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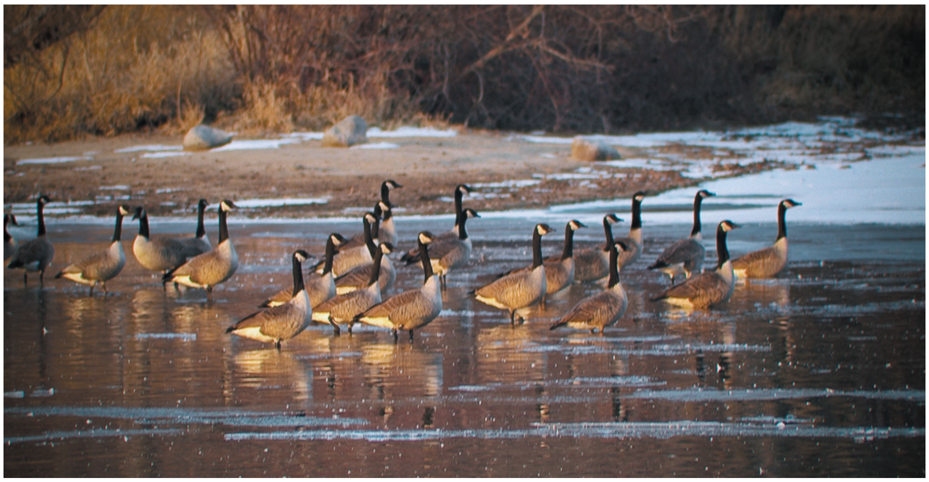
Upper Mississippi River Bacteria TMDL: Data Analysis, Source Assessment, and Monitoring Recommendations



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Upper Mississippi River Bacteria TMDL: Data Analysis, Source Assessment, and Monitoring Recommendations

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Abbreviations

BMP	Best management practice
CFU	Colony-forming units
CSO	Combined sewer overflow
E. coli	*Escherichia coli*
EPA	United States Environmental Protection Agency
ISTS	Individual sewage treatment system
LDC	Load duration curve
MCES	Metropolitan Council Environmental Services
MDH	Minnesota Department of Health
MPCA	Minnesota Pollution Control Agency
MPN	Most probable number
MS4	Municipal separate storm sewer systems
RM	River mile
SSTS	Subsurface sewage treatment system
STORET	Storage and retrieval database
SWCD	Soil and Water Conservation District
TMDL	Total maximum daily load
UMRB	Upper Mississippi River Basin
USGS	United States Geological Survey
WD	Watershed District
WMO/C	Watershed Management Organization / Commission
WWTF	Wastewater treatment facility

1. EXECUTIVE SUMMARY

A large number of Minnesota's residents rely on the Mississippi River for both drinking water and as a place for recreational activities. While specific recreational user data (boating, swimming, wading) is not known at this time, between 940,000 and 950,000 Minnesotans use the Mississippi River within this project's study area for drinking water. The Upper Mississippi River Bacteria Total Maximum Daily Load (TMDL) Project is a joint effort between the Minnesota Pollution Control Agency (MPCA) and the Minnesota Department of Health (MDH) in close coordination with many project partners to address recreational use impairments due to bacterial contamination in the Mississippi River and associated tributaries. The study area includes drainage to that part of the Upper Mississippi River that extends from St. Cloud to Hastings, Minnesota. The work plan for the project can be found on the MPCA's project website: http://www.pca.state.mn.us/water/tmdl/project-uppermiss-bacteria.html.

This first phase of the project includes data analysis, preliminary source assessment, and monitoring recommendations. Existing mainstem and adjacent tributary bacteria data are analyzed in *Section 3. Water Quality Analysis*. Water quality and flow data within the project area from 1999 to 2008 were gathered from MPCA, project partners, and stakeholders. Analyses help to identify both spatial and temporal trends in bacteria and will help focus future phases of the project. The following list represents a compilation of the preliminary trends and findings from the water quality analysis:

- Data at individual sites often show increasing bacteria concentrations into the fall. In several cases, this trend appears only after 2004.
- High winter concentrations are not uncommon among sites having winter data. In particular, River Mile (RM) 863.0 and 815.6 experience high winter concentrations. Data from a downstream site on the Minnesota River also experiences high winter concentrations. Several water quality monitoring sites do not have winter data. Even though the aquatic recreation standard does not apply during the winter months, winter bacteria sources are relevant due to the potential survival of bacteria in sediments of downstream waterbodies. Winter bacteria sources are also relevant to source water protection efforts.
- Bacteria concentrations along the Mississippi River mainstem peak around the metropolitan area.
- Increases in bacteria concentrations between adjacent monitoring sites along the Mississippi River mainstem mainly occur in late summer and fall and never occur in the spring. Mississippi RMs 858.5, 839.1, and 831.0 experience increases in bacteria concentrations between adjacent monitoring sites only during winter months.
- Tributary sites tend to experience more exceedances above the *E. coli* standard than Mississippi River mainstem sites.
- Storm sewer data available from only four sites (out of hundreds of outfalls to the Mississippi River in the project area) exhibit high *E. coli* concentrations and experience some of the greatest concentrations of all monitoring sites.
- Exceedances in *E. coli* concentrations above the standard (126 org/100mL) are experienced under all flow regimes demonstrating no clear pattern and suggesting a possible mix of

bacteria sources. The lack of trends is especially apparent, and expected, on mainstem, large river data; it is a function of the inherent convergence of a variety of bacteria sources and flow regimes from both local and regional watersheds.

- Mainstem data indicate that neither temperature, total suspended solids nor turbidity alone is a surrogate for *E. coli*.
- Annual trends in geometric mean bacteria concentrations of AUIDs indicate a relatively common decrease in *E. coli* and fecal coliform concentrations in the years 2006 and 2008 as compared to the year before. Increases are less common.

Relevant information regarding potential bacteria sources is gathered and summarized in *Section 4. Source Assessment*. Source categories include human sources, livestock, pets, wildlife, urban stormwater, sediments, and other hot-spots.

Human sources can be divided into two source categories: subsurface sewage treatment systems (SSTS) and municipal wastewater. Within the SSTS category, fecal contamination can come from individual and community septic systems, straight pipes, and septage application. Within the Upper Mississippi watershed 141 communities identified some type of wastewater need (MPCA 2008). Within the municipal wastewater category, fecal contamination can come from wastewater treatment facility (WWTF) bypasses and violations, combined sewer overflows (CSOs), leaking sanitary sewers, and biosolids application. CSOs have become relatively rare in Minneapolis and St. Paul; the most recent CSOs occurred in 2006. The contribution of fecal contamination from WWTF bypasses and violations, from leaking sanitary systems, and from biosolids application has not been determined.

Sources of fecal bacteria contamination from livestock include feedlots and pasture (grazing livestock and field-applied manure). NPDES-permitted feedlots are required to have zero discharges to surface water. Feedlots that are not permitted through the NPDES program may also be sources of fecal material to surface waters. Pastures are neither permitted nor registered with the state, and the quantity of fecal contamination from this source is difficult to quantify. The land application of manure has the potential to be a substantial source of fecal contamination, entering waterways from overland runoff and drain tile intakes.

Pets as a source of fecal contamination may be only minor on a watershed scale. However, the location of pets in the immediate vicinity of a waterway could result in contributions to local areas.

Fecal coliform can be contributed to surface water by wildlife from dwelling in waterbodies, within conveyances to waterbodies, or when their waste is carried to storm inlets, creeks, and lakes during storm runoff events.

Urban stormwater contains many of the bacteria sources already presented in this discussion; it is discussed as a separate topic due to the extent of the bacteria impairment in the urban portions of the study area. The sources of bacteria in urban stormwater may include the following: leakage from sanitary sewers, domestic pets, wildlife, and, combined sewer overflows. Bacteria may accumulate in the sediments of sump catch basins, stormwater ponds, and streams. Certain environmental conditions may encourage the growth of *E. coli*, such as slow flowing water (*e.g.* ponds and dammed portions of the river) and/or high temperature.

Potential next steps for further investigation of the possible sources are also included.

Data gaps were identified in *Section 5* that include reaches along the stretch of the Mississippi River within the project area and tributaries to the Mississippi River (only tributary reaches directly adjacent to the Mississippi River) that have not yet been assessed for bacteria. Other *E. coli* data gaps are discussed, including winter data, paired monitoring sites, and data from storm sewers. To be able to examine bacteria data with respect to loading and not just concentration, more flow data are also needed.

Recommendations for additional monitoring are based on these data gaps. Table 1 through Table 3 identify specific AUIDs recommended for future monitoring. These tables, additional monitoring protocols, and general guidance for future monitoring efforts can be found in *Section 6. Monitoring Recommendations*.

Table 1. Mississippi River mainstem and adjacent tributaries with no *E. coli* or fecal coliform data. Repeat of Table 20.

AUID	Stream Name	Reach Description	County	Municipality / Township	Watershed Organization
07010201-505	Mississippi River	Platte R to Little Rock Cr	Benton, Morrison, Stearns	Brockway Township, Rice City, Two Rivers Township, Watab Langola Township, Township	NA
07010201-508	Mississippi River	Spunk Cr to Platte R	Benton, Morrison	Langola Township, Two Rivers Township	NA
07010201-509	Mississippi River	Two R to Spunk Cr	Benton, Morrison	Langola Township, Two Rivers Township, Bellevue Township	NA
07010201-513	Mississippi River	Little Rock Cr to Sartell Dam	Benton, Stearns	Le Sauk Township, Sartell City, Sauk Rapids Township, Watab Township, Brockway Township	NA
07010201-514	Mississippi River	Sartell Dam to Watab R	Stearns	Sartell City	NA
07010201-516	Little Two River	Headwaters to Mississippi R	Morrison	Bellevue Township, Elmdale City, Elmdale Township, Swan River Township, Swanville Township, Two Rivers Township	NA
07010201-555	Unnamed spring (Smart's Creek)	Headwaters to Mississippi R	Stearns	Brockway Township	NA
07010201-569	Hazel Creek	Unnamed ditch to Mississippi R	Morrison	Two Rivers Township	NA
07010201-577	Little Rock Creek	Little Rock Lk to Mississippi R	Benton, Stearns	Watab Township	NA
07010203-503	Mississippi River	Elk R to Crow R	Sherburne, Wright	Elk River City, Otsego Township	NA
07010203-513	Mississippi River	St Cloud Dam to Clearwater R	Sherburne, Stearns	Clear Lake Township, Haven Township, Lynden Township, St. Cloud City, Clear Lake Township	NA
07010203-525	Elk River	Orono Lk to Mississippi R	Sherburne, Wright	Elk River City, Otsego Township	NA
07010203-528	Unnamed creek	T121 R23W S19, south line to Mississippi R	Sherburne, Wright	Elk River City, Otsego Township	NA
07010203-554	Fish Creek	Fish Lk to Mississippi R	Sherburne, Wright	Clear Lake Township, Clearwater Township	NA
07010203-557	Silver Creek	Locke Lk to Mississippi R	Wright	Clear Lake Township, Silver Creek Township	NA
07010203-562	Johnson Creek (St Augusta Creek)	T123 R28W S15, south line to Mississippi R	Stearns	St. Augusta City, St. Cloud City	NA
07010203-572	Plum Creek	Warner Lk to Mississippi R	Stearns	Lynden Township	NA
07010203-575	Mississippi River	CSAH 7 in St Cloud to St Cloud Dam	Sherburne, Stearns	St. Cloud City	NA
07010206-510	Mississippi River	Rum R to Elm Cr	Anoka, Hennepin	Anoka City, Champlin City	West Mississippi River, Elm Creek
07010206-511	Mississippi River	Elm Cr to Coon Rapids Dam	Anoka, Hennepin	Anoka City, Champlin City, Coon Rapids City, Brooklyn Park City	Lower Rum River, Six Cities, West Mississippi River, Elm Creek

AUID	Stream Name	Reach Description	County	Municipality / Township	Watershed Organization
07010206-512	Mississippi River	Coon Rapids Dam to Coon Cr	Anoka, Hennepin	Coon Rapids City	Six Cities, West Mississippi River
07010206-513	Mississippi River	Upper St Anthony Falls to Lower St Anthony Falls	Hennepin	Minneapolis City	Mississippi River
07010206-514	Mississippi River	L & D #1 to Minnesota R	Hennepin, Ramsey	Fort Snelling Unorganized, Minneapolis City, St. Paul City	Minnehaha Creek, Capitol Region
07010206-530	Coon Creek	Unnamed cr to Mississippi R	Anoka, Ramsey	Andover City, Coon Rapids City, Ham Lake City	Coon Creek, Six Cities
07010206-534	Unnamed stream	Pigs Eye Lk to Mississippi R	Ramsey	St. Paul City	Lower Mississippi River, Ramsey/Washington/Metro
07010206-542	Unnamed creek	Unnamed cr to Mississippi R	Dakota, Ramsey	Lilydale City, Mendota Heights City, St. Paul City	Capitol Region, Lower Mississippi River
07010206-557	County Ditch 17	Headwaters to Mississippi R	Anoka	Blaine City, Coon Rapids City, Fridley City	Six Cities, Lower Rum River, Elm Creek
07010206-567	Mississippi River	Crow R to NW city limits of Anoka	Anoka, Hennepin, Sherburne, Wright	Dayton City, Ramsey City, Elk River City, Otsego Township	Elm Creek
07010206-586	Rice Creek	Locke Lk to Mississippi R	Anoka	Fridley City	Rice Creek
07010206-590	Unnamed creek	Pickerel Lk to Mississippi R	Ramsey	St. Paul City	Lower Mississippi River
07010206-597	Unnamed creek	Within Mississippi R Polygon	Washington	Cottage Grove City	South Washington
07010206-608	Fish Creek	Unnamed (North Star) Lk to Mississippi R	Ramsey	St. Paul City	Lower Mississippi River, Ramsey/Washington/Metro
07010206-621	Trout Brook	Unnamed ditch to Mississippi R	Ramsey	St. Paul City	Capitol Region, Lower Mississippi River
07010206-661	Unnamed creek	Headwaters to Mississippi R	Ramsey	Minneapolis City, St. Paul City	Capitol Region
07010206-662	Unnamed creek	Headwaters to Mississippi R	Ramsey	St. Paul City	Capitol Region
07010206-902	Unnamed creek	to Mississippi R	Hennepin	Brooklyn Park City	West Mississippi River
07010206-912	Unnamed creek (Kaposia Creek)	Headwaters to Mississippi R	Dakota	South St. Paul City, West St. Paul City	Lower Mississippi River
07010206-913	Unnamed creek	to Mississippi R Spring Lk	Dakota	Nininger Township	Vermillion River
07010207-556	Rum River	Madison/Rice St in Anoka to Mississippi R	Anoka	Anoka City	Lower Rum River, West Mississippi River

Table 2. Mississippi River mainstem and adjacent tributaries with fecal coliform data but no *E. coli* data.
Repeat of Table 21

Waterbody	AUID	Reach Description	Mississippi RM of Entry into Mississippi River	Flow Data Available? (Y/N)	Flow Station ID
Two River	07010201-523	North & South Two R to Mississippi R	953.5	N	N/A
Spunk Creek*	07010201-525	Lower Spunk Lk to Mississippi R	949.7	N	N/A
Watab River	07010201-528	Rossier Lk to Mississippi R	932.5	N	N/A
Clearwater River	07010203-511	Clearwater Lk to Mississippi R	914.4	N	N/A
Shingle Creek	07010206-506	Headwaters (Eagle Cr/Bass Cr) to Mississippi R	857.7	Y	5288705
Mississippi River	07010206-501	L & D #2 to St Croix R (RM 815.2 to 811.3)	N/A	Y	5331580

*Listed as impaired

Table 3. Mississippi River mainstem RMs having *E. coli* data from April through October and having at least one month with fewer than five samples; table identifies number of samples per month.
Repeat of Table 22

			Month						
AUID	**Reach Description**	**RM**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
07010201-501	End HUC 07010104 (below Swan R) to Two R	**953.5**	4	3	4	2	3	2	1
07010201-502	Watab R to Sauk R	**930.2**	4	3	4	2	3	2	1
07010203-574	Sauk R to CSAH 7 in St Cloud	**929.4**	3	4	4	4	3	3	3
		928.4	4	4	4	15	31	33	31
07010203-510	Clearwater R to Elk R	**914.0**	3	4	4	4	3	3	4
		896.9	3	4	4	3	2	2	4
07010206-568	NW city limits of Anoka to Rum R	**871.7**			2	2	2	2	
07010206-509	Coon Cr to Upper St Anthony Falls	**863.0**	3			2	3	2	4
		858.8	2	3	4	3	4	4	3
		857.5	2	3	3	3	2	3	
07010206-505	Minnesota R to Metro WWTP (RM 844.0 to 835.0)	**839.7**	3	2	5	2	3	4	4
		836.8*							
07010206-502	Rock Island RR bridge to L & D #2 (RM 830.0 to 815.2)	**826.4**	3	3	3	2	3	4	3
		821.8			4	7	6	6	2
		815.2	4	3	4	2	3	4	3

* Data available only November through March

2. INTRODUCTION

A. PURPOSE OF TMDL

A large number of Minnesota's residents rely on the Mississippi River for both drinking water and as a place for recreational activities. While specific recreational user data (boating, swimming, wading) is not known at this time, between 940,000 and 950,000 Minnesotans use the Mississippi River within this project's study area for drinking water. The ultimate goal of this project is to describe the reduction in pollutant loading and implementation activities needed so that Upper Mississippi River reaches can meet the water quality standard for *Escherichia coli (E. coli*), a bacteria used to indicate the potential presence of waterborne pathogens that can be harmful to human health. In meeting this goal, the implementation of best management practices (BMPs) in critical areas may also help reduce other contaminants of concern investigated during this study.

This project is a joint effort between the Minnesota Pollution Control Agency (MPCA) and the Minnesota Department of Health (MDH) in close coordination with a multitude of project partners. Future phases of this project consist of additional monitoring based on findings herein and additional collection of source information. The final phases of this project consist of the development of a TMDL report and an implementation plan. In this first phase of the project, existing data are analyzed and recommendations are provided for monitoring. The work plan for the project can be found on the MPCA's project website:
http://www.pca.state.mn.us/water/tmdl/project-uppermiss-bacteria.html.

Data presented herein include bacteria data and potential source data.

B. PROJECT PARTNERS

Several advisory groups have been or will be involved in guiding the project's approach and reviewing deliverables. See the MPCA's project website for meeting agendas, presentations, and meeting minutes: http://www.pca.state.mn.us/water/tmdl/project-uppermiss-bacteria.html

Table 4 lists the project partners who were invited to participate in the Stakeholder Advisory Team and Technical Advisory Committee Meetings. Stakeholder and technical teams will likely be broadened or adjusted as necessary as the project progresses. Public meetings are also anticipated.

Table 4. Project partner organizations.

- Anoka Conservation District
- Bassett Creek Watershed Management Organization (WMO)
- Benton County
- Benton County Soil and Water Conservation District (SWCD)
- Capitol Region Watershed District (WD)
- Carver County
- Centra Sota Cooperative
- City of Anoka
- City of Becker
- City of Champlin
- City of Coon Rapids
- City of Fridley
- City of Golden Valley
- City of Melrose
- City of Minneapolis Public Works
- City of Minneapolis Water Treatment & Distribution Services
- City of Ramsey
- City of South St. Paul
- City of St. Cloud
- City of St. Paul
- City of St. Paul Public Works
- City of St. Paul Regional Water Services
- Clearwater River WD
- Crow River Organization of Water
- Dairy Producers
- Dakota County
- Dakota County SWCD
- Elk River Wastewater Treatment Facility
- Elk River Watershed Assn
- Elm Creek WMO
- Friends of the Mississippi River
- Great River Greening
- Hennepin County Environmental Services
- Hennepin County Public Health Protection
- Hennepin County Public Works
- Hennepin County-Environmental Health
- League of MN Cities
- Lower Minnesota River WD
- Lower Mississippi River WMO
- Lower Rum River WMO
- Metropolitan Council
- Middle Fork Crow River WD
- Minneapolis Park & Recreation Board
- Minnehaha Creek WD
- Mississippi River WMO
- MN Agriculture Water Resources Coalition (MAWRC)
- MN Board of Water and Soil Resources
- MN Board of Water and Soil Resources
- MN Cities Stormwater Coalition
- MN Department of Agriculture
- MN Department of Agriculture
- MN Department of Health
- MN Department of Health
- MN Department of Natural Resources
- MN Department of Transportation
- MN Milk Producers Association
- MN Pollution Control Agency
- MN Rural Water Association
- MN Rural Water Association
- Morrison County Courthouse
- Morrison SWCD
- North Fork Crow River WD
- NPS Mississippi National River and Recreation Area
- Ramsey County Public Works
- Ramsey Washington Metro WD
- Rice Creek WD
- Sauk River Watershed
- Sauk River WD
- Sherburne County SWCD
- Shingle Creek WMC
- Six Cities WMO
- Stearns County
- Stearns County SWCD
- Stearns County Water Planning
- Three Rivers Park District
- Todd County SWCD
- U.S. Army Corps of Engineers
- U.S. Geological Survey
- University of Minnesota
- University of Minnesota-Water Resources Center
- Upper Mississippi River Source Water Protection Project
- USDA Natural Resources Conservation Service
- West Mississippi Management Commission
- Wright County Commissioner
- Wright County Farm Bureau
- Wright County Soil and Water Conservation District
- Xcel Energy

C. Background

Upper Mississippi River Basin

The Upper Mississippi River Basin (UMRB) covers approximately 20,100 square miles of the State of Minnesota (Figure 1). The basin stretches from the headwaters of the Mississippi River at Lake Itasca to Lock and Dam Number 2 near Hastings. The basin drains 15 of the 81 major watersheds in Minnesota and all or parts of 21 counties. The basin includes the major population centers of the state including the Cities of Minneapolis, St. Paul, and St. Cloud. Additionally, some of the fastest growing areas and major lake vacation areas in the state are included in the UMRB. The river drains a mixture of forested, prairie, agricultural, and urban land and aquatic (e.g. wetland, stream, and lake) areas. Additionally, over the course of the Mississippi River drainage, water quality changes depending on the geographic area, dominant land uses and societal influences.

