 Beef Animal Units | 89 | 6,593 | |
| | Feedlots or Stockpiles without Runoff Controls | 76 Dairy Animal Units | 58 | 4,445 | 37,410 |
| | | 370 Beef Animal Units | 89 | 32,965 | |
| | | 0 Poultry Animal Units | 21 | 0 | |
| | Surface Applied Manure*** | 4,888 Dairy Animal Units | 58 | 284,448 | 915,090 |
| | | 6,956 Beef Animal Units | 89 | 619,739 | |
| | | 332 Swine Units | 33 | 10,860 | |
| | | 0 Poultry Animal Units | 21 | 3 | |
| | Incorporated Manure | 2,597 Dairy Animal Units | 58 | 151,134 | 248,873 |
| | | 0 Beef Animal Units | 89 | 0 | |
| | | 2,989 Swine Units | 33 | 97,739 | |
| | | 0 Poultry Animal Units | 21 | 0 | |
| Human | Failing Septic Systems and Unsewered Communities | 1,524 People | 2.0 | 3,048 | 11,120 |
| | Municipal Wastewater Treatment Facilities | 4,036 People | 2.0 | 8,072 | |
| Wildlife | Deer | 561 Deer | 0.5 | 281 | 771 |
| | Geese | 262 Geese | 0.4 | 105 | |
| | Other Wildlife | Equivalent of deer and geese | | 385 | |
| Urban Stormwater | Improperly Managed Waste from Dogs and Cats | 189 Dogs and Cats | 4.5 | 850 | 850 |
| Total | | | | | 1,225,151 |

* Example – 508,273 Dairy Animal Units in Basin x 1% on Overgrazed Pasture in Riparian Areas = 5083 Animal Units
** Derived from literature values in Mulla et. Al (2001), USEPA (2001), and Alderisio and DeLuca (1999)
*** Total fecal coliform available reduced by seasonal assumptions to reflect manure application practices. For example, 20% of surface applied manure was assumed to be available in the spring, 20% in the summer, and 60% in the fall.

**Table 7.4. Estimated Daily Fecal Coliform Available for <u>Potential</u> Runoff or Discharge into Silver Creek**

| Category | Source | Animal Units or Individuals Derived from Tables 4.10 and 4.20* | Fecal Coliform Organisms Produced Per Unit Per Day ($10^9$)** | Total Fecal Coliform Available ($10^9$) | Total Fecal Coliform Available by Source ($10^9$) |
|---|---|---|---|---|---|
| Livestock | Overgrazed Pasture near Streams or Waterways | 27 Dairy Animal Units | 58 | 1,589 | 3,764 |
| | | 24 Beef Animal Units | 89 | 2,175 | |
| | Feedlots or Stockpiles without Runoff Controls | 27 Dairy Animal Units | 58 | 1,589 | 12,466 |
| | | 122 Beef Animal Units | 89 | 10,875 | |
| | | 0 Poultry Animal Units | 21 | 2 | |
| | Surface Applied Manure*** | 1,748 Dairy Animal Units | 58 | 101,726 | 310,155 |
| | | 2,295 Beef Animal Units | 89 | 204,442 | |
| | | 115 Swine Units | 33 | 3,771 | |
| | | 11 Poultry Animal Units | 21 | 216 | |
| | Incorporated Manure | 929 Dairy Animal Units | 58 | 54,042 | 87,978 |
| | | 0 Beef Animal Units | 89 | 0 | |
| | | 1,038 Swine Units | 33 | 33,937 | |
| | | 0 Poultry Animal Units | 21 | 0 | |
| Human | Failing Septic Systems and Unsewered Communities | 599 People | 2.0 | 1,199 | 1,199 |
| | Municipal Wastewater Treatment Facilities | 0 People | 2.0 | 0 | |
| Wildlife | Deer | 215 Deer | 0.5 | 108 | 295 |
| | Geese | 100 Geese | 0.4 | 40 | |
| | Other Wildlife | Equivalent of deer and geese | | 148 | |
| Urban Stormwater | Improperly Managed Waste from Dogs and Cats | 0 Dogs and Cats | 4.5 | 0 | 0 |
| Total | | | | | 415,858 |

* Example –Dairy Animal Units in Basin x 1% on Overgrazed Pasture in Riparian Areas = Animal Units
** Derived from literature values in MPCA (2002), Mulla et. Al (2001), USEPA (2001), and Alderisio and DeLuca (1999)
*** Total fecal coliform available reduced by seasonal assumptions to reflect manure application practices. For example, 20% of surface applied manure was assumed to be available in the spring, 20% in the summer, and 60% in the fall.

### 7.3.1 Fecal Coliform Delivery Potential

The second set of assumptions provides information on the potential for the previously quantified source areas to reach surface waters. Developing the delivery potential for each source is based on assigning risk values on a scale of 1-5 (1= very low risk and 5 = very high risk). These risk assignments are then translated into delivery percentages where a low potential delivers one percent, moderate is two percent, high is four percent, and very high is 6 percent. (Table 7.5; Mulla et al. 2001).

These numbers were based on those used in the Southeast Minnesota Regional Bacteria TMDL (MPCA 2002) and adjusted to reflect conditions in the watershed. Additionally, these assumptions are divided into wet weather conditions and dry weather conditions to differentiate between those sources that are precipitation driven versus those which are not dependent on precipitation. The only assumed dry weather sources are septic systems, overgrazed pastures with direct access to the streams, and wildlife.

Each of the delivery potentials is presented seasonally, however no seasonal difference in the delivery from the source was assumed. Seasonality was accounted for in the amount available for wash off due to seasonal differences in application practices. Septic system delivery potential was not doubled here to reflect some of the variability in assessing failing septic systems. Some septic systems are considered failing due to interaction with the water table, but do not have a direct connection to surface waters. The delivery potential remains high though, due to the extensive drain tiling in the region.

**Table 7.5. Assumed Fecal Coliform Delivery Potential**

| **Source** | **Estimated Delivery Potential** | | | | | |
|---|---|---|---|---|---|---|
| | **Spring (Wet)** | **Spring (Dry)** | **Summer (Wet)** | **Summer (Dry)** | **Fall (Wet)** | **Fall (Dry)** |
| Overgrazed Pasture near Streams or Waterways | High (4%) | Low (1%) | High (4%) | Low (1%) | High (4%) | Low (1%) |
| Feedlots or Manure Stockpiles without Runoff Controls | High (4%) | N/A | Moderate (2%) | N/A | Moderate (2%) | N/A |
| Surface Applied Manure | Low (1%) | N/A | Low (1%) | N/A | Low (1%) | N/A |
| Incorporated Manure | Very Low (0.1%) | N/A | Very Low (0.1%) | N/A | Very Low (0.1%) | N/A |
| Failing Septic Systems and Unsewered Communities | Very High (6%) | Very High (6%) | Very High (6%) | Very High (6%) | Very High (6%) | Very High (6%) |
| Municipal Wastewater Treatment Facilities (excluding bypasses) | Contribution estimated directly based on discharge reports | | | | | |
| Deer | Low (1%) | Low (1%) | Low (1%) | Low (1%) | Low (1%) | Low (1%) |
| Geese | High (4%) | High (4%) | High (4%) | High (4%) | High (4%) | High (4%) |
| Other Wildlife | Low | Low | Low | Low | Low | Low |

**Table 7.5. Assumed Fecal Coliform Delivery Potential**

| Source | Estimated Delivery Potential | | | | | |
|---|---|---|---|---|---|---|
| | **Spring (Wet)** | **Spring (Dry)** | **Summer (Wet)** | **Summer (Dry)** | **Fall (Wet)** | **Fall (Dry)** |
| | (1%) | (1%) | (1%) | (1%) | (1%) | (1%) |
| Urban Stormwater Runoff | High (4%) | N/A | High (4%) | N/A | High (4%) | N/A |

### 7.3.2 Estimated Source Load Proportions

Current load proportions were estimated by multiplying the delivery potential by the amount of fecal coliform available for runoff. WWTP effluent was calculated directly from effluent monitoring. Seasonal load proportions are presented in Figures 7.1, 7.2, and 7.3 for the three watersheds. Dry weather loads were dominated by septic systems and overgrazed pastures. Wet weather loads were more varied with surface applied manure and feedlots dominating the loads. There are some seasonal patterns in the load proportions with fall, wet weather loads dominated by surface application of manure. Fall is the period of greatest application of manure. In Silver Creek, overgrazed pastures had a higher load proportion than septic systems. This reflects the relative amounts of animals in the watershed versus people.

**Figure 7.1. Seasonal Load Proportions for Carver Creek.**

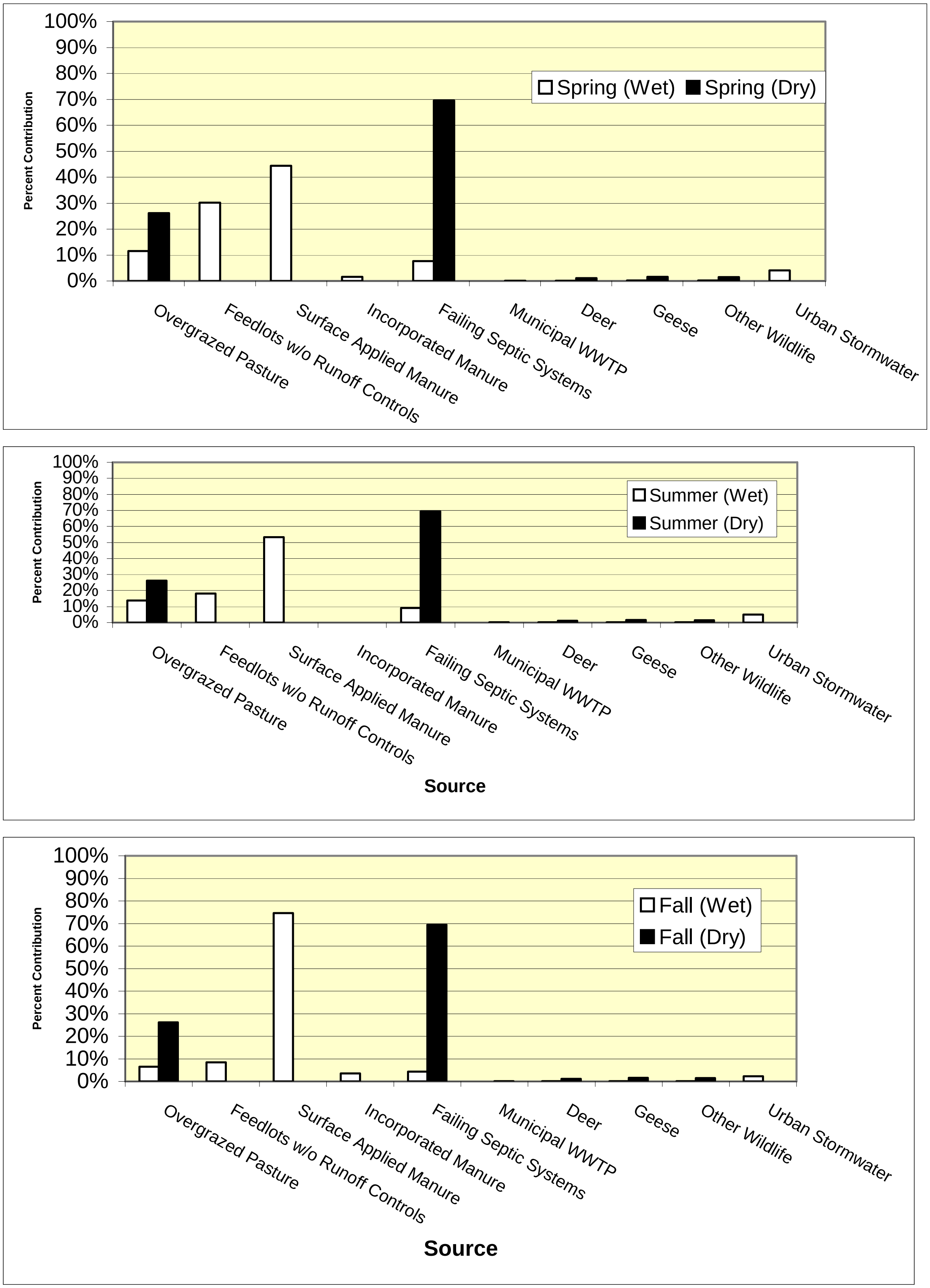


**Figure 7.2**

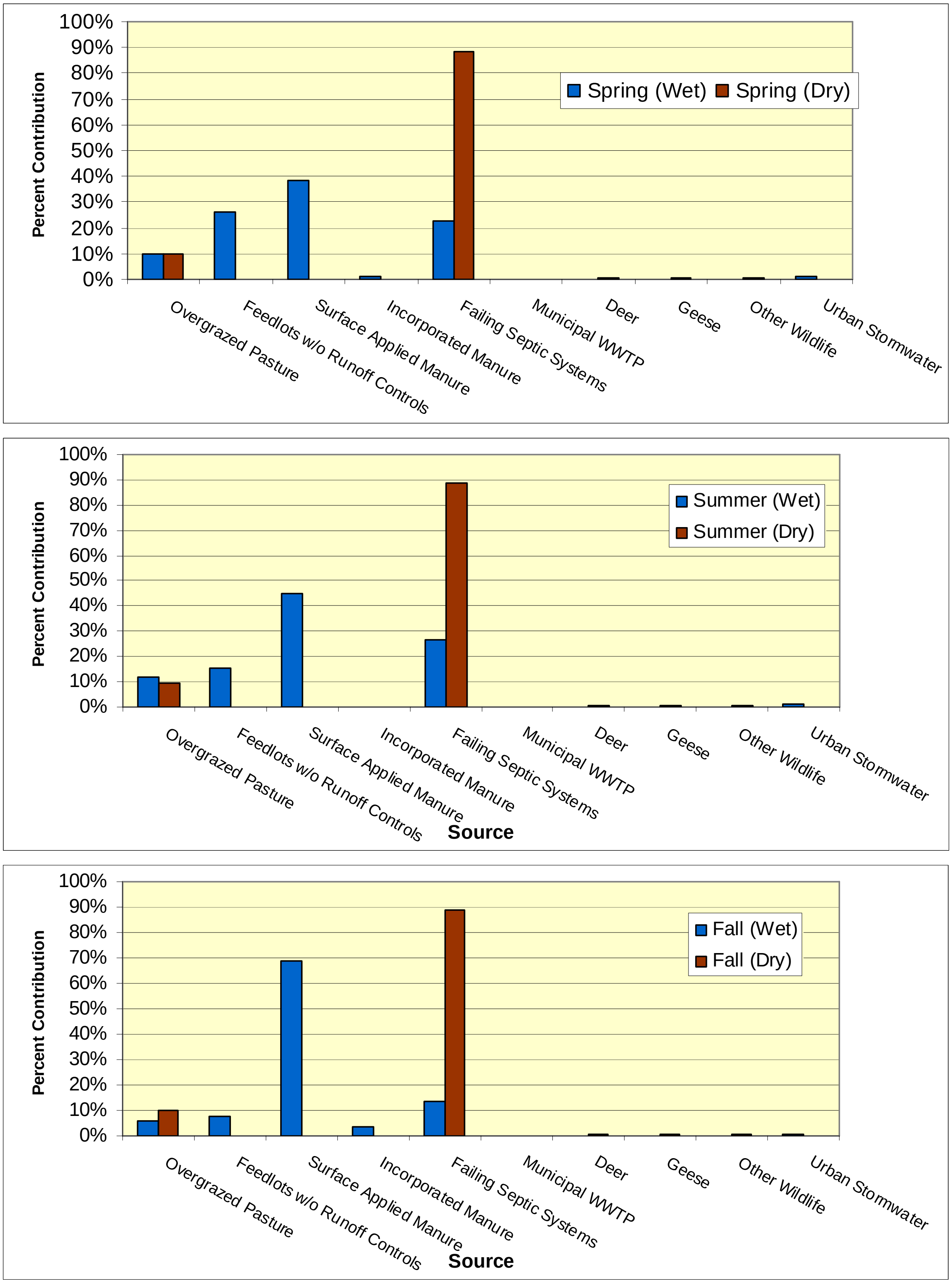
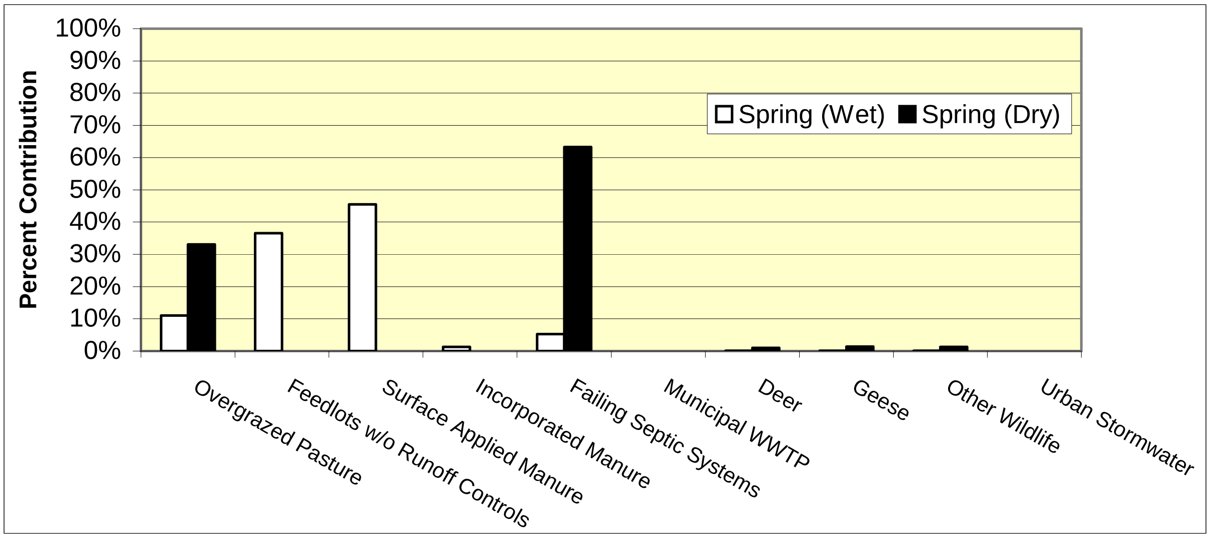
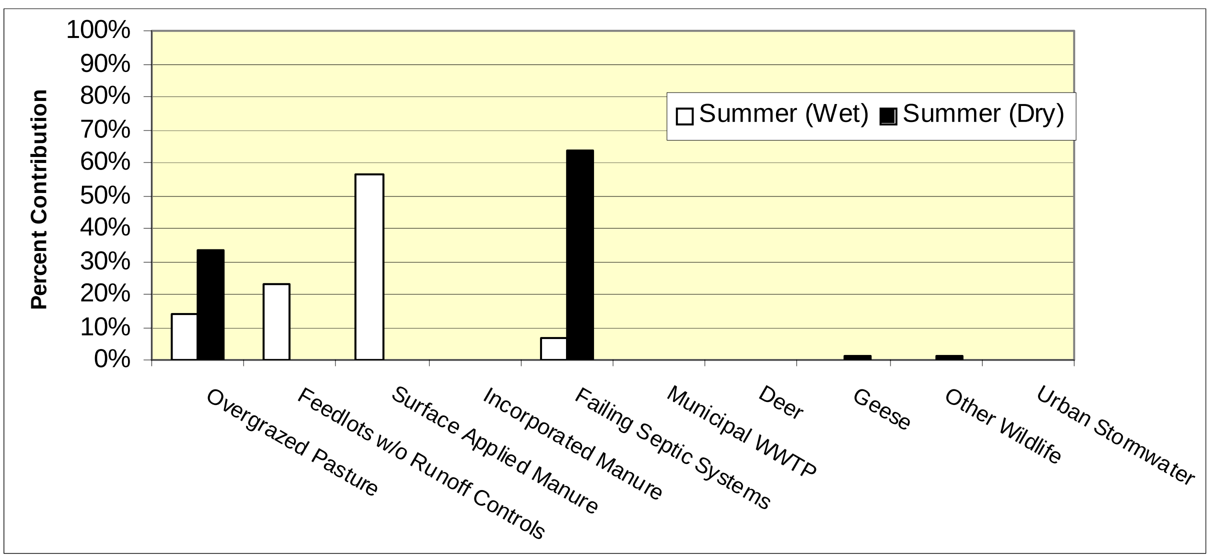
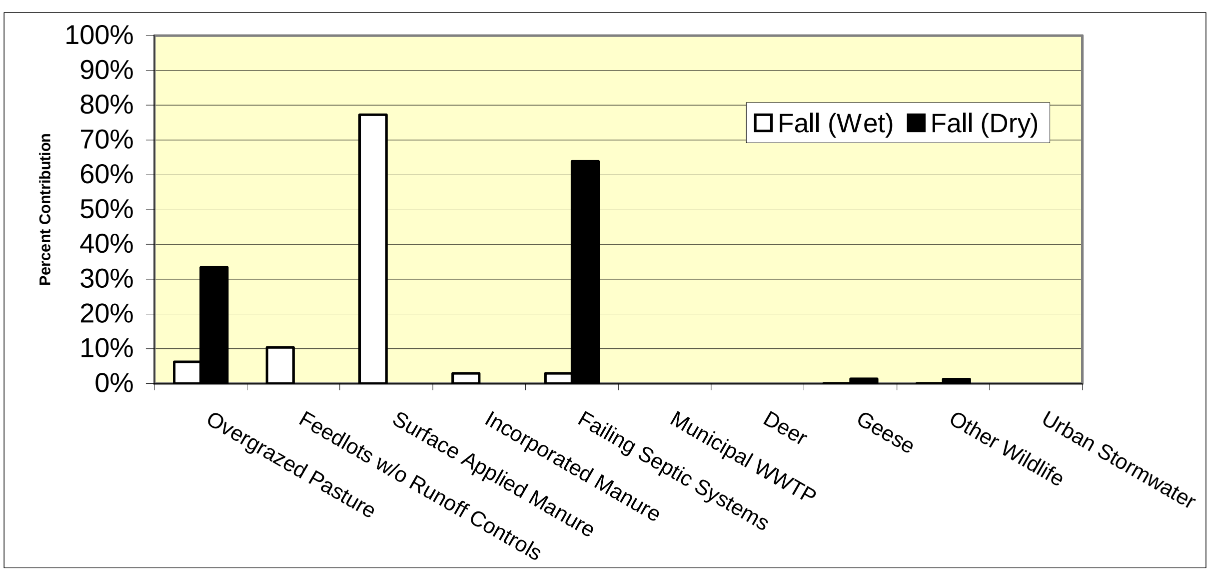

Percent Contribution
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Spring (Wet)
Spring (Dry)
Overgrazed Pasture
Feedlots w/o Runoff Controls
Surface Applied Manure
Incorporated Manure
Failing Septic Systems
Municipal WWTP
Deer
Geese
Other Wildlife
Urban Stormwater
Summer (Wet)
Summer (Dry)
Source
Fall (Wet)
Fall (Dry)

**Figure 7.3. Seasonal Load Proportions for Silver Creek.**



# 8.0 TMDL Allocation

### 8.1 TMDL

Because fecal coliform is primarily a nonpoint source issue in the Carver, Bevens and Silver Creek watersheds, it is inappropriate to define the TMDL as a single number since the TMDL is entirely dependent upon the daily flow and concentration, which is highly dynamic. To this effect, the TMDL is represented by an allowable daily load across all flow conditions as is demonstrated in Figure 8.1. To determine acceptable loads under the critical flow regimes, chronic standard concentrations were multiplied by the flow at each interval.