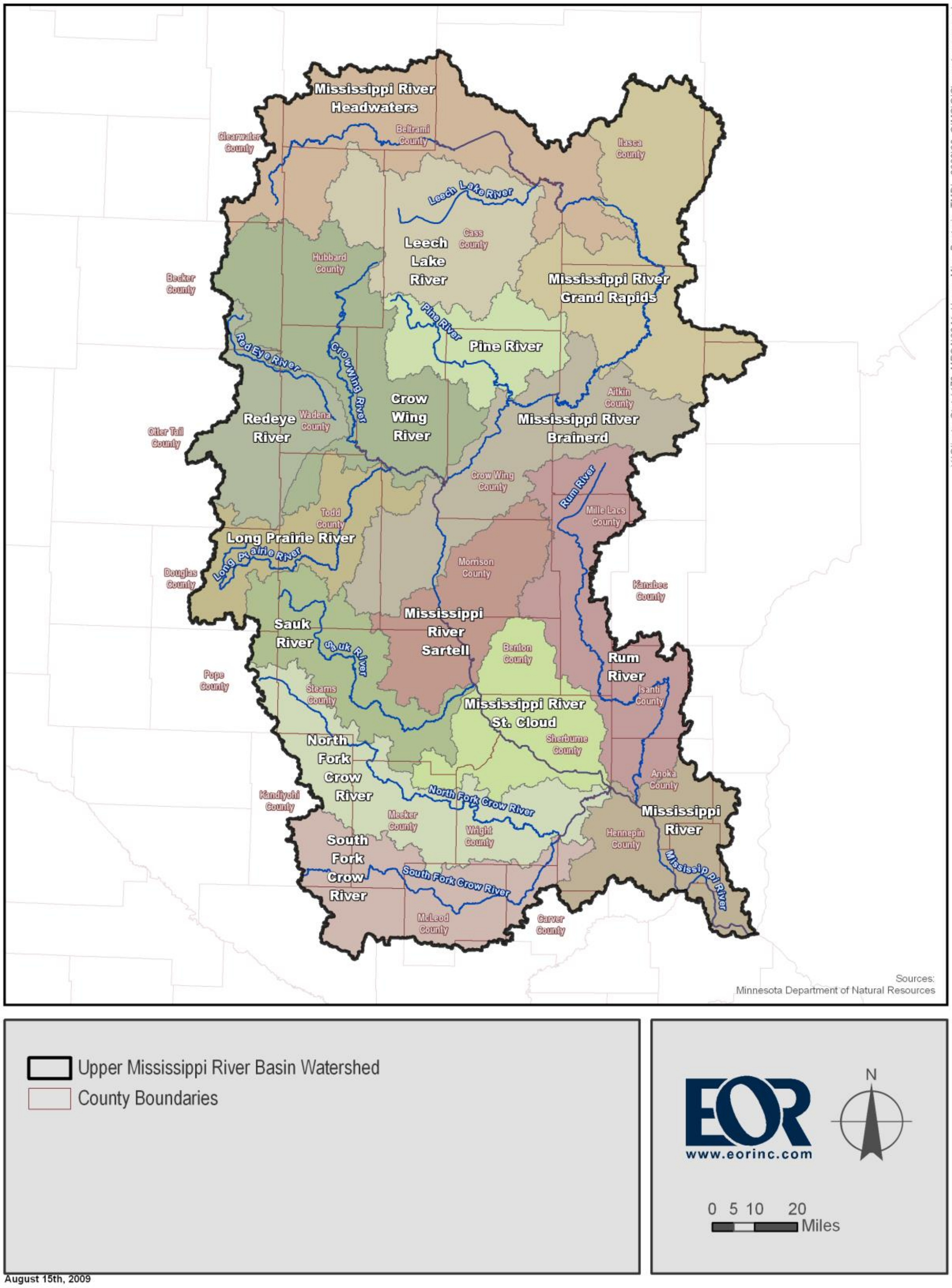

Figure 1. Map of the Upper Mississippi River Basin.

Minnesota River Basin

The Minnesota River Basin covers approximately 16,770 square miles, roughly 10 million acres. Thirteen major watersheds in Minnesota drain into the basin, which touches 37 counties. The Minnesota River flows southeast from its source at Big Stone Lake on the South Dakota border to Mankato then northeast to join the Mississippi River at Fort Snelling (about 335 total miles).

Bacteria Impairments and TMDLs

Twelve TMDL projects addressing waters impaired for fecal coliform have been approved by the U.S. Environmental Protection Agency (EPA) to date (see below) for the State of Minnesota, one is currently out for public comment, and 15 are underway (Table 5) (MPCA: http://www.pca.state.mn.us/water/tmdl/tmdl-development.html). Lessons learned from the approaches used in these TMDL projects, other local projects, and possibly those conducted in other states will be used to help inform the process of developing this TMDL.

Table 5. Bacteria TMDLs within MN

TMDL Projects	TMDL Status*	Implementation Plan Approved*	Major Basin	In Study Area?°
Yellow Medicine (South Branch) TMDL: Fecal Coliform Bacteria	Approved 9/30/2004	9/27/05	Minnesota River Basin	
Lower Mississippi River Basin TMDL: Regional Fecal Coliform	Approved 4/5/2006	9/07	Lower Mississippi River Basin	
Chippewa River TMDL: Fecal Coliform	Approved 1/11/2007	TBD	Minnesota River Basin	
Sunrise River, North Branch TMDL: Fecal Coliform Bacteria	Approved 2/22/2007	2/07	St. Croix River Basin	
Carver-Bevens-Silver Creeks TMDL: Fecal Coliform	Approved 3/14/2007	3/07	Minnesota River Basin	
Blue Earth River TMDL: Fecal Coliform	Approved 11/14/2007	11/14/07	Minnesota River Basin	
Pomme de Terre: Fecal Coliform	Approved 12/7/2007	9/29/08	Minnesota River Basin	
Rock River TMDL: Fecal and Turbidity	Approved 4/23/2008	10/08	Missouri and Des Moines River Basins	
Pipestone Creek TMDL: Fecal Coliform Bacteria and Turbidity	Approved 7/3/2008	9/08	Missouri and Des Moines River Basins	
High Island Creek - Rush River: Fecal Coliform	Approved 11/14/2008	TBD	Minnesota River Basin	
West Fork Des Moines River Watershed: Multiple Impairments	Approved 12/18/2008	TBD	Missouri and Des Moines River Basins	
Groundhouse River: Fecal Coliform and Impaired Biota	Approved 5/12/2009	7/15/09	St. Croix River Basin	
Clearwater River Watershed: Low Dissolved Oxygen, Fecal Coliform, Lake Nutrients	Public notice (through 9/16/2009)	TBD	UMRB	Y
Cottonwood River: Fecal Coliform	Underway	TBD	Minnesota River Basin	
Hawk Creek - Beaver Creek Watershed TMDL Project: Turbidity and Fecal Coliform	Underway	TBD	Minnesota River Basin	
Lac qui Parle River-Yellow Bank: Bacteria, Turbidity, and Low Dissolved Oxygen	Underway	TBD	Minnesota River Basin	
Little Cottonwood River: Turbidity and Fecal Coliform	Underway	TBD	Minnesota River Basin	
Redwood River: Fecal Coliform	Underway	TBD	Minnesota River Basin	
Seven Mile Creek: Fecal Coliform and Turbidity	Underway	TBD	Minnesota River Basin	
Clearwater River: Dissolved Oxygen and Fecal Coliform	Underway	TBD	Red River Basin	
Red River- Moorhead: Fecal Coliform	Underway	TBD	Red River Basin	
Crow River (South Fork)- Buffalo Creek: Multiple Impairments	Underway	TBD	UMRB	Y
Elk River Watershed — Multiple Impairments	Underway	TBD	UMRB	Y
Lower Crow River (North Fork): multiple impairments	Underway	TBD	UMRB	Y
Lower Sauk River - Turbidity, Fecal Coliform and Nutrients	Underway	TBD	UMRB	Y
Minnehaha Creek	Underway	TBD	UMRB	Y
Sauk River: Fecal Coliform	Underway	TBD	UMRB	Y
Upper Mississippi River: Bacteria	Underway	TBD	UMRB	Y

* TMDL final approval by EPA; implementation plan final approval by MPCA
° See Figure 2 for a map of the study area.

D. Study Area

The study area includes drainage to that part of the Upper Mississippi River that extends from St. Cloud to Hastings, Minnesota and was based on National Hydrography Dataset (NHD) 8 digit hydrologic unit code (HUC) watersheds (subbasins). Subbasins were selected starting one subbasin upstream of St. Cloud, and included any subbasin downstream of St. Cloud that eventually discharges at the confluence of the St. Croix and Mississippi Rivers (excepting the St. Croix Basin). The included subbasins capture both direct Mississippi River and tributary drainage. Only a portion of the Minnesota River Subbasin (which extends into far western Minnesota) was included in the study area. The portion included was refined using DNR lake sheds that identify direct drainage to the Minnesota River. Five mainstem reaches and all or portions of 13 tributaries in the study area are impaired for aquatic recreation due to fecal coliform (Figure 2 and Table 6). Note that reaches or tributaries not listed as impaired may not yet have been assessed.

Figure 2. Upper Mississippi River Bacteria TMDL Study Area.

Table 6. Summary of information about reaches for the Upper Mississippi River Bacteria TMDL Project known to be impaired for bacteria.

Listed Reach Name	**Reach Description**	**AUID #**	**Listed Pollutant** (addressed in this TMDL)	**Impaired Use**	**Year Listed**	**Other Listed Pollutant(s)** (not addressed in this TMDL)	**Beneficial Use Class**[1]	**Source Water Area**
Mississippi River	Clearwater R to Elk R	07010203-510	Fecal Coliform	Aquatic Recreation	2002	Fish Bioassessment	1C, 2Bd, 3B	Priority Area B (St. Paul, Minneapolis)
Mississippi River	NW city limits of Anoka to Rum R	07010206-568	Fecal Coliform	Aquatic Recreation	2002	PCB in Fish Tissue	1C, 2Bd, 3B	Priority Area A and B (St. Paul, Minneapolis)
Mississippi River	Coon Cr to Upper St Anthony Falls	07010206-509	Fecal Coliform	Aquatic Recreation	2006	PCB in Fish Tissue	1C, 2Bd, 3B	Priority Area A and B (St. Paul, Minneapolis)
Mississippi River	Lower St Anthony Falls to Lock & Dam #1 (RM 853.3 to RM 847.6)	07010206-503	Fecal Coliform	Aquatic Recreation	2002		2B	
Mississippi River	Minnesota R to Metro WWTP (RM 844 to 835)	07010206-505	Fecal Coliform	Aquatic Recreation	1996	PCB in Fish Tissue, Turbidity, PFOS in Fish	2B	
Bassett Creek	Medicine Lk to Mississippi R	07010206-538	Fecal Coliform	Aquatic Recreation	2008	Fish Bioassessment		Priority Area B (St. Paul, Minneapolis) [2]
Buffalo Creek	JD 15 to S Fk Crow R	07010205-501	Fecal Coliform	Aquatic Recreation	2008	Turbidity, Fish Bioassessment, Aquatic Macroinvertebrate Bioassessment	7	Priority Area B (St. Paul, Minneapolis)
Buffalo Creek	Headwaters to JD 15	07010205-502	Fecal Coliform	Aquatic Recreation	2008	Fish Bioassessment, Aquatic Macroinvertebrate Bioassessment	7	Priority Area B (St. Paul, Minneapolis)
Chaska Creek	Headwaters to Minnesota R	07020012-512	Fecal Coliform	Aquatic Recreation	2006			
Clearwater River	CD 44 to Lk Betsy	07010203-549	Fecal Coliform	Aquatic Recreation	1996	Dissolved Oxygen		Priority Area B (St. Paul, Minneapolis)
Crow River	S Fk Crow R to Mississippi R	07010204-502	Fecal Coliform	Aquatic Recreation	2004	Fish Bioassessment, Turbidity		Priority Area B (St. Paul, Minneapolis)

Listed Reach Name	Reach Description	AUID #	Listed Pollutant (addressed in this TMDL)	Impaired Use	Year Listed	Other Listed Pollutant(s) (not addressed in this TMDL)	Beneficial Use Class[1]	Source Water Area
Crow River, South Fork	Buffalo Cr to N Fk Crow R	07010205-508	Fecal Coliform	Aquatic Recreation	2006	Fish Bioassessment, Turbidity		Priority Area B (St. Paul, Minneapolis)
Elk River	Elk Lk (71-0141-00) to St Francis R	07010203-579	Fecal Coliform	Aquatic Recreation	2008	Turbidity, Aquatic Macroinvertebrate Bioassessment		Priority Area B (St. Paul, Minneapolis)
Mill Creek	Headwaters to Sauk R	07010202-537	Fecal Coliform	Aquatic Recreation	2006	Dissolved Oxygen		Priority Area B (St. Paul, Minneapolis)
Minnehaha Creek	Lk Minnetonka to Mississippi R	07010206-539	Fecal Coliform	Aquatic Recreation	2008	Fish Bioassessment, Chloride		
Minnesota River	RM 22 to Mississippi R	07020012-505	Fecal Coliform	Aquatic Recreation	1994	PCB in Fish Tissue, Turbidity	2C, 3C	
Sauk River	Mill Cr to Mississippi R	07010202-501	Fecal Coliform	Aquatic Recreation	1994	PCB in Fish Tissue, Turbidity		Priority Area A and B (St. Paul, Minneapolis)
Skunk River	Hillman Cr to Platte R	07010201-521	Fecal Coliform	Aquatic Recreation	2008		7	Priority Area B (St. Paul, Minneapolis)
Spunk Creek	Lower Spunk Lk to Mississippi R	07010201-525	Fecal Coliform	Aquatic Recreation	2008			Priority Area B (St. Paul, Minneapolis)
Unnamed creek	Headwaters to Minnesota R	07020012-528	Fecal Coliform	Aquatic Recreation	2006			
Unnamed creek (East Creek)	Unnamed cr to Minnesota R	07020012-581	Fecal Coliform	Aquatic Recreation	2006	Turbidity, Fish Bioassessment		
Unnamed creek (Lambert Creek)	Unnamed ditch to Vadnais Lk	07010206-637	Fecal Coliform	Aquatic Recreation	2008			Priority Area B (St. Paul, Minneapolis)

[1]All waters, whether designated with a specific beneficial use classification or not, are also classified as 3C, 4A, 4B, 5, and 6 waters. For waters with multiple classifications, the more restrictive standards apply.
[2]Last 500 feet only.

Beneficial Uses

All surface waters in Minnesota, including lakes, rivers, streams, and wetlands, are protected for aquatic life and recreation where these uses are attainable. The beneficial use classes listed in Table 6 are associated with a specific numeric water quality standard for bacteria that sets the limit for a safe concentration of this pollutant in water. See Minnesota Rules Chapter 7050 for a more detailed description of beneficial uses (https://www.revisor.leg.state.mn.us/rules/?id=7050).

Drinking Water Source

A large number of Minnesota's residents rely on the Mississippi River for both drinking water and as a place for recreational activities. Between 940,000 and 950,000 Minnesotans rely on that part of the Mississippi River that is in the study area for drinking water. The Mississippi River is the exclusive drinking supply for St. Cloud (also serves St. Augusta) and the Minneapolis Water Treatment and Distribution Services (serves the cities of Golden Valley, Crystal, New Hope, Columbia Heights, Hilltop, Fort Snelling, parts of Bloomington and Edina (Morning Side), and the Minneapolis/St. Paul airport). It is also one of the main sources for the St. Paul Regional Water Services (serves at least part of the cities of Falcon Heights, Lauderdale, Maplewood, Arden Hills, Little Canada, Saint Paul, West Saint Paul, South Saint Paul, Lilydale, Mendota and Mendota Heights, Roseville, and Sunfish Lake).

The protection of surface water intakes is not required, but many of Minnesota's 24 community water supply systems that use surface water have expressed interest in developing protection plans. The Minnesota Department of Health has convened a work group to help determine how these plans should be prepared and who should approve them. The work group has prepared a guidance document to define Minnesota's approach to source water protection for surface water intakes. The cities of St. Cloud, St. Paul, and Minneapolis have State endorsed Source Water Protection Plans following the MDH guidance for surface water intakes. In each of these plans, cities have identified "contaminants of concern" and have designated priority areas for drinking water protection (Figure 3). A few examples of these contaminants of concern are *Cryptosporidium*, fecal coliform, *Giardia*, other viruses, total suspended solids, sediment, and suspended organics.

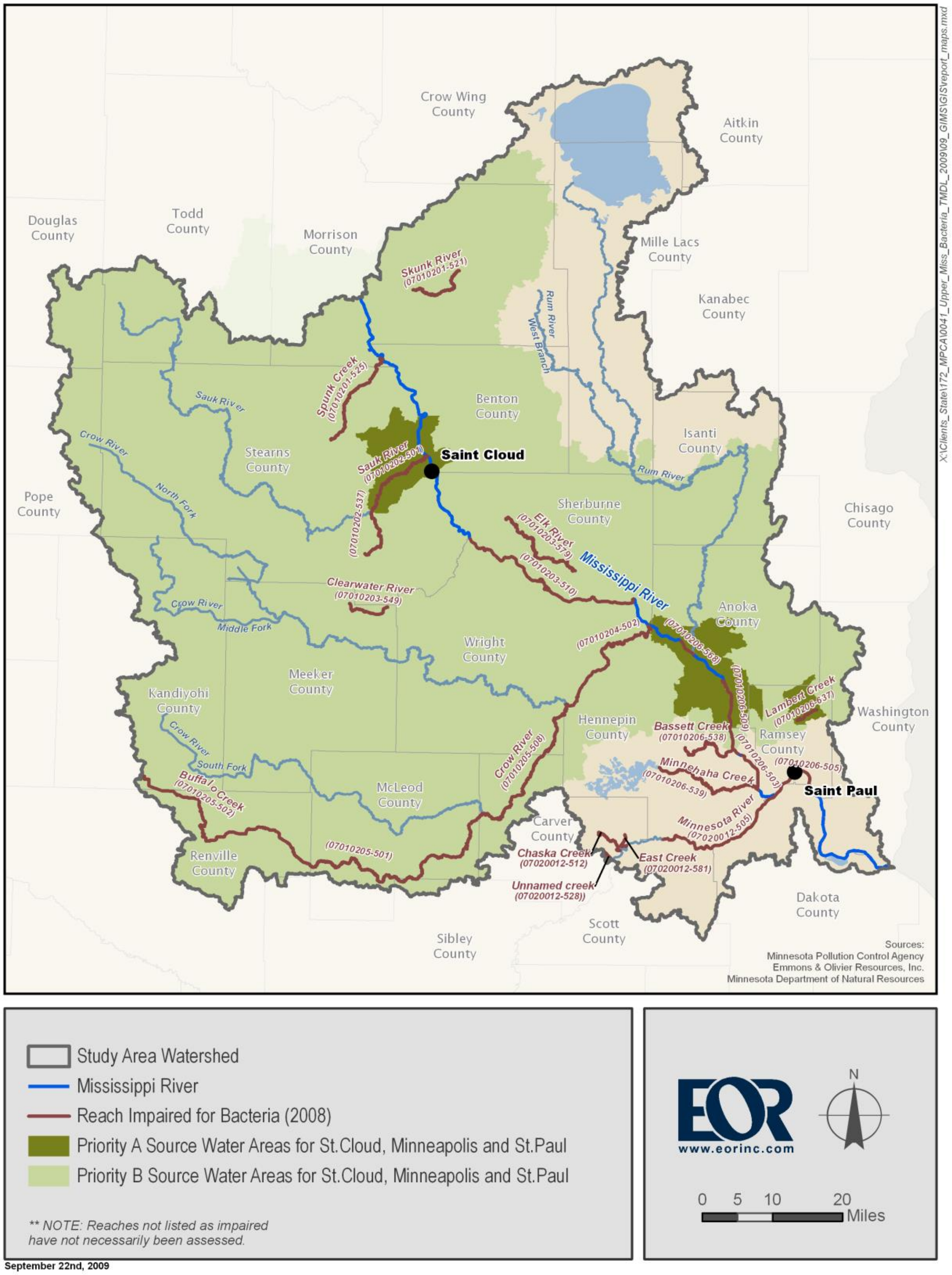

Figure 3. Composite Source Water Protection areas for Minneapolis, St. Cloud, St. Paul, and UMR Bacteria TMDL study area.
The study area shown is that of the TMDL study area.

Use Impairment, Pollutant, and Water Quality Standard

Mississippi River reaches were listed on the Minnesota Pollution Control Agency's 303(d) List in 1996, 2002, and 2006 as impaired for fecal coliform; tributaries were listed between 1994 and 2008 (Table 6). The past fecal coliform and new *E. coli* numeric water quality standards for Class 2 waters are shown in Table 7. *E. coli* and fecal coliform are fecal bacteria used as indicators for waterborne pathogens that have potential to cause human illness. Although most are harmless themselves, fecal indicator bacteria are used as an easy-to-measure surrogate to evaluate the microbiological suitability of recreational and drinking waters, specifically, the presence of pathogens and probability of illness. Pathogenic bacteria, viruses and protozoa pose a health risk to humans, potentially causing illnesses with gastrointestinal symptoms (nausea, vomiting, fever, headache, and diarrhea), skin irritations, or other symptoms.

The total maximum daily load (TMDL) project will use the standard for *E. coli*. All available relevant data including fecal coliform data will also be used as needed for understanding sources of fecal contamination. The change in the water quality standard to *E. coli* is supported by an EPA guidance document on bacteriological criteria (EPA 1986). Minnesota Rules Chapter 7050 states the following for water quality standards:

> *Escherichia (E.) coli - Not to exceed 126 organisms per 100 milliliters as a geometric mean of not less than five samples representative of conditions within any calendar month, nor shall more than ten percent of all samples taken during any calendar month individually exceed 1,260 organisms per 100 milliliters. The standard applies only between April 1 and October 31.*

Table 7. Past and new numeric water quality standards of bacteria (fecal coliform and *E. coli*) for the beneficial use of aquatic recreation (primary and secondary body contact).

Past Standard	Units	New Standard	Units	Notes
Fecal coliform	200 orgs per 100 ml	*E. coli*	126 orgs per 100 ml	Geometric mean of ≥5 samples per month (April – October)
Fecal coliform	2,000 orgs per 100 ml	*E. coli*	1,260 orgs per 100 ml	10% of all samples per month (April – October) individually exceed

Geometric mean is used in place of arithmetic mean in order to measure the central tendency of the data, dampening the effect that very high values have on arithmetic means. The geometric mean differs from the arithmetic mean in that it uses multiplication rather than addition in its calculation. Since bacteria data sets often contain a few very high values, the geometric mean more appropriately characterizes the central tendency of the data.

E. Additional Studies

Other studies in addition to this report have been or are being developed as a part of this project to identify and/or address knowledge gaps in the field of bacterial contamination of waterways and drinking water sources.

Literature Summary of Bacteria – Environmental Associations

Currently under MPCA review, *Literature Summary of Bacteria - Environmental Associations* is a literature review that identifies relationships between *E. coli* in surface waters and other pollutants, contaminants of concern, or water quality parameters. It is designed to increase understanding about how the indicator relates to other parameters to shed light on sources of bacterial contamination from fecal material and how to address the sources. The literature search resulted in a compilation of available literature on the factors associated with fecal bacteria outbreaks in streams.

Overview of Literature on Special Topics

Currently under MPCA review, *Overview of Literature on Special Topics* provides a list of the work that has been done to date on the following topics:

- Bacteria growth, die-off, and transport in sediments
- Bacteria delivery from urban stormwater runoff
- Effectiveness of BMPs in treating bacteria in urban stormwater runoff

Bacteria Source Tracking

Bacteria source tracking may be incorporated into future monitoring prior to TMDL development. Monitoring recommendations for source tracking are included in *Section 6C: Monitoring Recommendations, Source Tracking*.

3. WATER QUALITY ANALYSIS

Water quality data were analyzed to tell the story of bacteria within and in tributaries to the Mississippi River within the project area. Data were assessed primarily along the mainstem and secondarily on tributaries with respect to bacteria contributions to the mainstem. Analyses help to identify both spatial and temporal trends in bacteria. *E. coli* data were the primary bacteria data analyzed. Fecal coliform data were used where *E. coli* data were scarce or unavailable for this study. By using this approach, this analysis lays the groundwork for the state of the watershed now being assessed with respect to the *E. coli* standard. Throughout the analysis, availability of data dictated the temporal grouping of bacteria data (e.g. daily/ungrouped, by month across years, by month by year). Additional water quality constituents were analyzed with respect to their relationship to *E. coli* in order to determine whether they may function as surrogates where a history of *E. coli* data is unavailable.

A distinction was made between MPCA impairment assessments and the data analysis conducted here. The *E. coli* standard dictates the assessment process employed by the MPCA when identifying waters for listing or delisting as an impaired waterbody. The assessment in this report strives to provide analysis that examines spatial and temporal changes in bacteria concentrations (*E. coli* in particular) and causes for these changes. For example, although the bacteria standard for protection of aquatic recreation applies only to the months of April through October, data from all months are assessed here. Year-round data may provide information regarding sources of fecal contamination, and data from all months are relevant for drinking water source protection. In addition, analyses reference AUIDs and provide a temporal analysis specific to AUIDs, but a greater portion of this water quality analysis is dedicated to an individual look at each bacteria monitoring site along the Mississippi River in terms of bacteria levels therein and relationships to adjacent monitoring sites.

Monitoring sites are identified by their River Mile (RM) throughout this analysis. Mississippi RMs are designated according to the established Army Corps of Engineers mile markers. RMs decrease from upstream to downstream. RM is used because of the spatial identification characteristics of the label and in order to standardize the naming of sites from multiple entities. Figure 4 identifies Mississippi RMs of all *E. coli* and/or fecal coliform monitoring stations. For reference, Table 8 identifies the locations of Mississippi RMs with respect to Mississippi River AUIDs within the project area.

Figure 4. Mississippi River mainstem river miles of all *E. coli* and/or fecal coliform monitoring sites.

Table 8. Association of Mississippi River AUIDs and RM.

AUID	Reach Description	RM Range		Known to be Impaired as of 2008?	RM of Bacteria Monitoring Location
		Upstream	Down-stream		
07010201-501	End HUC 07010104 (below Swan R) to Two R	960.9	953.4		**953.5**
07010201-509	Two R to Spunk Cr	953.4	949.7		**none**
07010201-508	Spunk Cr to Platte R	949.7	947.4		**none**
07010201-505	Platte R to Little Rock Cr	947.4	937.3		**none**
07010201-513	Little Rock Cr to Sartell Dam	937.3	932.7		**none**
07010201-514	Sartell Dam to Watab R	932.7	932.6		**none**
07010201-502	Watab R to Sauk R	932.6	930.0		**930.2**
07010203-574	Sauk R to CSAH 7 in St Cloud	930.0	926.6		**929.4**
					928.4
07010203-575	CSAH 7 in St Cloud to St Cloud Dam	926.6	926.4		**none**
07010203-513	St Cloud Dam to Clearwater R	926.4	914.4		**none**
07010203-510	Clearwater R to Elk R	914.4	884.6	Y	**914.0**
					896.9
07010203-503	Elk R to Crow R	884.6	879.5		**none**
07010206-567	Crow R to NW city limits of Anoka	879.5	874.0		**none**
07010206-568	NW city limits of Anoka to Rum R	874.0	871.4	Y	**871.7**
					871.6
07010206-510	Rum R to Elm Cr	871.4	871.0		**none**
07010206-511	Elm Cr to Coon Rapids Dam	871.0	866.3		**none**
07010206-512	Coon Rapids Dam to Coon Cr	866.3	865.3		**none**
07010206-509	Coon Cr to Upper St Anthony Falls	865.3	854.0	Y	**863.0**
					862.8
					859.1
					859.0
					858.8
					858.5
					857.6
					857.5
					855.0
					854.9
07010206-513	Upper St Anthony Falls to Lower St Anthony Falls	854.0	853.3		**none**
07010206-503	Lower St Anthony Falls to L & D #1 (RM 853.3 to 847.6)	853.3	847.6	Y	**853.1**
					852.2
					849.9
					848.1
					847.7
07010206-514	L & D #1 to Minnesota R	847.6	844.0		**none**
07010206-505	Minnesota R to Metro WWTP (RM 844.0 to 835.0)	844.0	835.0	Y	**839.7**
					839.1
					836.8
07010206-504	Metro WWTP to Rock Island RR bridge (RM 835.0 to 830.0)	835.0	830.0		**831.0**
07010206-502	Rock Island RR bridge to L & D #2 (RM 830.0 to 815.2)	830.0	815.2		**826.7**
					826.4
					821.8
					815.6
					815.2
07010206-501	L & D #2 to St Croix R (RM 815.2 to 811.3)	815.2	811.3		**813.9**
					812.8

A. Database Development

Existing water quality and flow data within the project area from 1999 to 2008 were gathered from MPCA, project partners, and stakeholders through letters of request and, in some cases, meetings that took the form of information exchanges. The following data requests were made:

1) Flow and water quality data were requested from MPCA, USGS, Metropolitan Council Environmental Services (MCES), MDH, Minnesota Department of Agriculture (MDA), St. Cloud Water Treatment Plant, Minneapolis Water Works, and St. Paul Regional Water Services
2) Flow, *E. coli*, and fecal coliform data were requested from the project partners listed in Table 4.

Precipitation data were acquired through download from the National Weather Service website. The USGS and MCES were the primary resources for flow data, which were acquired through direct data download from their respective websites. Flow data were supplemented by submittals from other entities through the data requests. Water quality data were compiled into a single Microsoft Access database that can be queried for specific analyses. Flow data were also compiled. A geographic information system (GIS) database contains all monitoring sites and associated metadata.

Additional data that becomes available after the time of writing this report will be included in future studies associated with the Upper Mississippi River Bacteria TMDL.

B. Available *E. coli* Data

An inventory of *E. coli* data along the mainstem of the Mississippi River is provided in Table 9. Data from monitoring locations are organized by Mississippi RM from upstream to downstream. The number of samples taken during a given month of a given year is bracketed. The table highlights the scarcity of winter data.

Table 9. Mississippi River *E. coli* data inventory by RM, month and year; number of samples is bracketed.

AUID	RM	Total Samples	Month 1	2	3	4	5	6	7	8	9	10	11	12
07010201-501	953.5	21				2007 [2]	2007 [2]	2007 [3]	2007 [1]	2007 [2]	2007 [2]	2007 [1]	2007 [1]	
					2008 [1]	2008 [2]	2008 [1]	2008 [1]	2008 [1]	2008 [1]				
	930.2	22				2007 [2]	2007 [2]	2007 (3)	2007 [1]	2007 [2]	2007 [2]	2007 [1]	2007 [1]	
			2008 [1]		2008 [1]	2008 [2]	2008 [1]	2008 [1]	2008 [1]	2008 [1]				
07010203-574	929.4	24							2000 [1]	2000 [1]	2000 [1]			
												2001 [1]		
							2002 [1]	2002 [1]	2002 [1]	2002 [1]	2002 [1]			
						2005 [1]	2005 [1]	2005 [1]	2005 [1]					
						2006 [1]	2006 [1]	2006 [1]	2006 [1]			2006 [2]		
						2007 [1]	2007 [1]	2007 [1]		2007 [1]	2007 [1]			
	928.4	203				2007 [2]	2007 [2]	2007 [2]	2007 [2]	2007 [2]	2007 [2]	2007 [1]	2007 [2]	2007 [2]
			2008 [2]	2008 [2]	2008 [2]	2008 [2]	2008 [2]	2008 [2]	2008 [13]	2008 [29]	2008 [31]	2008 [30]	2008 [32]	2008 [33]
07010203-510	914.0	25							2000 [1]	2000 [1]	2000 [1]			
												2001 [1]		
							2002 [1]	2002 [1]	2002 [1]	2002 [1]	2002 [1]			
												2004 [1]		
						2005 [1]	2005 [1]	2005 [1]	2005 [1]					
						2006 [1]	2006 [1]	2006 [1]	2006 [1]			2006 [2]		
						2007 [1]	2007 [1]	2007 [1]		2007 [1]	2007 [1]			
	896.9	24								2000 [1]	2000 [1]			
												2001 [1]		
							2002 [1]	2002 [1]	2002 [1]	2002 [1]	2002 [1]			
												2004 [1]		
						2005 [1]	2005 [1]	2005 [1]	2005 [1]					
						2006 [1]	2006 [1]	2006 [1]	2006 [1]			2006 [2]		
						2007 [1]	2007 [1]	2007 [1]		2007 [1]	2007 [1]			
07010206-568	871.7	8						2002 [2]	2002 [2]	2002 [2]	2002 [2]			
	871.6	137						2005 [3]	2005 [2]	2005 [4]	2005 [3]	2005 [3]	2005 [2]	2005 [2]
			2006 [3]	2006 [2]	2006 [2]	2006 [4]	2006 [5]	2006 [3]	2006 [5]	2006 [3]	2006 [4]	2006 [5]	2006 [2]	2006 [1]
			2007 [3]	2007 [1]	2007 [4]	2007 [5]	2007 [3]	2007 [4]	2007 [5]	2007 [3]	2007 [4]	2007 [5]	2007 [2]	2007 [1]
			2008 [2]	2008 [2]	2008 [5]	2008 [3]	2008 [4]	2008 [5]	2008 [3]	2008 [4]	2008 [5]	2008 [3]	2008 [2]	2008 [1]
07010206-509	863.0	32							2006 [1]	2006 [1]	2006 [1]	2006 [2]		
			2007 [4]	2007 [1]	2007 [2]	2007 [1]			2007 [1]	2007 [1]				2007 [2]
			2008 [2]	2008 [2]	2008 [2]	2008 [2]				2008 [1]	2008 [1]	2008 [2]	2008 [1]	2008 [2]
	862.8	107						2005 [1]	2005 [2]	2005 [4]	2005 [3]	2005 [3]	2005 [2]	
			2006 [1]			2006 [3]	2006 [5]	2006 [3]	2006 [5]	2006 [3]	2006 [4]	2006 [5]	2006 [2]	
			2007 [1]		2007 [1]	2007 [5]	2007 [3]	2007 [4]	2007 [5]	2007 [3]	2007 [4]	2007 [5]	2007 [2]	
						2008 [2]	2008 [3]	2008 [5]	2008 [3]	2008 [4]	2008 [5]	2008 [3]	2008 [2]	2008 [1]
	859.1	301						2003 [16]	2003 [19]	2003 [15]	2003 [16]	2003 [13]		
								2004 [9]	2004 [9]	2004 [9]	2004 [9]	2004 [2]		
								2005 [5]	2005 [7]	2005 [10]	2005 [6]	2005 [6]		
						2006 [6]	2006 [6]	2006 [7]	2006 [7]	2006 [8]	2006 [7]	2006 [8]	2006 [1]	
						2007 [6]	2007 [8]	2007 [5]	2007 [8]	2007 [6]	2007 [6]	2007 [7]	2007 [2]	
						2008 [7]	2008 [6]	2008 [8]	2008 [7]	2008 [7]	2008 [8]	2008 [8]	2008 [1]	
	858.8	23								2000 [1]	2000 [1]			
							2002 [1]	2002 [1]	2002 [1]	2002 [1]	2002 [1]			
												2004 [1]		
							2005 [1]	2005 [1]	2005 [1]					
						2006 [1]	2006 [1]	2006 [1]	2006 [1]	2006 [1]	2006 [1]	2006 [2]		
						2007 [1]		2007 [1]		2007 [1]	2007 [1]			
	857.6	309						2003 [17]	2003 [19]	2003 [15]	2003 [16]	2003 [13]		
								2004 [9]	2004 [9]	2004 [9]	2004 [8]	2004 [6]		
							2005 [1]	2005 [5]	2005 [7]	2005 [10]	2005 [6]	2005 [6]		
						2006 [6]	2006 [6]	2006 [7]	2006 [7]	2006 [8]	2006 [7]	2006 [8]	2006 [1]	
						2007 [6]	2007 [8]	2007 [5]	2007 [8]	2007 [6]	2007 [6]	2007 [8]	2007 [2]	
						2008 [7]	2008 [6]	2008 [8]	2008 [8]	2008 [7]	2008 [8]	2008 [9]	2008 [1]	
	857.5	16				2008 [2]	2008 [3]	2008 [3]	2008 [3]	2008 [2]	2008 [3]			
	854.9	314						2003 [17]	2003 [19]	2003 [15]	2003 [16]	2003 [13]		
								2004 [9]	2004 [9]	2004 [9]	2004 [9]	2004 [8]		
							2005 [1]	2005 [5]	2005 [7]	2005 [10]	2005 [7]	2005 [6]		
						2006 [6]	2006 [6]	2006 [7]	2006 [8]	2006 [8]	2006 [7]	2006 [8]	2006 [1]	
						2007 [6]	2007 [8]	2007 [5]	2007 [8]	2007 [6]	2007 [6]	2007 [8]	2007 [2]	
						2008 [8]	2008 [6]	2008 [8]	2008 [8]	2008 [7]	2008 [8]	2008 [8]	2008 [1]	

Table 9. Continued

AUID	RM	Total Samples	Month 1	2	3	4	5	6	7	8	9	10	11	12
07010206-503	852.2	312						2003 [17]	2003 [19]	2003 [15]	2003 [16]	2003 [13]		
								2004 [9]	2004 [9]	2004 [10]	2004 [9]	2004 [6]		
							2005 [1]	2005 [5]	2005 [7]	2005 [10]	2005 [7]	2005 [6]		
						2006 [6]	2006 [6]	2006 [7]	2006 [7]	2006 [8]	2006 [7]	2006 [8]	2006 [1]	
						2007 [6]	2007 [8]	2007 [5]	2007 [8]	2007 [6]	2007 [6]	2007 [7]	2007 [2]	
						2008 [8]	2008 [6]	2008 [8]	2008 [8]	2008 [7]	2008 [8]	2008 [9]	2008 [1]	
	849.9	310						2003 [17]	2003 [19]	2003 [15]	2003 [16]	2003 [13]		
								2004 [9]	2004 [9]	2004 [9]	2004 [9]	2004 [5]		
							2005 [1]	2005 [5]	2005 [7]	2005 [10]	2005 [7]	2005 [6]		
						2006 [6]	2006 [6]	2006 [7]	2006 [7]	2006 [8]	2006 [7]	2006 [8]	2006 [1]	
						2007 [6]	2007 [8]	2007 [5]	2007 [8]	2007 [6]	2007 [6]	2007 [8]	2007 [2]	
						2008 [8]	2008 [6]	2008 [8]	2008 [8]	2008 [6]	2008 [8]	2008 [9]	2008 [1]	
	848.1	286						2003 [16]	2003 [19]	2003 [13]	2003 [16]	2003 [13]		
								2004 [9]	2004 [9]	2004 [9]	2004 [9]	2004 [2]		
							2005 [1]	2005 [5]	2005 [7]	2005 [10]	2005 [7]	2005 [6]		
						2006 [6]	2006 [6]	2006 [7]	2006 [7]	2006 [8]				
						2007 [6]	2007 [8]	2007 [5]	2007 [7]	2007 [6]	2007 [6]	2007 [8]	2007 [2]	
						2008 [8]	2008 [6]	2008 [8]	2008 [7]	2008 [6]	2008 [8]	2008 [9]	2008 [1]	
	847.7	134						2005 [3]	2005 [2]	2005 [4]	2005 [3]	2005 [3]		2005 [1]
			2006 [3]	2006 [2]	2006 [2]	2006 [4]	2006 [4]	2006 [4]	2006 [5]	2006 [3]	2006 [4]	2006 [5]	2006 [2]	2006 [1]
			2007 [3]	2007 [1]	2007 [4]	2007 [5]	2007 [3]	2007 [4]	2007 [5]	2007 [3]	2007 [4]	2007 [5]	2007 [2]	2007 [1]
			2008 [2]	2008 [2]	2008 [5]	2008 [3]	2008 [4]	2008 [5]	2008 [3]	2008 [4]	2008 [4]	2008 [3]	2008 [2]	2008 [2]
07010206-505	839.7	22								2000 [1]	2000 [1]			
							2002 [1]	2002 [1]	2002 [1]	2002 [1]	2002 [1]	2002 [1]		
												2004 [1]		
								2005 [2]	2005 [1]					
						2006 [2]	2006 [1]	2006 [1]		2006 [1]	2006 [1]	2006 [2]		
						2007 [1]		2007 [1]			2007 [1]			
	839.1	130						2005 [3]	2005 [3]	2005 [5]	2005 [3]	2005 [4]	2005 [3]	2005 [1]
			2006 [2]	2006 [2]	2006 [3]	2006 [4]	2006 [5]	2006 [3]	2006 [5]	2006 [3]	2006 [4]	2006 [4]	2006 [3]	2006 [1]
			2007 [1]	2007 [1]	2007 [3]	2007 [4]	2007 [4]	2007 [4]	2007 [4]	2007 [4]	2007 [4]	2007 [4]	2007 [5]	2007 [2]
			2008 [1]	2008 [2]	2008 [4]	2008 [4]	2008 [4]	2008 [4]	2008 [4]	2008 [4]	2008 [5]	2008 [3]	2008 [1]	2008 [1]
	836.8	12	2007 [1]	2007 [1]	2007 [1]									2007 [2]
			2008 [1]	2008 [2]	2008 [2]								2008 [1]	2008 [1]
07010206-504	831.0	141						2005 [3]	2005 [3]	2005 [5]	2005 [3]	2005 [4]	2005 [3]	2005 [1]
			2006 [2]	2006 [2]	2006 [3]	2006 [4]	2006 [4]	2006 [3]	2006 [5]	2006 [3]	2006 [4]	2006 [4]	2006 [3]	2006 [1]
			2007 [2]	2007 [2]	2007 [4]	2007 [4]	2007 [4]	2007 [4]	2007 [4]	2007 [4]	2007 [4]	2007 [5]	2007 [2]	2007 [2]
			2008 [2]	2008 [2]	2008 [4]	2008 [4]	2008 [4]	2008 [4]	2008 [4]	2008 [4]	2008 [4]	2008 [4]	2008 [2]	2008 [2]
07010206-502	826.7	142						2005 [3]	2005 [3]	2005 [5]	2005 [3]	2005 [4]	2005 [3]	2005 [1]
			2006 [2]	2006 [2]	2006 [3]	2006 [4]	2006 [5]	2006 [3]	2006 [4]	2006 [4]	2006 [4]	2006 [4]	2006 [3]	2006 [1]
			2007 [2]	2007 [2]	2007 [4]	2007 [4]	2007 [4]	2007 [4]	2007 [4]	2007 [4]	2007 [4]	2007 [5]	2007 [2]	2007 [2]
			2008 [2]	2008 [2]	2008 [4]	2008 [4]	2008 [4]	2008 [4]	2008 [4]	2008 [4]	2008 [4]	2008 [4]	2008 [2]	2008 [2]
	826.4	21								2000 [1]	2000 [1]			
							2002 [1]	2002 [1]	2002 [1]	2002 [1]	2002 [1]			
												2004 [1]		
							2005 [1]		2005 [1]					
						2006 [2]	2006 [1]	2006 [1]		2006 [1]	2006 [1]	2006 [2]		
						2007 [1]		2007 [1]			2007 [1]			
	821.8	25						2007 [2]	2007 [3]	2007 [3]	2007 [2]			
								2008 [2]	2008 [4]	2008 [3]	2008 [4]	2008 [2]		
	815.6	141						2005 [3]	2005 [3]	2005 [5]	2005 [3]	2005 [4]	2005 [3]	2005 [1]
			2006 [2]	2006 [2]	2006 [3]	2006 [4]	2006 [5]	2006 [3]	2006 [4]	2006 [4]	2006 [4]	2006 [4]	2006 [3]	2006 [1]
			2007 [2]	2007 [2]	2007 [4]	2007 [4]	2007 [4]	2007 [4]	2007 [4]	2007 [4]	2007 [4]	2007 [5]	2007 [2]	2007 [2]
			2008 [2]	2008 [2]	2008 [3]	2008 [4]	2008 [4]	2008 [4]	2008 [4]	2008 [4]	2008 [4]	2008 [4]	2008 [2]	2008 [2]
	815.2	23								2000 [1]	2000 [1]			
						2002 [1]	2002 [1]	2002 [1]	2002 [1]	2002 [1]	2002 [1]			
												2004 [1]		
							2005 [1]	2005 [1]	2005 [1]					
						2006 [2]	2006 [1]	2006 [1]		2006 [1]	2006 [1]	2006 [2]		
						2007 [1]		2007 [1]			2007 [1]			

C. Assessment of Data Quality

The quality of data in general, and *E. coli* and fecal coliform in particular, was evaluated based on sampling protocol, quality assurance and quality control protocol, and lab and field methods of the sources providing the data. In addition, data quality was evaluated based on the use of MPCA protocol for bacteria data collection for a study of this kind. (MPCA large river water quality monitoring protocol is to sample surface waters in the middle of the river from a bridge, using a bucket attached to a rope.) Specific factors influencing quality of bacteria data include sampling techniques, facilities, personnel, equipment, glassware preparation, sterilization, media preparation, and analytical test procedures. Sampling techniques are of primary concern for this study because different laboratory procedures were deemed comparable for the purposes of the Phase I assessment. However, MPCA only uses EPA approved laboratory methods for assessment and listing of impaired waters. Details follow regarding the data quality for each data source.

STORET (short for STOrage and RETrieval) is the U.S. Environmental Protection Agency's (EPA's) repository for water quality, biological, and physical data and is used by state environmental agencies, EPA and other federal agencies, universities, private citizens, and many others. A large portion of the data for this analysis was retrieved from the MPCA's STORET. Data are submitted from a variety of monitoring efforts conducted throughout the State including those by cities, watershed organizations and counties. The submittal process is controlled with specific procedures and reporting requirements including forms that specify field procedures and information from the laboratory where samples were analyzed such as standard methods for analyses, field preservation methods, and detection limits. Data submitted undergoes two stages of review, routine data review during the year and final data review at the end of the monitoring year. Routine data review includes reviewing the data received from the lab, processing it, and formatting it for STORET. During final data review, data in the STORET project data file is compared to all lab and field results for accuracy. In addition, STORET allows us to filter out data with "improper sample preservation" noted. STORET quality assurance and control protocol is strong, but the volume of entities and project managers submitting data to STORET leaves room for error including the collection of nearshore samples.

MCES follows sampling and field collection quality assurance and quality control as outlined in *Quality Assurance Program Plan: Stream Monitoring* (MCES 2003) and the MCES Laboratory methods (Metropolitan Council 2009a & 2009b). MCES does not routinely collect field replicates, but duplicate analyses are performed on 10% of samples and blanks. Stream samples are collected from one foot below the surface and from as near to the thalweg as safety allows.

The City of St. Cloud Water Treatment Plant *Quality Assurance Manual* (Hartung and Young 2009) and *Standard Operating Procedures* (St. Cloud Water Laboratory, 2007) provide complete guidance on collection, sampling, and preservation procedures for bacteriological examination. Quality control protocols used include analytical duplicates on 10% of samples, parallel testing, and sterility checks. In addition, the laboratory participates in proficiency testing on an annual basis. However, for the purpose of this analysis, data quality is ranked low because sample collection procedures do not follow MPCA's large river sampling protocol. MPCA protocol is to sample surface water in the middle of the river; the City of St. Cloud Water Treatment Plant collects samples approximately 30 feet from the bank and about 10 feet below the surface.

Minneapolis Water Treatment and Distribution Services also collects samples nearer to the bank than the center of the river. Before September 25, 2008, samples were taken from surface water that spilled into a forebay 2 feet below the surface. Since then, samples have been collected at least 6 feet below the surface. Again, this collection technique does not follow MPCA's large river sampling protocol as outlined above, but the majority of data used in this analysis was taken from surface water. Minneapolis Water Works collects raw water in order to assess levels of treatment required; duplicate samples are not taken. It is clear that laboratory methods, like that of the other two water treatment plants, are well established and analysts are well seasoned.