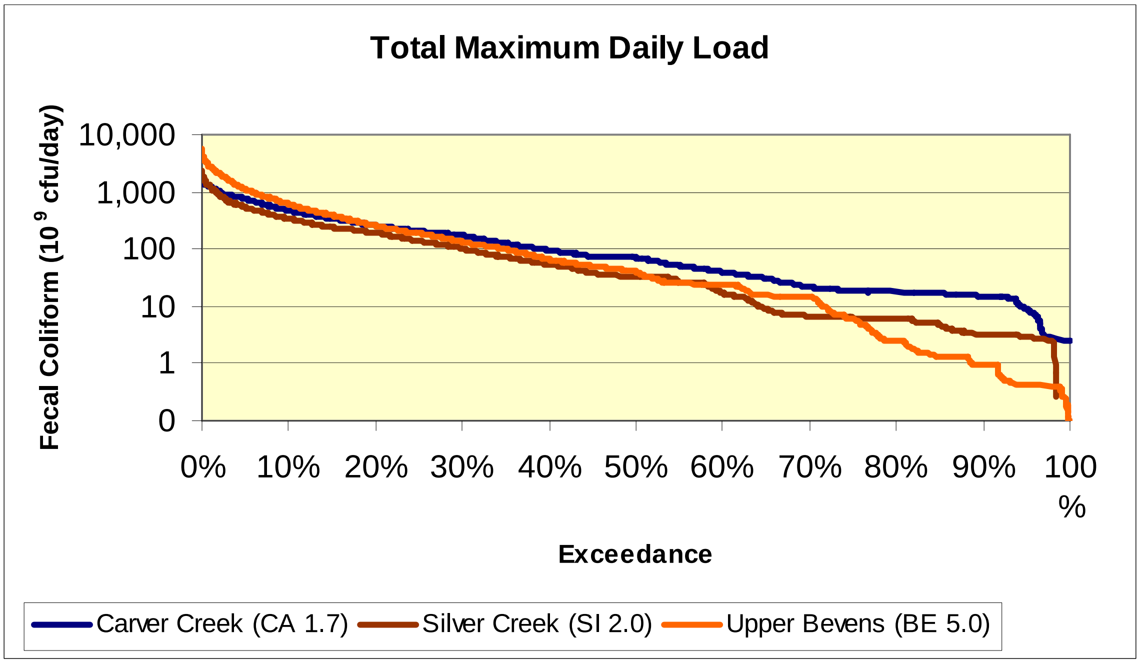



**Figure 8.1. The Total Maximum Daily Load Across Flow Exceedances for Carver, Bevens, and Silver Creeks.** Data used to calculate the load duration curve was from 1997 through 2003. This graph represents the allowable load while meeting the State standard.

To develop the TMDL equations for each watershed, seasonal mean discharge was calculated at the outlets of each of the watersheds. These data were then multiplied by the standard of 200 cfu/100 ml to establish the TMDL (Table 8.1). The MOS was established using all existing watershed data to quantify uncertainty in the data. The MOS in the TMDL is essentially the ratio of the geomean of all data to the upper confidence interval of the geomean for all data. For example, in Carver Creek, the spring geomean was 68% of the upper confidence interval. So, the allocation (wasteload and load) was 68% of the load at 200 cfu/100 ml and the MOS was the remaining load. Consequently, the MOS represents the uncertainty in the estimate of the geomean.

In the recently approved Lower Mississippi River Basin Fecal Coliform TMDL (MPCA, 2006), a somewhat different approach was taken to expressing the TMDL’s and MOS’s. Whereas the Lower Mississippi Basin report expressed the TMDL’s and associated allocations for five flow zones; for Carver, Bevens, and Silver Creeks they are expressed for the three seasons spring, summer, and fall. Due to the relationship between seasonality and flow, the MPCA has indicated that this is a viable approach. Furthermore, it provides a strong linkage to sources of fecal coliform, many of which are seasonal in nature as well as flow-related.

In the Lower Mississippi Basin report, MOS’s are calculated based on flow variability within each of the five flow zones. In this report, as described above, the MOS’s are based on variability of the fecal coliform data for Carver, Bevens, and Silver Creeks. The MOS values range from 27 to 44 percent of the seasonal TMDL values. In the Lower Mississippi Basin report, MOS values range from 1 to 53 percent over the five flow zones and 39 reaches addressed, with most in the 20 to 40 percent range. While the approaches in the two reports are different, both result in relatively large and protective MOS’s. As such, the MPCA has expressed support for the MOS calculation method.

A recent D.C. Circuit Court of Appeals ruling (No. 05-5015; D.C. Cir. 2006), and subsequent USEPA guidance, suggests that TMDL’s must generally be expressed in daily terms. Table 8.1 satisfies this requirement. However, because the TMDL’s, allocations, and MOS’s were calculated based on the monthly geometric mean standard, they should be viewed as average daily values rather than absolute daily limits. The monthly TMDL’s, allocations, and MOS’s, which relate more directly to the monthly geometric mean standard and point source discharge limits, are simply the values in Table 8.1 multiplied by 30.

**Table 8.1. The TMDL for Fecal Coliform in Carver, Bevens, and Silver Creeks.** Loads are based on seasonal mean discharge at the outlets of each watershed.

| Reach | Critical Condition | Wasteload Allocation ($10^9$ cfu/day) | Load Allocation ($10^9$ cfu/day) | Margin of Safety ($10^9$ cfu/day) | TMDL ($10^9$ cfu/day) |
|---|---|---|---|---|---|
| Carver Creek | Spring | 20 | 180 | 93 | 293 |
| | Summer* | 20 | 147 | 78 | 245 |
| | Fall | 20 | 45 | 29 | 94 |
| Bevens Creek, Silver Cr to Minnesota R | Spring | 11 | 248 | 117 | 376 |
| | Summer* | 11 | 225 | 106 | 342 |
| | Fall | 11 | 32 | 16 | 59 |
| Bevens | Spring | 11 | 248 | 117 | 376 |

| | | | | | |
|---|---|---|---|---|---|
| Creek, Headwaters (Washington Lk) to Silver Cr | Summer* | 11 | 225 | 106 | 342 |
| | Fall | 11 | 32 | 16 | 59 |
| Silver Creek | Spring | 0 | 117 | 91 | 208 |
| | Summer | 0 | 110 | 86 | 196 |
| | Fall | 0 | 29 | 23 | 52 |

Discharges from pond facilities are not permitted after June 15 and before September 15. Refer to specific facility permits for details.

Note that the TMDLS for the two Bevens Creek Reaches are the same given the size of the stream and watershed and the distribution of sources in the watershed.

The wasteload allocations (WLA) for the TMDLs were calculated based on the existing NPDES permitted point sources in each watershed. The NPDES permit for Bongards' Creamery will provide a fecal coliform concentration limit of 200 organisms per 100 ml as a monthly geometric mean for the discharge from the wastewater treatment ponds. **The facility will be permitted to discharge an average of 0.756 MGD (million gallons per day) and a maximum of 2.0 MGD during the discharge window of April through June 15 and September 15 through November each year. The permitted average daily load at the fecal coliform limit is 5.72 * $10^9$ organisms/day. Using the maximum daily discharge, the wasteload allocation is calculated to be 15.1 * $10^9$ organisms/day.** Given that the facility's permitted average daily discharge is much lower and the pond discharges do not occur every day, the WLA for Bongards provides an implicit margin of safety for the TMDL.

The NPDES permits for municipal wastewater treatment facilities in the watersheds provide a fecal coliform concentration limit of 200 organisms per 100 ml as a monthly geometric mean for the facilities' discharges. The city of Cologne WWTP and city of Carver WWTP have permitted average wet weather flows of 325,000 and 361,000 gallons per day, respectively. Both facilities have continuous discharges to Carver Creek. WWTP discharges to Bevens Creek include the cities of Norwood Young America and Hamburg. The Norwood Young America WWTP is a continuous discharge facility with a permitted average wet weather flow of 908,000 gallons per day. The city of Hamburg is a controlled discharge facility with a permitted discharge up to six inches of their secondary treatment pond per day. Given that the pond is 3.33 acres, the discharge can be up to 651,348 gallons per day during the discharge windows of April 1st through June 15th and September 15th through December 15th.

Wasteload allocations were calculated by multiplying the permitted concentration by the allowable flows for each facility. The numbers used in the calculations for the industrial and municipal facilities are summarized in Table 8.3 (need to renumber tables). Summing the individual WLAs for each stream provides the total WLA for each stream as shown in Table 8.4.

The City of Waconia is the only municipality currently designated for NPDES Phase II MS4 permit coverage in the Carver County Bacterial TMDL. The City of Waconia has not been issued a MS4 permit Id number because their application for their NPDES Phase II MS4 permit is not due at the MPCA until February 15, 2007.

The city of Waconia is considered deminimus in regard to fecal coliform and is not assigned a Wasteload allocation in this TMDL.

**Table 8.2. Seasonal Fecal Coliform Statistics Utilized in the Development of Percent Reductions and the Associated TMDL for Carver, Bevens, and Silver Creeks in Carver County, Minnesota.**

| | | | | | | % Reduction | |
|---|---|---|---|---|---|---|---|
| | **Watershed** | **N** | **STDEV** | **Geomean (cfu/ 100 ml)** | **UCI (cfu/ 100 ml)** | Geomean | *UCI |
| Fall | Bevens | 89 | 7.6 | 1,277 | 1,991 | 84% | 90% |
| | Carver | 94 | 6.4 | 906 | 1,344 | 78% | 85% |
| | Silver | 21 | 7.4 | 926 | 2,283 | 78% | 91% |
| | Grand Total | 204 | 7.0 | 1,055 | 1,397 | 81% | 86% |
| | | | | | | | |
| Spring | Bevens | 90 | 7.4 | 655 | 992 | 69% | 80% |
| | Carver | 84 | 8.0 | 290 | 442 | 31% | 55% |
| | Silver | 23 | 6.9 | 971 | 2,689 | 79% | 93% |
| | Grand Total | 197 | 8.1 | 485 | 650 | 59% | 69% |
| | | | | | | | |
| Summer | Bevens | 193 | 6.7 | 891 | 1,199 | 78% | 83% |
| | Carver | 192 | 6.5 | 335 | 456 | 40% | 56% |
| | Silver | 53 | 10.7 | 1,168 | 2,019 | 83% | 90% |
| | Grand Total | 438 | 7.3 | 600 | 737 | 67% | 73% |

***** Upper Confidence Interval

**Table 8.3. Wasteload Allocation Calculations for the NPDES point sources discharging treated wastewater to Carver and Bevens Creeks.**

<table>
<tr><th>Facility</th><th>Fecal Coliform Limit (cfu/100 mL)</th><th>Permitted Flow</th><th colspan="2">Conversion Factors</th><th>Wasteload Allocation</th></tr>
<tr><td>Bongards Creamery<br>Daily Average<br>Daily Maximum</td><td rowspan="5">200</td><td>0.756 MGD<br>2.0 MGD</td><td rowspan="5">3,785.41</td><td>1,000</td><td>5.72<br>15.1</td></tr>
<tr><td>Cologne WWTP</td><td>325,000<br>0.325 MGD</td><td rowspan="4"></td><td>2.46</td></tr>
<tr><td>Carver WWTP</td><td>361,000<br>0.361 MDG</td><td>2.73</td></tr>
<tr><td>Norwood Young America WWTP</td><td>908,000<br>0.908 MGD</td><td>6.87</td></tr>
<tr><td>Hamburg WWTP</td><td>651,348<br>0.651 MGD</td><td>4.11</td></tr>
</table>

Units: Fecal Coliform Limit – cfu/100 mL as a monthly geometric mean
MGD – million gallons per day
gpd – gallons per day
Fecal Coliform WLA – $10^9$ cfu per day

**Table 8.4. Wasteload allocations ($10^9$ cfu per day) for Carver and Bevens Creeks.**

| Facility | Carver Creek | Bevens Creek |
|---|---|---|
| Bongards Creamery | 15.1 | |
| Cologne WWTP | 2.46 | |
| Carver WWTP | 2.73 | |
| Norwood Young America WWTP | | 6.87 |
| Hamburg WWTP | | 4.11 |
| TOTAL WLA* | 20 | 11 |

* Numbers rounded to the nearest integer

## 8.2 ALTERNATIVE EXPRESSION OF THE TMDL

To better facilitate implementation, EPA TMDL guidance suggests that alternate expressions of the TMDL can be applied where appropriate. In this case, the TMDL is also represented as a percent reduction across the flow regimes needed to meet the standard (Tables 8.5 and 8.6). Reductions were calculated using the difference between the geomean and the standard. In essence, the reduction represents what is needed so that the geomean meets the standard of 200-

cfu/100 ml.  The margin of safety is the difference between the reduction needed for the upper 95% confidence interval to meet the standard and the reduction needed for the geomean to meet the standard.  For further discussion of the margin of safety, see section 8.4.

**Table 8.5.  Seasonal Fecal Coliform Statistics Utilized in the Development of Percent Reductions and the Associated TMDL for Carver, Bevens, and Silver Creeks in Caver County, Minnesota.**

| | **Watershed** | **N** | **STDEV** | **Geomean (cfu/ 100 ml)** | **UCI (cfu/ 100 ml)** | **% Reduction** | |
|---|---|---|---|---|---|---|---|
| | | | | | | Geomean | *UCI |
| Fall | Bevens | 89 | 7.6 | 1,277 | 1,991 | 84% | 90% |
| | Carver | 94 | 6.4 | 906 | 1,344 | 78% | 85% |
| | Silver | 21 | 7.4 | 926 | 2,283 | 78% | 91% |
| | Grand Total | 204 | 7.0 | 1,055 | 1,397 | 81% | 86% |
| | | | | | | | |
| Spring | Bevens | 90 | 7.4 | 655 | 992 | 69% | 80% |
| | Carver | 84 | 8.0 | 290 | 442 | 31% | 55% |
| | Silver | 23 | 6.9 | 971 | 2,689 | 79% | 93% |
| | Grand Total | 197 | 8.1 | 485 | 650 | 59% | 69% |
| | | | | | | | |
| Summer | Bevens | 193 | 6.7 | 891 | 1,199 | 78% | 83% |
| | Carver | 192 | 6.5 | 335 | 456 | 40% | 56% |
| | Silver | 53 | 10.7 | 1,168 | 2,019 | 83% | 90% |
| | Grand Total | 438 | 7.3 | 600 | 737 | 67% | 73% |

***** Upper Confidence Interval

**Table 8.6.  The TMDL for Fecal Coliform in Carver, Bevens, and Silver Creeks as Represented by a Percent Reduction.**

| **Reach** | **Critical Condition** | **Wasteload Allocation (percent reduction)** | **Load Allocation (percent reduction)** | **Margin of Safety (percent reduction)** | **TMDL (percent reduction)** |
|---|---|---|---|---|---|

| | | | | | |
|---|---|---|---|---|---|
| Carver Creek | Spring | 0% | 31% | 24% | 55% |
| | Summer | 0% | 40% | 16% | 56% |
| | Fall | 0% | 78% | 7% | 85% |
| Bevens Creek | Spring | 0% | 69% | 11% | 80% |
| | Summer | 0% | 78% | 5% | 83% |
| | Fall | 0% | 84% | 6% | 90% |
| Silver Creek | Spring | 0% | 79% | 14% | 93% |
| | Summer | 0% | 83% | 7% | 90% |
| | Fall | 0% | 78% | 13% | 91% |

This expression of the TMDL is provided to help managers responsible for implementing the TMDL. The percent reduction expression is easy to understand and explain to local stakeholders and interested public. Additionally, selection of BMPs can be guided by their known effectiveness and treatment areas within the watershed without complex modeling where the uncertainty in predictions can often present significant obstacles. For example, if changes to manure spreading is expected to decrease export by 50% and runoff from fields is calculated as 50% of the load, we can expect a 25% reduction which can be applied to the TMDL. BMPs can then be chosen to achieve the percent reduction allocation to meet the TMDL. Subsequent monitoring under adaptive management will verify that the predicted reductions were actually achieved.

## 8.3 RATIONALE FOR LOAD AND WASTELOAD ALLOCATIONS

Section 7 documented gross estimates of the fecal coliform contribution from several sources in the watersheds. In contrast, Section 8 evaluates actual water quality data from the streams against the standard in the development of the TMDL, allocations, and percent reductions needed to meet the standard. While estimates of fecal coliform contributions are derived from literature values and knowledge of the land practices, actual fecal coliform data is the result of field monitoring.

Load and wasteload allocations were based on thorough watershed wide monitoring of fecal coliform from April 1 through October 31. This robust data set provided for a thorough seasonal evaluation of loads and consequently the magnitude of the exceedances and reductions needed to meet the standard.

Linkages to sources were developed through a thorough accounting of fecal coliform produced in the watershed and assumptions regarding the potential for these sources to reach surface waters. Based on this accounting, load reductions can be targeted to those sources contributing the greatest amount of fecal coliform under both wet and dry conditions. These linkages provide a framework for targeting source areas that are contributing during both wet and dry conditions.

## 8.4 MARGIN OF SAFETY (MOS)

The margin of safety is established to account for variability and lack of knowledge in the relationship between load and wasteload allocations and water quality. This margin of safety can be established through explicit quantification of variability or through implicit conservative assumptions in the analysis. In this TMDL, both an implicit (conservative assumptions and adaptive management) and explicit (quantified variability around the geometric mean) margin of safety has been utilized.

To be listed as impaired, the geometric mean must exceed the standard of 200 cfu/100 ml. However, there is some uncertainty associated with the estimate of the true geometric mean. This uncertainty can be quantified through the calculation of a confidence interval around the geometric mean. The 95% confidence interval identifies the upper and lower bounds around the geometric mean where we can be 95% confident that the real geometric mean falls. Consequently, by calculating the percent reduction needed for the upper confidence interval to meet the standard, we can be 95% confident that the real geometric mean, following restoration, is below the standard. This results in an explicit Margin of Safety for the TMDL allocation. It is calculated using all existing watershed data to quantify uncertainty in the data. The MOS in the TMDL is essentially the ratio of the geomean of all data to the upper confidence interval of the geomean for all data. For example, in Carver Creek, the spring geomean was 68% of the upper confidence interval. So, the allocation (wasteload and load) was 68% of the load at 200 cfu/100 ml and the MOS was the remaining load. Consequently, the MOS represents the uncertainty in the estimate of the geomean. With this understanding, we determined the explicit Margin of Safety to be the difference between the percent reduction needed for the geometric mean to meet the standard and the percent reduction needed for the upper confidence interval to meet the standard (Table 8.1).

Implicit margins of safety are provided in the TMDLs through the use of the maximum daily flow discharge for Bongards Creamery in calculating the WLA rather than the average daily flow provides an implicit margin of safety for Carver Creek and keeping the summer WLA the same as the spring and fall WLAs for the streams even though discharges from pond facilities are not permitted after June 15 and before September 15.

## 8.5 SEASONAL VARIATION

Seasonal variation was addressed in both the accounting of fecal coliform sources and in the analysis of stream concentration data. Fecal coliform sources potentially available for runoff were varied seasonally to reflect the seasonality of practices in manure application and handling. For example, it was assumed that 20% of surface applied manure was applied (or available) in the spring, 20% in the summer, and 60% in the fall. Additionally, load and wasteload allocations were varied seasonally to reflect changes in stream loads and concentrations among seasons. The winter season is not included because the standard is for April 1 through October 31.