St. Paul Regional Water Services also collects Mississippi River samples that are analyzed for bacteria. The intake is nearshore and approximately 15 feet below the surface; samples are drawn from there. Duplicate laboratory analyses were at least performed on total coliform, but the frequency protocol is unknown.

The Minnesota Department of Health collects all samples from the same places as those of the water utilities described above, with the exception of St. Paul. In the case of St. Paul Regional Water Services, the Mississippi River water has traveled through a chain of lakes, including Charles, Pleasant, Sucker, and Vadnais before reaching the sample point. For this reason, St. Paul Regional Water Services' raw water collected by MDH was not used in this analysis. Sample collection methods do not follow MPCA large river sampling protocol.

D. Mississippi Mainstem

Data from 1999 through 2008 along the mainstem of the Mississippi River were analyzed using a variety of methods to identify spatial and temporal trends of the river and potential major *E. coli* sources. *E. coli* data were prioritized for analyses, but in some cases more abundant fecal coliform data were analyzed in parallel in an effort to reduce the effects of outliers and achieve the closest approximation of average conditions. Tributary data are discussed in *Section 3.E.*

Overview

The spatial distribution of bacteria data along the mainstem provides insight into potential sources of *E. coli*; sources identified could include tributaries that should be further evaluated, wastewater treatment plants, feedlots, wildlife, leaky septics, or the occurrence of CSOs, among other potential sources. All available *E. coli* and fecal coliform data on the Mississippi River in the project area are summarized in Figure 5 and Figure 6, respectively. Data show geometric mean bacteria concentrations; dotted vertical lines indicate the location of major tributary inputs, backwaters and locks and dams (see Figure 4 for a map of the study area). In general, bacteria levels appear to increase as the river approaches the Twin Cities metropolitan area. Data were not available from mainstem reaches near where the Elk and Crow Rivers enter the Mississippi between RM 905 and 895. This area may or may not be experiencing the increase in bacteria data from upstream Mississippi River reaches. Based on available data, bacteria levels peak around RM 871 (downstream of Elk River and Crow River) and again around RM 857 (downstream of Shingle Creek), maintaining higher levels until RM 835 beyond Ramsey County. Tributaries are not likely to be the sole source of heightened bacteria levels.

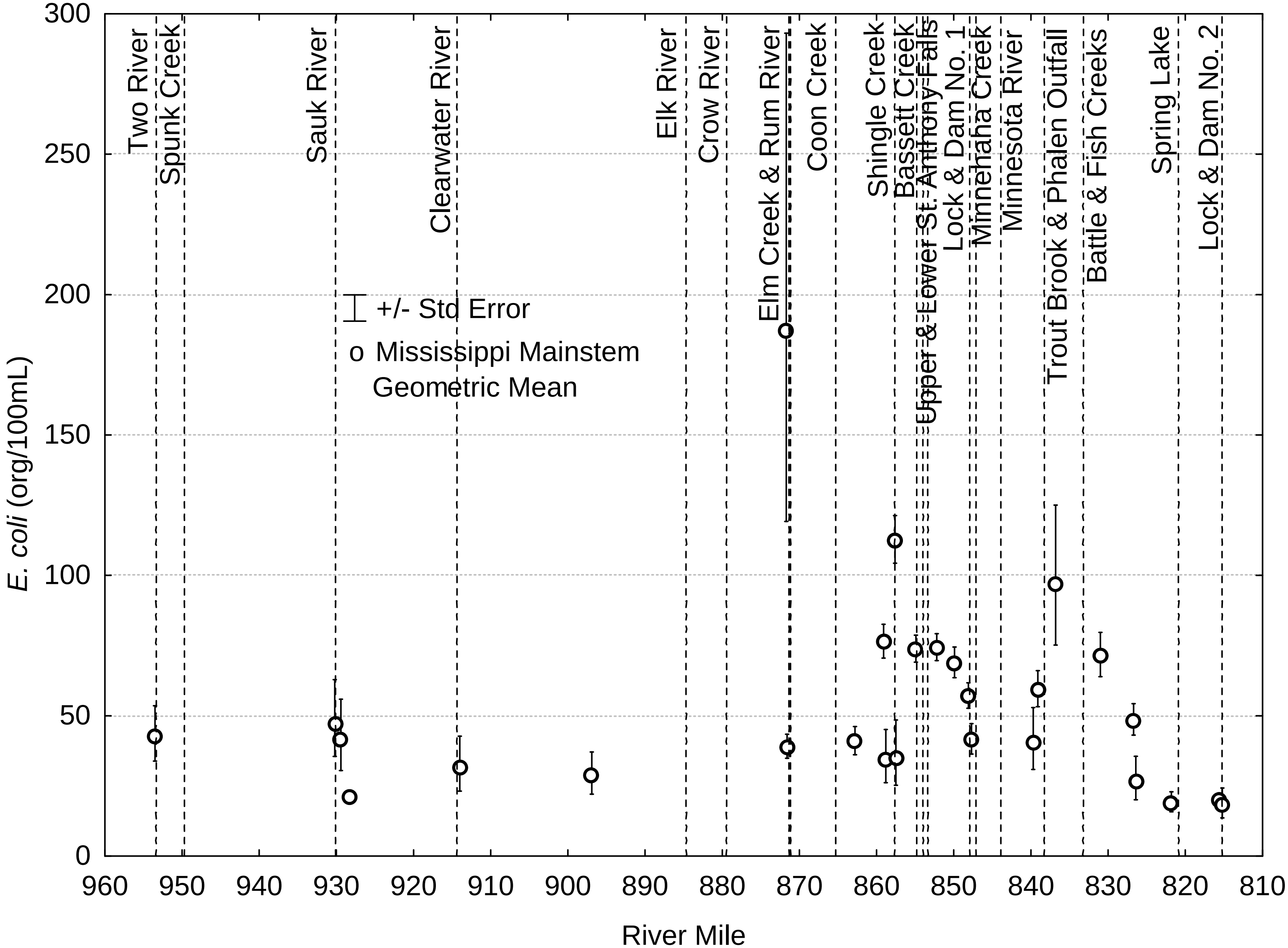

Figure 5. *E. coli* along the Mississippi River from 1999 through 2008, dotted vertical lines represent the location of major tributary inputs, backwaters and lock and dams, providing a reference to general location along the river.

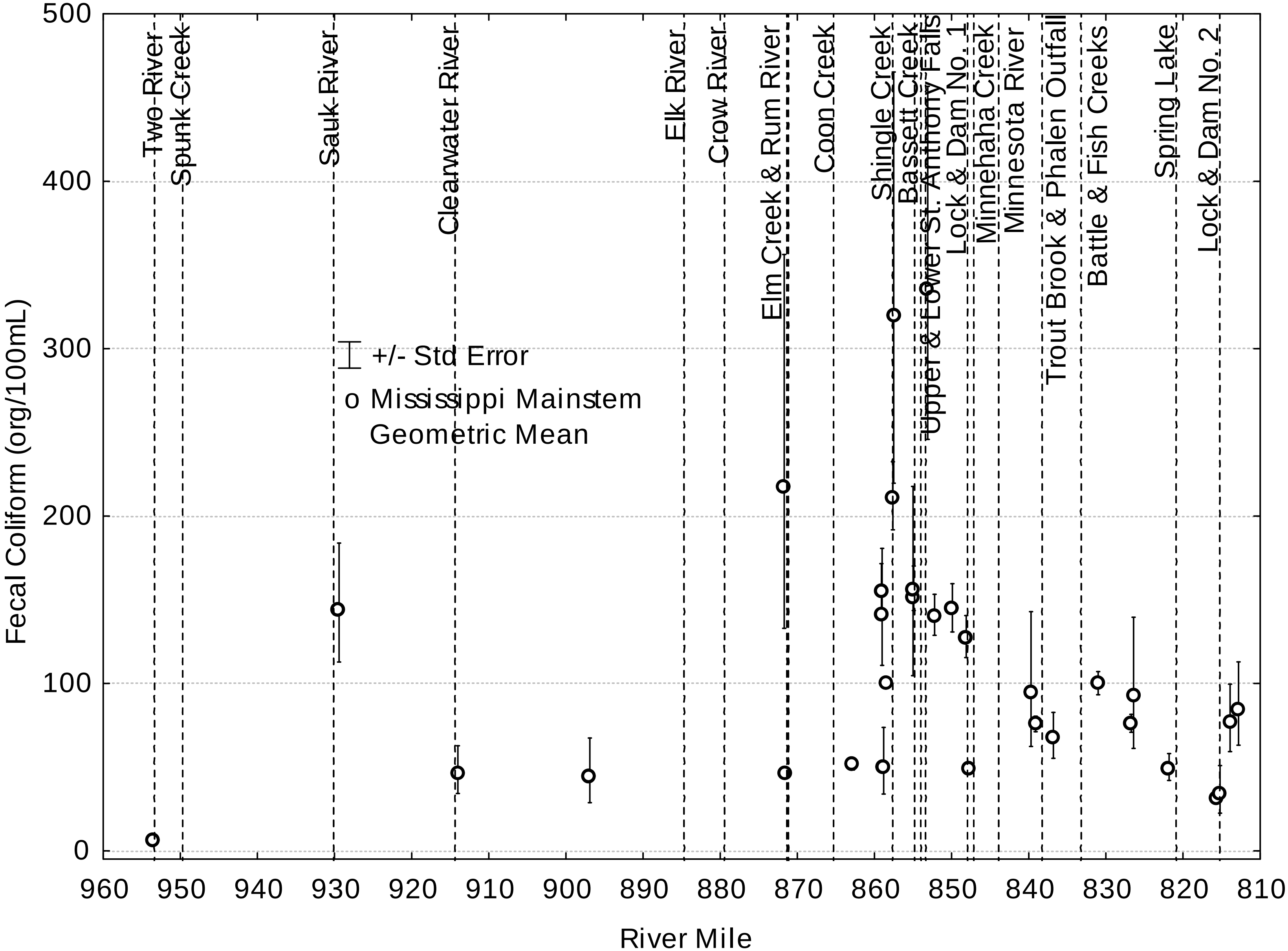

Figure 6. Fecal coliform along the Mississippi River from 1999 through 2008; dotted vertical lines represent the location of major tributary inputs, backwaters and lock and dams, providing a reference to general location along the river.

Analysis by River Mile

Several analyses were performed for each bacteria monitoring site along the Mississippi River based on availability of data from the study period from 1999 through 2008. A summary of *E. coli* and fecal coliform geometric means and related statistics are summarized by RM by year by month and across all years in tables in Appendix A (*E. coli*) and Appendix B (fecal coliform). Data for any RM may contain data from more than one monitoring entity. For the purposes of this analysis, year implies 365 days.

Jumps in Bacteria Concentrations along the Mississippi River

The means of Mississippi River mainstem log-transformed *E. coli* and fecal coliform data were evaluated by month in order to identify jumps in bacteria concentrations between adjacent monitoring locations. The assessment is intended to provide guidance related to bacteria sources and the spatial distribution of bacteria along the Mississippi River. Confidence intervals account for the number of samples taken and the variability in data and assume a normal distribution of data. *Jumps* are where the 95% confidence interval for a downstream monitoring location exceeds that of the adjacent upstream monitoring location (where the confidence interval does not overlap). This analysis only tracks increases in bacteria concentrations and not decreases. The logarithms of the bacteria data more closely fit a normal distribution than do the raw data; therefore, data were log-transformed prior to analysis. This analysis was performed using one graph for each month of the year, with means of bacteria data at all monitoring sites. For example, Figure 7 shows mainstem *E. coli* data for the month of October having one jump in *E. coli* from RM 858.8 to 857.6. The decrease from RM 857.6 to 854.9 is not tracked in this analysis.

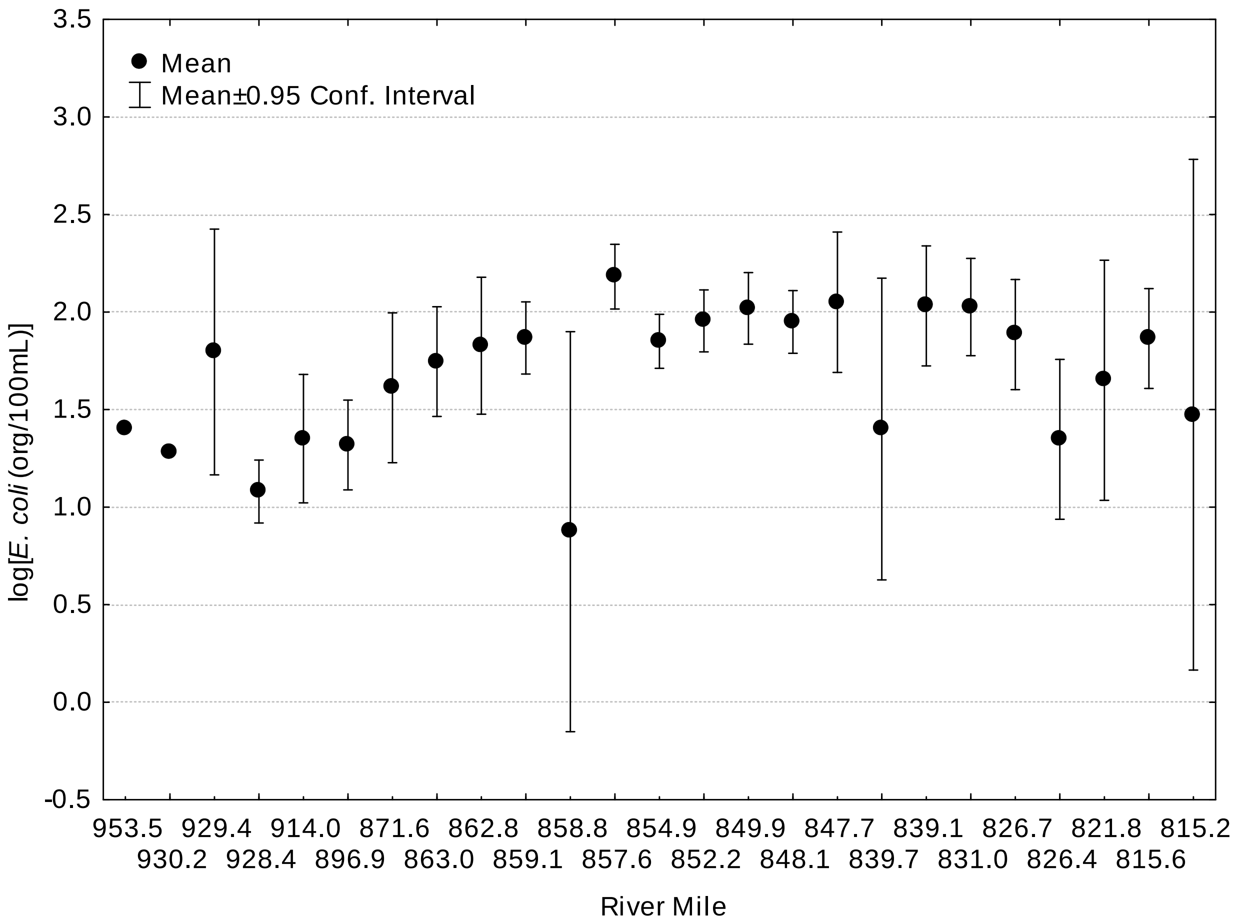

Figure 7. Mean of log-transformed *E. coli* data along the Mississippi River (x-axis not to scale) during the month of October from 1999 through 2008.
Log of the *E. coli* standard of 126 org/100 mL = 2.1

It should be noted that this analysis is dependent, in part, on spatial distribution of data. Where long river reaches separate adjacent monitoring stations, significant increases in bacteria concentrations may be realized but distance may preclude findings related to causes of the increase. In the extreme case, jumps were experienced between RM 928.4 and 871.6 but these are not included in this analysis for the reason just explained. Where available data were insufficient in number to establish a confidence interval (e.g. only one or two samples constitute the mean), jumps were not counted. Among other possible explanations, this is one reason that *E. coli* jumps are fewer in number than fecal coliform jumps. Data were grouped by month rather than by month and year in a two-fold effort: in order to 1) prevent the occurrence of insufficient data that precludes confidence intervals, and 2) identify those jumps that are significant and/or consistent enough to appear across multiple years.

Table 10 summarizes the jumps experienced along the mainstem of the Mississippi River between adjacent RMs. Recall that where available data were insufficient in number (only one or two samples constitute the mean), jumps were not counted. Among other possible explanations, this is one reason that *E. coli* jumps are fewer in number than fecal coliform jumps. Jumps do not occur from May through July. The majority of jumps occur in the late summer and fall, but RMs 858.5, 839.1 and 831.0 experience only winter jumps.

Table 10. Jumps in *E. coli* and fecal coliform between adjacent monitoring locations along the Mississippi River from 1999 through 2008.

RM	Upstream RM	Parameter	No. of Jumps* by Bacteria Type	Total No. of Jumps*	AUID	AUID Impaired? (Y/N)	Occurances of Jumps* in Bacteria Concentrations by Month											
							1	2	3	4	5	6	7	8	9	10	11	12
914.0	928.4	***E. coli***	1	3	07010203-510	Y									x			
	928.4	**Fecal Coliform**	2												x	x		
859.1	862.8	***E. coli***	2	6	07010206-509	Y								x	x			
	862.8	**Fecal Coliform**	4							x				x	x	x		
858.5	862.8	**Fecal Coliform**	4	4	07010206-509	Y	x	x	x									x
857.6	858.8	***E. coli***	2	5	07010206-509	Y								x		x		
	858.5	**Fecal Coliform**	3											x	x	x		
839.1	847.7	**Fecal Coliform**	2	2	07010206-505	Y		x	x									
831.0	836.8	**Fecal Coliform**	2	2	07010206-504	N	x	x										
815.6	821.8	**Fecal Coliform**	1	1	07010206-502	N										x		

* Increases only

Correlation Analyses

In some cases where bacteria data were available for the same day in both the Mississippi River and nearby tributaries, correlations and relative concentrations between river and tributary data were examined. These analyses and related discussion can be found among the discussion of RM 914.0 and 871.6. Table 11 summarizes results from the correlation analyses. In each case, the paired tributary site is upstream of the Mississippi River site. Fecal coliform concentrations on the Sauk River describe 60% of the variability of fecal coliform concentrations at Mississippi RM 914.0. *E. coli* concentrations on the Elk River describe 67% of the variability at Mississippi RM 871.6. In both cases, the correlation is positive.

Table 11. Mississippi River and tributary bacteria correlation analysis for data taken on the same day.

Mississippi River Site (RM)	Paired Tributary Site		*E. coli*			fecal coliform		
	Waterbody	RM	R-squared value [N]	p-value	Pos. (+) or Neg. (-) Correlation	R-squared value [N]	p-value	Pos. (+) or Neg. (-) Correlation
914.0	Sauk River	0.1	0.1089 [25]	0.1071	+	0.5967 [12]	0.0032	+
871.6	Elk River	9.0	0.6650 [8]	0.0136	+	0.0803 [36]	0.0939	+

Load Duration Curves and Precipitation Analyses

The RM water quality analysis also includes load duration curves (LDC) and relationships between precipitation, flow, and *E. coli* in order to provide further information regarding the trends and sources of *E. coli* in the Mississippi River. LDCs illustrate *E. coli* concentrations with respect to flow on the same day providing a clearer picture as to the timing and source of high levels of *E. coli* in the river. The x-axis of LDCs represents *E. coli* load, and the y-axis represents flow in terms of the probability of occurrence. Low flows have a high probability of occurrence and high flows have a low probability of occurrence. A given mass of *E. coli* at low flows would have a much lower concentration if occurring during high flows; this input would also likely have a different source in each case (e.g. septic field leaching versus stormwater runoff). LDC analyses on large rivers may have a different meaning than those on small rivers. On small rivers, high flows are the result of runoff within the immediate area that is the subwatershed. On a large river system, high flows may be the result of a rain event away from the vicinity of the monitoring point at a far upstream location where precipitation patterns differ than that experienced locally. In that case, high *E. coli* loading at high flows may actually be a dry weather input from adjacent land that did not receive precipitation. Alternatively, the adjacent land may be the source of the precipitation, but the *E. coli* may be from dry (or wet) weather input upstream. In order to better address the source of flows, local precipitation data from the National Weather Service were plotted against gauged flow as part of this analysis. In addition, existing monitoring (and proposed future monitoring) on adjacent tributaries inform source assessment and help address the shortcomings of mainstem LDCs (see *Section 3.E. Water Quality Analysis: Tributaries and Storm Sewers* and *Section 6. Monitoring Recommendations*).

LDC analyses were limited by availability of flow data. In the ideal case, flow data are collected at the same location, or adjacent to, water quality data. This was not the case for many of the water quality monitoring sites. Where flow data on the Mississippi mainstem were not available immediately adjacent to the water quality site, flow could have been gathered from a site farther downstream. In an effort to provide more accurate information for these sites, flow was calculated based on the nearest USGS gauge station and addition or subtraction of tributary flow between it and the water quality site. Where tributary flow data were not available for major water courses, this method was not used and an LDC was not created. For these sites, *E. coli* data were compared to precipitation only. Calculating flows in the manner described, values for *E. coli* loading are less reliable than where an adjacent flow site is used. However, the relationship between monitored *E. coli* data and the standard remain valid. Figures showing relationships between precipitation, flow (where available), and *E. coli* have also been plotted. Metadata identifying the pairing of water quality monitoring sites with flow and precipitation sites are summarized in Table C - 1 in the Appendix.

Exceedances identified from this analysis refer not to an analysis of whether the waterbody is impaired. Rather, they refer to those *E. coli* loads that exceed the *E. coli* loading at the numeric standard of 126 org/100mL. In addition, the state standard applies only from April to October, but this analysis evaluates *exceedances* throughout the calendar year.

Table 12 summarizes the results of the LDC analyses including the quantity and monthly distribution of exceedances (monitored *E. coli* loading above loading at the standard of 126 org/100mL). Fall is the season with the most exceedances (49%, 124/253). Summer has the second highest number of exceedances (38%, 97/253) followed by spring at 8% (20/253) and winter at 5% (12/253). Impaired AUID 07010206-503 experiences the most exceedances of all the AUIDs (127), but also has the most RMs. Four of the five RMs within the AUID experience exceedances. Impaired AUID 07010206-509 experiences 57 exceedances, the second highest number of exceedances among AUIDs. Impaired AUID 07010206-505 experiences 34 exceedances, the third highest number. None of the other AUIDs that experience exceedances are listed as impaired. RM 815.6 experiences 60% (3/5) of exceedances during the winter. RM 863.0 experiences all three exceedances during the winter. It is apparent from the dataset, in particular the graphs (geometric means as well as load duration curves), that on a RM-by-RM basis *E. coli* concentrations are not necessarily highest during high flow periods.

Table 12. Mississippi River *E. coli* summary of exceedances; concentrations above the standard of 126 org/100mL.