## 8.6 ANNUAL VARIABILITY

To address annual variability in the TMDL, precipitation patterns during the monitoring season were compared to average precipitation patterns for the Twin Cities metropolitan area. Average precipitation is around 29 inches for the Twin Cities metro area (Table 8.7). The majority of the monitoring occurred in 2004 where annual precipitation was 34 inches, slightly higher than normal (Table 8.8). Consequently, the TMDL is conservative since it is based on monitoring during a higher than normal precipitation year where fecal coliform loads would be expected to be higher due to the increased runoff.

**Table 8.7. Average Monthly and Annual Precipitation (Normal 1971-2000) for the Twin Cities Metropolitan Area.**

| Month | Precipitation (Inches) |
|---|---|
| January | 0.04 |
| February | 0.79 |
| March | 1.86 |
| April | 2.31 |
| May | 3.24 |
| June | 4.34 |
| July | 4.04 |
| August | 4.05 |
| September | 2.69 |
| October | 2.11 |
| November | 1.94 |
| December | 1 |
| TOTAL | 29.41 |

Source: State Climatologist – MSP/STP data

**Table 8.8. Precipitation During the Monitoring Years.**

| Month | 2003 Precipitation (Inches) | 2004 Precipitation (Inches) |
|---|---|---|
| January | 0.28 | 0.43 |
| February | 0.71 | 1.27 |
| March | 1.34 | 1.82 |
| April | 2.62 | 2.39 |
| May | 5.04 | 7.5 |
| June | 3.56 | 5.2 |
| July | 2.41 | 4.53 |
| August | 0.92 | 1.99 |

| Month | 2003 Precipitation (Inches) | 2004 Precipitation (Inches) |
|---|---|---|
| September | 2.6 | 5.58 |
| October | 0.76 | 2.33 |
| November | 0.86 | 0.95 |
| December | 0.71 | 0.37 |
| **TOTAL** | 21.81 | 34.36 |

## 8.7 FUTURE GROWTH

The basin population is expected to grow over the next 20 years, with urban areas increasing from 12 to 176% (Table 8.9). This population growth has the potential to increase fecal coliform loads through increased loads to municipal wastewater treatment plants, increased stormwater runoff, and increased number of septic systems. However, this growth will occur with adequate WWTP and/or good septic systems such that fecal coliform will not increase. Municipal WWTP currently represent a small proportion of the watershed loads and are regulated through NPDES permits. Under these permits, WWTP must discharge below the standard of 200 cfu / 100 ml. New septic systems that are functioning properly will not discharge fecal coliform to surface waters. Urban stormwater is currently regulated under the NPDES Phase II construction permit in addition to the Carver County Water Management Rules. These regulations should help mitigate fecal coliform discharges from new housing developments. Changes in the human population should not change the load allocations provided in this TMDL. Consequently no provisions for changes in human population have been identified in this TMDL.

**Table 8.9. Population Growth Estimates for Urban Areas in the Carver and Bevens Creek Watersheds** (Quality of Life Report 2003).

| Watershed | Urban Populations | 2002 | 2010 | 2020 | Percent Change from 2002 thru 2020 |
|---|---|---|---|---|---|
| Carver | Waconia | 6814 | 7600 | 9600 | +40.9% |
| Carver | Cologne | 1012 | 1103 | 1250 | +23.5% |
| Carver | Carver | 1266 | 1600 | 2350 | +85.6% |
| Bevens | NYA | 3108 | 3162 | 4500 | +44.8% |
| Bevens | Hamburg | 538 | 540 | 550 | +2.2% |

The other major source of fecal coliform in the watershed is livestock. No current trends have been identified for animal numbers in the watershed. However, the number of operators in the watersheds has been decreasing and this trend will likely continue as the watershed urbanizes. Livestock facilities and practices are heavily scrutinized and often are permitted. Consequently, changes in animal numbers, practices, or facility size and type, will be associated with permits and mitigation practices to minimize export of fecal coliform. As a result of this close scrutiny, potential increases in fecal coliform from livestock practices in the watershed should be mitigated.  A provision for an increase in livestock in the watersheds is not necessary at this time.

# 9.0 Public Participation

## 9.1 INTRODUCTION

The County has an excellent track record with inclusive participation of its citizens, as evidenced through the public participation in completion of the Carver County Water Management Plan, approved in 2001. The county has utilized stakeholder meetings, citizen surveys, workshops and permanent citizen advisory committees to gather input from the public and help guide implementation activities. The use of this public participation structure will aid in the development of this and other TMDLs in the County.

## 9.2 ADVISORY COMMITTEES

The Water, Environment, & Natural Resource Committee (WENR) is established as a permanent advisory committee. The WENR is operated under the County's standard procedures for advisory committees. WENR works with staff to make recommendations to the County Board on matters relating to watershed planning.

The make-up of the Water, Environment, & Natural Resource Committee (WENR) is as follows:

- 1 County Board Member
- 1 Soil and Water Conservation District Member
- 5 citizens – (1 appointed from each commissioner district)
- 1 City of Chanhassen (appointed by city)
- 1 City of Chaska (appointed by city)
- 1 City of Waconia (appointed by city)
- 1 appointment from all other cities (County Board will appoint)
- 2 township appointments (County Board will appoint– must be on existing township board.)
- 4 other County residents (1 from each physical watershed area – County )

The full WENR committee received updates on the TMDL process from its conception.

As part of the WENR committee, two sub-committees are in place and have held specific discussions on the fecal TMDL. These are the Technical sub-committee and the policy/finance sub-committee. Sub-committee review meetings were held on:
November 10, 2004; December 15, 2004; January 12, 2005

TMDL progress, data results and implementation procedures were presented and analyzed at the WENR meetings mentioned. Committee members comments included ISTS failure rates, percent contribution allocations, target reductions, and implementation plans. All issues commented on were considered in the development of the Draft TMDL.

The Sibley County Water and Resources Advisory Committee is appointed by the County Board of Commissioners and composed of broad based public and private interests. The Advisory committee is made up of county commissioners, citizens and natural resource agency staff. It meets biannually to review the Water Plan implementation and to identify emerging problems, opportunities and issues and serves as the initial body to receive proposed amendments to the county water plan.

Carver County Staff presented the background of the TMDL to the Sibley County Water and Resources Advisory Committee on November 22, 2004. The committee expressed interest in proposed allocation procedures.

## 9.3 STAKEHOLDER/PUBLIC MEETINGS

Carver County, coupled with Sibley County staff, held local area meetings, published news releases, and implemented public mailings to gather public comment on the draft TMDL implementation plan. The following public meetings were held:

**WENR Committee (open to public) January 25, 2005**

The Draft TMDL was presented to the WENR Committee in January 2005 in the format of a power point presentation. Staff explained the results of the TMDL and collected remarks on the data results and implementation plans considered. Comments on the achievability of the State Standards were discussed and considered for future evaluation. Suggestions were made to target implementation efforts in smaller sub-watersheds in order to focus funding and to better gauge effectiveness of implementation efforts.

**Public Open House February 2, 2005**

A public meeting, in the form of an open house, was held on February 2, 2005. The meeting was held in Cologne which is central to the watersheds included in the study. Individual invitations to key stakeholders along with news releases in several local papers announced the date, time and content of the open house. Attendees were accounted for by utilizing registration cards. A total of 36 landowners attended. In addition, two phone calls were received and two landowners visited the County offices in order to receive information on the TMDL. Public were persuaded to communicate opinions on the draft TMDL in person, by email or phone within the comment period ending on February 22$^{nd}$. All comments were recorded, summarized and considered in the development of the draft TMDL.

***Comment Summary:***

Staff persuaded attendees to comment on the data results and implementation plans. Several remarks were made of the allocation of fecal coliform to non-conforming ISTS. Landowners seemed to agree with the results of the TMDL in that ISTS have a high potential to contribute to fecal coliform loading. However, it seems that education on the subject is needed. There were several comments made about BMPs. Some landowners were interested to know how many miles of buffer strips were currently in the project area and what programs they were installed with. It is concluded that landowners whom attended the open house are generally interested in installing BMPs but again, more education is needed. Several comments were made about the suggested implementation plan of targeting small, upstream sub-watersheds with high fecal coliform loading. This plan was welcomed by landowners because effects of BMP installation would be recognized more easily in the smaller sub-watersheds. The overall attitude towards the draft TMDL was very supportive.

**Sibley County Board February 22, 2005**

A motion was made and seconded by Sibley County commissioners on the 22$^{nd}$ of February, 2005 to support the submission of the Draft Bevens Creek Total Maximum Daily Load Study to the Minnesota Pollution Control Agency.

**Carver County Board March 1, 2005**

A motion was made and seconded by the Carver County Board of Commissioners on the 1$^{st}$ of March, 2005 to support the submission of the Draft Fecal Coliform Total Maximum Daily Load Study to the Minnesota Pollution Control Agency.

The Carver County Board of Commissioners had several comments on the Draft TMDL. Remarks were made about the allocations of fecal coliform in regards to wildlife, Canada Geese in particular. It was questioned whether the TMDL accurately assessed Canada geese contributions to the bacteria problem. Next, there were concerns about how Sibley County will be incorporated into the implementation plans due to the dual coverage of Bevens and Silver Creek watersheds. There were also remarks made about what BMPs would be implemented for manure management. Credit was given to the programs already in place in Carver County due to the Water Management Plan. Lastly, commissioners agreed that focusing on small subwatersheds is the best way to implement the TMDL. In addition to these remarks, a county landowner submitted a request to the county board via a written memo. The landowner indicated his thoughts that earthen liquid manure storage basins contribute high levels of bacteria to the creeks studied. The landowner voiced his concern that these basins must be assessed along with other potential bacteria sources in allocating bacteria sources.

Additional public meetings will be held upon approval of the TMDL by the EPA and completion of the TMDL Implementation Plan.

# 10.0 Reasonable Assurance

## 10.1 INTRODUCTION

When establishing a TMDL, reasonable assurances must be provided demonstrating the ability to reach and maintain water quality endpoints. Several factors control reasonable assurances including a thorough knowledge of the ability to implement BMPs, the state and local authority to implement, as well as the overall effectiveness of the BMPs. Carver County is positioned to implement the TMDL and ultimately achieve water quality standards.

## 10.2 MANAGEMENT OF BEVENS, CARVER, AND SILVER CREEK WATERSHEDS

Carver County is the water management authority for Carver Creek and its portion of Bevens and Silver Creek. The County is uniquely qualified through its zoning and land use powers to implement corrective actions to achieve TMDL goals. The County has stable funding for water management each year, and will continue its baseline-monitoring program. Carver County recognizes the importance of the natural resources within its boundaries, and seeks to manage those resources to attain the following goals:

1. Protect, preserve, and manage natural surface and groundwater storage and retention systems;
2. Effectively and efficiently manage public capital expenditures needed to correct flooding and water quality problems;
3. Identify and plan for means to effectively protect and improve surface and groundwater quality;
4. Establish more uniform local policies and official controls for surface and groundwater management;
5. Prevent erosion of soil into surface water systems;
6. Promote groundwater recharge;
7. Protect and enhance fish and wildlife habitat and water recreational facilities; and
8. Secure the other benefits associated with the proper management of surface and ground water.

The Carver County Board of Commissioners (County Board), acting as the water management authority for the former Bevens Creek (includes Silver Creek), Carver Creek, Chaska Creek, Hazeltine-Bavaria Creek, and South Fork Crow River watershed management organization areas, has established the “Carver County Water Resource Management Area”. The purpose of establishing the CCWRMA is to fulfill the County’s water management responsibilities under Minnesota Statue and Rule. The County chose this structure because it will provide a framework for water resource management as follows:

- Provides a sufficient economic base to operate a viable program;
- Avoids duplication of effort by government agencies;
- Avoids creation of a new bureaucracy by integrating water management into existing County departments and related agencies;
- Establishes a framework for cooperation and coordination of water management efforts among all of the affected governments, agencies, and other interested parties; and
- Establishes consistent water resource management goals and standards for at least 80% of the county.

The County Board is the "governing body" of the CCWRMA for surface water management and the entire county for groundwater management. In function and responsibility the County Board is essentially equivalent to a joint powers board or a watershed district board of managers.

Water management is an interdisciplinary effort and involves several County departments and associated County agencies including: Planning and Zoning, Environmental Services, County Extension and the Carver SWCD. The County Planning & Zoning Department is responsible for administration of the water plan and coordinating implementation. Other departments and agencies will be called upon to perform water management duties that fall within their area of responsibility. These responsibilities may change as the need arises. The key entities (Planning and Zoning, Environmental Services, County Extension and the SWCD) meet regularly as part of the Joint Agency Meeting (JAM) process to coordinate priorities, activities, and funding.

Carver County has established a stable source of funding through a watershed levy in the CCWRMA taxing district (adopted 2001). This levy allows for consistent funding for staff, monitoring, engineering costs and also for on the ground projects. The County has also been very successful in obtaining grant funding from local, state and federal sources due to its organizational structure. Sibley County has been the recipient of several state and federal grants as well.

Within one year of the approval of the Bacteria TMDL by the EPA, a Final Implementation Plan will be released. This Implementation Plan charts the course Carver County will take to incorporate TMDL results into local management activities as well as the Carver County Water Management Plan. The ultimate goal of the Implementation Plan is to achieve the identified load reductions in Carver, Bevens, and Silver Creeks needed to reach the State Standard for fecal coliform.

## 10.3 REGULATORY APPROACHES

### 10.3.1 Watershed Rules

Water Rules establish standards and specifications for the common elements relating to watershed resource management including: Water Quantity, Water Quality, Natural Resource Protection, Erosion and Sediment Control, Wetland Protection, Shoreland Management, and Floodplain Management. Of particular benefit to Fecal TMDL reduction strategies are the stormwater management and infiltration standards which are required of new development in the CCWRMA. The complete water management rules are contained in the Carver County Code, Section 153.

### 10.3.2 NPDES MS4 Stormwater Permits

The Stormwater Program for MS4s is designed to reduce the amount of sediment and pollution that enters surface and ground water from storm sewer systems to the maximum extent practicable. Stormwater discharges associated with MS4s are regulated through the use of National Pollutant Discharge Elimination System (NPDES) permits. NPDES permits are legal documents. Through this permit, the owner or operator is required to develop a stormwater pollution prevention program (SWPPP) that incorporates best management practices (BMPs) applicable to their MS4.

Under the stormwater program, MS4s are required to develop and implement a Stormwater Pollution Prevention Program (SWPPP). The SWPPP must cover six minimum control measures:

- Public education and outreach;
- Public participation/involvement;
- Illicit discharge, detection and elimination;
- Construction site runoff control;
- Post-construction site runoff control; and
- Pollution prevention/good housekeeping.

The MS4 must identify best management practices (BMPs) and measurable goals associated with each minimum control measure. An annual report on the implementation of the SWPPP must be submitted each year. Annual reports are to be submitted to:
MPCA
Stormwater Management Unit
Municipal Division
520 Lafayette Rd. N
St Paul, MN. 55155-4194

More information about the Phase II Storm Water Program can be found at EPA's Web site:
*http://www.epa.gov/owm/sw/phase2/index.htm*

The City of Waconia is the only municipality currently designated for NPDES Phase II MS4 permit coverage in the Carver County Bacterial TMDL. The City of Waconia has not been issued a MS4 permit Id number because their application for their NPDES Phase II MS4 permit is not due at the MPCA until February 15, 2007.

Additionally, stormwater permits for construction sites greater than one acre and any industrial site on EPA's list of mandatory industrial facilities, per the Standard industrial code, are required.

### 10.3.3 MPCA Permits

The MPCA issues NPDES permits for any discharge into waters of the state. Cologne and Carver Wastewater Treatment Plants, and Bongard's Creamery, located in the Carver Creek watershed, and Norwood/Young America and Hamburg Wastewater Treatment Plants, located in Bevens Creek, are permitted by the MPCA. These permits have both general and specific limits on pollutants that are based on water quality standards. Permits regulate discharges with the goals of 1) protecting public health and aquatic life, and 2) assuring that every facility treats wastewater. More information about permits, water quality data and other MPCA programs can be found on the agency's Web site; *http://www.pca.state.mn.us/water*

### 10.3.4 Feedlot Permitting

The County feedlot Management Program includes the feedlot permitting process. The permit process ensures that the feedlot meets State pollution control standards and locally adopted standards. The County has had a locally operated permitting process under delegation from the MPCA since 1980. The County adopted a Feedlot Ordinance in 1996. The Feedlot Ordinance incorporates State standards plus additional standards and procedures deemed necessary to appropriately manage feedlots in Carver County.

Most feedlots in Carver County and the State are not required to have an ongoing operating permit. All feedlots of 10 animal units or more in the Shoreland Zoned area and 50 animal units or more outside of the Shoreland area must by registered with the MN Pollution Control Agency. The information collected states who owns the feedlot, the location of the feedlot and the type and number of animals. This information must be updated every four years. Carver County requires all feedlots of 10 animal units or more to be registered. Over 400 feedlots have completed this process. We believe this process has identified the vast majority of feedlots in the County.

Feedlots that make substantial changes in animal numbers or manure management must obtain permits before making changes. Carver County manages this process according to State regulations via a Delegation Agreement with the MPCA. About 10 feedlots per year receive construction related permits for construction of new buildings or manure management improvements.

The County also requires feedlots of 10 animal units or more in the Shoreland, feedlots of 300 animal units or more in the eastern part of the County, and feedlots of 600 animal units or more in the western part of the County to obtain Conditional Use Permits. These permits cover feedlot activities in sensitive areas and those of larger feedlots. About 15 of the 84 feedlots [80 in Shoreland, 4 larger operations not in Shoreland] that fall in these categories have CUPs. The others are brought into the CUP process when they expand or make other changes in their operations. Most of these operations have not made recent changes and have not been required to complete the CUP process.

No feedlots have yet been required to obtain the Federal NPDES Confined Animal Feeding Operation permit. No Carver County Feedlots have been identified that meet the criteria for these permits. These are typically feedlots of over 1,000 animal units.

More information on the County Feedlot Management Program can be found in the Carver County Water Management Plan 2001 or on the County's Web site:
*http://www.co.carver.mn.us/water/wmp.asp*

### 10.3.5 County ISTS Ordinance

The ISTS ordinance regulates the design, location, installation, construction, alteration, extension, repair, and maintenance of ISTSs. The County currently enforces the ordinance in the unincorporated area; cities are responsible in their jurisdiction. The law gives responsibility throughout the county unless a city specifically develops and implements its own program and ISTS ordinance. Although this ordinance is currently voluntary it may be enforced upon approval of the Implementation Plan.

## 10.4 NON-REGULATORY AND INCENTIVE BASED APPROACHES

### 10.4.1 Education

The implementation of this plan relies on three overall categories of activities: 1) Regulation, 2) Incentives, and 3) Education. For most issues, all three means must be part of an implementation program. The County has taken the approach that regulation is only a supplement to a strong education and incentive based program to create an environment of low risk. Understanding the risk through education can go a long way in preventing problems. In addition, education, in many cases, can be a simpler, less costly and more community friendly way of achieving goals and policies. Education efforts can provide the framework for more of a "grass roots", community plan implementation, while regulation and incentives traditionally follow a more "top-down" approach. It is recognized however, that education by itself will not always meet intended goals, has certain limitations, and is characteristically more of a long-term approach.

To this end, Carver County created the Environmental Education Coordinator position in 2000. This position has principal responsibility for development and implementation of the water education workplan.

Several issues associated with the water plan were identified as having a higher priority for education efforts. These were identified through discussions with the advisory committees, ease of immediate implementation and knowledge of current problem areas and existing programs. The higher priority objectives are not organized in any particular order. The approach to implement the fecal TMDL will mimic the education strategy of the water plan. Each source reduction strategy will each need an educational component and will be prioritized based on number of landowners, type of source, and coordination with existing programs.

### 10.4.2 Incentives

Many of the existing programs, on which the water management plan relies, are incentive based programs offered through the County and the Carver & Sibley SWCDs. Some examples include state and federal cost share funds directed at conservation tillage, crop nutrient management, rock inlets, conservation buffers, and low interest loan programs for ISTS upgrades. Reducing fecal sources will need to rely on a similar strategy of incorporating incentives into implementing practices on the ground. After the approval of the TMDL by the EPA and the County enters the implementation phase it is anticipated that we will apply for moneys to assist landowners in the application of BMPs identified in the Implementation Plan.

## 10.5 EFFICACY OF BEST MANAGEMENT PRACTICES

The source reduction strategies listed in section 11.0 (Implementation) have been shown to be successful in reducing fecal coliform transport and survival. Many of the mentioned strategies are already adopted by the County Water Management Plan. However, after the approval of the Draft TMDL, additional funding will enable the strategies to be aggressively approached.

**Individual Sewage Treatment Systems-** ISTS with correct drain fields provide virtually complete treatment of fecal coliform bacteria. Acceptable designs for ISTS are described in Minn. R. ch. 7020. The County ISTS Ordinance regulates the design, location, installation, construction, alteration, extension, repair, and maintenance of ISTSs. Carver County is entrusted to implement these rules, which require conformance with state standards for new construction and disclosure of the state of the ISTS when property transfers ownership.