AUID	Reach Description	RM (Site)	Percent Excee-dances	Total Excee-dances	Total *E. coli* Measure-ments	Exceedances by Month												Percent Exceedances by Season (No. Exceedances / Total Exceedances)			
						1	2	3	4	5	6	7	8	9	10	11	12	Winter (12-2)	Spring (3-5)	Summer (6-8)	Fall (9-11)
07010201-501	End HUC 07010104 (below Swan R) to Two R	**953.5**	19%	4	21	0/0	0/0	0/1	0/4	0/3	0/4	0/2	1/3	2/2	0/1	1/1	0/0	N/A	0%	25%	75%
07010201-502	Watab R to Sauk R	**930.2**	27%	6	22	1/1	0/0	0/1	0/4	0/3	1/4	0/2	2/3	2/2	0/1	0/1	0/0	17%	0%	50%	33%
07010203-574	Sauk R to CSAH 7 in St Cloud	**929.4**	15%	4	26	0/0	0/0	0/0	0/4	0/4	1/4	0/4	1/3	2/3	0/4	0/0	0/0	N/A	0%	50%	50%
		928.4	2.5%	4	162	1/2	0/2	0/2	0/4	0/4	1/4	0/14	0/29	0/32	1/29	0/32	1/8	50%	0%	25%	25%
07010206-509*	Coon Cr to Upper St Anthony Falls	**863.0**	9.7%	3	31	2/6	0/3	0/4	0/3	0/0	0/0	0/2	0/3	0/2	0/4	0/1	1/3	100%	0%	0%	0%
		862.8	18%	19	107	1/2	0/0	0/1	0/10	1/11	3/13	2/15	2/14	5/16	4/16	1/8	0/1	5%	5%	37%	53%
		854.9	24%	35	146	0/0	0/0	0/0	0/2	3/15	2/17	2/30	7/31	12/28	9/22	0/1	0/0	N/A	9%	31%	60%
07010206-503*	Lower St Anthony Falls to L & D #1 (RM 853.3 to 847.6)	**852.2**	27%	39	144	0/0	0/0	0/0	0/2	3/15	2/17	6/29	9/31	11/28	8/21	0/1	0/0	N/A	8%	44%	49%
		849.9	24%	41	174	0/0	0/0	0/0	0/17	3/21	2/25	5/30	10/30	13/28	8/22	0/1	0/0	N/A	7%	41%	51%
		848.1	17%	27	157	0/0	0/0	0/0	0/17	3/21	2/25	4/28	5/30	8/21	5/14	0/1	0/0	N/A	11%	41%	48%
		847.7	21%	20	95	0/0	0/0	0/0	0/10	0/11	2/16	3/15	4/14	4/15	7/13	0/1	0/0	N/A	0%	45%	55%
07010206-505*	Minnesota R to Metro WWTP (RM 844.0 to 835.0)	**839.7**	13%	3	24	0/0	0/0	0/0	0/4	0/3	1/5	1/2	1/3	0/4	0/3	0/0	0/0	N/A	0%	100%	0%
		839.1	25%	31	125	0/4	2/3	0/8	3/12	3/13	3/14	2/16	4/16	5/16	8/13	1/8	0/2	6%	19%	29%	45%
07010206-504	Metro WWTP to Rock Island RR bridge (RM 835.0 to 830.0)	**831.0**	26%	11	43	0/0	0/0	0/0	0/0	1/4	4/6	0/8	1/8	2/7	2/8	1/2	0/0	N/A	9%	45%	45%
07010206-502	Rock Island RR bridge to L & D #2 (RM 830.0 to 815.2)	**815.6**	6.3%	5	80	2/4	0/4	0/7	0/8	0/8	0/8	0/8	0/8	0/8	1/9	1/5	1/3	60%	0%	0%	40%
		815.2	7.7%	1	13	0/0	0/0	0/0	0/2	0/1	0/2	0/1	1/2	0/3	0/2	0/0	0/0	N/A	0%	100%	0%

* Listed as impaired.

AUID 07010201-501 (Not Listed as Impaired)

Figure 8 identifies AUID 07010201-501 and RM 953.5, the only RM within the AUID. *E. coli* and fecal coliform data for this RM (by month and year and by month across all years) and related statistics can be found in Appendix A and B, respectively.

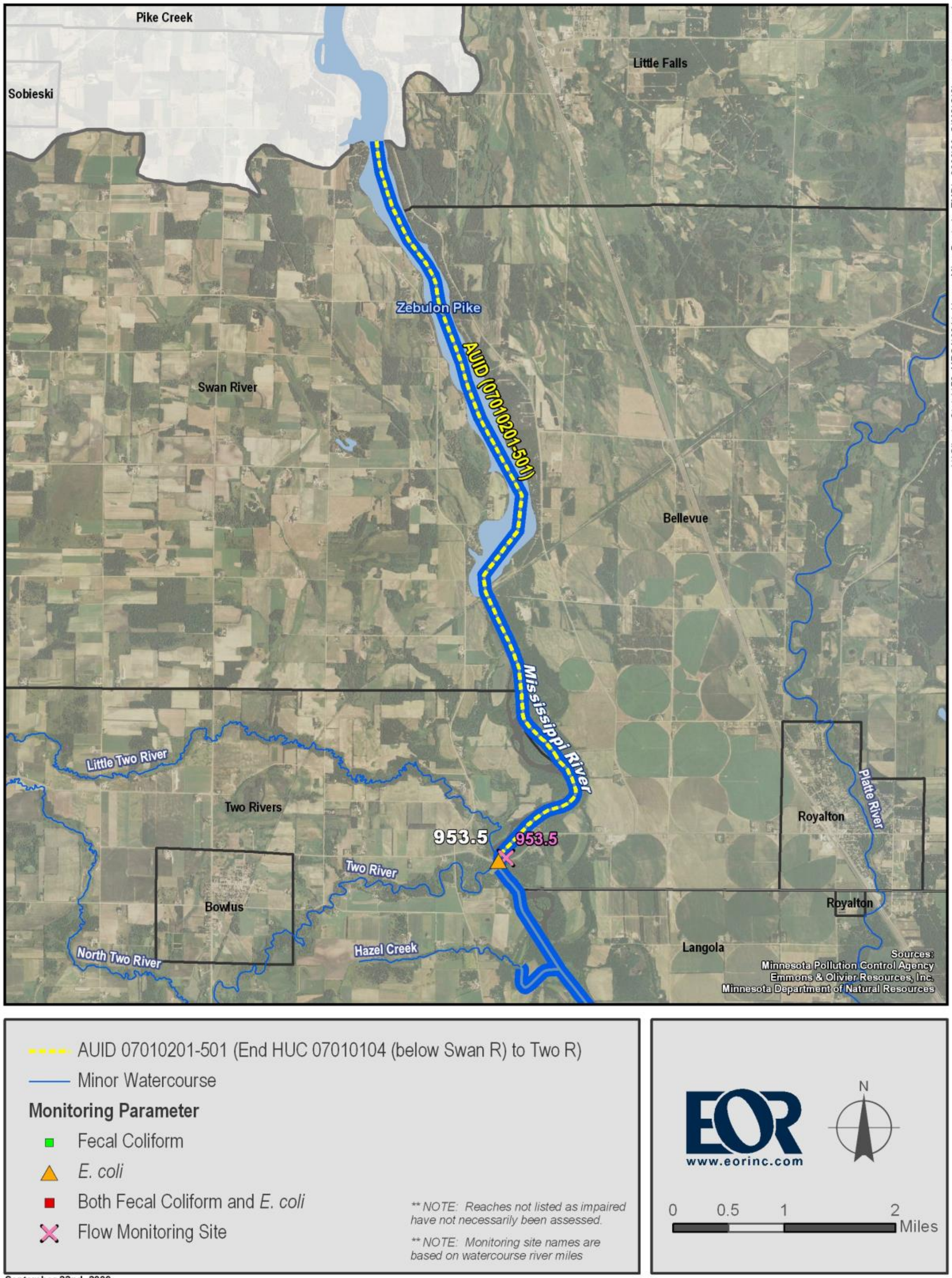

Figure 8. Mississippi River AUID 07010201-501 and mainstem bacteria and flow monitoring sites.

Mississippi RM 953.5

Mississippi RM 953.5 is the uppermost bacteria monitoring location on the mainstem of the Mississippi River. Figure 9 illustrates geometric mean *E. coli* concentrations by month and year as compared to flow (mean by month and year) and precipitation (total by month and year). Since precipitation and flow appear to pattern each other it is likely that local precipitation patterns are the driving source of flow during this time period. *E. coli* concentrations appear low during occurrences of highest flow and precipitation. August 2008 experiences a spike above 300 org/100mL. *Section 3.F. Surrogates Analysis* identifies for this RM a negative correlation between *E. coli* and TSS (R-squared value of 0.3348, p-value of 0.0119). Recall that the number of sample points for any given *E. coli* data point in figures of this type can be found in Table 9 or in Table A - 2 of Appendix A.

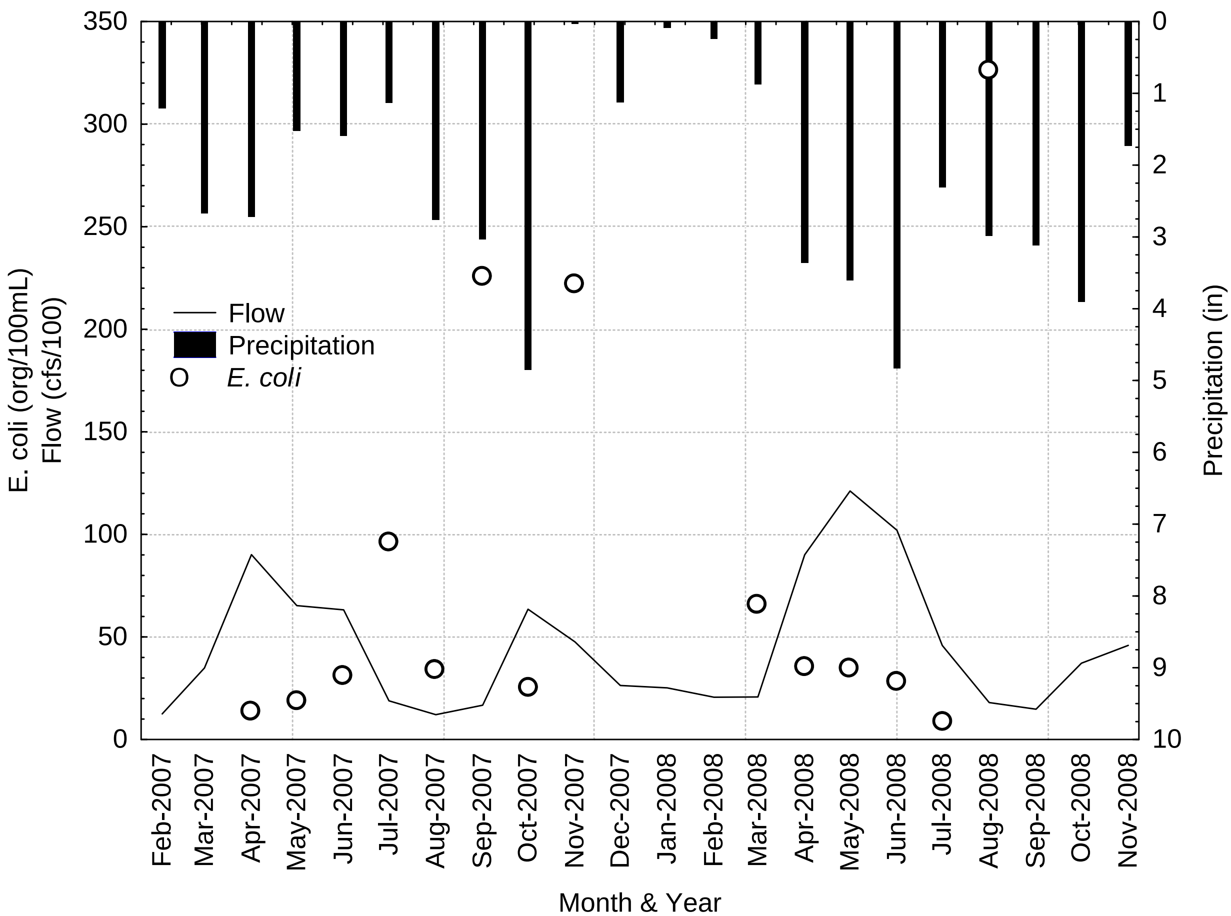

Figure 9. *E. coli* geometric means, mean flow and total precipitation at RM 953.5.

Figure 10 illustrates the LDC analysis where monitored *E. coli* loading was compared to hypothetical loading at the standard concentration (126 org/100mL). For an explanation of the LDC analysis refer to *Section 3.D. Mississippi Mainstem: Analysis by River Mile*, specifically page 34. A total of 19% (4/21) of monitored data exceeds the standard loading. Exceedances are experienced in late summer and fall at dry and low flow conditions.

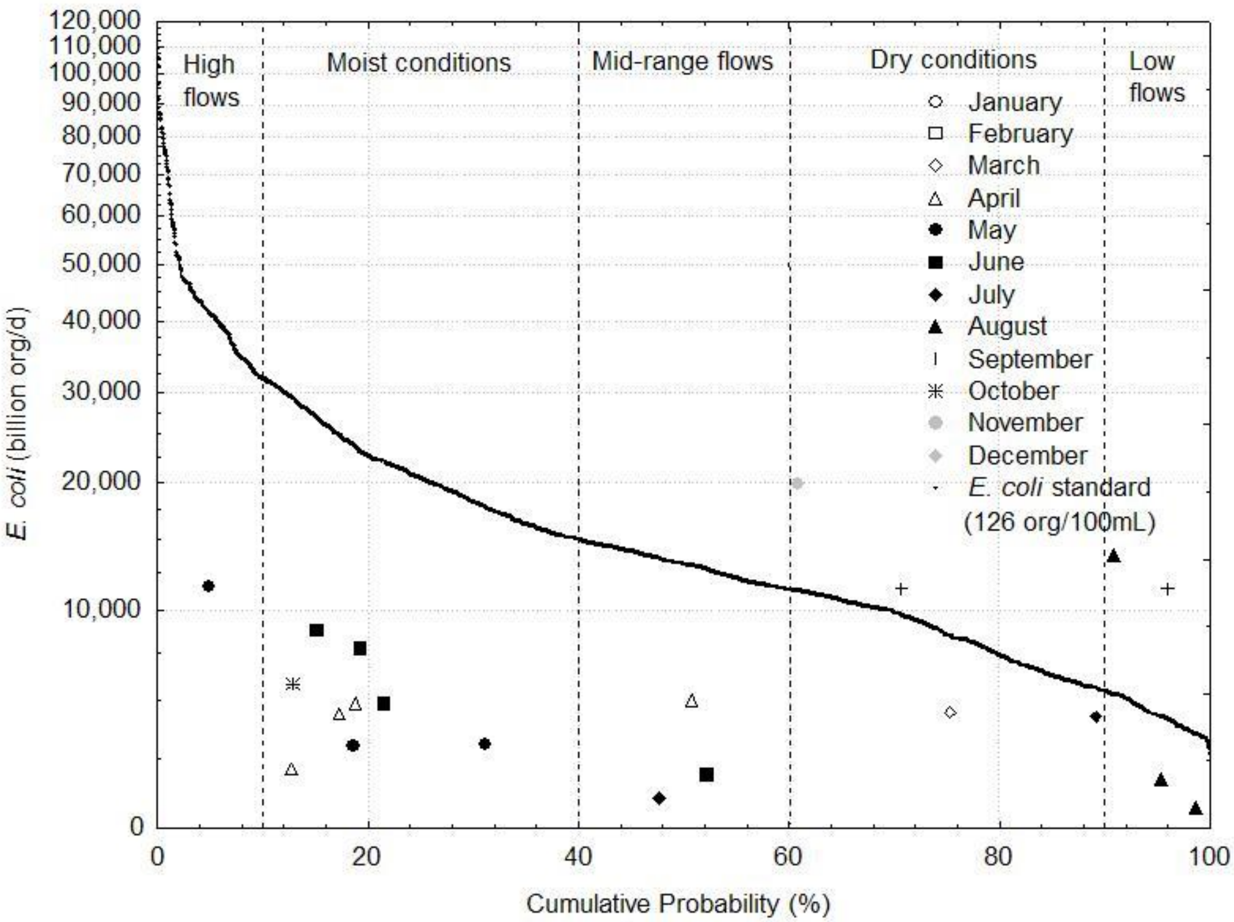

Figure 10. Load duration curve for *E. coli* at RM 953.5.

AUID 07010201-502 (Not Listed as Impaired)

Figure 11 identifies AUID 07010201-502 and RM 930.2, the only RM within the AUID. Note that AUID 07010201-502 begins at RM 932.6 and six upstream AUIDs from RM 953.4 to 932.6 do not have bacteria data (see Table 8). *E. coli* data for RM 930.2 (by month and year and by month across all years) and related statistics can be found in Appendix A. No fecal coliform data was available for this RM for this study.

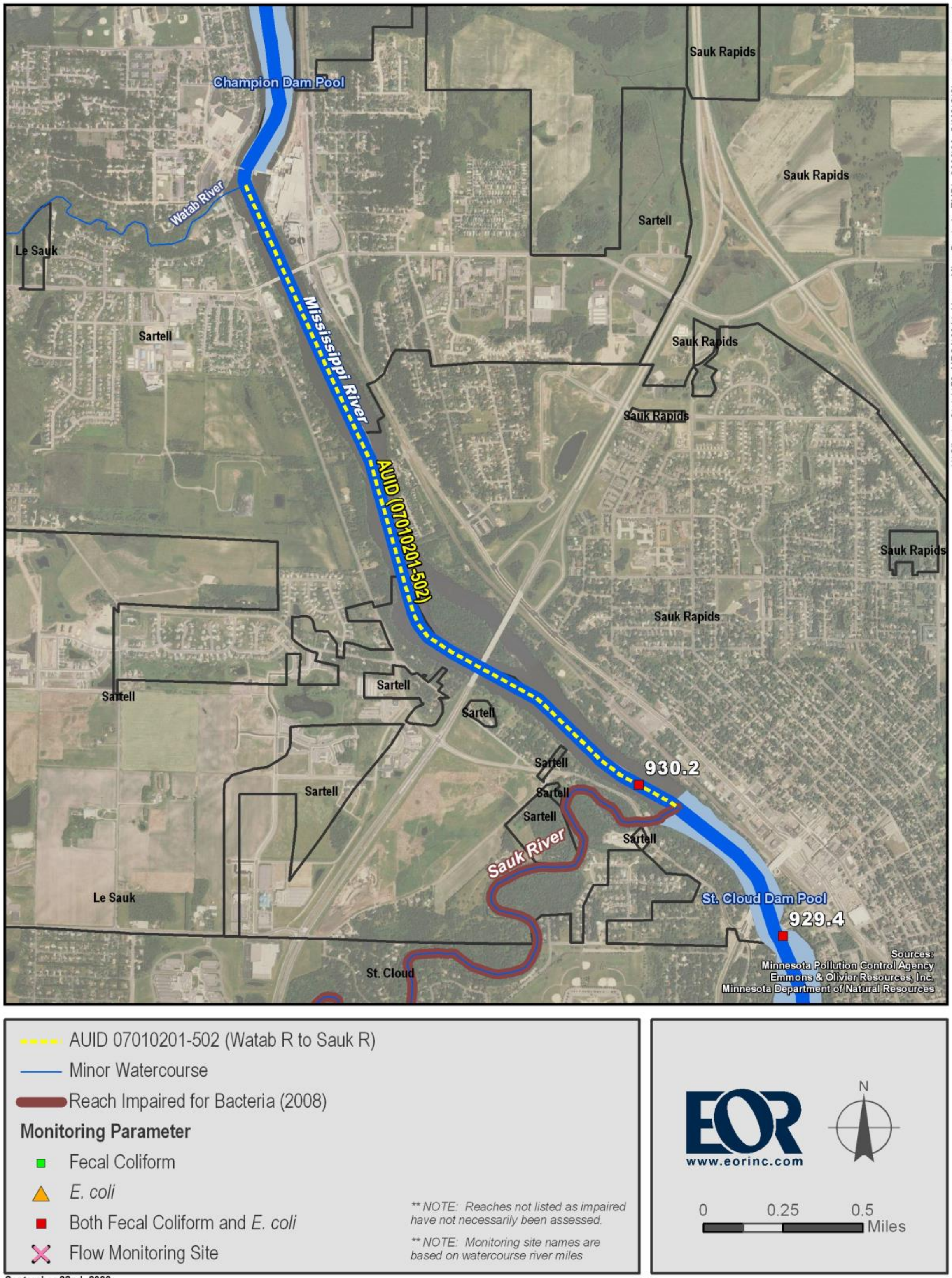

Figure 11. Mississippi River AUID 07010201-502 and mainstem bacteria and flow monitoring sites.

Mississippi RM 930.2

Mississippi RM 930.2 is the only bacteria monitoring site in AUID 07010201-502. Figure 12 illustrates geometric mean *E. coli* concentrations by month and year as compared to flow (mean by month and year) and precipitation (total by month and year). Precipitation and flow somewhat pattern each other but precipitation in watersheds draining to the Mississippi River upstream of this site likely drives flow during some periods at this monitoring site. *E. coli* concentrations do not appear to pattern either flow or precipitation trends.

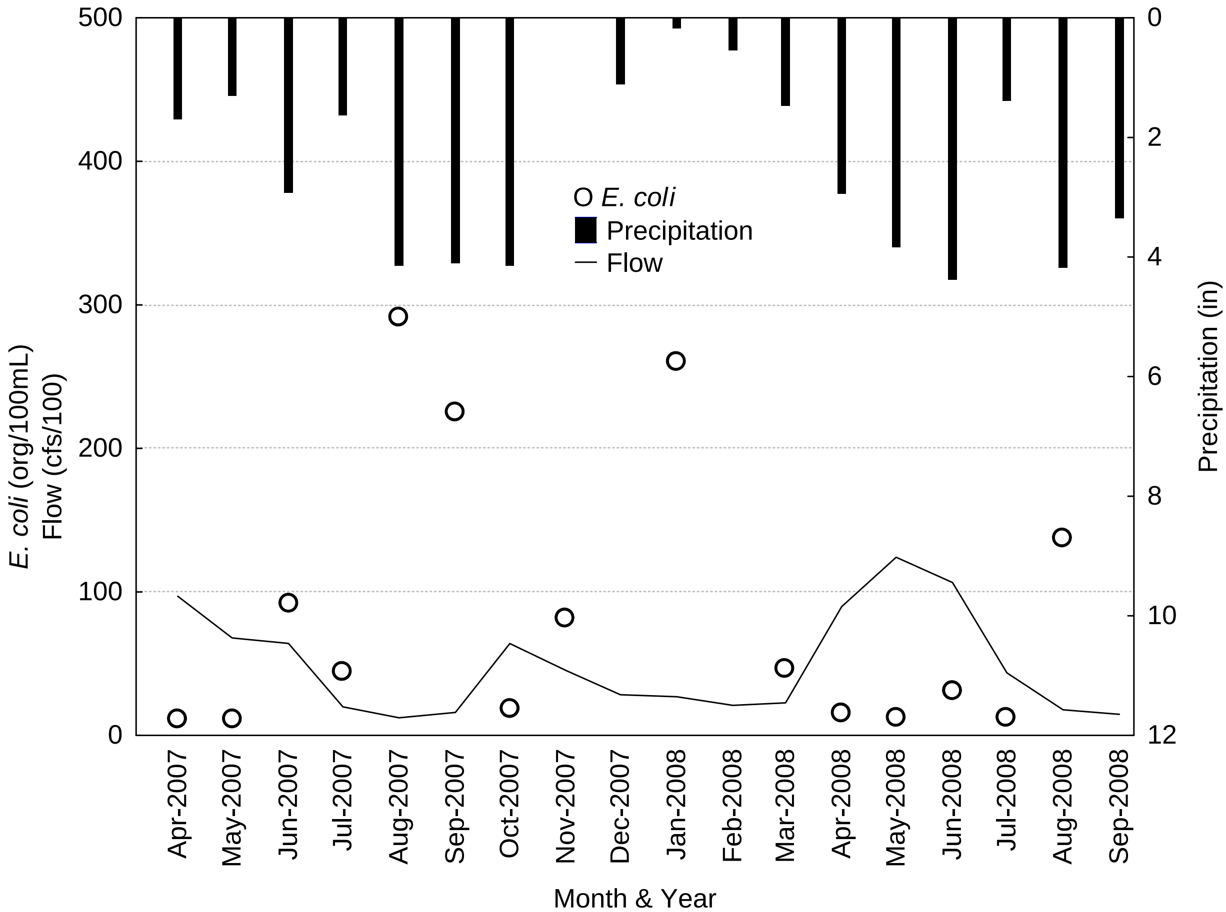

Figure 12. *E. coli* geometric means, mean flow and total precipitation at RM 930.2.

Figure 13 illustrates the LDC analysis where monitored *E. coli* loading was compared to hypothetical loading at the standard concentration (126 org/100mL). A total of 27% (6/22) of monitored data exceeds the standard loading. Exceedances are experienced in all seasons except spring.

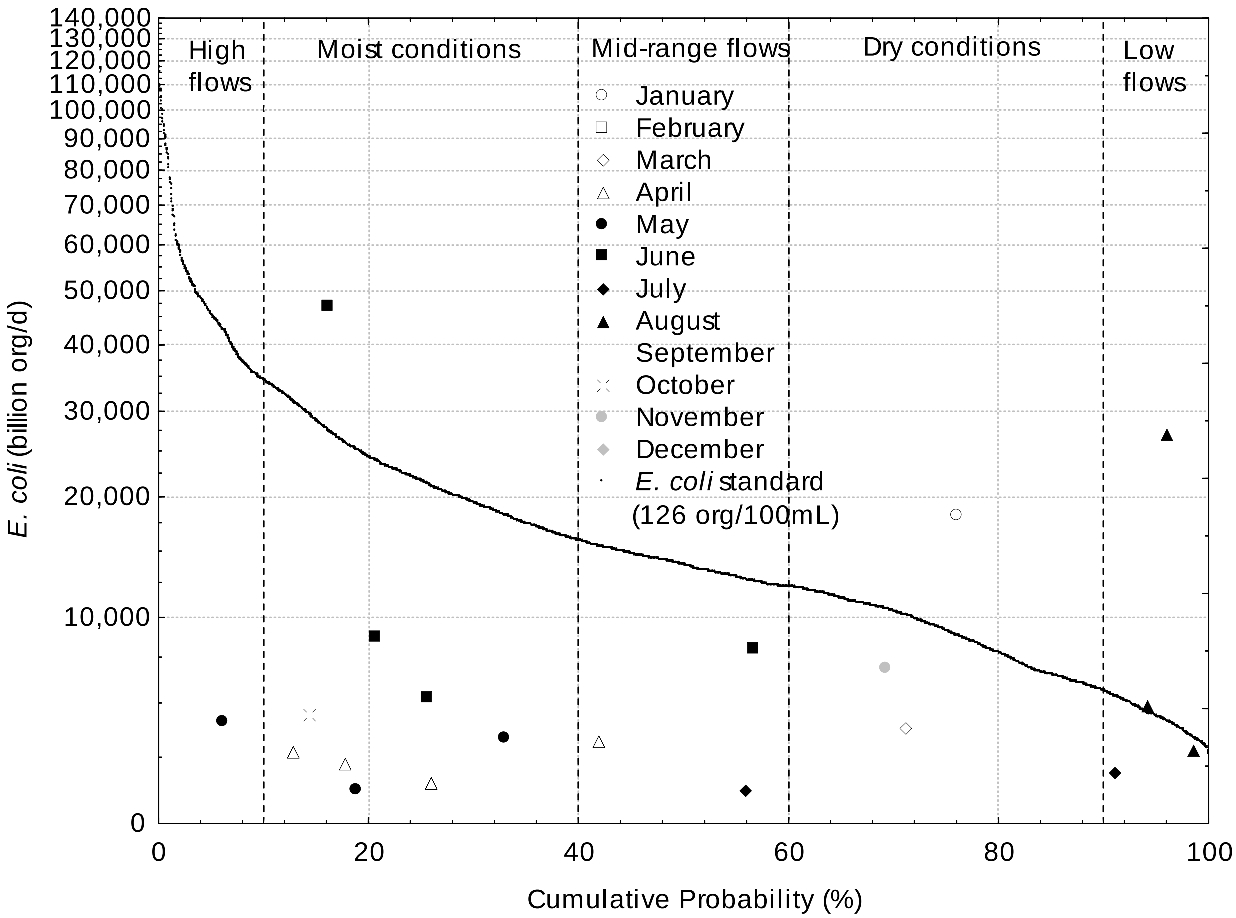

Figure 13. Load duration curve for *E. coli* at RM 930.2.

AUID 07010203-574 (Not Listed as Impaired)

The following Mississippi RMs are within AUID 07010203-574 (Figure 14) and will be discussed from page 47 to page 51:

- 929.4
- 928.4

Bacteria data and related statistics for these RMs (by month and year and by month across all years) can be found in Appendix A (*E. coli*) and Appendix B (fecal coliform). No fecal coliform data was available for this RM for this study.

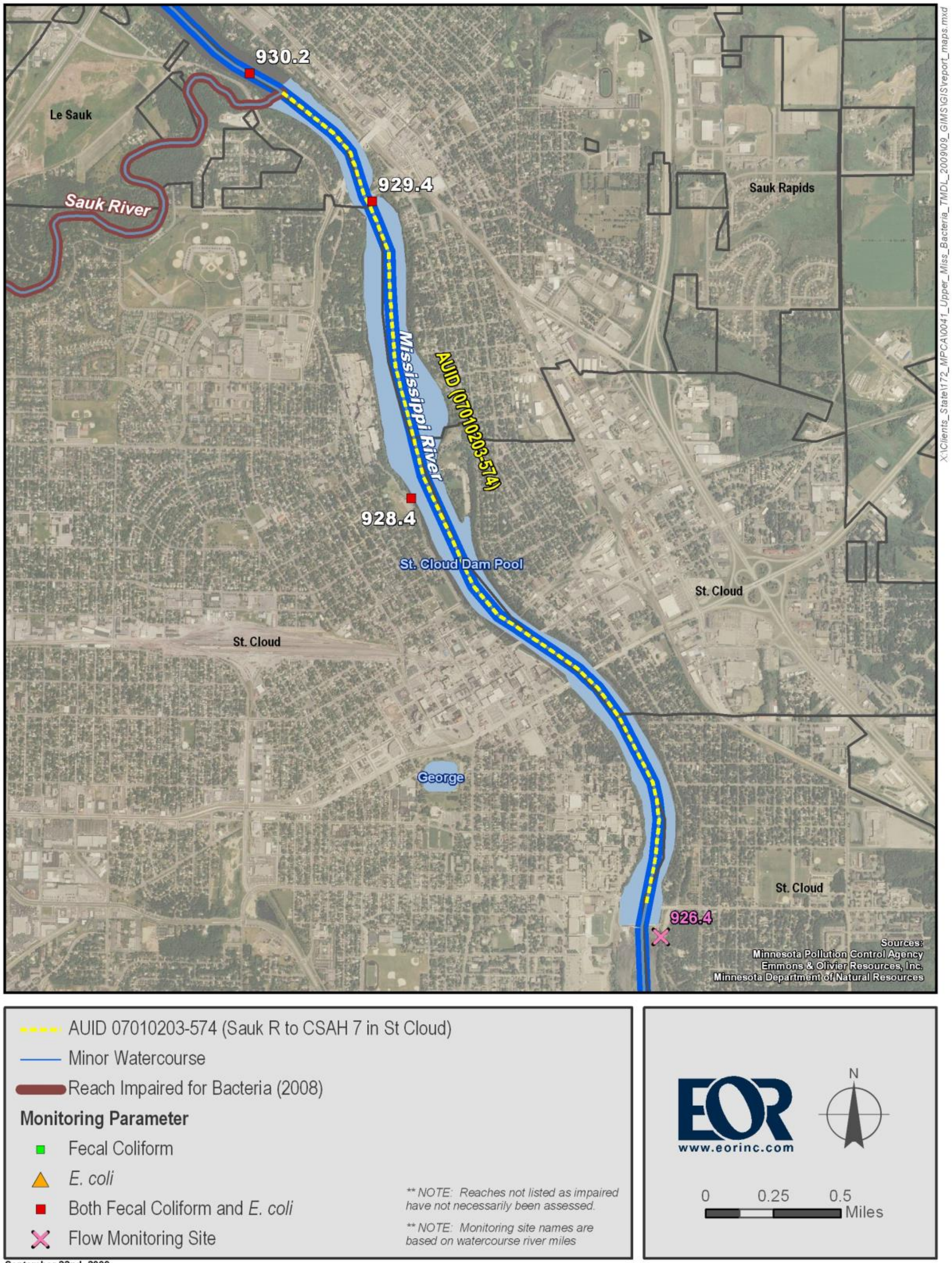

Figure 14. Mississippi River AUID 07010203-574 and mainstem bacteria and flow monitoring sites.

Mississippi RM 929.4

Figure 15 and Figure 16 illustrate mean *E. coli* concentrations by month and year as compared to flow and precipitation for the years 2000-2002 and 2005-2007, respectively. *E. coli* concentrations sometimes appear to increase from spring and summer into the fall. In some instances, flow does not appear to pattern local precipitation.

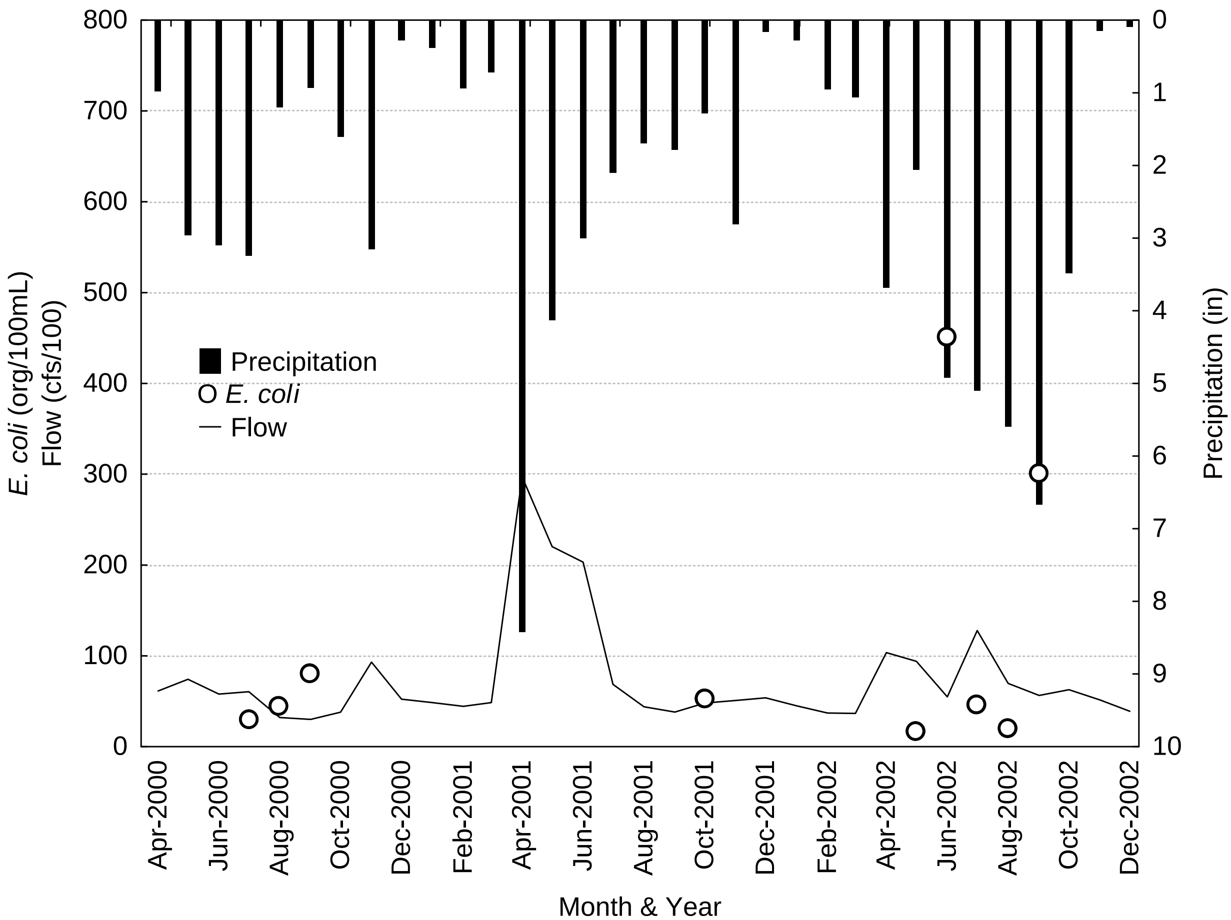

Figure 15. *E. coli* geometric means, mean flow and total precipitation at RM 929.4 from 2000-2002.

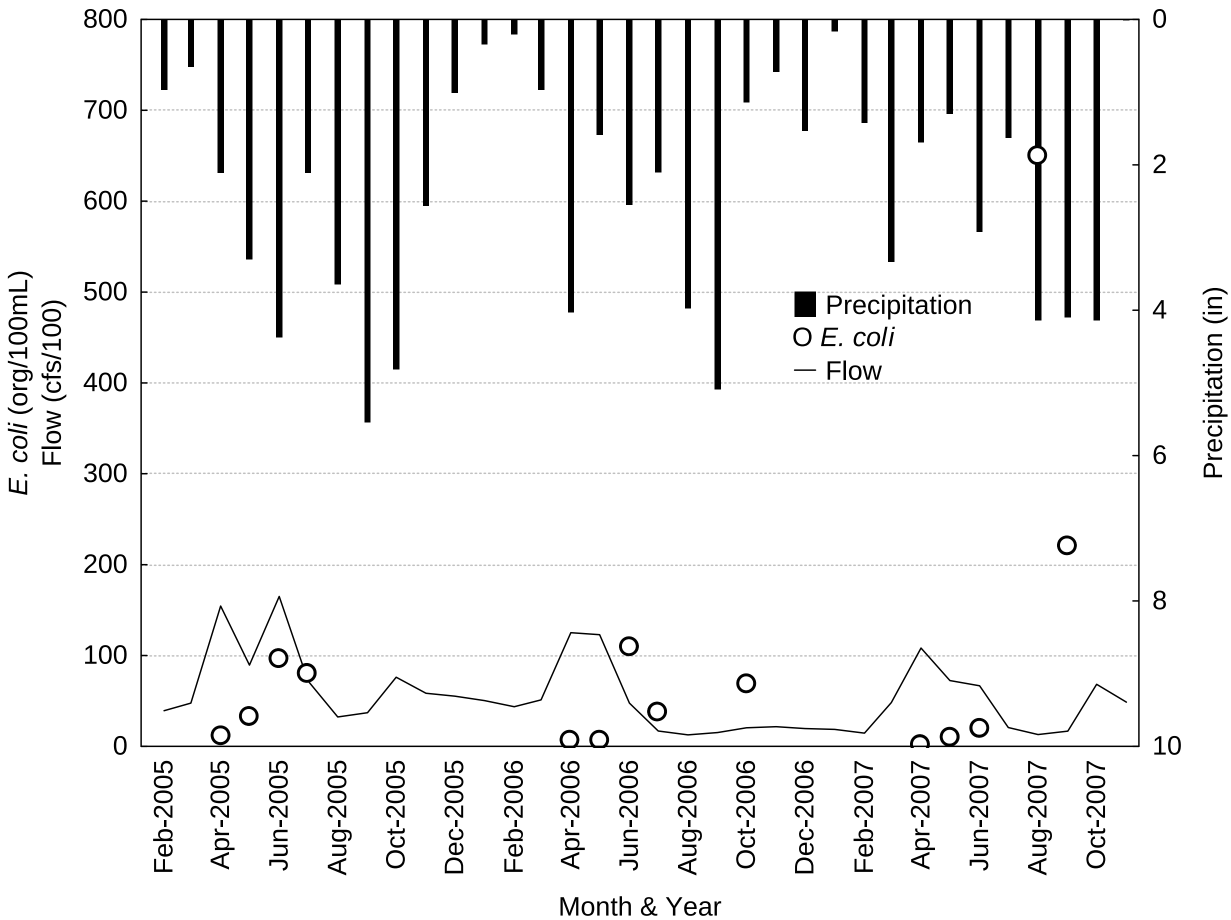

Figure 16. *E. coli* geometric means, mean flow and total precipitation at RM 929.4 from 2005-2007.

Figure 17 illustrates the LDC analysis where monitored *E. coli* loading was compared to hypothetical loading at the standard concentration (126 org/100mL). A total of 15% (4/26) of monitored data exceeds the standard loading. Exceedances are experienced at a variety of flows; they occur once in June and three times in August and September.

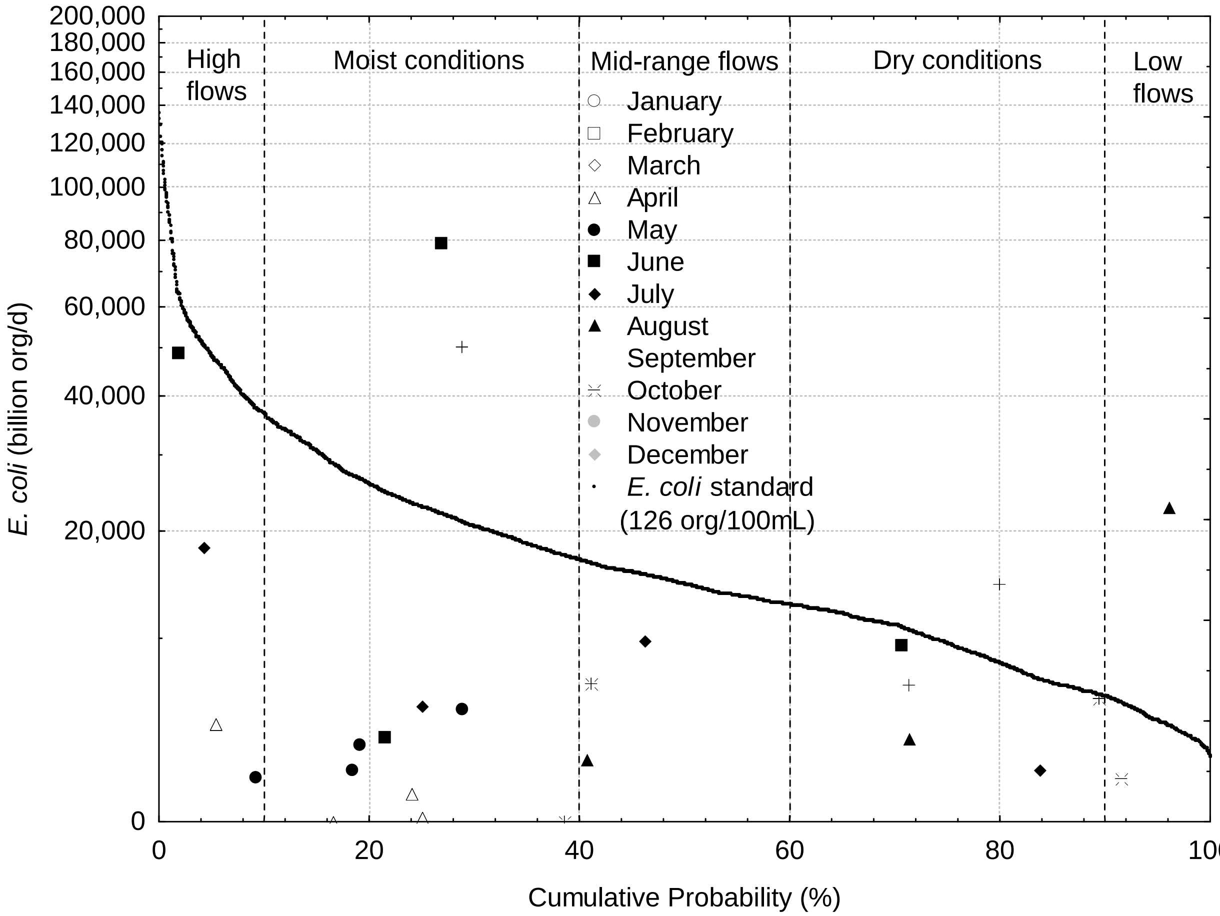

Figure 17. Load duration curve for *E. coli* at RM 929.4.

Mississippi RM 928.4

Figure 18 illustrates geometric mean *E. coli* concentrations by month and year as compared to flow and precipitation. *E. coli* concentrations appear highest in the winter time. In some instances, flow does not appear to pattern local precipitation.

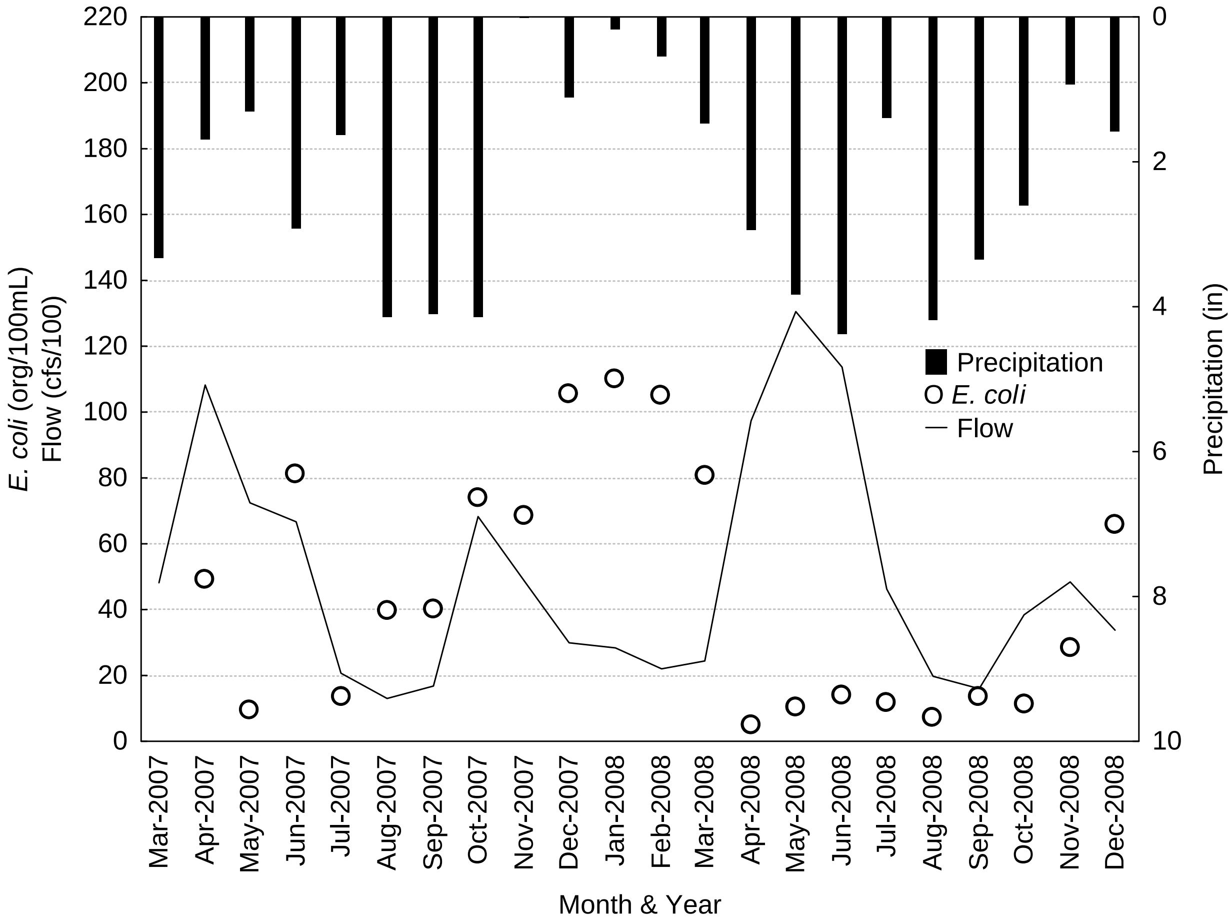

Figure 18. *E. coli* geometric means, mean flow and total precipitation at RM 928.4.