**Feedlots-** When feedlots are managed properly, the quality of surface water and groundwater will not be impaired. Feedlots in the County must obtain a permit as required by the County Ordinance and will be operated and managed according to the Ordinance and current best management practices. Runoff controls are evaluated by professional engineers through the Feedlot Evaluation Model referenced in Minn. R. ch 7080. These rules are implemented by MPCA, SWCD and county staff.

**Rural Practices-** Carver County and Carver SWCD promote a Core-4 approach, developed by the Conservation Technology Information Center (CITC) and its agricultural partners, to farmers including 1) Conservation Tillage; 2) Crop Nutrient Management; 3) Insect, Weed and Disease Management; and 4) Conservation Buffers. Core-4 benefits both crop production and natural resource conservation. These methods are practical and when planned and applied properly reduce runoff and soil erosion, improve water quality and reduce risk of potential pollution. State feedlot rules (Minn. R. ch 7020) require manure application record-keeping and manure management planning with the exact requirements differing according to size of operation and pollution risk of application, based on method, time and place of application.

**Stormwater Management-** Practices such as runoff detention, infiltration, and street sweeping have been shown to be effective in reducing urban runoff and associated pollutants. Communities in the watershed are required to have a Local Stormwater Management Plan and to meet County Water Management Rules, which are being amended to mirror NPDES Phase II construction permit requirements, all of which address treatment of stormwater runoff.

**Follow-Up Monitoring-** The goals of the monitoring plan are to assess the success of the implementation strategies for attaining water quality standards and designated uses. Bevens, Carver and Silver Creeks will remain on the 303(d) list until the standards for fecal coliform are met. Fecal coliform sampling will be on-going and similar to that of the 2004 monitoring season. Fecal coliform samples along with field duplicates and blanks, for quality control, will be measured bi-weekly from April 1 to October 31. However, the exact sites and schedule will be determined upon implementation of BMPs. The mentioned sampling frequency will allow for estimates of the effectiveness of implementation activities at the sub watershed level and allow for adaptive management. Annual results will be included in the Carver County annual Water Quality Report.

Goals for Carver, Bevens and Silver Creeks are documented in the Water Plan as outlined below.

***Bevens Creek Watershed (Includes Silver)***

- Maintain baseline water quality data for the lakes in the watershed and conduct extended monitoring for future TMDLs.
- Maintain current monitoring regimes for fecal coliform. Schedule to be determined after implementation of BMPs.
- Maintain and evaluate the Tacoma Stream sampling site, former SWCD sites, and ensure the Met Council sites are not abandoned.
- Maintain bio-monitoring data at sampling sites and other stream sites if more data is needed.

***Carver Creek Watershed***

- Maintain baseline water quality data for the lakes in the watershed and conduct extended monitoring for future TMDLs.
- Maintain current monitoring regimes for fecal coliform. Schedule to be determined after implementation of BMPs.
- Maintain the Carver County sites near Miller Lake, the Met Council site at the mouth of Carver Creek and the MDA site near Waconia.
- Maintain bio-monitoring data at sampling sites and other stream sites if more data is needed.

# 11.0 Implementation

## 11.1 INTRODUCTION

Carver County, through their Water Management Plan, has embraced a watershed wide goal for protecting water quality in the Carver, Bevens, and Silver Creek watersheds. Currently, Carver County has developed detailed action strategies to address several of the issues identified in this TMDL. The Carver Soil and Water Conservation District (SWCD) is active in these watersheds and works with landowners to implement best management practices on their land. This Implementation Plan charts the course Carver County will take to incorporate TMDL results into local management activities as well as the Carver County Water Management Plan. The ultimate goal of the Implementation Plan is to achieve the identified load reductions in Carver, Bevens, and Silver Creeks needed to reach the State Standard for fecal coliform.

For portions of the Bevens and Silver Creek watersheds existing in Sibley County, Carver County will work closely with Sibley County to integrate the TMDL implementation plans into the Sibley County local management activities as well as the Sibley County Comprehensive Water Management Plan.

## 11.2 THE CARVER COUNTY WATER MANAGEMENT PLAN

To respond to County established goals for Natural Resource Management, the Carver County Water Management Plan describes the set of issues requiring implementation action. MN Rule 8410 describes a list of required plan elements. Carver County has determined the following issues, bulleted below, to be of higher priority. Items not covered in this plan will be addressed as necessary to accomplish the higher priority goals. Each issue is summarized in the Carver County Water Management Plan followed by background information, a specific goal, and implementation steps. The issues included in the plan which addresses fecal coliform TMDL sources and reductions are:

- ISTS
- Feedlots
- Stormwater Management
- Land Use Practices for Rural & Urban Areas
- Water Quality

## 11.3 SIBLEY COUNTY WATER MANAGEMENT PLAN

The Sibley County Comprehensive local water plan covers existing water and related land uses, water resource issues, problems and a plan of action to promote sound management of water and related land resources, effective environmental protection and efficient management. The plan was written in accordance with Minnesota Stature 103B. Items not covered in this plan will be addressed as necessary to accomplish the higher priority goals set forth by the TMDL results. Some key issues identified include:

- ISTS
- Feedlots
- groundwater
- Municipal sanitary sewer systems
- Urban practices affecting water resources

## 11.4 SOURCE REDUCTION STRATEGIES

Carver County has embraced a watershed-wide goal of achieving water quality standards for fecal coliform bacteria. The final implementation plan will be developed within a year of the final approval of the TMDL report by the EPA. It will list what and where BMPs will be applied in each watershed and identify the cost and funding sources for their application. To reach the reduction goals Carver County will rely largely on its current Water Management Plan, which identifies the Carver SWCD as the local agency for implementing best management practices. Implementation goals not covered in the Water Management Plan will be identified and amended to the implementation plan.

The implementation under consideration will focus on high contributing sub watersheds. The strategy of our sampling design was to divide the study area into sub watersheds in an attempt to determine the locations of large discharges of water and pollutants. The watersheds become 27 sub watersheds ranging in drainage size from over 13,000 acres to under 50 acres. This process enabled us to identify high contributing sub-watersheds. Before the development of the final Implementation Plan, we will prioritize the sub watersheds which we will target first. Prioritization of sub-watersheds will also consider TMDLs completed for specific lakes in the watersheds, the size of the sub-watersheds, the amount of funding available, and future TMDL analysis and water quality monitoring.

As stated above, the County will rely largely on its current Water Management Plan for implementing best management practices. The following is a list of the best management practices as outlined by the Carver County Water Management Plan.

### 11.4.1 ISTS

Based on the results of the TMDL, ISTS contribute over 60 percent of fecal coliform loads during dry weather conditions. Addressing these risks will be a priority to ensure the waters will meet water quality standards. By meeting the goals set forth by the County Water Management

Plan, fecal coliform load contributions, from nonpoint sources, will be eliminated during wet weather conditions.
*Goals:*

- *Elimination of all non-conforming systems that are or are likely to become a pollution or health hazard. Systems directly discharging to surface water are considered crucial systems and all reasonable, feasible means will be used to eliminate them.*
- *Ensure that all ISTS repairs, replacements, and new systems are properly designed and installed.*
- *Ensure that all ISTS are properly managed, operated and maintained.*

### 11.4.2 Feedlots

Feedlots without runoff controls are demonstrated to contribute to fecal coliform loading during wet conditions. Surface water concerns include: contamination by open lot runoff into a water body, ditch or open tile inlet. In order to address this pollution, the County will rely on goals and policies set fourth in the County Water Management Plan. Properly managed feedlots will assist in meeting fecal coliform standards during wet conditions.
*Goals:*

- *Feedlots must be managed so that the quality of surface water and groundwater is not impaired.*
- *Utilize existing regulations and rules (County Feedlot Management Ordinance Chapter 54, and MPCA Rule-Chapter 7020) to ensure compliance.*

### 11.4.3 Rural Practices

Rural practices such as manure application, both surface applied and incorporated contribute to fecal coliform loading during wet conditions. Surface applied manure is proven to contribute the largest portions during the mentioned conditions. The Counties along with the Carver and Sibley SWCDs will work to ensure that core practices explained in the Water Management Plan are applied. The practices include: Conservation Tillage, Crop Nutrient Management and Conservation Buffers. The application of these BMPs will aid in meeting water quality standards.
*Goal:*

- *Promote water resource protection in the county and encourage public and private landowners to implement conservation practices, through educational programs on watershed management and urban and rural landowner practices that support water quality and water quantity improvements.*

### 11.4.4 Stormwater Management

The current land use of the Carver and Bevens/Silver Creek watersheds is primarily non-urban. Consequently, urban stormwater is currently a small proportion of fecal coliform loads in the watersheds. However, the rapid growth of the County will raise the potential for urban runoff contributing to fecal loads. The requirements set forth in the County Water Management Plan and rules along with NPDES Phase II should ensure that anticipated increases in urban stormwater runoff do not contribute to fecal coliform loading.

*Goal:*

- *Attenuate stormwater and minimize degradation of Carver County's water resources through reducing the amount and rate of surface water runoff from agricultural and urban land uses.*

# *Memorandum*

1800 Pioneer Creek Center, Maple Plain, MN 55359
Phone: 763-479-4200 Fax: 763-479-4242

**Wenck**

***To:*** Joe Bischoff
Kent Torve, P.E.

***From:*** Rebecca Kluckhohn, P.E.

***Date:*** December 10, 2004

***Subject:*** Carver County TMDL Hydrology

---

This memo documents the technical evaluation of hydrology for the Carver County TMDL. These analyses are described in the sections below.

**HYDROLOGY:**

In order to construct load duration curves for outlets of Carver Creek, Bevens Creek, and Silver Creek, a complete flow record is required. The only complete flow record for period of interest is the downstream-most site on Bevens Creek, BE 2.0. For this site, average daily flow records are provided. There are gaps in the flow records for an upstream site on Bevens Creek, BE 5.0, and sites on Carver Creek and Silver Creek.

To fill in these data gaps, existing flow data for BE 2.0 was evaluated. Known average daily flows from BE 5.0, SI 2.0 and CA 1.7 were compared to concurrent average daily flows from BE 2.0. Once the relationship was established, missing flow data could be filled in using that relationship. This section summarizes the method used for each site.

The average daily flows used were furnished through the Metropolitan Council WOMP stations. The flow records were constructed using stage readings collected continuously, and a stage discharge relationship. Based on analysis of the existing data, the rating curves used for these sites are not the standard accepted power functions, instead, they are high-order polynomial best-fit curves. While not hydraulically appropriate, they do provide a fit to measured data.

It is important to note that these relationships should not be used to estimate flows outside the measured range of data because they tend to greatly overestimate high flows, and may over or underestimate low flows depending on the function used. They even yield negative flows, which (if they exist) cannot generally be predicted in this manner.

The table below compares the range of measured discrete flows to the range of average daily flows generated using these curves. The number of average daily flows that are outside of the range are small, however, it would be more appropriate to quantify the number of readings in the continuous flow record.

*Table 1: Measured Flow Values Used in Met Council Rating Curves Compared to Average Daily Flows in Flow Record*

| Site ID | Range of Measured Values used to Establish Rating Curve | Range of Flows in Flow Record | Number of Average Daily Flows Outside the Range of the Rating Curve |
|---|---|---|---|
| **BE 2.0** | 2 to 1371 cfs | -0.9 to **1564** cfs | 1 |
| **BE 5.0** | 0 to 640 cfs | 0 to **824** cfs | 5 |
| **CA 1.7** | Not provided | 0.5 to 349 cfs | Unknown |

**Carver Creek, CA 1.7** The flow record for this site was missing from October 2003 on due to bridge reconstruction. To reconstruct the missing flow record, average daily flows from this site (generated using stage readings and a stage-discharge relationship) were compared to concurrent flows on Beavens Creek at BE 2.0 (Figure 1). In a log-log graph, the power function trendline yielded the best description of the relationship of the data pairs for cases when flow at BE 2.0 was less than 300 cfs (R-squared=0.87, n=1,216). The relationship when flow is over 300 cfs at BE 2.0 is shown using a different trendline for data in that range (R-squared=0.13, n=138).

***Figure 1: Regression of Concurrent Average Daily Flows for BE 2.0 and CA 1.7 (Data Collected 1997 to 2004)***

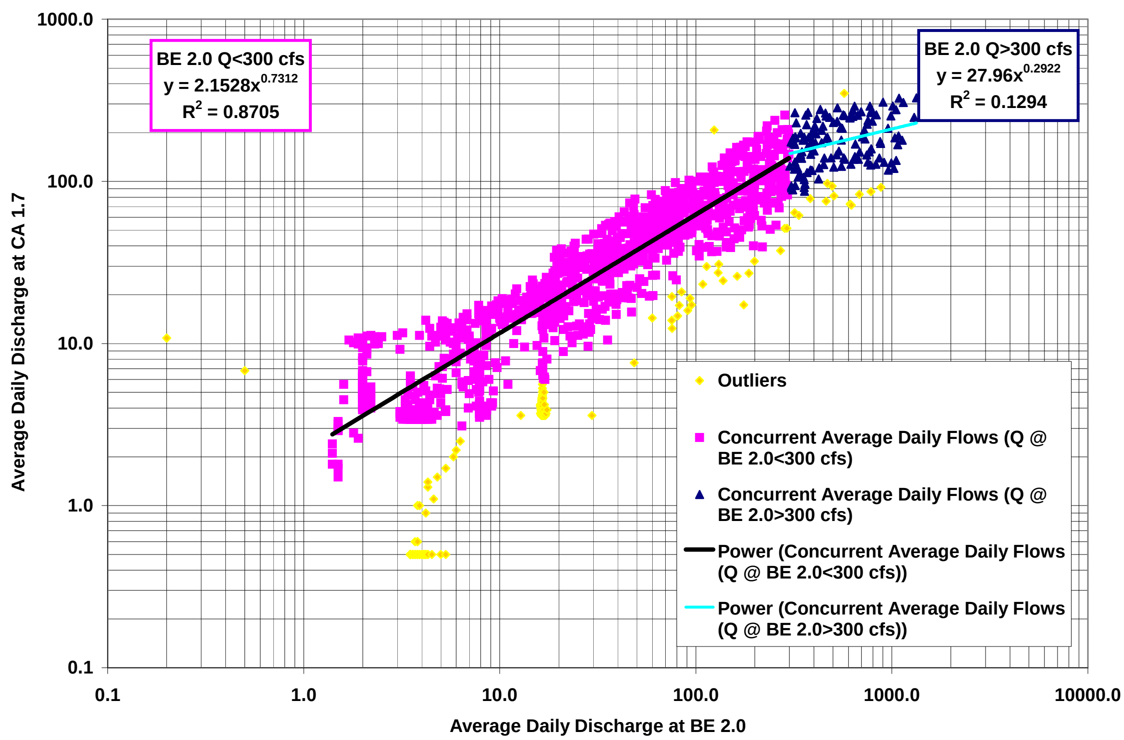
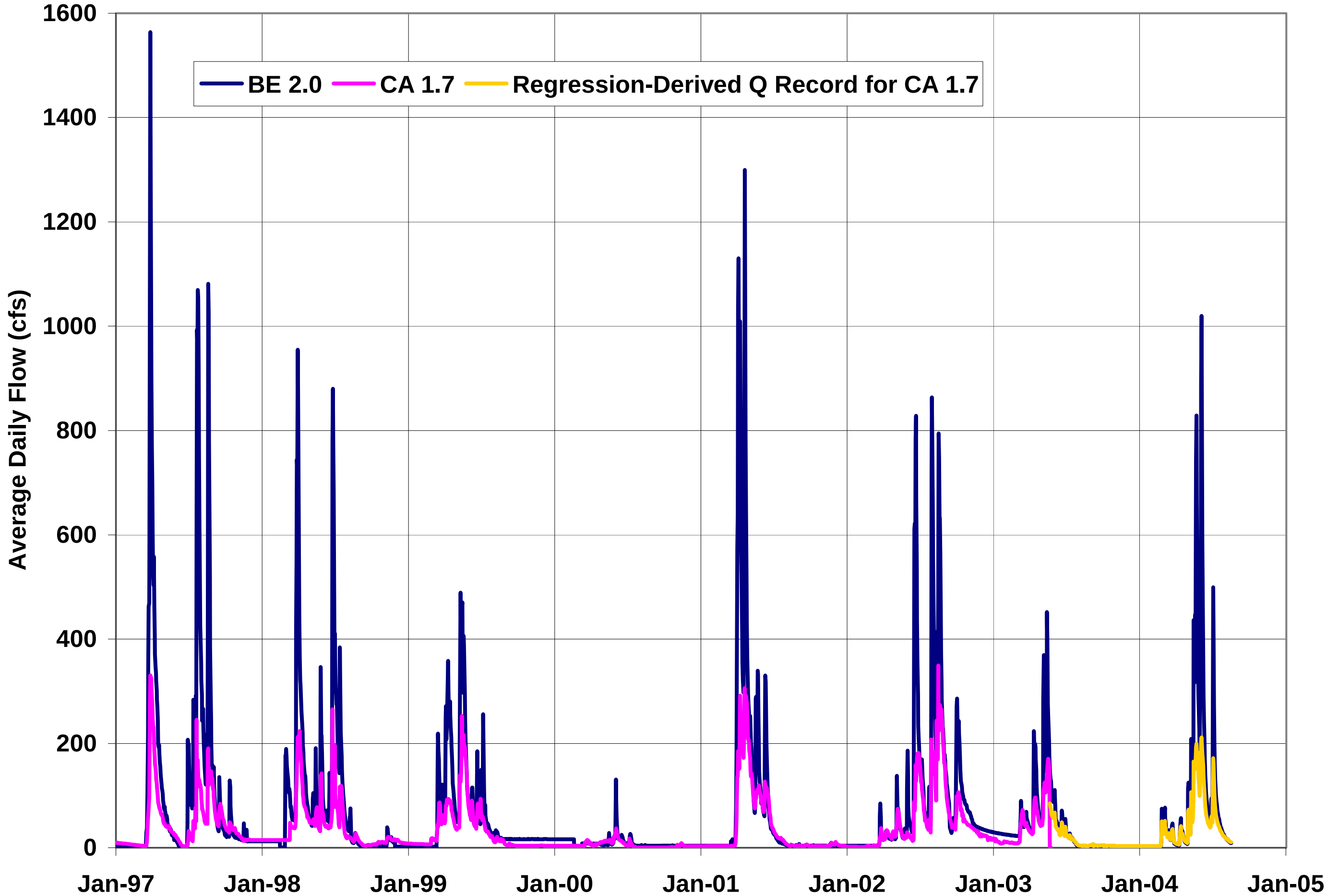


***Figure 2: Complete CA 1.7 Flow Record resulting from Regression of Concurrent Average Daily Flows for BE 2.0 and CA 1.7***




**<u>Bevens Creek, BE 5.0</u>** is located upstream of BE 2.0. Data for this station was missing prior to 2001. To complete the flow record, average daily flows from this site were compared to concurrent flows on Bevens Creek at BE 2.0. In a log-log graph, the power function trendline yielded the best description of the relationship of data where flow at BE 2.0 was below 20 cfs (R-squared=0.84, n=112). The relationship when flow at BE 2.0 is greater than 20 cfs is shown using a different power function trendline for data in that range (R-squared=0.98, n=557).

The 2004 data was not used in the regression. In the files provided, it was noted that this data was preliminary. Based on graphical analysis, it appeared that this data was off-set (an over-estimation of flow) and will need to be revisited before it is finalized.

*Figure 3: Regression of Concurrent Average Daily Flows for BE 2.0 and BE 5.0 (Data Collected 2001 to 2003)*

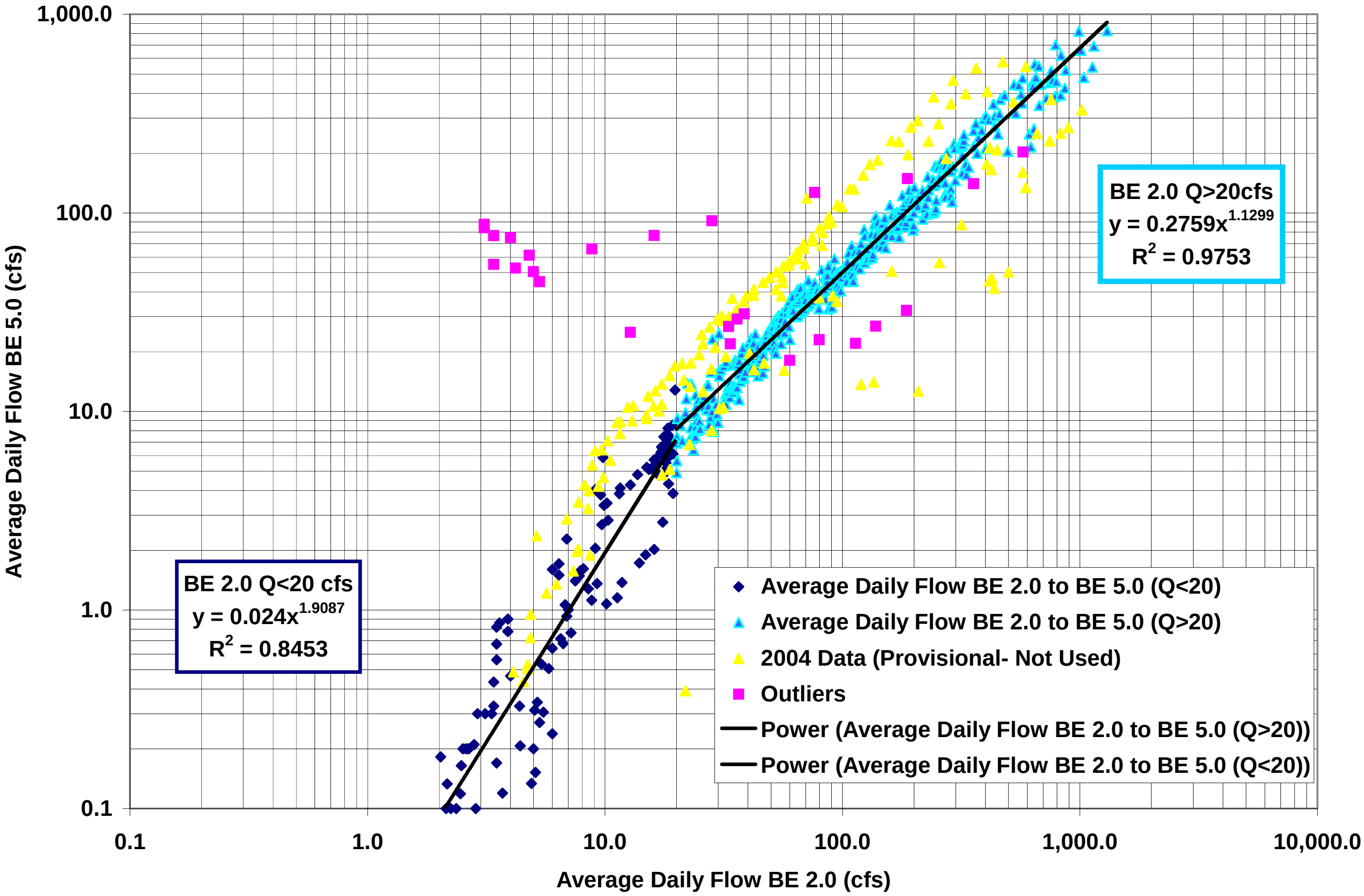
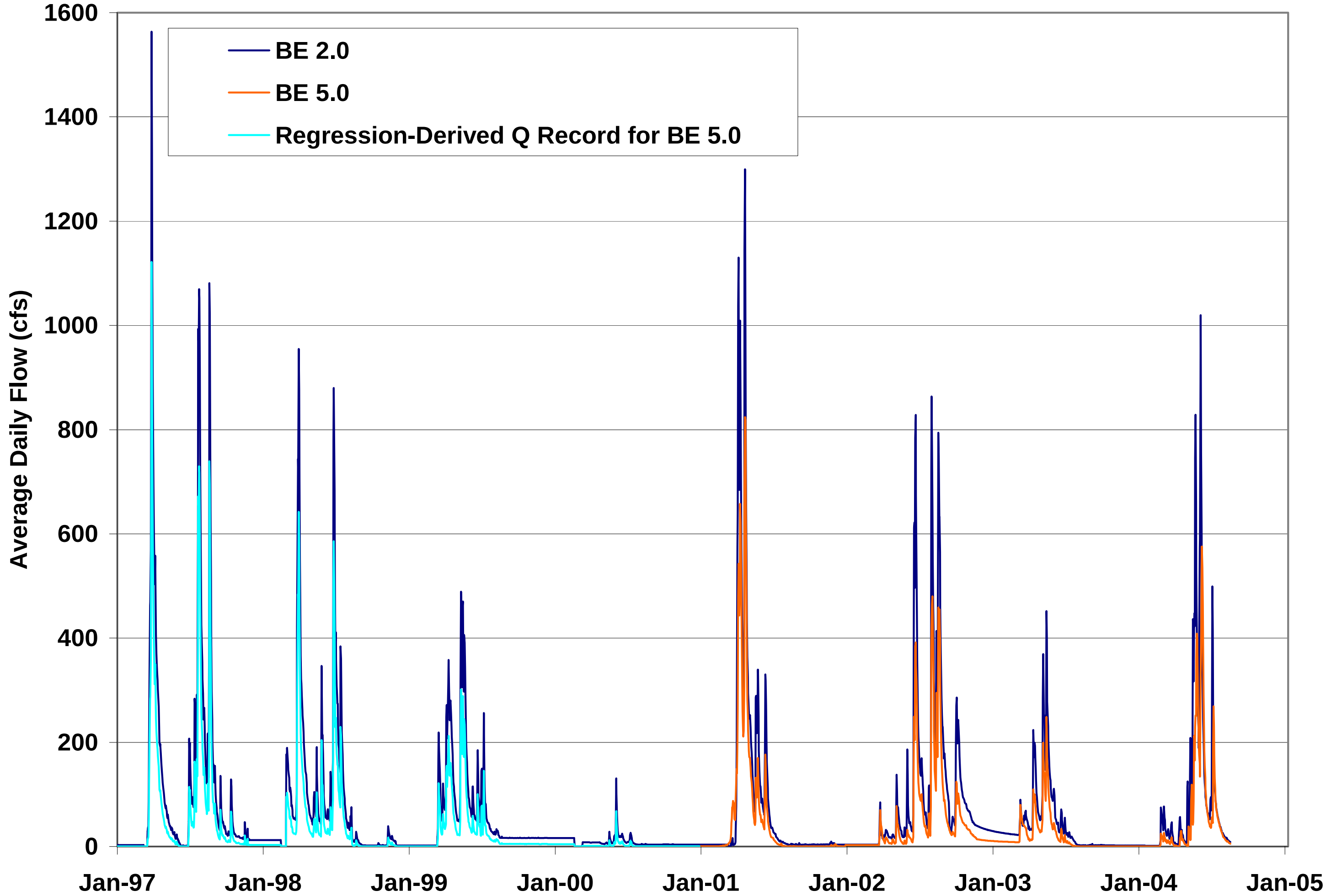


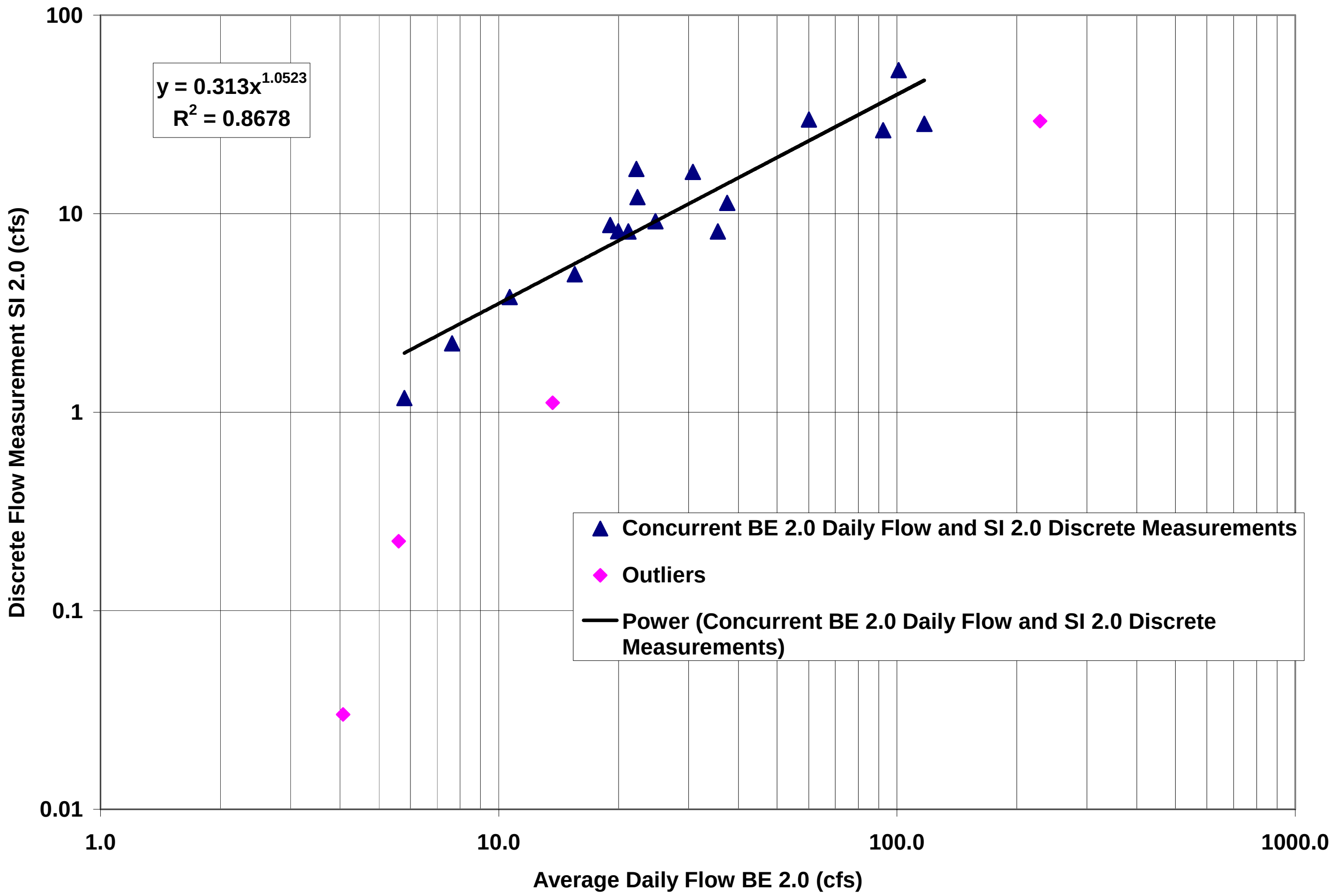
***Figure 4: Complete BE 5.0 Flow Record resulting from Regression of Concurrent Average Daily Flows for BE 2.0 and BE 5.0***




**Silver Creek, SI 2.0** Data for this station consisted of 21 manual flow measurements. To complete the flow record, measured flows from this site were compared to concurrent average daily flows on Beavens Creek at BE 2.0.

In a log-log graph (Figure 5), the power function trendline yielded the best description of the relationship for values of flow at BE 2.0 below 100 cfs (R-squared=0.87, n=17, 3 were outliers).

***Figure 6: Regression of Concurrent Average Daily Flows for BE 2.0 and Discrete Measured Flows at SI 2.0 (Data Collected 2000 to 2001)***

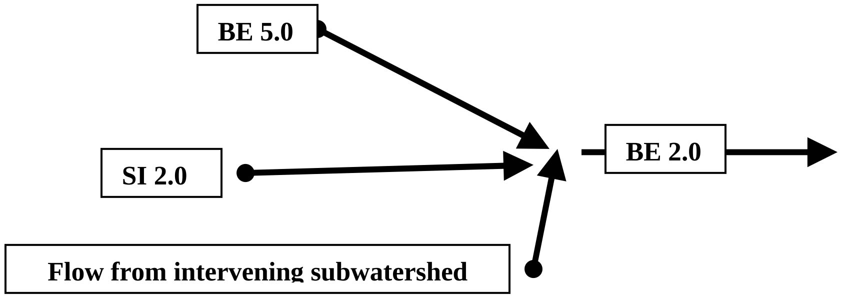



It is critical to note that the range of flows over which this relationship is applicable is limited to 0 to 100 cfs. Since large parts of BE 2.0 flow record are higher than 100 cfs, a different approach was needed to estimate flows in SI 2.0 when flow in BE 2.0 exceeded 100 cfs. To understand that approach, it is important to understand the location of the stations with respect to each other. BE 2.0 is downstream of both BE 5.0 and SI 2.0.

So, the flow at BE 2.0 is equal to the flow at BE 5.0, plus the flow at SI 2.0, plus the flow from the intervening watershed (which is about 20% of the entire area of SI 2.0 plus the intervening area). Assuming runoff form the watershed is uniform over the area, by definition:

When flow at BE 2.0 >100 cfs, Flow at SI 2.0 is estimated by the following equation:

$$Q_{SI\ 2.0} = .80*[Q_{BE\ 2.0} - Q_{BE\ 5.0}]$$




This relationship doesn't work for the values in 2004, since as discussed in the previous section, the 2004 data for BE 5.0 is offset (it is higher than it should be as evident in Figure 3). To generate the 2004 flow record, a second regression was conducted using the average daily flows at BE 2.0 over 100 cfs and the corresponding flows generated for SI 2.0 using the above referenced method (Figure 7).

***Figure 7: Regression of Concurrent Average Daily Flows for BE 2.0 and Generated SI 2.0 Average Daily Flows (Generated data for SI 2.0, BE 2.0 data >100 cfs)***

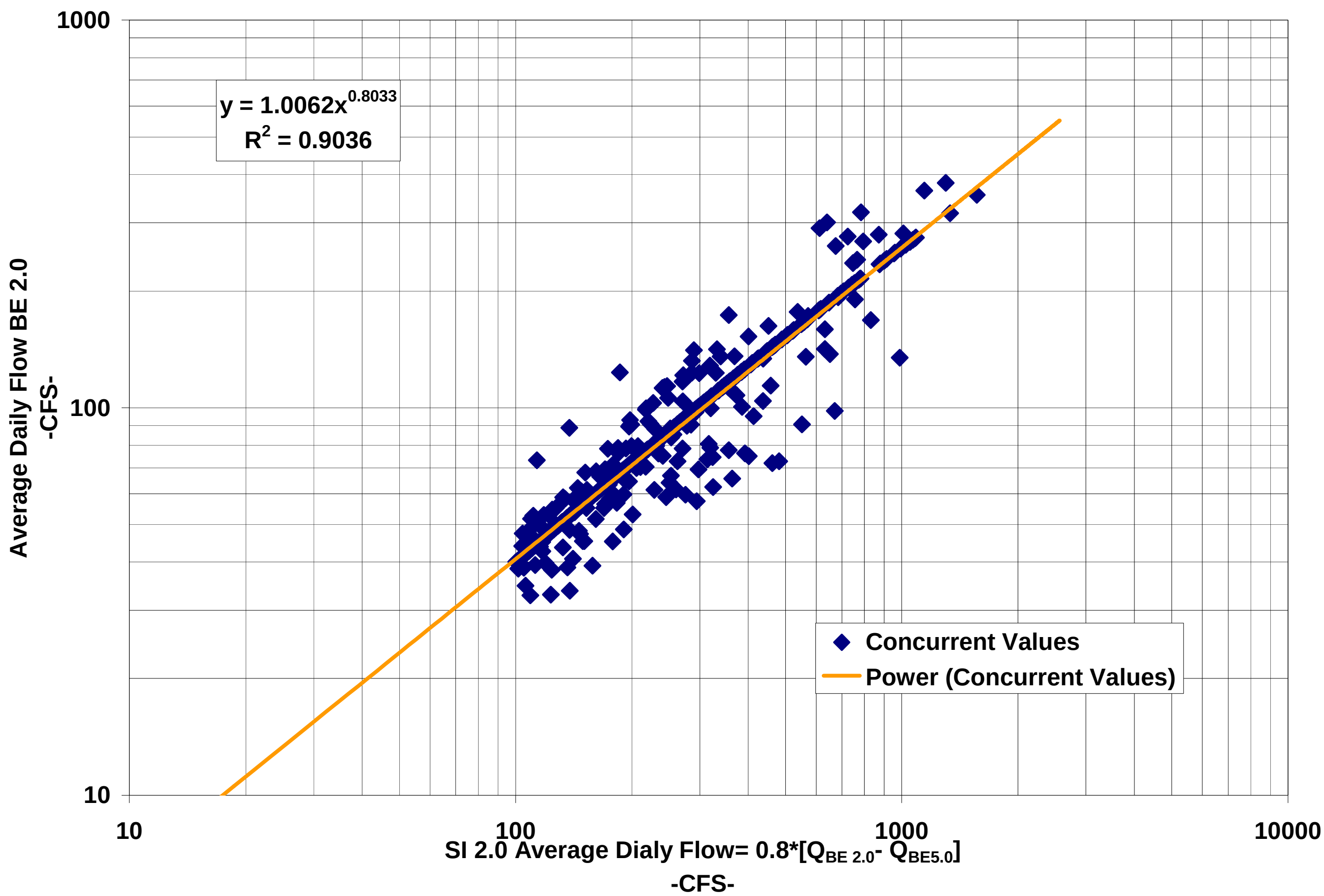


*Figure 8: Complete SI 2.0 Flow Record Resulting from Regression Analyses*

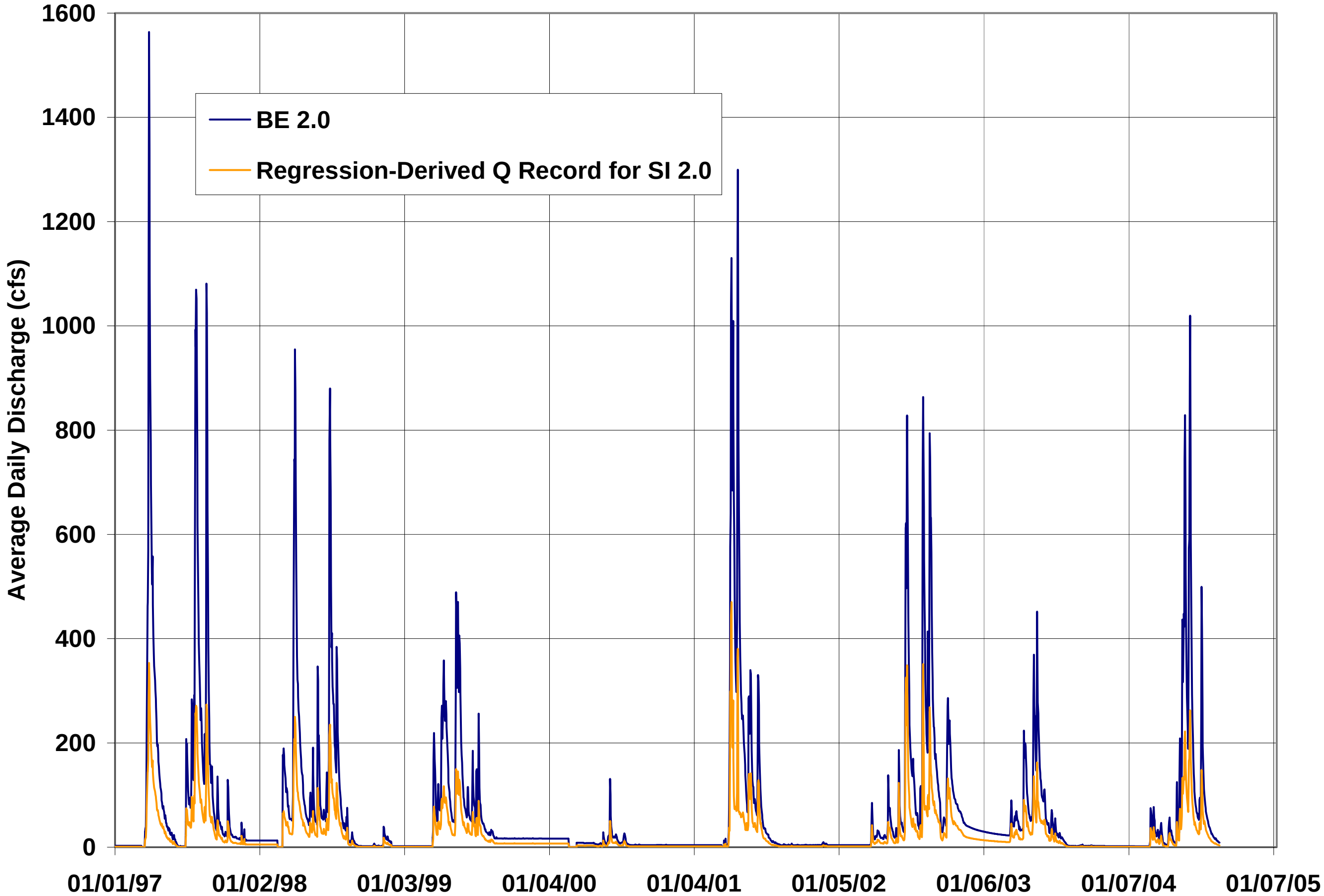



*Table 2. SI2.0 Flow Record Estimation Formulas*

| Criteria | SI 2.0 Flow Record Estimation |
| --- | --- |
| When Q at BE 2.0< 100 cfs | $Q_{SI\ 2.0}=0.313*Q_{BE\ 2.0}^{1.0523}$ |
| When Q at BE 2.0> 100 cfs | $Q_{SI\ 2.0}=0.8*[Q_{BE\ 2.0}-Q_{BE5.0}]$ |
| 2004 Data, When Q at BE 2.0> 100 cfs | $Q_{SI\ 2.0}=1.0062*Q_{BE\ 2.0}^{0.8033}$ |

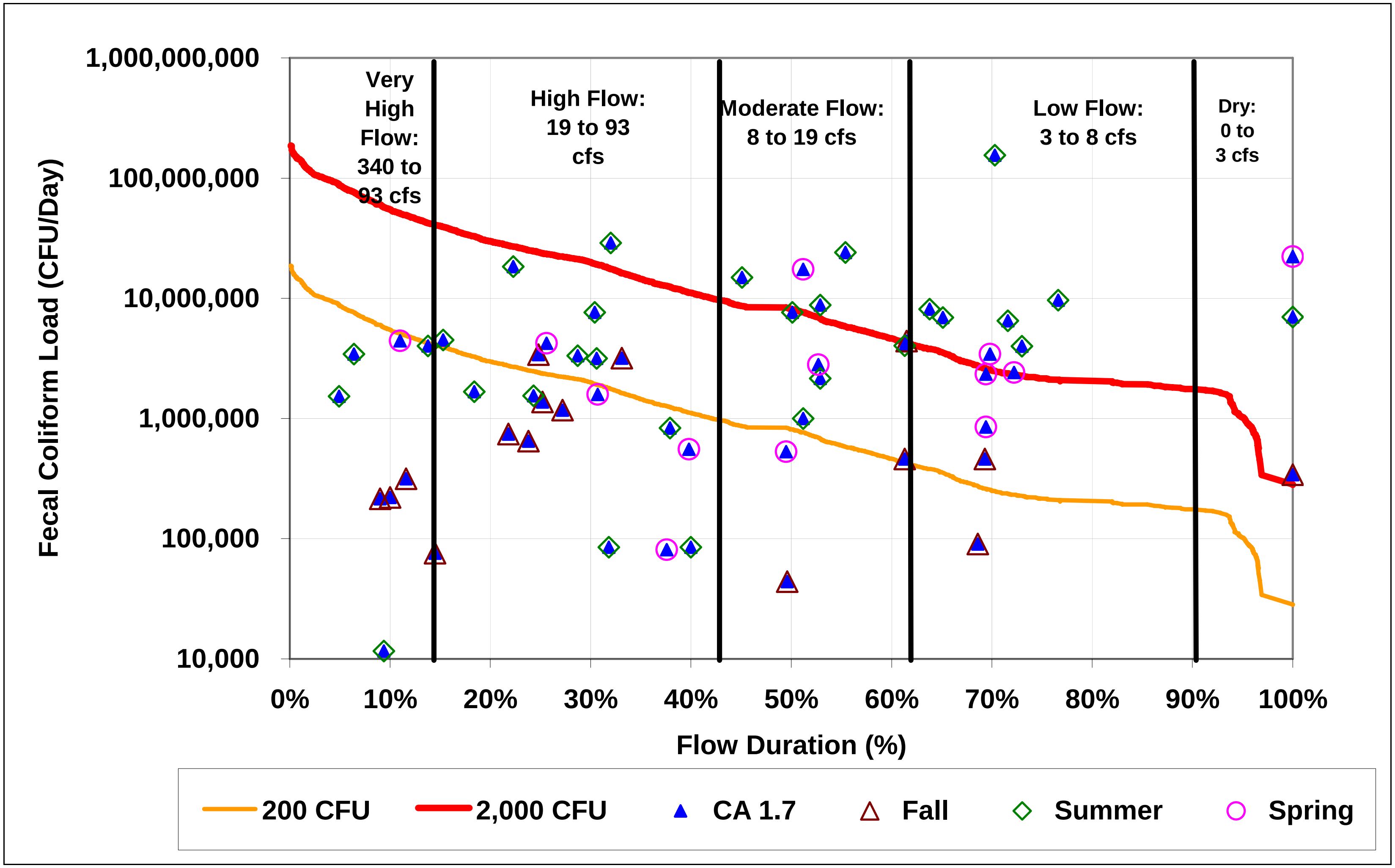



Figure B1. Carver Creek (outlet) Load Duration Curve.