Figure 19 illustrates the LDC analysis where monitored *E. coli* loading was compared to hypothetical loading at the standard concentration (126 org/100mL). A total of only 2.4% (4/162) of monitored data exceeds the standard loading. Exceedances are experienced twice in the winter between 75% and 80% flow (dry conditions). An October exceedance occurs under dry conditions.

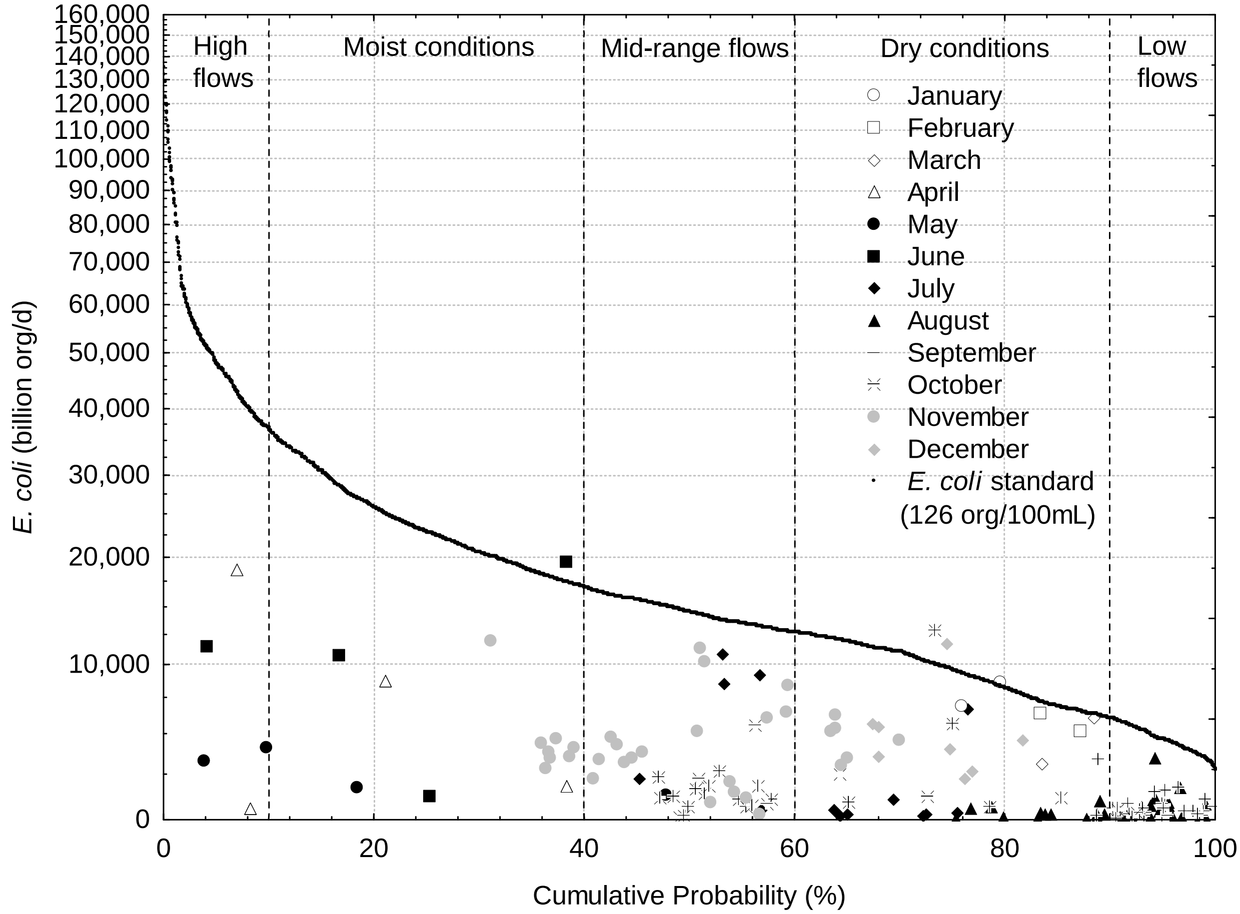

Figure 19. Load duration curve for *E. coli* at RM 928.4.

AUID 07010203-510 (Impaired)

The following Mississippi RMs are within AUID 07010203-510 (Figure 20) which is known to be impaired:

- 914.0
- 896.9

These RMs will be discussed from page 54 to page 59. Bacteria data and related statistics for these RMs (by month and year and by month across all years) can be found in Appendix A (*E. coli*) and Appendix B (fecal coliform).

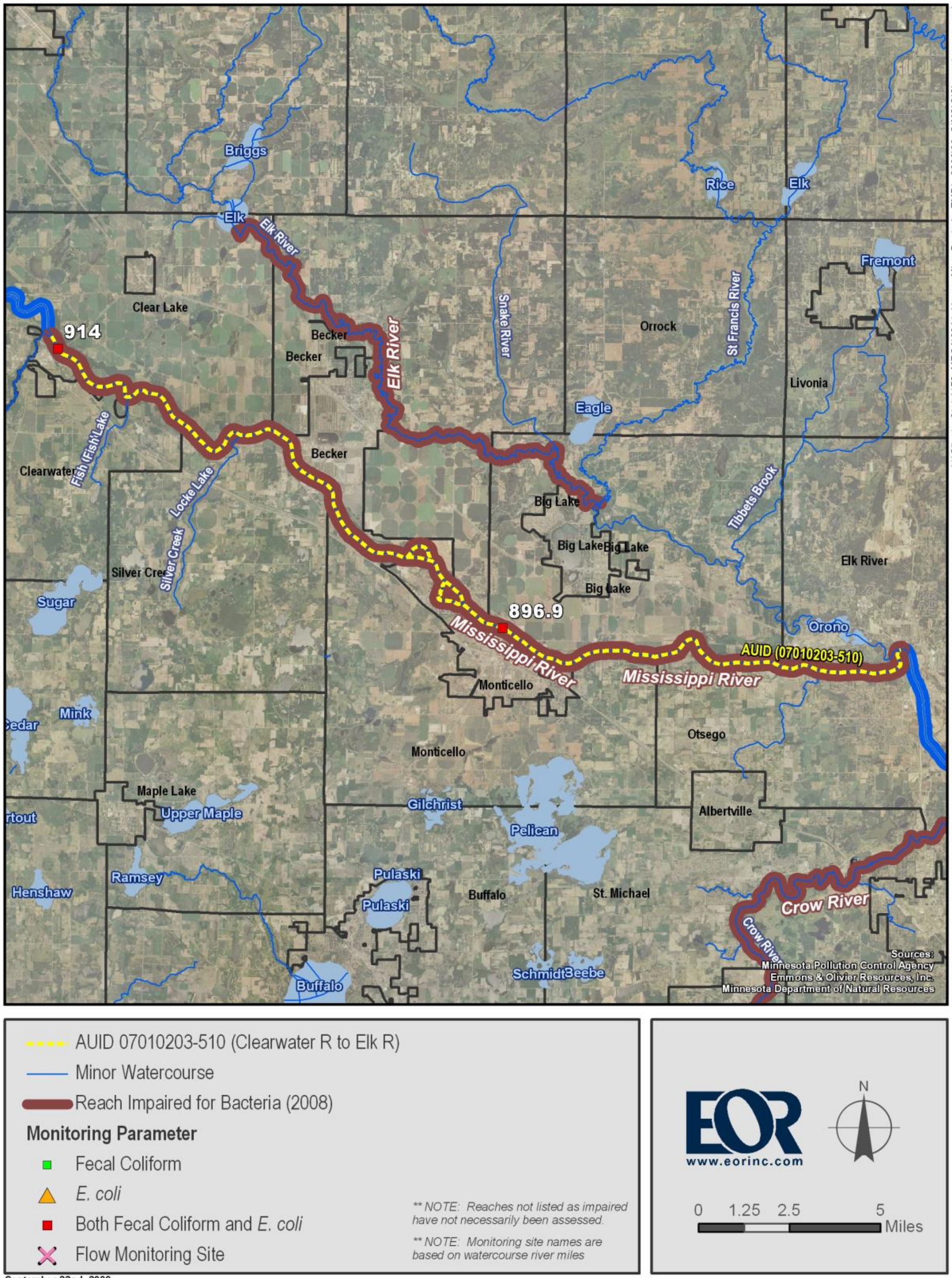

Figure 20. Mississippi River AUID 07010203-510 and mainstem bacteria and flow monitoring sites.

Mississippi RM 914.0

Mississippi RM 914.0 experiences three jumps in bacteria concentrations where bacteria concentrations increased substantially from upstream RM 928.4 to RM 914.0 during September and October. Flow data were not available for this site for this study. Figure 21 and Figure 22 illustrate mean by month and year *E. coli* concentrations as compared to precipitation (total by month and year). The two highest mean *E. coli* concentrations (June 2002 and August 2007) occur during months with at least 4 inches of rain.

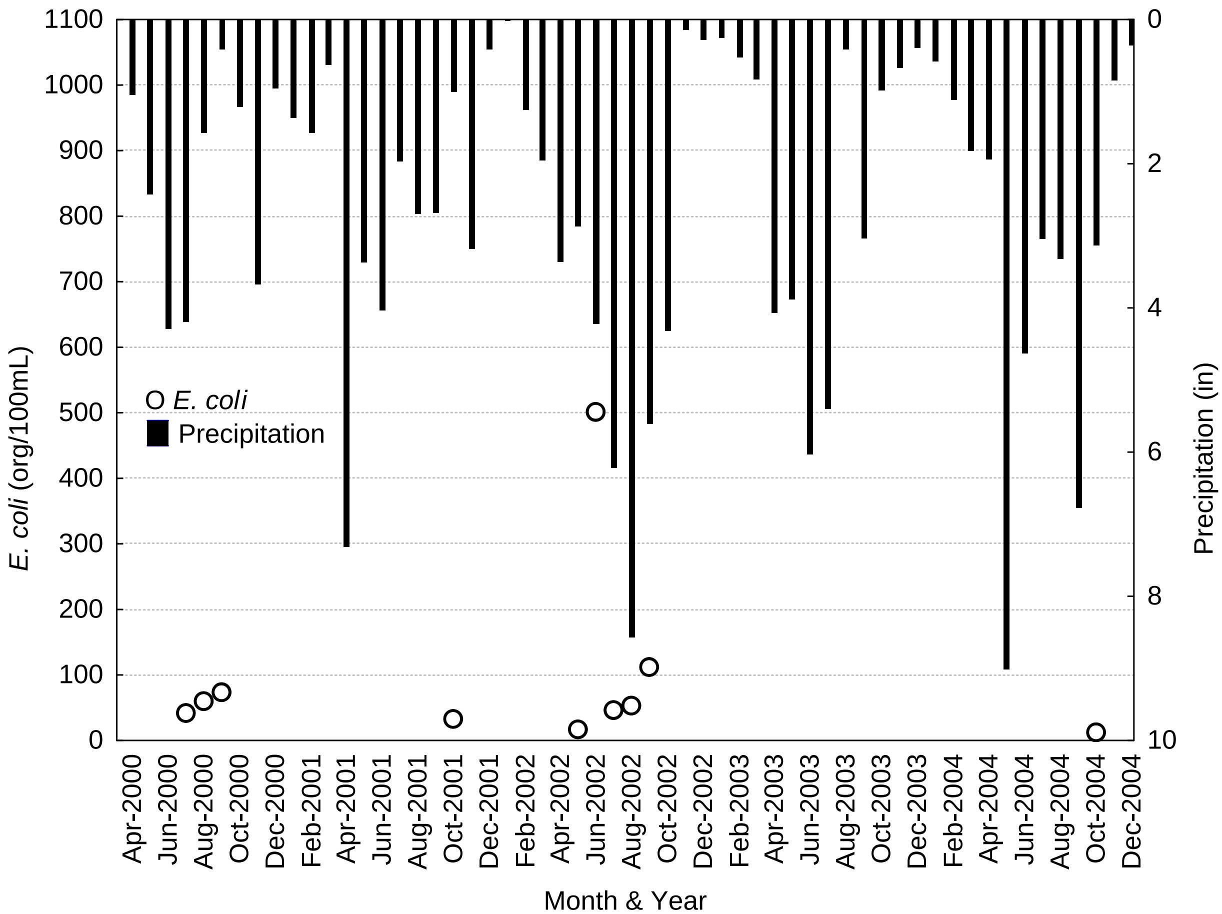

Figure 21. *E. coli* geometric means and total precipitation at RM 914.0 for 2000-2004.

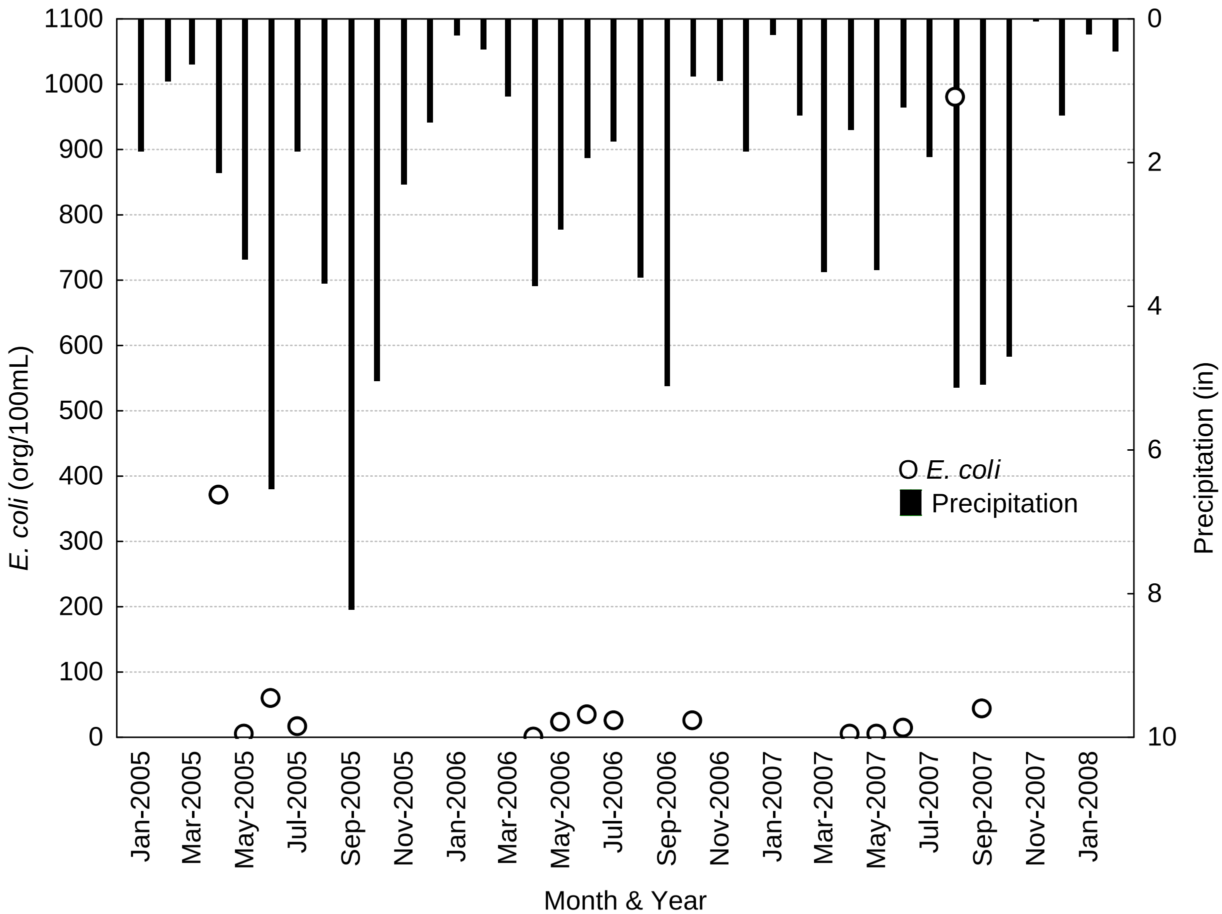

Figure 22. *E. coli* geometric means and total precipitation at RM 914.0 for 2005-2007.

Figure 23 and Figure 24 illustrate the correlation between Mississippi RM 914.0 and the Sauk River for *E. coli* and fecal coliform measurements, respectively, taken on the same day. Scatter in the *E. coli* plot of values greater than approximately 150 org/100 mL make the relationship difficult to interpret. Although there is a relatively high correlation ($R^2 = 0.60$) in the fecal coliform plot, this does not imply that the Sauk River is causing the high concentrations found in the Mississippi; an independent factor could be causing the high concentrations in both. However, the majority of the points in both the *E. coli* and the fecal coliform relationships fall above the 1:1 line, indicating that the bacteria concentration in the Sauk River is often higher than the concentration in the Mississippi River. Both of these relationships were developed with a limited number of data points due to the relative scarcity of data at both sites taken on the same day; conclusions from these relationships should be considered preliminary.

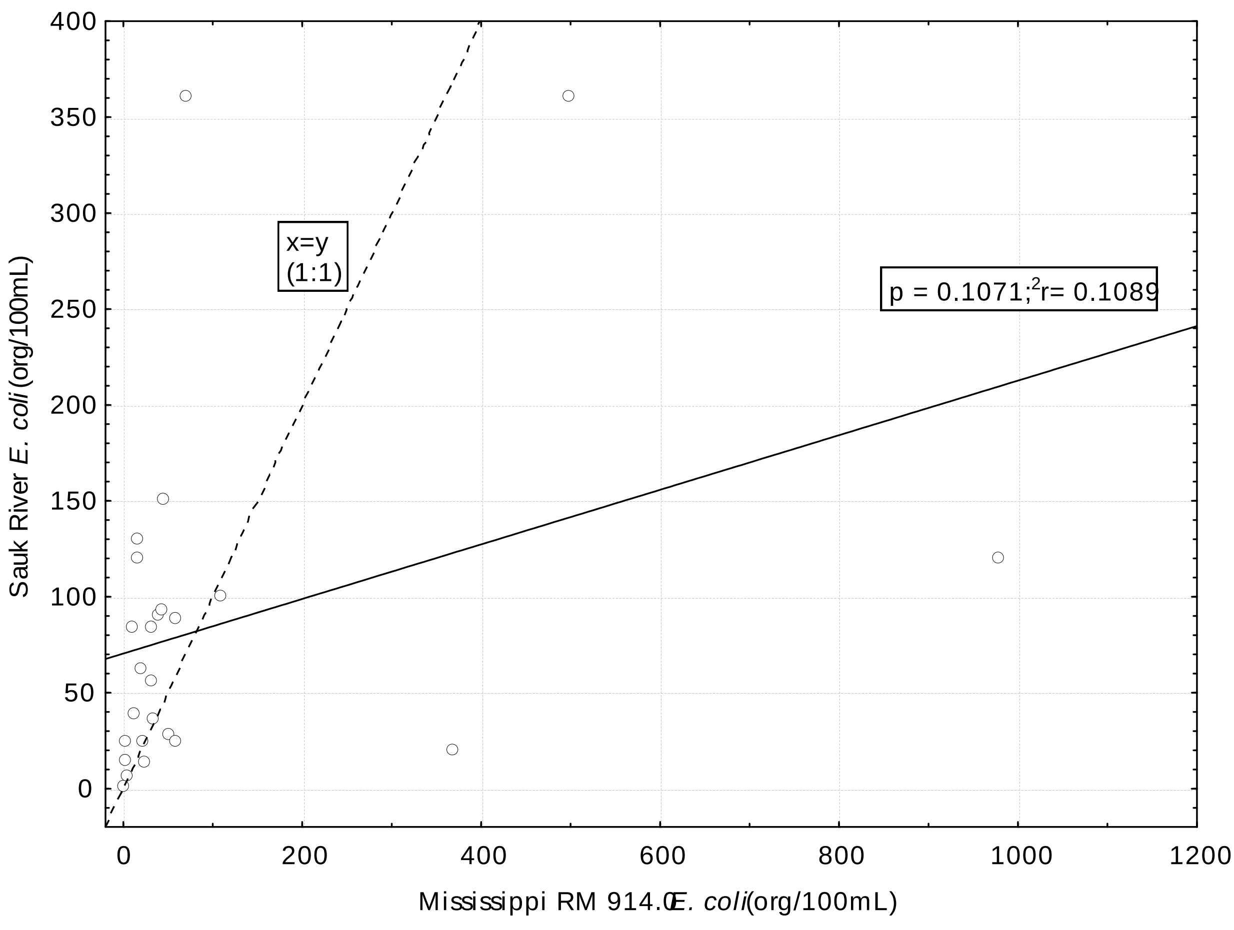

Figure 23. Relationship between Mississippi RM 914.0 and the Sauk River for *E. coli* data taken on the same day.