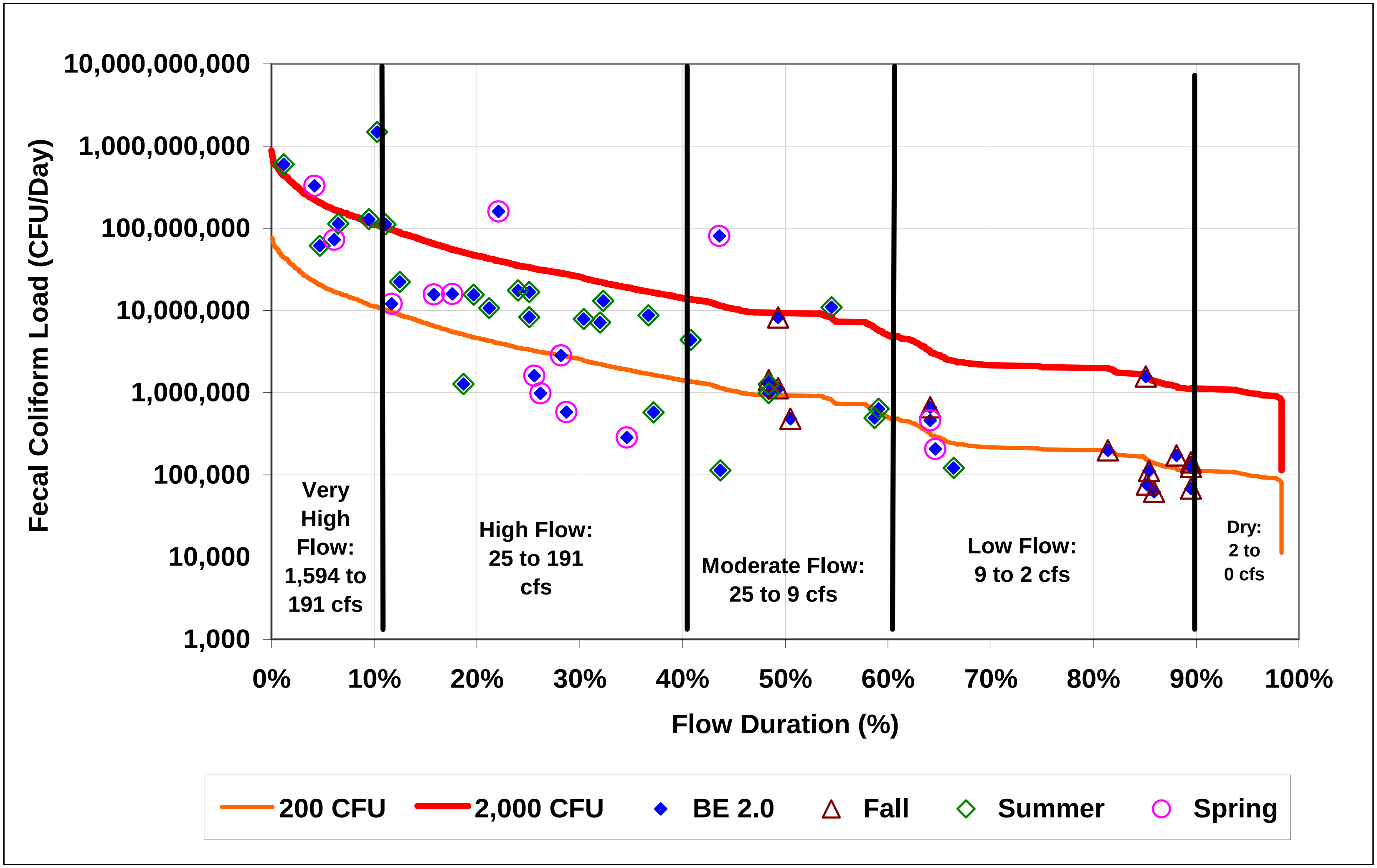



Figure B2. Bevens Creek (outlet) Load Duration Curve.

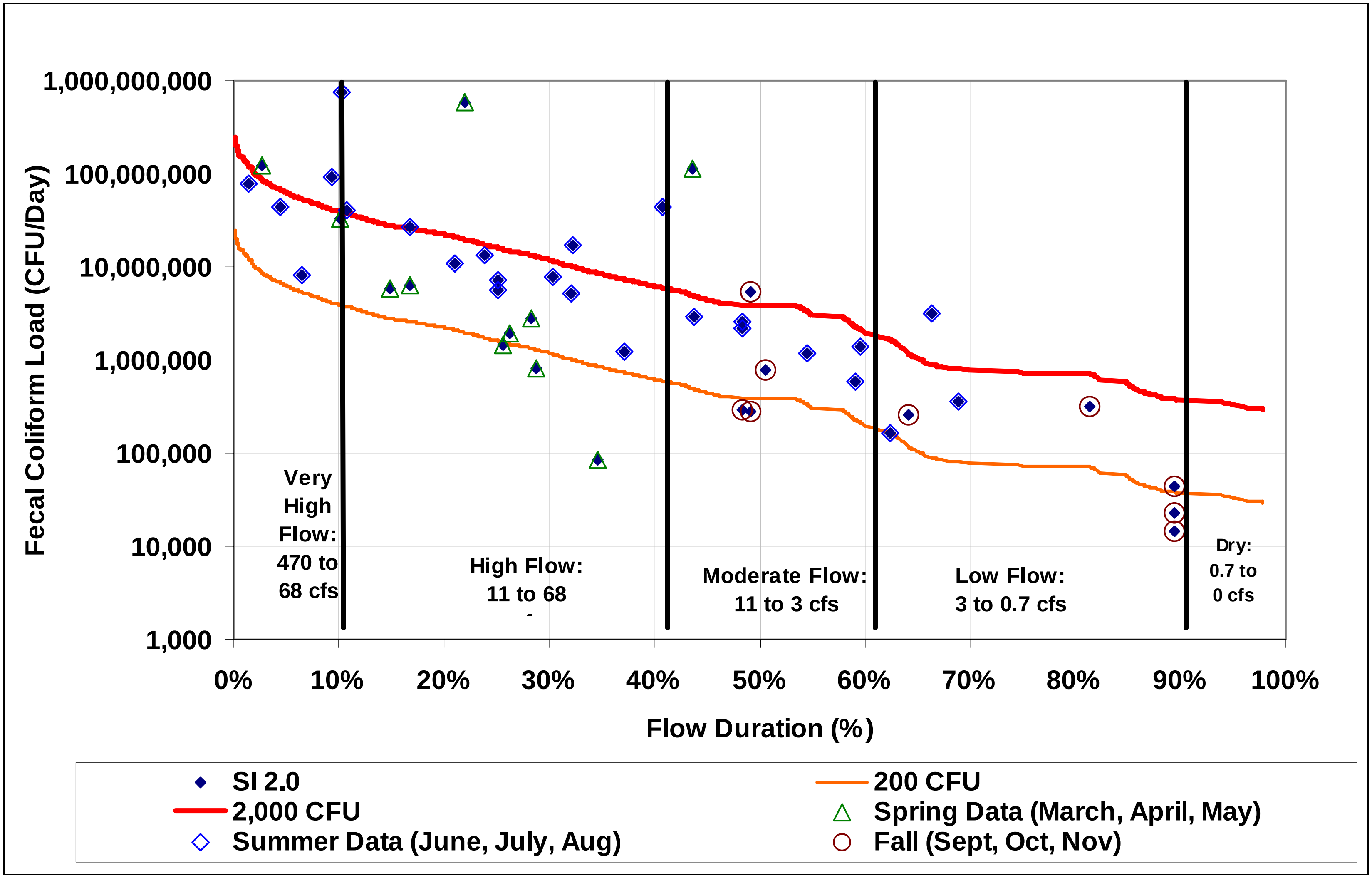



Figure B3. Silver Creek (outlet) Load Duration Curve.

| DATE | Site # | Coliform Units/100ml |
|---|---|---|
| 5/6/1997 | BE 21_0 | 50 |
| 5/19/1997 | BE 21_0 | 390 |
| 5/19/1997 | TACOMA | 250 |
| 6/5/1997 | BE 21_0 | 2200 |
| 6/20/1997 | BE 21_0 | 2400 |
| 7/3/1997 | BE 21_0 | 700 |
| 7/3/1997 | TACOMA | 550 |
| 7/17/1997 | BE 21_0 | 17000 |
| 7/17/1997 | TACOMA | 900 |
| 7/29/1997 | BE 21_0 | 1400 |
| 7/29/1997 | TACOMA | 260 |
| 8/11/1997 | BE 21_0 | 1100 |
| 8/11/1997 | TACOMA | 370 |
| 10/7/1997 | BE 21_0 | 1200 |
| 10/7/1997 | BENT | 1600 |
| 10/7/1997 | CA 8_7 | 1100 |
| 10/7/1997 | BE 24_0 | 4100 |
| 10/7/1997 | CA 1.7 | 330 |
| 5/4/1998 | BE 21_0 | 119 |
| 5/4/1998 | HA 15 | 46 |
| 5/4/1998 | SI 2.0 | 127 |
| 5/4/1998 | BENT | 7 |
| 5/4/1998 | CA 10_4 | 40 |
| 5/4/1998 | CA 8_7 | 5 |
| 5/4/1998 | TACOMA | 46 |
| 5/4/1998 | BE 24_0 | 54 |
| 5/4/1998 | BE 2 | 42 |
| 5/4/1998 | CA 1.7 | 330 |
| 5/4/1998 | BE 5 | 68 |
| 5/18/1998 | BE 21_0 | 860 |
| 5/18/1998 | HA 15 | 338 |
| 5/18/1998 | SI 2.0 | 416 |
| 5/18/1998 | BENT | 82 |
| 5/18/1998 | CA 10_4 | 254 |
| 5/18/1998 | TACOMA | 250 |
| 5/18/1998 | BE 24_0 | 284 |
| 5/18/1998 | BE 2 | 576 |
| 5/18/1998 | CA 1.7 | 200 |
| 5/18/1998 | BE 5 | 520 |
| 6/1/1998 | BE 21_0 | 1227 |
| 6/1/1998 | HA 15 | 320 |
| 6/1/1998 | SI 2.0 | 2200 |
| 6/1/1998 | BENT | 100 |
| 6/1/1998 | CA 10_4 | 1600 |
| 6/1/1998 | CA 8_7 | 45 |
| 6/1/1998 | TACOMA | 240 |
| 6/1/1998 | BE 24_0 | 982 |
| 6/1/1998 | BE 2 | 2200 |
| 6/1/1998 | CA 1.7 | 900 |
| 6/1/1998 | BE 5 | 4200 |
| 6/15/1998 | BE 21_0 | 2600 |
| 6/15/1998 | HA 15 | 880 |

| Date | Site | CFU/100ml |
|---|---|---|
| 6/15/1998 | SI 2.0 | 700 |
| 6/15/1998 | BENT | 65 |
| 6/15/1998 | CA 10_4 | 300 |
| 6/15/1998 | CA 8_7 | 108 |
| 6/15/1998 | TACOMA | 405 |
| 6/15/1998 | BE 24_0 | 560 |
| 6/15/1998 | BE 2 | 500 |
| 6/15/1998 | CA 1.7 | 340 |
| 6/15/1998 | BE 5 | 400 |
| 6/22/1998 | BE 21_0 | 1500 |
| 6/22/1998 | CA 10_4 | 275 |
| 6/22/1998 | BE 2 | 660 |
| 6/22/1998 | CA 1.7 | 300 |
| 6/22/1998 | BE 5 | 567 |
| 6/29/1998 | BE 21_0 | 4300 |
| 6/29/1998 | HA 15 | 1600 |
| 6/29/1998 | SI 2.0 | 1267 |
| 6/29/1998 | BENT | 190 |
| 6/29/1998 | CA 10_4 | 980 |
| 6/29/1998 | CA 8_7 | 158 |
| 6/29/1998 | TACOMA | 400 |
| 6/29/1998 | BE 24_0 | 2040 |
| 6/29/1998 | BE 2 | 2700 |
| 6/29/1998 | CA 1.7 | 980 |
| 6/29/1998 | BE 5 | 1517 |
| 7/13/1998 | BE 21_0 | 300 |
| 7/13/1998 | CA 10_4 | 230 |
| 7/13/1998 | BE 2 | 500 |
| 7/13/1998 | CA 1.7 | 80 |
| 7/13/1998 | BE 5 | 430 |
| 7/16/1998 | BE 21_0 | 2600 |
| 7/16/1998 | HA 15 | 1150 |
| 7/16/1998 | SI 2.0 | 1300 |
| 7/16/1998 | BENT | 305 |
| 7/16/1998 | CA 10_4 | 440 |
| 7/16/1998 | CA 8_7 | 35 |
| 7/16/1998 | TACOMA | 2460 |
| 7/16/1998 | BE 24_0 | 550 |
| 7/16/1998 | BE 2 | 600 |
| 7/16/1998 | CA 1.7 | 280 |
| 7/16/1998 | BE 5 | 520 |
| 8/11/1998 | BE 21_0 | 2100 |
| 8/11/1998 | HA 15 | 300 |
| 8/11/1998 | SI 2.0 | 1050 |
| 8/11/1998 | BENT | 160 |
| 8/11/1998 | CA 10_4 | 240 |
| 8/11/1998 | CA 8_7 | 1 |
| 8/11/1998 | BE 24_0 | 700 |
| 8/11/1998 | BE 2 | 500 |
| 8/11/1998 | CA 1.7 | 280 |
| 8/11/1998 | BE 5 | 780 |
| 8/21/1998 | BE 21_0 | 6550 |

| Date | Site | CFU/100ml |
| --- | --- | --- |
| 8/21/1998 | CA 10_4 | 500 |
| 8/21/1998 | BE 2 | 160 |
| 8/21/1998 | CA 1.7 | 370 |
| 8/21/1998 | BE 5 | 580 |
| 8/26/1998 | BE 21_0 | 11636 |
| 8/26/1998 | HA 15 | 659 |
| 8/26/1998 | SI 2.0 | 700 |
| 8/26/1998 | BENT | 435 |
| 8/26/1998 | CA 10_4 | 1450 |
| 8/26/1998 | CA 8_7 | 137 |
| 8/26/1998 | TACOMA | 720 |
| 8/26/1998 | BE 24_0 | 4400 |
| 8/26/1998 | BE 2 | 2700 |
| 8/26/1998 | CA 1.7 | 709 |
| 8/26/1998 | BE 5 | 3500 |
| 9/2/1998 | BE 21_0 | 10700 |
| 9/2/1998 | HA 15 | 350 |
| 9/2/1998 | SI 2.0 | 425 |
| 9/2/1998 | BENT | 210 |
| 9/2/1998 | CA 10_4 | 493 |
| 9/2/1998 | CA 8_7 | 222 |
| 9/2/1998 | TACOMA | 880 |
| 9/2/1998 | BE 24_0 | 1517 |
| 9/2/1998 | BE 2 | 420 |
| 9/2/1998 | CA 1.7 | 220 |
| 9/2/1998 | BE 5 | 1280 |
| 9/9/1998 | BE 21_0 | 8900 |
| 9/9/1998 | CA 10_4 | 1150 |
| 9/9/1998 | BE 2 | 290 |
| 9/9/1998 | CA 1.7 | 40 |
| 9/9/1998 | BE 5 | 720 |
| 9/17/1998 | BE 21_0 | 10300 |
| 9/17/1998 | HA 15 | 670 |
| 9/17/1998 | SI 2.0 | 120 |
| 9/17/1998 | BENT | 240 |
| 9/17/1998 | CA 10_4 | 1400 |
| 9/17/1998 | CA 8_7 | 324 |
| 9/17/1998 | TACOMA | 2220 |
| 9/17/1998 | BE 24_0 | 500 |
| 9/17/1998 | BE 2 | 220 |
| 9/17/1998 | CA 1.7 | 1210 |
| 9/17/1998 | BE 5 | 620 |
| 9/22/1998 | BE 21_0 | 7450 |
| 9/22/1998 | HA 15 | 100 |
| 9/22/1998 | SI 2.0 | 235 |
| 9/22/1998 | BENT | 290 |
| 9/22/1998 | CA 10_4 | 800 |
| 9/22/1998 | CA 8_7 | 374 |
| 9/22/1998 | TACOMA | 1600 |
| 9/22/1998 | BE 24_0 | 1240 |
| 9/22/1998 | BE 2 | 250 |
| 9/22/1998 | CA 1.7 | 900 |
| 9/22/1998 | BE 5 | 2400 |

| Date | Site | CFU/100ml |
|---|---|---|
| 10/7/1998 | BE 21_0 | 6950 |
| 10/7/1998 | SI 2.0 | 77 |
| 10/7/1998 | BENT | 80 |
| 10/7/1998 | CA 10_4 | 880 |
| 10/7/1998 | CA 8_7 | 355 |
| 10/7/1998 | BE 24_0 | 500 |
| 10/7/1998 | BE 2 | 120 |
| 10/7/1998 | CA 1.7 | 180 |
| 10/7/1998 | BE 5 | 700 |
| 5/5/1999 | BE 21_0 | 1008 |
| 5/5/1999 | HA 15 | 164 |
| 5/5/1999 | SI 2.0 | 416 |
| 5/5/1999 | BENT | 656 |
| 5/5/1999 | CA 10_4 | 151 |
| 5/5/1999 | CA 8_7 | 42 |
| 5/5/1999 | TACOMA | 428 |
| 5/5/1999 | BE 24_0 | 1508 |
| 5/5/1999 | BE 2 | 199 |
| 5/5/1999 | CA 1.7 | 50 |
| 5/5/1999 | BE 5 | 268 |
| 5/20/1999 | BE 21_0 | 1700 |
| 5/20/1999 | HA 15 | 410 |
| 5/20/1999 | CA 10_4 | 192 |
| 5/20/1999 | TACOMA | 284 |
| 5/20/1999 | BE 24_0 | 710 |
| 5/20/1999 | BE 2 | 860 |
| 5/20/1999 | BE 5 | 564 |
| 6/24/1999 | BE 21_0 | 18300 |
| 6/24/1999 | HA 15 | 4100 |
| 6/24/1999 | CA 10_4 | 6240 |
| 6/24/1999 | CA 8_7 | 168 |
| 6/24/1999 | TACOMA | 3340 |
| 6/24/1999 | BE 24_0 | 7190 |
| 6/24/1999 | BE 5 | 280 |
| 7/15/1999 | BE 21_0 | 3500 |
| 7/15/1999 | HA 15 | 1040 |
| 7/15/1999 | SI 2.0 | 1600 |
| 7/15/1999 | BENT | 66 |
| 7/15/1999 | CA 10_4 | 5 |
| 7/15/1999 | TACOMA | 210 |
| 7/15/1999 | BE 24_0 | 970 |
| 7/15/1999 | BE 2 | 1000 |
| 7/15/1999 | CA 1.7 | 424 |
| 7/15/1999 | BE 5 | 808 |
| 8/5/1999 | BE 21_0 | 4200 |
| 8/5/1999 | HA 15 | 1410 |
| 8/5/1999 | SI 2.0 | 330 |
| 8/5/1999 | CA 10_4 | 610 |
| 8/5/1999 | CA 8_7 | 2110 |
| 8/5/1999 | TACOMA | 1650 |
| 8/5/1999 | BE 24_0 | 1830 |
| 8/5/1999 | BE 2 | 70 |

| Date | Site | CFU/100ml |
|---|---|---|
| 8/5/1999 | CA 1.7 | 484 |
| 8/5/1999 | BE 5 | 180 |
| 8/12/1999 | BE 21_0 | 11000 |
| 8/12/1999 | BENT | 114 |
| 8/12/1999 | CA 10_4 | 376 |
| 8/12/1999 | TACOMA | 1400 |
| 8/12/1999 | BE 2 | 1032 |
| 8/12/1999 | CA 1.7 | 568 |
| 8/12/1999 | BE 5 | 2 |
| 8/19/1999 | BE 21_0 | 11100 |
| 8/19/1999 | HA 15 | 2400 |
| 8/19/1999 | SI 2.0 | 1300 |
| 8/19/1999 | BENT | 74 |
| 8/19/1999 | CA 10_4 | 544 |
| 8/19/1999 | CA 8_7 | 300 |
| 8/19/1999 | BE 24_0 | 500 |
| 8/19/1999 | BE 2 | 268 |
| 8/19/1999 | CA 1.7 | 7550 |
| 8/19/1999 | BE 5 | 500 |
| 8/24/1999 | BE 21_0 | 5600 |
| 8/24/1999 | SI 2.0 | 1100 |
| 8/24/1999 | BENT | 400 |
| 8/24/1999 | CA 10_4 | 900 |
| 8/24/1999 | CA 8_7 | 100 |
| 8/24/1999 | TACOMA | 600 |
| 8/24/1999 | BE 24_0 | 520 |
| 8/24/1999 | BE 2 | 210 |
| 8/24/1999 | CA 1.7 | 800 |
| 8/24/1999 | BE 5 | 468 |
| 9/1/1999 | BE 21_0 | 7800 |
| 9/1/1999 | HA 15 | 660 |
| 9/1/1999 | SI 2.0 | 150 |
| 9/1/1999 | CA 10_4 | 480 |
| 9/1/1999 | CA 8_7 | 128 |
| 9/1/1999 | TACOMA | 1400 |
| 9/1/1999 | BE 2 | 300 |
| 9/1/1999 | CA 1.7 | 100 |
| 9/1/1999 | BE 5 | 308 |
| 9/14/1999 | BE 21_0 | 1080 |
| 9/14/1999 | HA 15 | 3260 |
| 9/14/1999 | SI 2.0 | 2700 |
| 9/14/1999 | BENT | 190 |
| 9/14/1999 | CA 10_4 | 2840 |
| 9/14/1999 | CA 8_7 | 234 |
| 9/14/1999 | TACOMA | 246 |
| 9/14/1999 | BE 24_0 | 4980 |
| 9/14/1999 | BE 2 | 1764 |
| 9/14/1999 | CA 1.7 | 1600 |
| 9/14/1999 | BE 5 | 2660 |
| 9/21/1999 | BE 21_0 | 4000 |
| 9/21/1999 | HA 15 | 682 |
| 9/21/1999 | SI 2.0 | 140 |
| 9/21/1999 | BENT | 296 |

| Date | Site | CFU/100ml |
|---|---|---|
| 9/21/1999 | CA 8_7 | 374 |
| 9/21/1999 | TACOMA | 336 |
| 9/21/1999 | BE 24_0 | 2380 |
| 9/21/1999 | BE 2 | 242 |
| 9/21/1999 | CA 1.7 | 478 |
| 9/21/1999 | BE 5 | 660 |
| 10/4/1999 | BE 21_0 | 660 |
| 10/4/1999 | HA 15 | 460 |
| 10/4/1999 | SI 2.0 | 400 |
| 10/4/1999 | BENT | 84 |
| 10/4/1999 | CA 10_4 | 200 |
| 10/4/1999 | CA 8_7 | 140 |
| 10/4/1999 | TACOMA | 210 |
| 10/4/1999 | BE 24_0 | 900 |
| 10/4/1999 | BE 2 | 104 |
| 10/4/1999 | CA 1.7 | 210 |
| 10/4/1999 | BE 5 | 130 |
| 5/1/2000 | BE 21_0 | 1400 |
| 5/1/2000 | HA 15 | 800 |
| 5/1/2000 | BENT | 90 |
| 5/1/2000 | CA 10_4 | 410 |
| 5/1/2000 | CA 8_7 | 5800 |
| 5/1/2000 | TACOMA | 330 |
| 5/1/2000 | BE 24_0 | 630 |
| 5/1/2000 | BE 2 | 290 |
| 5/1/2000 | CA 1.7 | 550 |
| 5/1/2000 | BE 5 | 3055 |
| 5/1/2000 | DA 12 | 114 |
| 5/1/2000 | CR 19 | 66 |
| 5/16/2000 | BE 21_0 | 75800 |
| 5/16/2000 | HA 15 | 500 |
| 5/16/2000 | BENT | 130 |
| 5/16/2000 | CA 10_4 | 260 |
| 5/16/2000 | CA 8_7 | 800 |
| 5/16/2000 | TACOMA | 1920 |
| 5/16/2000 | BE 24_0 | 70 |
| 5/16/2000 | BE 2 | 140 |
| 5/16/2000 | CA 1.7 | 630 |
| 5/16/2000 | BE 5 | 200 |
| 5/16/2000 | DA 12 | 490 |
| 5/16/2000 | CR 19 | 140 |
| 5/16/2000 | Sibley | 20 |
| 05/31/00 | BE 21_0 | 3700 |
| 05/31/00 | CM 28 | 800 |
| 05/31/00 | HA 15 | 20500 |
| 05/31/00 | SI 2.0 | 46200 |
| 05/31/00 | BENT | 2856 |
| 05/31/00 | CA 10_4 | 2970 |
| 05/31/00 | CA 8_7 | 390 |
| 05/31/00 | TACOMA | 3150 |
| 05/31/00 | BE 2 | 14050 |
| 05/31/00 | CA 1.7 | 5500 |
| 05/31/00 | BE 5 | 3000 |

| Date | Site | CFU/100ml |
|---|---|---|
| 05/31/00 | DA 12 | 780 |
| 05/31/00 | CR 19 | 210 |
| 05/31/00 | Sibley | 1120 |
| 6/14/2000 | BE 21_0 | 3200 |
| 6/14/2000 | HA 15 | 6700 |
| 6/14/2000 | SI 2.0 | 1200 |
| 6/14/2000 | BENT | 36 |
| 6/14/2000 | CA 10_4 | 40 |
| 6/14/2000 | CA 8_7 | 60 |
| 6/14/2000 | TACOMA | 130 |
| 6/14/2000 | BE 2 | 20 |
| 6/14/2000 | CA 1.7 | 200 |
| 6/14/2000 | BE 5 | 400 |
| 6/14/2000 | DA 12 | 0 |
| 6/14/2000 | CR 19 | 430 |
| 6/14/2000 | Sibley | 290 |
| 6/27/2000 | BE 21_0 | 11100 |
| 6/27/2000 | HA 15 | 7400 |
| 6/27/2000 | SI 2.0 | 1300 |
| 6/27/2000 | BENT | 600 |
| 6/27/2000 | CA 10_4 | 710 |
| 6/27/2000 | CA 8_7 | 30 |
| 6/27/2000 | TACOMA | 60 |
| 6/27/2000 | CA 1.7 | 1000 |
| 6/27/2000 | BE 5 | 3600 |
| 6/27/2000 | DA 12 | 200 |
| 6/27/2000 | CR 19 | 150 |
| 6/27/2000 | Sibley | 4510 |
| 7/17/2000 | BE 21_0 | 125250 |
| 7/17/2000 | HA 15 | 1400 |
| 7/17/2000 | SI 2.0 | 200 |
| 7/17/2000 | BENT | 100 |
| 7/17/2000 | CA 10_4 | 16530 |
| 7/17/2000 | CA 8_7 | 400 |
| 7/17/2000 | TACOMA | 0 |
| 7/17/2000 | BE 2 | 0 |
| 7/17/2000 | CA 1.7 | 0 |
| 7/17/2000 | BE 5 | 800 |
| 7/17/2000 | DA 12 | 190 |
| 7/17/2000 | CR 19 | 540 |
| 7/17/2000 | Sibley | 400 |
| 7/28/2000 | BE 21_0 | 8100 |
| 7/28/2000 | HA 15 | 12000 |
| 7/28/2000 | SI 2.0 | 890 |
| 7/28/2000 | BENT | 3400 |
| 7/28/2000 | CA 10_4 | 13770 |
| 7/28/2000 | CA 8_7 | 1200 |
| 7/28/2000 | TACOMA | 2500 |
| 7/28/2000 | CA 1.7 | 600 |
| 7/28/2000 | BE 5 | 900 |
| 7/28/2000 | DA 12 | 0 |
| 7/28/2000 | CR 19 | 102 |
| 7/28/2000 | Sibley | 11500 |

| Date | Site | CFU/100ml |
|---|---|---|
| 8/11/2000 | BE 21_0 | 6200 |
| 8/11/2000 | HA 15 | 0 |
| 8/11/2000 | SI 2.0 | 7000 |
| 8/11/2000 | BENT | 0 |
| 8/11/2000 | CA 8_7 | 1 |
| 8/11/2000 | TACOMA | 1000 |
| 8/11/2000 | CA 1.7 | 0 |
| 8/11/2000 | BE 2 | 100 |
| 8/11/2000 | BE 5 | 2200 |
| 8/11/2000 | DA 12 | 620 |
| 8/11/2000 | CR 19 | 54 |
| 8/11/2000 | Sibley | 300 |
| 8/22/2000 | BE 21_0 | 0 |
| 8/22/2000 | HA 15 | 100 |
| 8/22/2000 | SI 2.0 | 0 |
| 8/22/2000 | BENT | 0 |
| 8/22/2000 | CA 10_4 | 40 |
| 8/22/2000 | CA 8_7 | 1 |
| 8/22/2000 | TACOMA | 0 |
| 8/22/2000 | BE 2 | 0 |
| 8/22/2000 | CA 1.7 | 600 |
| 8/22/2000 | BE 5 | 0 |
| 8/22/2000 | DA 12 | 0 |
| 8/22/2000 | CR 19 | 12 |
| 8/22/2000 | Sibley | 0 |
| 8/22/2000 | Co Rd 33 | 200 |
| 9/7/2000 | BE 21_0 | 300 |
| 9/7/2000 | SI 2.0 | 900 |
| 9/7/2000 | CA 10_4 | 470 |
| 9/7/2000 | CA 8_7 | 1 |
| 9/7/2000 | TACOMA | 15680 |
| 9/7/2000 | BE 2 | 200 |
| 9/7/2000 | CA 1.7 | 310 |
| 9/7/2000 | BE 5 | 0 |
| 9/7/2000 | DA 12 | 1194 |
| 9/7/2000 | CR 19 | 222 |
| 9/7/2000 | Sibley | 0 |
| 9/7/2000 | Co Rd 33 | 100 |
| 4/9/2003 | BE 21_0 | 250 |
| 4/9/2003 | SI 2.0 | 20 |
| 4/9/2003 | BENT | 90 |
| 4/9/2003 | CA 10_4 | 110 |
| 4/9/2003 | CA 8_7 | < 10 |
| 4/9/2003 | TACOMA | 550 |
| 4/9/2003 | BE 2 | 30 |
| 4/9/2003 | CA 1.7 | < 10 |
| 4/9/2003 | BE 5 | 40 |
| 4/9/2003 | DA 12 | 160 |
| 4/9/2003 | CR 19 | < 10 |
| 4/9/2003 | Sibley | 30 |
| 4/9/2003 | Co Rd 33 | 8000 |
| 4/22/2003 | BE 21_0 | 800 |
| 4/22/2003 | CM 28 | 300 |

| Date | Site | CFU/100ml |
|---|---|---|
| 4/22/2003 | SI 2.0 | 1700 |
| 4/22/2003 | BENT | 220 |
| 4/22/2003 | CA 10_4 | 70 |
| 4/22/2003 | CA 8_7 | 300 |
| 4/22/2003 | TACOMA | 4500 |
| 4/22/2003 | BE 2 | 250 |
| 4/22/2003 | CA 1.7 | 110 |
| 4/22/2003 | BE 5 | 350 |
| 4/22/2003 | DA 12 | 3000 |
| 4/22/2003 | CR 19 | < 10 |
| 4/22/2003 | Sibley | 90 |
| 5/5/2003 | BE 21_0 | 310 |
| 5/5/2003 | SI 2.0 | 260 |
| 5/5/2003 | BENT | 130 |
| 5/5/2003 | CA 10_4 | 220 |
| 5/5/2003 | CA 8_7 | 10 |
| 5/5/2003 | TACOMA | 600 |
| 5/5/2003 | BE 2 | 63 |
| 5/5/2003 | CA 1.7 | 45 |
| 5/5/2003 | BE 5 | 480 |
| 5/5/2003 | DA 12 | 25000 |
| 5/5/2003 | CR 19 | < 10 |
| 5/5/2003 | Sibley | 280 |
| 5/21/2003 | BE 21_0 | 2200 |
| 5/21/2003 | SI 2.0 | 2800 |
| 5/21/2003 | BENT | 310 |
| 5/21/2003 | CA 10_4 | 460 |
| 5/21/2003 | CA 8_7 | 270 |
| 5/21/2003 | TACOMA | 1600 |
| 5/21/2003 | BE 2 | 2900 |
| 5/21/2003 | CA 1.7 | 400 |
| 5/21/2003 | BE 5 | 3100 |
| 5/21/2003 | DA 12 | 4800 |
| 5/21/2003 | CR 19 | 100 |
| 5/21/2003 | Sibley | 5800 |
| 6/4/2003 | BE 21_0 | 1100 |
| 6/4/2003 | SI 2.0 | 2100 |
| 6/4/2003 | BENT | 180 |
| 6/4/2003 | CA 10_4 | 1300 |
| 6/4/2003 | CA 8_7 | 40 |
| 6/4/2003 | TACOMA | 220 |
| 6/4/2003 | BE 2 | 50 |
| 6/4/2003 | CA 1.7 | 910 |
| 6/4/2003 | BE 5 | 99 |
| 6/4/2003 | DA 12 | 490 |
| 6/4/2003 | CR 19 | 27 |
| 6/4/2003 | Sibley | 500 |
| 6/4/2003 | Co Rd 33 | 210 |
| 6/17/2003 | BE 21_0 | 2600 |
| 6/17/2003 | SI 2.0 | 1400 |
| 6/17/2003 | BENT | 820 |
| 6/17/2003 | CA 10_4 | 4000 |
| 6/17/2003 | CA 8_7 | 360 |

| Date | Site | CFU/100ml |
|---|---|---|
| 6/17/2003 | TACOMA | 1400 |
| 6/17/2003 | BE 2 | 640 |
| 6/17/2003 | CA 1.7 | 730 |
| 6/17/2003 | BE 5 | 1000 |
| 6/17/2003 | DA 12 | 4500 |
| 6/17/2003 | CR 19 | 910 |
| 6/17/2003 | Sibley | 1900 |
| 6/17/2003 | Co Rd 33 | 3000 |
| 6/30/2003 | BE 21_0 | 2300 |
| 6/30/2003 | SI 2.0 | 3400 |
| 6/30/2003 | BENT | 170 |
| 6/30/2003 | CA 10_4 | 500 |
| 6/30/2003 | CA 8_7 | < 10 |
| 6/30/2003 | TACOMA | 700 |
| 6/30/2003 | BE 2 | 1200 |
| 6/30/2003 | CA 1.7 | 1000 |
| 6/30/2003 | BE 5 | 1400 |
| 6/30/2003 | DA 12 | 12000 |
| 6/30/2003 | CR 19 | 300 |
| 6/30/2003 | Sibley | 1000 |
| 6/30/2003 | Co Rd 33 | 1500 |
| 7/17/2003 | BE 21_0 | 42000 |
| 7/17/2003 | SI 2.0 | 15000 |
| 7/17/2003 | BENT | 400 |
| 7/17/2003 | CA 10_4 | 1300 |
| 7/17/2003 | CA 8_7 | 230 |
| 7/17/2003 | TACOMA | 1400 |
| 7/17/2003 | BE 2 | 640 |
| 7/17/2003 | CA 1.7 | 1300 |
| 7/17/2003 | BE 5 | 1000 |
| 7/17/2003 | DA 12 | 30000 |
| 7/17/2003 | CR 19 | 2300 |
| 7/17/2003 | Sibley | 1000 |
| 7/17/2003 | Co Rd 33 | 1100 |
| 7/29/2003 | BE 21_0 | 2500 |
| 7/29/2003 | SI 2.0 | 500 |
| 7/29/2003 | BENT | 500 |
| 7/29/2003 | CA 10_4 | 3100 |
| 7/29/2003 | CA 8_7 | 730 |
| 7/29/2003 | TACOMA | 3000 |
| 7/29/2003 | BE 2 | 220 |
| 7/29/2003 | CA 1.7 | 1200 |
| 7/29/2003 | BE 5 | 440 |
| 7/29/2003 | CR 19 | 200 |
| 7/29/2003 | Sibley | 21000 |
| 7/29/2003 | Co Rd 33 | 2400 |
| 9/10/2003** | BE 21_0 | 8000 |
| 9/10/2003** | BE 2 | 2000 |
| 9/10/2003** | BE 9 | 9000 |
| 9/10/2003** | TACOMA | 4000 |
| 9/10/2003** | CR 19 | 220 |
| 9/10/2003** | CA 1.7 | 360 |

| Date | Site | CFU/100ml |
| --- | --- | --- |
| 9/10/2003** | CA 1.7 | 360 |
| 9/11/2003** | W 11 | 5600 |
| 9/11/2003** | CC 9 | 4600 |
| 9/11/2003** | CC 11 | 8000 |
| 9/11/2003** | BENT | > 60000 |
| 9/11/2003** | Distilled h20 | <10 |
| 9/22/2003** | BE 2 | 100 |
| 9/22/2003** | BE 9 | 50 |
| 9/22/2003** | BE 21_0 | 6000 |
| 9/22/2003** | Co Rd 33 | 46 |
| 9/22/2003** | Sibley | 9000 |
| 9/22/2003** | TACOMA | 3900 |
| 9/22/2003** | CR 19 | 280 |
| 9/22/2003** | CA 1.7 | 3500 |
| 9/22/2003** | EC3 | 1700/1100 |
| 9/23/2003** | W 11 | 140 |
| 9/23/2003** | CA 8_7 | 1700 |
| 9/23/2003** | CA 10_4 | 1500 |
| 9/23/2003** | B 1 | 4300 |
| 9/23/2003** | CC 10 | 26000 |
| 9/23/2003** | CC 9 | 2700 |
| 9/23/2003** | CC 11 | 450 |
| 9/23/2003** | CC 8 | 1500 |
| 9/23/2003** | BENT | 140 |
| 9/23/2003** | Distilled h20 | <10 |
| 10/7/2003** | BE 2 | 150 |
| 10/7/2003** | BE 9 | 45 |
| 10/7/2003** | BE 21_0 | 4000 |
| 10/7/2003** | TACOMA | 170 |
| 10/7/2003** | CR 19 | 20 |
| 10/7/2003** | CA 1.7 | 73 |
| 10/7/2003** | EC 3 | 260/730 |
| 10/8/2003** | W 11 | 140 |
| 10/8/2003** | CA 8_7 | 1100 |
| 10/8/2003** | CA 10_4 | 2200 |
| 10/8/2003** | CC 10 | 1000 |
| 10/8/2003** | CC 9 | 2300 |
| 10/8/2003** | CC 11 | 500 |
| 10/8/2003** | BENT | 1300 |
| 10/8/2003** | Distilled h20 | <10 |
| 10/22/2003** | BE 2 | 90 |
| 10/22/2003** | BE 9 | 10000 |
| 10/22/2003** | BE 21_0 | 23000 |
| 10/22/2003** | Co Rd 33 | 2100 |
| 10/22/2003** | Sibley 3 | 350 |
| 10/22/2003** | Sibley | 1400 |
| 10/22/2003** | TACOMA | 900 |
| **Date** | **Site** | **CFU/100ml** |
| 10/22/2003** | CR 19 | 80 |
| 10/22/2003** | CA 1.7 | 290 |

| | | |
|---|---|---|
| 10/22/2003** | BE 9 | 10000/5700 |
| 10/23/2003** | W 11 | 160 |
| 10/23/2003** | CA 10_4 | 2500 |
| 10/23/2003** | CC 10 | 3600 |
| 10/23/2003** | CC 9 | 17000 |
| 10/23/2003** | CC 11 | 660 |
| 10/23/2003** | BENT | 5800 |
| 10/23/2003** | Distilled h20 | <10 |
| 4/19/2004** | BE 2 | 100 |
| 4/19/2004** | BE 5 | 2500 |
| 4/19/2004** | BE 9 | 5000 |
| 4/19/2004** | SI 2.0 | 190 |
| 4/19/2004** | SI 4 | 9000 |
| 4/19/2004** | SI 3 | 530 |
| 4/19/2004** | BE 21_0 | 12000 |
| 4/19/2004** | Co Rd 33 | 16000 |
| 4/19/2004** | Sibley 3 | 500 |
| 4/19/2004** | Sibley | 29000 |
| 4/19/2004** | TACOMA | 8000 |
| 4/19/2004** | Sibley 2 | 26000 |
| 4/19/2004** | CR 19 | 20 |
| 4/19/2004** | CA 1.7 | 73 |
| 4/19/2004** | EC 3.2 | 4600/9000 |
| 4/20/2004** | W 11 | 170 |
| 4/20/2004** | CA 8_7 | 1400 |
| 4/20/2004** | CA 10_4 | 1500 |
| 4/20/2004** | B 1 | <10 |
| 4/20/2004** | CC 10 | 1500 |
| 4/20/2004** | CC 9 | 2300 |
| 4/20/2004** | CC 11 | 40 |
| 4/20/2004** | CC 8 | 380 |
| 4/20/2004** | G 1 | 82 |
| 4/20/2004** | CC 1 | 100 |
| 4/20/2004** | BENT | 2900 |
| 4/20/2004** | CC 7 | 27 |
| 4/20/2004** | Distilled h20 | <10 |
| 5/7/2004** | BE 2 | 480 |
| 5/7/2004** | BE 5 | 210 |
| 5/7/2004** | BE 9 | 36 |
| 5/7/2004** | SI 2.0 | 500 |
| 5/7/2004** | SI 4 | 60 |
| 5/7/2004** | BE 21_0 | 1700 |
| 5/7/2004** | Co Rd 33 | 560 |
| 5/7/2004** | Sibley 3 | 240 |
| 5/7/2004** | Sibley | 900 |
| 5/7/2004** | TACOMA | 1800 |
| **Date** | **Site** | **CFU/100ml** |
| 5/7/2004** | Sibley 2 | 70 |
| 5/7/2004** | CR 19 | 110 |
| 5/7/2004** | CA 1.7 | 120 |

| | | |
|---|---|---|
| 5/7/2004** | Distilled h20 | <10 |
| 5/6/2004** | W 11 | 90 |
| 5/6/2004** | CA 8_7 | 100 |
| 5/6/2004** | CA 10_4 | 4600 |
| 5/6/2004** | B 1 | 27 |
| 5/6/2004** | CC 10 | 110 |
| 5/6/2004** | CC 9 | 120 |
| 5/6/2004** | CC 11 | 120 |
| 5/6/2004** | CC 8 | 220 |
| 5/6/2004** | G 1 | <10 |
| 5/6/2004** | CC 1 | 2300 |
| 5/6/2004** | BENT | 40 |
| 5/6/2004** | CC 7 | 10 |
| 5/6/2004** | CC 10 | 30 |
| 5/18/2004** | BE 2 | 8000 |
| 5/18/2004** | DA 12 | 5700 |
| 5/18/2004** | BE 5 | 5000 |
| 5/18/2004** | BE 9 | >60000 |
| 5/18/2004** | SI 2.0 | >60000 |
| 5/18/2004** | SI 4 | 24000 |
| 5/18/2004** | SI 3 | >60000 |
| 5/18/2004** | BE 21_0 | 2800 |
| 5/18/2004** | Co Rd 33 | 2600 |
| 5/18/2004** | Sibley 3 | 410 |
| 5/18/2004** | Sibley | 340 |
| 5/18/2004** | TACOMA | 3500 |
| 5/18/2004** | Sibley 2 | 240 |
| 5/18/2004** | CR 19 | 18 |
| 5/18/2004** | CA 1.7 | 250 |
| 5/18/2004** | SI 4 | 550 |
| 5/20/2004** | W 11 | 1400 |
| 5/20/2004** | CA 8_7 | 3100 |
| 5/20/2004** | CA 10_4 | 2500 |
| 5/20/2004** | B 1 | 7000 |
| 5/20/2004** | CC 10 | 1400 |
| 5/20/2004** | CC 9 | 37000 |
| 5/20/2004** | CC 11 | 900 |
| 5/20/2004** | CC 8 | 600 |
| 5/20/2004** | G 1 | 150 |
| 5/20/2004** | CC 1 | lab accident |
| 5/20/2004** | W 10 | 2700 |
| 5/20/2004** | BENT | 720 |
| 5/20/2004** | CC 7 | 600 |
| 5/20/2004** | Distilled h20 | <10 |
| **Date** | **Site** | **CFU/100ml** |
| 6/2/2004** | BE 2 | 1400 |
| 6/2/2004** | DA 12 | 3100 |
| 6/2/2004** | BE 5 | 1400 |
| 6/2/2004** | BE 9 | 700 |
| 6/2/2004** | SI 2.0 | 310 |

| | | |
|---|---|---|
| 6/2/2004** | SI 4 | 2500 |
| 6/2/2004** | SI 3 | 1100 |
| 6/2/2004** | BE 21_0 | 560 |
| 6/2/2004** | Co Rd 33 | 460 |
| 6/2/2004** | Sibley 3 | 230 |
| 6/2/2004** | Sibley | 600 |
| 6/2/2004** | TACOMA | 1000 |
| 6/2/2004** | Sibley 2 | 280 |
| 6/2/2004** | CR 19 | 380 |
| 6/2/2004** | CA 1.7 | 200 |
| 6/2/2004** | CR 19 | 240 |
| 6/3/2004** | W 11 | 64 |
| 6/3/2004** | CA 8_7 | 60 |
| 6/3/2004** | CA 10_4 | 140 |
| 6/3/2004** | B 1 | 180 |
| 6/3/2004** | CC 10 | 40 |
| 6/3/2004** | CC 9 | 500 |
| 6/3/2004** | CC 11 | 10 |
| 6/3/2004** | CC 8 | 45 |
| 6/3/2004** | G 1 | 50 |
| 6/3/2004** | CC 1 | 300 |
| 6/3/2004** | W 10 | 190 |
| 6/3/2004** | BENT | 230 |
| 6/3/2004** | CC 7 | 210 |
| 6/3/2004** | Distilled h20 | <10 |
| 6/17/2004** | BE 2 | 2200 |
| 6/17/2004** | DA 12 | 9000 |
| 6/17/2004** | BE 5 | 9000 |
| 6/17/2004** | BE 9 | 5100 |
| 6/17/2004** | SI 2.0 | 4500 |
| 6/17/2004** | SI 4 | 500 |
| 6/17/2004** | SI 3 | 2100 |
| 6/17/2004** | BE 21_0 | 3200 |
| 6/17/2004** | Co Rd 33 | 3400 |
| 6/17/2004** | Sibley 3 | 2100 |
| 6/17/2004** | Sibley | 4000 |
| 6/17/2004** | TACOMA | 4000 |
| 6/17/2004** | Sibley 2 | 1500 |
| 6/17/2004** | CR 19 | 3900 |
| 6/17/2004** | CA 1.7 | 230 |
| 6/17/2004** | Distilled h20 | <10 |
| 6/17/2004** | CC 12 | 440 |
| 6/15/2004** | W 11 | 400 |
| **Date** | **Site** | **CFU/100ml** |
| 6/15/2004** | CA 8_7 | 440 |
| 6/15/2004** | CA 10_4 | 450 |
| 6/15/2004** | B 1 | 580 |
| 6/15/2004** | CC 10 | 2800 |
| 6/15/2004** | CC 9 | 2100 |
| 6/15/2004** | CC 11 | 340 |
| 6/15/2004** | CC 8 | 2400 |

| | | |
|---|---|---|
| 6/15/2004** | G 1 | 790 |
| 6/15/2004** | CC 1 | 300 |
| 6/15/2004** | W 10 | 2800 |
| 6/15/2004** | BENT | 2900 |
| 6/15/2004** | CC 7 | 1900 |
| 6/15/2004** | CC 11.2 | 2800 |
| 6/23/2004** | CC 12 | 410 |
| 6/29/2004** | BE 2 | 1000 |
| 6/29/2004** | DA 12 | 3700 |
| 6/29/2004** | BE 5 | 2000 |
| 6/29/2004** | BE 9 | 540 |
| 6/29/2004** | SI 2.0 | 900 |
| 6/29/2004** | SI 4 | 470 |
| 6/29/2004** | SI 3 | 2100 |
| 6/29/2004** | BE 21_0 | 1100 |
| 6/29/2004** | Co Rd 33 | 3300 |
| 6/29/2004** | Sibley 3 | 540 |
| 6/29/2004** | Sibley | 470 |
| 6/29/2004** | TACOMA | 370 |
| 6/29/2004** | Sibley 2 | 260 |
| 6/29/2004** | CR 19 | 150 |
| 6/29/2004** | CA 1.7 | 800 |
| 6/29/2004** | Distilled h20 | <10 |
| 6/28/2004** | W 11 | 260 |
| 6/28/2004** | CA 8_7 | 1100 |
| 6/28/2004** | CA 10_4 | 280 |
| 6/28/2004** | B 1 | 50 |
| 6/28/2004** | CC 10 | 280 |
| 6/28/2004** | CC 12 | 2000 |
| 6/28/2004** | CC 9 | 490 |
| 6/28/2004** | CC 11 | 300 |
| 6/28/2004** | CC 8 | 70 |
| 6/28/2004** | G 1 | 100 |
| 6/28/2004** | CC 1 | 160 |
| 6/28/2004** | W 10 | 10 |
| 6/28/2004** | BENT | 270 |
| 6/28/2004** | CC 7 | 200 |
| 6/28/2004** | B1.2 | 180 |
| 7/12/2004** | BE 2 | 27000 |
| 7/12/2004** | DA 12 | >60000 |
| 7/12/2004** | BE 5 | 14000 |
| 7/12/2004** | BE 9 | 33000 |
| **Date** | **Site** | **CFU/100ml** |
| 7/12/2004** | SI 2.0 | 39000 |
| 7/12/2004** | SI 4 | >60000 |
| 7/12/2004** | SI 3 | 34000 |
| 7/12/2004** | BE 21_0 | 39000 |
| 7/12/2004** | Co Rd 33 | 40000 |
| 7/12/2004** | Sibley 3 | 34000 |
| 7/12/2004** | Sibley | 46000 |
| 7/12/2004** | TACOMA | 2500 |

| | | |
|---|---|---|
| 7/12/2004** | Sibley 2 | 9000 |
| 7/12/2004** | CR 19 | 3500 |
| 7/12/2004** | CA 1.7 | 5400 |
| 7/12/2004** | CA 1.72 | 17000 |
| 7/13/2004** | W 11 | 1200 |
| 7/13/2004** | CA 8_7 | 400 |
| 7/13/2004** | CA 10_4 | 4200 |
| 7/13/2004** | B 1 | 180 |
| 7/13/2004** | CC 10 | 1800 |
| 7/13/2004** | CC 12 | 4200 |
| 7/13/2004** | CC 9 | 2500 |
| 7/13/2004** | CC 11 | 140 |
| 7/13/2004** | CC 8 | 1600 |
| 7/13/2004** | G 1 | 300 |
| 7/13/2004** | CC 1 | 2000 |
| 7/13/2004** | W 10 | 40 |
| 7/13/2004** | BENT | 250 |
| 7/13/2004** | CC 7 | 260 |
| 7/13/2004** | Distilled h20 | <10 |
| 7/28/2004** | BE 2 | 640 |
| 7/28/2004** | DA 12 | 1500 |
| 7/28/2004** | BE 5 | 540 |
| 7/28/2004** | BE 9 | 1100 |
| 7/28/2004** | SI 2.0 | 1000 |
| 7/28/2004** | SI 4 | 2000 |
| 7/28/2004** | SI 3 | 2400 |
| 7/28/2004** | BE 21_0 | 820 |
| 7/28/2004** | Co Rd 33 | 900 |
| 7/28/2004** | Sibley 3 | 2900 |
| 7/28/2004** | Sibley | 900 |
| 7/28/2004** | TACOMA | 480 |
| 7/28/2004** | Sibley 2 | 2800 |
| 7/28/2004** | CR 19 | 730 |
| 7/28/2004** | CA 1.7 | 730 |
| 7/28/2004** | Distilled h20 | <10 |
| 7/27/2004** | W 11 | 220 |
| 7/27/2004** | CA 8_7 | 100 |
| 7/27/2004** | CA 10_4 | 1300 |
| 7/27/2004** | B 1 | 2400 |
| 7/27/2004** | CC 10 | 800 |
| **Date** | **Site** | **CFU/100ml** |
| 7/27/2004** | CC 12 | 1200 |
| 7/27/2004** | CC 9 | 610 |
| 7/27/2004** | CC 11 | 100 |
| 7/27/2004** | CC 8 | 1800 |
| 7/27/2004** | G 1 | 200 |
| 7/27/2004** | CC 1 | 400 |
| 7/27/2004** | W 10 | <10 |
| 7/27/2004** | BENT | 640 |
| 7/27/2004** | CC 7 | 1000 |
| 7/27/2004** | CA 8.72 | 360 |

| | | |
|---|---|---|
| 8/26/2004** | BE 2 | 90 |
| 8/26/2004** | BE 5 | 300 |
| 8/26/2004** | BE 9 | 1500 |
| 8/26/2004** | SI 3 | 110 |
| 8/26/2004** | BE 21_0 | 6900 |
| 8/26/2004** | Co Rd 33 | 620 |
| 8/26/2004** | Sibley 3 | 760 |
| 8/26/2004** | Sibley | 380 |
| 8/26/2004** | TACOMA | 440 |
| 8/26/2004** | Sibley 2 | 260 |
| 8/26/2004** | CR 19 | 90 |
| 8/26/2004** | CA 1.7 | 300 |
| 8/26/2004** | Distilled h20 | <10 |
| 8/27/2004** | W 11 | 2600 |
| 8/27/2004** | CA 8_7 | 4000 |
| 8/27/2004** | CA 10_4 | 3900 |
| 8/27/2004** | CC 10 | 630 |
| 8/27/2004** | CC 12 | 90 |
| 8/27/2004** | CC 9 | 770 |
| 8/27/2004** | CC 11 | 8000 |
| 8/27/2004** | CC 8 | 2000 |
| 8/27/2004** | CC 1 | 8000 |
| 8/27/2004** | W 10 | 36 |
| 8/27/2004** | BENT | 520 |
| 8/27/2004** | CA 8.7 | 820 |
| 9/7/2004** | BE 2 | 900 |
| 9/7/2004** | BE 5 | 2000 |
| 9/7/2004** | BE 9 | 2700 |
| 9/7/2004** | SI 4 | 53000 |
| 9/7/2004** | SI 3 | 1600 |
| 9/7/2004** | BE 21_0 | 23000 |
| 9/7/2004** | Co Rd 33 | 12000 |
| 9/7/2004** | Sibley 3 | 9000 |
| 9/7/2004** | Sibley | 9000 |
| 9/7/2004** | TACOMA | 630 |
| 9/7/2004** | Sibley 2 | 5000 |
| 9/7/2004** | CR 19 | 640 |
| 9/7/2004** | CA 1.7 | 7000 |
| 9/7/2004** | Distilled | <10 |
| 9/8/2004** | CA 8_7 | 730 |
| 9/8/2004** | CA 10_4 | 2800 |
| 9/8/2004** | CC 10 | 1400 |
| 9/8/2004** | CC 12 | 900 |
| 9/8/2004** | CC 9 | 3100 |
| 9/8/2004** | CC 11 | 400 |
| 9/8/2004** | CC 8 | 1100 |
| 9/8/2004** | CC 1 | 2400 |
| 9/8/2004** | W 10 | 54 |
| 9/8/2004** | BENT | 820 |
| 9/8/2004** | CH 1 | 400/820 |

| | | |
|---|---|---|
| 9/23/2004** | BE 2 | |
| 9/23/2004** | DA 12 | 15000 |
| 9/23/2004** | BE 5 | 30000 |
| 9/23/2004** | BE 9 | 36000 |
| 9/23/2004** | SI 2.0 | 3000 |
| 9/23/2004** | SI 4 | >60000 |
| 9/23/2004** | SI 3 | 44000 |
| 9/23/2004** | BE 21_0 | 20000 |
| 9/23/2004** | Co Rd 33 | >60000 |
| 9/23/2004** | Sibley 3 | 9000 |
| 9/23/2004** | Sibley | 12000 |
| 9/23/2004** | TACOMA | 3200 |
| 9/23/2004** | Sibley 2 | 3200 |
| 9/23/2004** | CR 19 | 190 |
| 9/23/2004** | CA 1.7 | 1000 |
| 9/23/2004** | Distilled h20 | <10 |
| 9/22/2004** | W 11 | 2100 |
| 9/22/2004** | CA 8_7 | 1200 |
| 9/22/2004** | CA 10_4 | 55000 |
| 9/22/2004** | B 1 | 3900 |
| 9/22/2004** | CC 10 | 48000 |
| 9/22/2004** | CC 12 | >60000 |
| 9/22/2004** | CC 9 | >60000 |
| 9/22/2004** | CC 11 | 190 |
| 9/22/2004** | CC 8 | 7000 |
| 9/22/2004** | G 1 | 2600 |
| 9/22/2004** | CC 1 | 37000 |
| 9/22/2004** | W 10 | 70 |
| 9/22/2004** | BENT | 4000 |
| 9/22/2004** | CC 7 | 2200 |
| 9/22/2004** | CH 1.0 | 1200/1400 |

**Appendix D**
**Seasonal Load Proportion Confirmation**

| Source | Spring (Wet) | Spring (Dry) | Summer (Wet) | Summer (Dry) | Fall (Wet) | Fall (Dry) |
|---|---|---|---|---|---|---|
| Overgrazed Pasture | 243 | 61 | 243 | 61 | 243 | 61 |
| Feedlots w/o Runoff Controls | 635 | 0 | 317 | 0 | 317 | 0 |
| Surface Applied Manure | 935 | 0 | 935 | 0 | 2804 | 0 |
| Incorporated Manure | 33 | 0 | 0 | 0 | 134 | 0 |
| Failing Septic Systems | 554 | 554 | 554 | 554 | 554 | 554 |
| Municipal WWTP | 0.29 | 0.29 | 0.29 | 0.29 | 0.29 | 0.29 |
| Deer | 3 | 3 | 3 | 3 | 3 | 3 |
| Geese | 4 | 4 | 4 | 4 | 4 | 4 |
| Other Wildlife | 3 | 3 | 3 | 3 | 3 | 3 |
| Urban Stormwater | 23 | 0 | 23 | 0 | 23 | 0 |

# 12.0 References


Alderisio, K.A, and DeLuca, H. 1999. Seasonal Enumeration of Fecal Coliform Bacteria from the Feces of Ring-Billed Gulls (Larus dwlwwarensis) and Canada Geese (Branta Canadensis). Applied and Environmental Microbiology p. 5628-5630.

Bannerman, R., A. Legg and S. Greb. 1996. *Quality of Wisconsin Stormwater 1989-1994.* USGS Open File Report 96-458. U.S. Geological Survey, Reston, VA.

Bannerman, R., D. Owens, R. Dodds, and N. Hornewer. 1993. "Sources of Pollutants in Wisconsin Stormwater." *Water Science and Technology* 28(3-5):241-259.

Baxter-Potter, W and M. Gilliland, 1988. Bacterial Pollution in Runoff from Agricultural Lands. J. Environmental Quality, 17(1):27-34.

Carver County Water Management Plan

Howell, J. et. al., 1996. Effect of Sediment Particle Size and Temperature on Fecal Bacteria Mortality Rates and the Fecal Coliform/Fecal Streptococci Ratio. J. Environmental Quality. 25:1216-1220.

McMurry S. et.al., 1998. Fecal Coliform Transport Through Intact Soil Blocks Amended with Poultry Manure. J. Environmental Quality 27:86-92.

Minnesota Rules, Chapter 7020. Subpart 5.

Minnesota Pollution Control Agency. 1999. Fecal Coliform Bacteria in Rivers, January 1999.

Minnesota Pollution Control Agency. 2002. Regional Total Maximum Daily Load Evaluation of Fecal Coliform Bacteria Impairments in the Lower Mississippi River Basin in Minnesota. MPCA Report, October 2002.

Mulla, D.J., and A.S. Birr, G. Randall, J. Moncrief, M. Schmidt, A. Sekely, and E. Kerre. 2001. Technical Work Paper: Impacts of Animal Agriculture on Water Quality. Department of Soil, Water, and Climate, University of Minnesota. Prepared for the Minnesota Environmental Quality Board and Citizen Advisory Committee, April 3, 2001.

Schuler, David, 2004. South Branch Yellow Medicine River Fecal Coliform TMDL Report. MPCA, St. Paul MN. 47 pp.

Sovell, Laurie, et al., 2000 "Impacts of Rotational Grazing and Riparian Buffers on Physicochemical and Biological Characteristics of Southeastern Minnesota, USA, Streams" Environmental Management, 26(6) 629-641.

United States Environmental Protection Agency 2001. Protocol for Developing Pathogen TMDLs. EPA 841-R-00-002.