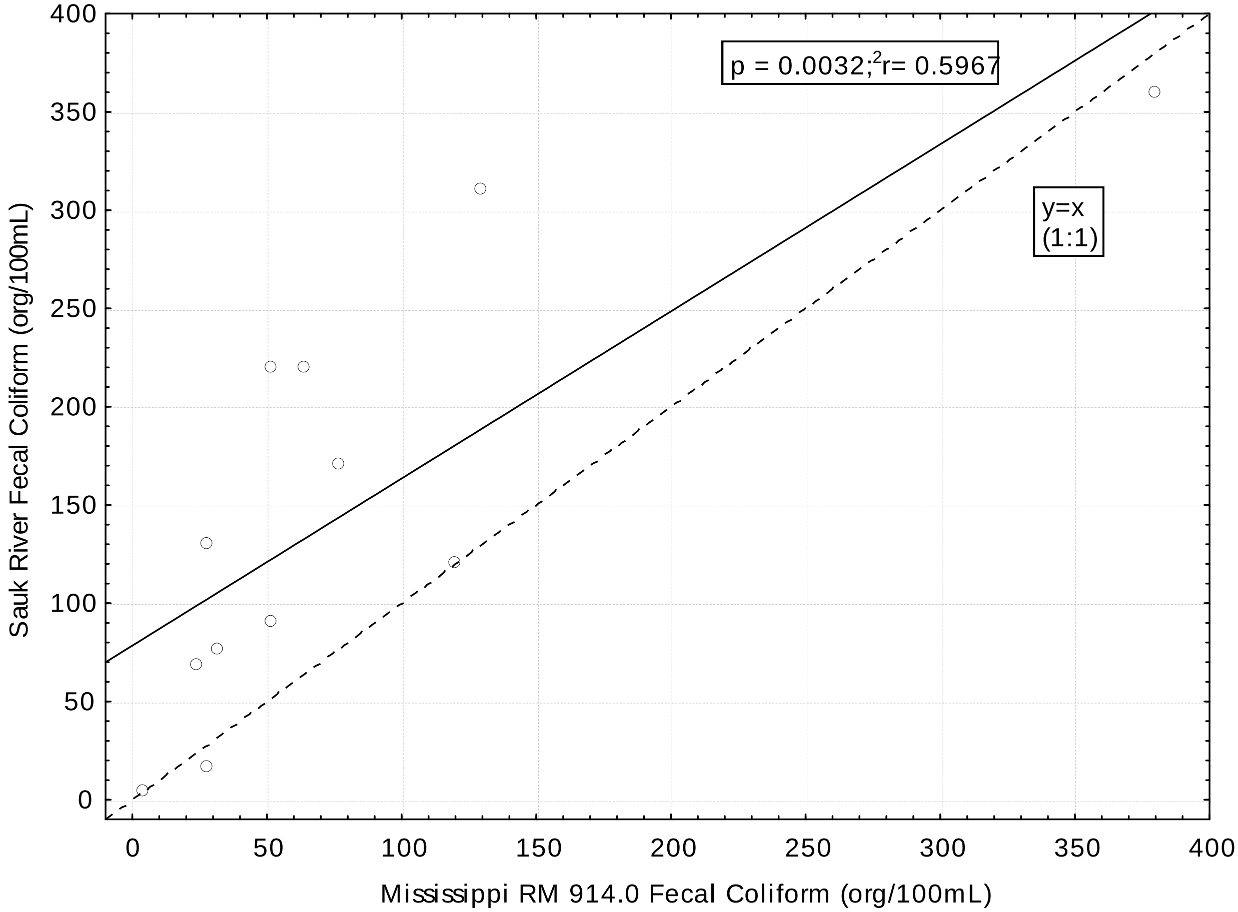

Figure 24. Relationship between Mississippi RM 914.0 and the Sauk River for fecal coliform data taken on the same day.

Mississippi RM 896.9

Mississippi RM 896.9, also within impaired AUID 07010203-510, experiences no jumps in bacteria concentrations despite the 17.1-mile separation from the adjacent upstream site. Flow data were not available for this site for this study. Figure 25 and Figure 26 illustrate geometric mean by month and year *E. coli* concentrations as compared to precipitation (total by month and year). Concentrations at or above 150 org/100mL tend to occur during very wet months; this occur in particular in June 2002. *Section 3.F. Surrogates Analysis* identifies for this RM a positive correlation between *E. coli* and TSS (R-squared value of 0.3166, p-value of 0.0121).

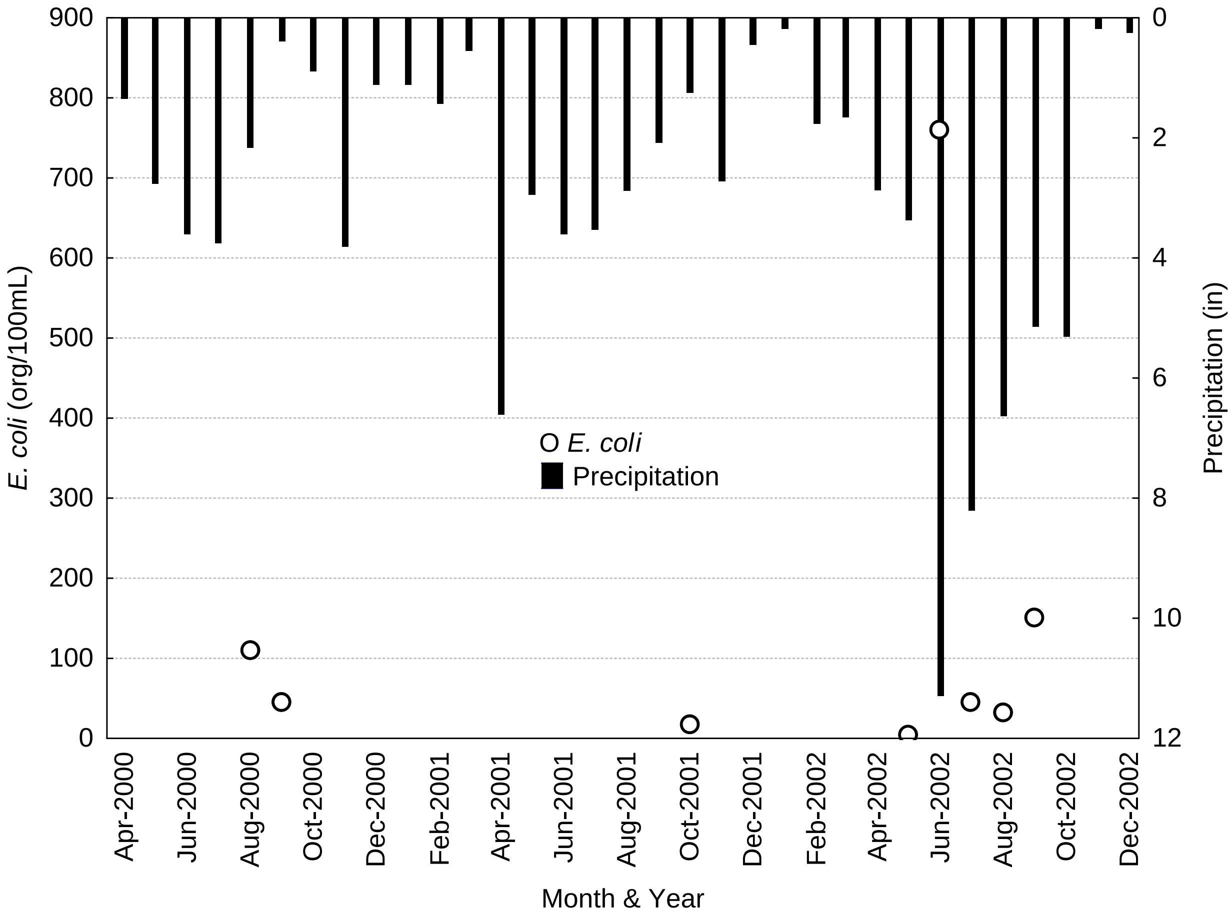

Figure 25. *E. coli* geometric means and total precipitation at RM 896.9 from 2000-2002.

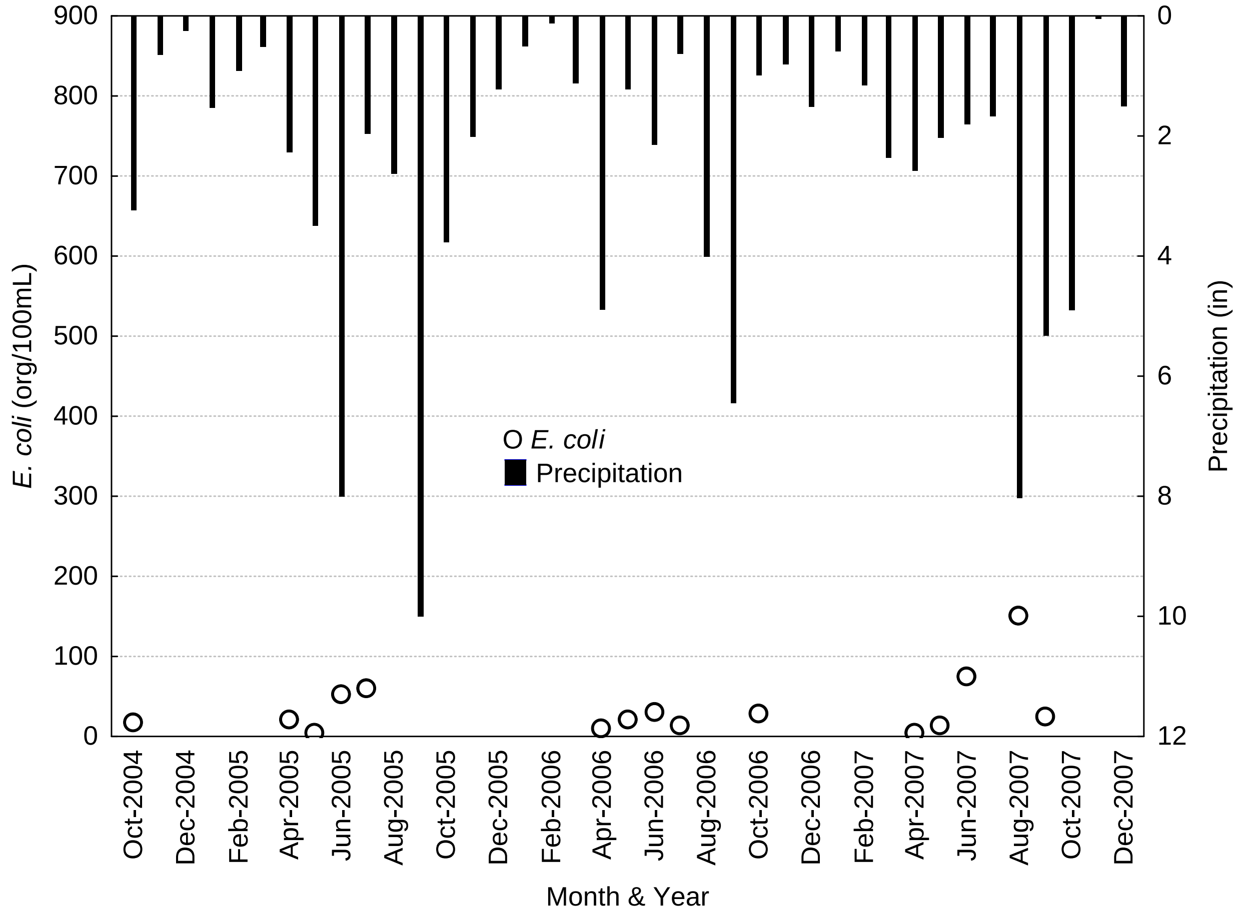

Figure 26. *E. coli* geometric means and total precipitation at RM 896.9 from 2004-2007.

AUID 07010206-568 (Impaired)

The following Mississippi RMs are within AUID 07010206-568 (Figure 27) which is known to be impaired:

- 871.7
- 871.6

These RMs will be discussed from page 62 to page 65. Bacteria data and related statistics for these RMs (by month and year and by month across all years) can be found in Appendix A (*E. coli*) and Appendix B (fecal coliform).

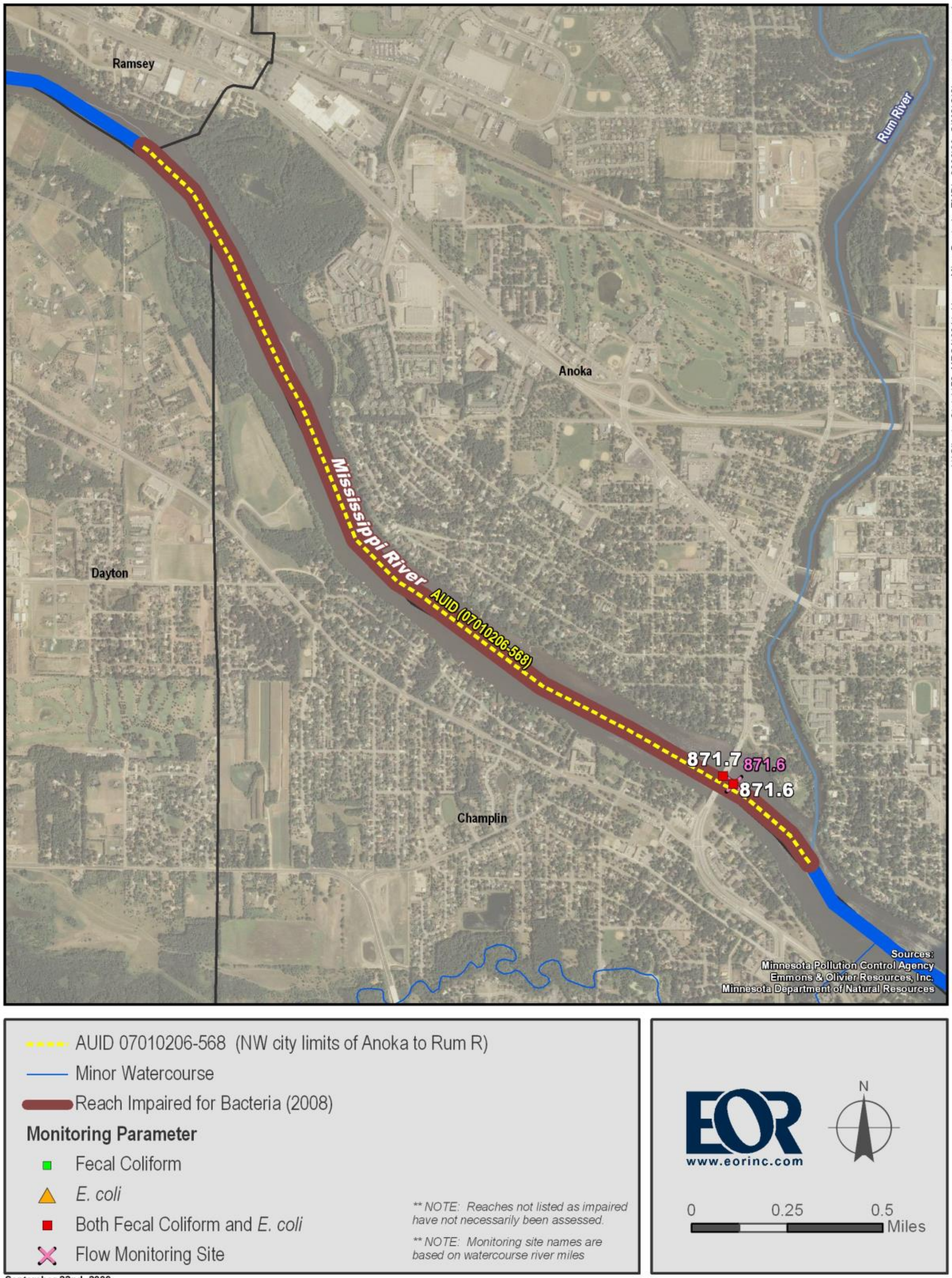

Figure 27. Mississippi River AUID 07010206-568 and mainstem bacteria and flow monitoring sites.

Mississippi RM 871.7

Mississippi RM 871.7 is the upstream-most monitoring site within impaired AUID 07010206-568. The site does not experience any jumps in bacteria concentrations but this is likely due to scarcity of data. With only two bacteria samples in any given month and year, RM 871.7 never had enough samples on a month by year basis to establish a 95% confidence interval. However, it is clear from Figure 5 and Figure 6 that RM 871.7 exhibits a substantial increase in bacteria from nearly all monitoring sites upstream of it.

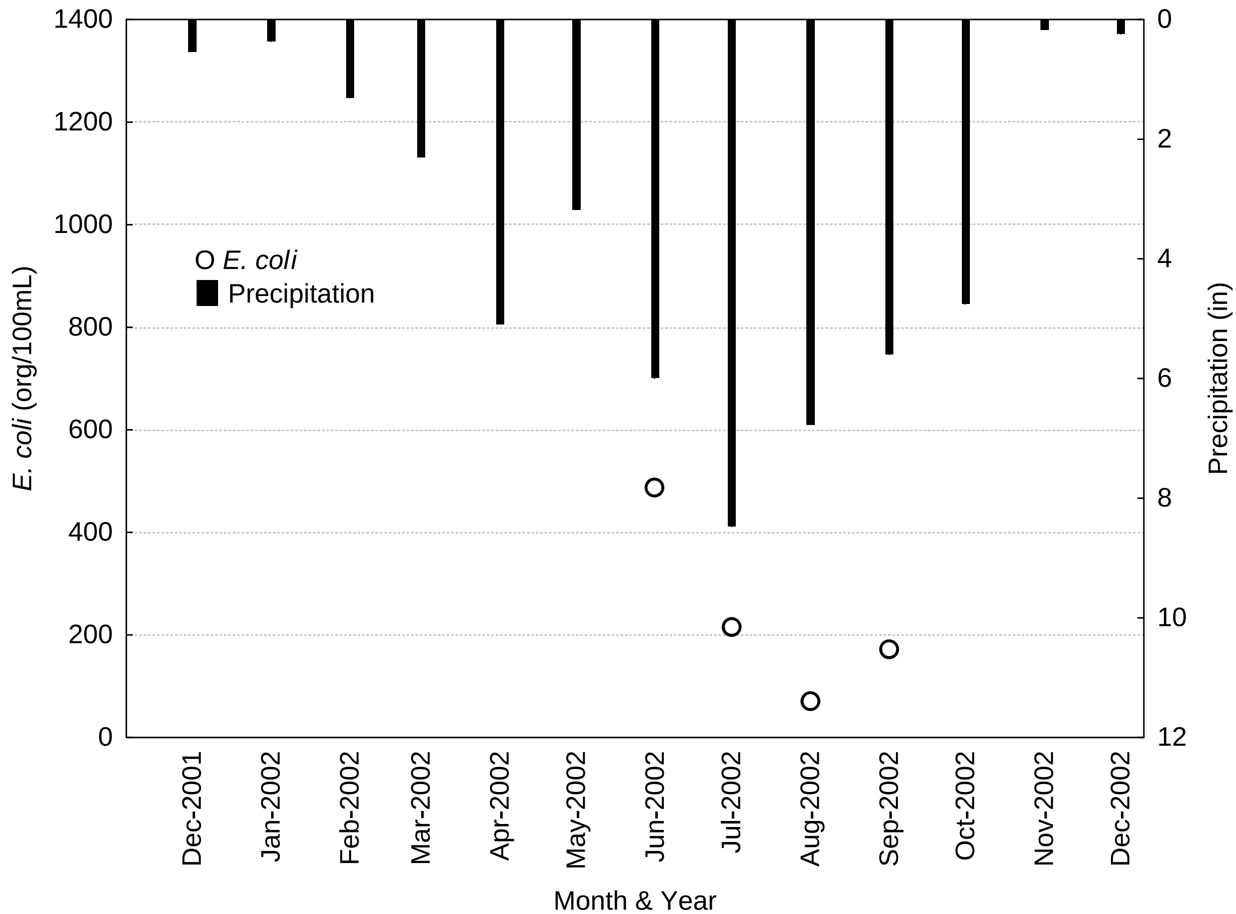

Figure 28. *E. coli* geometric means and total precipitation at RM 871.7.

Mississippi RM 871.6

Mississippi RM 871.6 also lies within impaired AUID 07010206-568. Elk River and the Crow River enter the Mississippi River at RM 884.6 and RM 879.5, respectively. A relatively small unnamed creek enters the Mississippi River upstream of Elk River and from the west at RM 887.1. Portions of Elk River and the Crow River are known to be impaired for fecal coliform.

Figure 29 and Figure 30 illustrate the correlation between Mississippi RM 871.6 and the Elk River for *E. coli* and fecal coliform measurements, respectively, taken on the same day. Data from the Elk River are taken upstream of Lake Orono. Although there is a relatively high correlation ($R^2 = 0.67$), this does not imply that the Elk River is causing the high concentrations found in the Mississippi; an independent factor could be causing the high concentrations in both. However, the majority of the points in both the *E. coli* and the fecal coliform relationships fall above the 1:1 line, indicating that the bacteria concentration in the Elk River is often higher than the concentration in the Mississippi River. Both of these relationships were developed with a limited number of data points due to the relative scarcity of data at both sites taken on the same day; conclusions from these relationships should be considered preliminary.

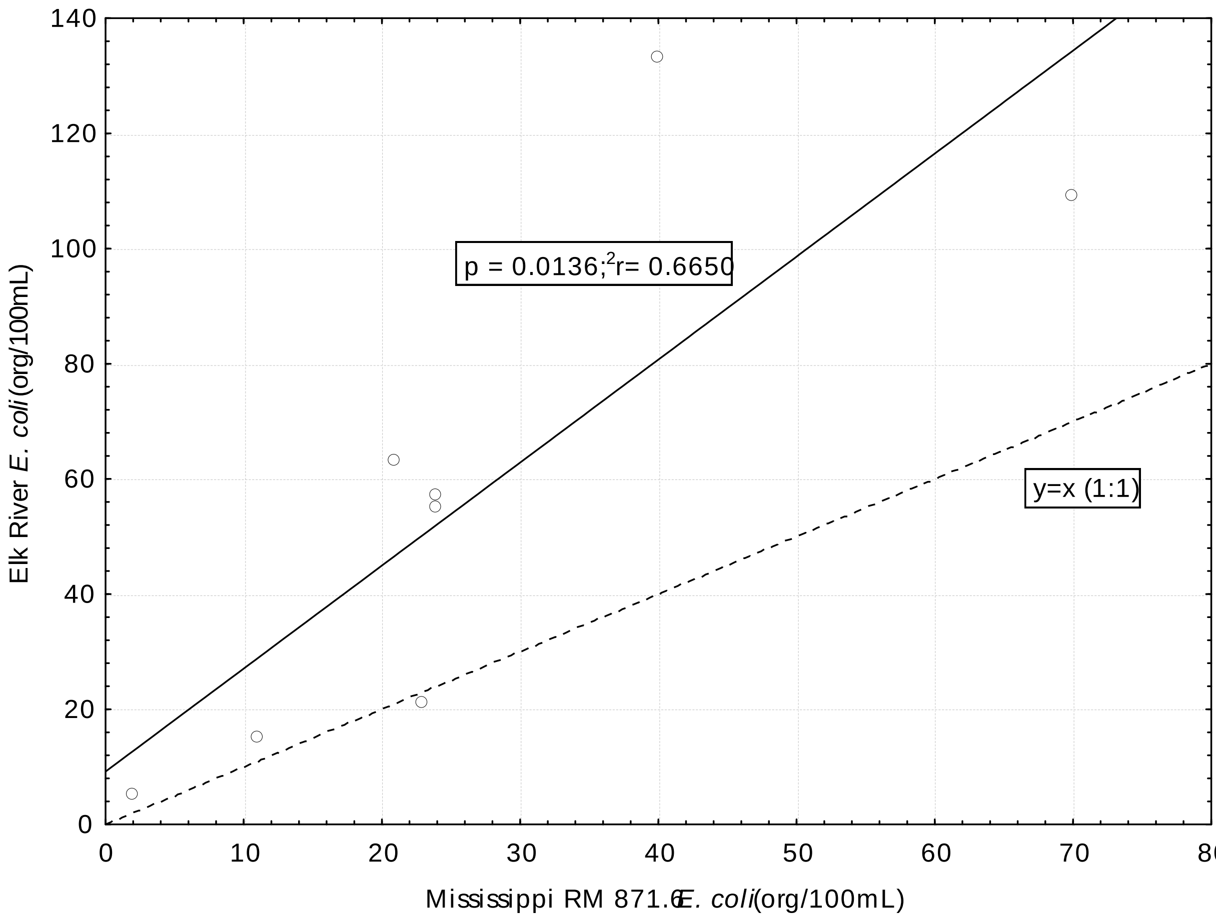

Figure 29. Relationship between Mississippi RM 871.6 and the Elk River upstream of Lake Orono for *E. coli* data taken on the same day.

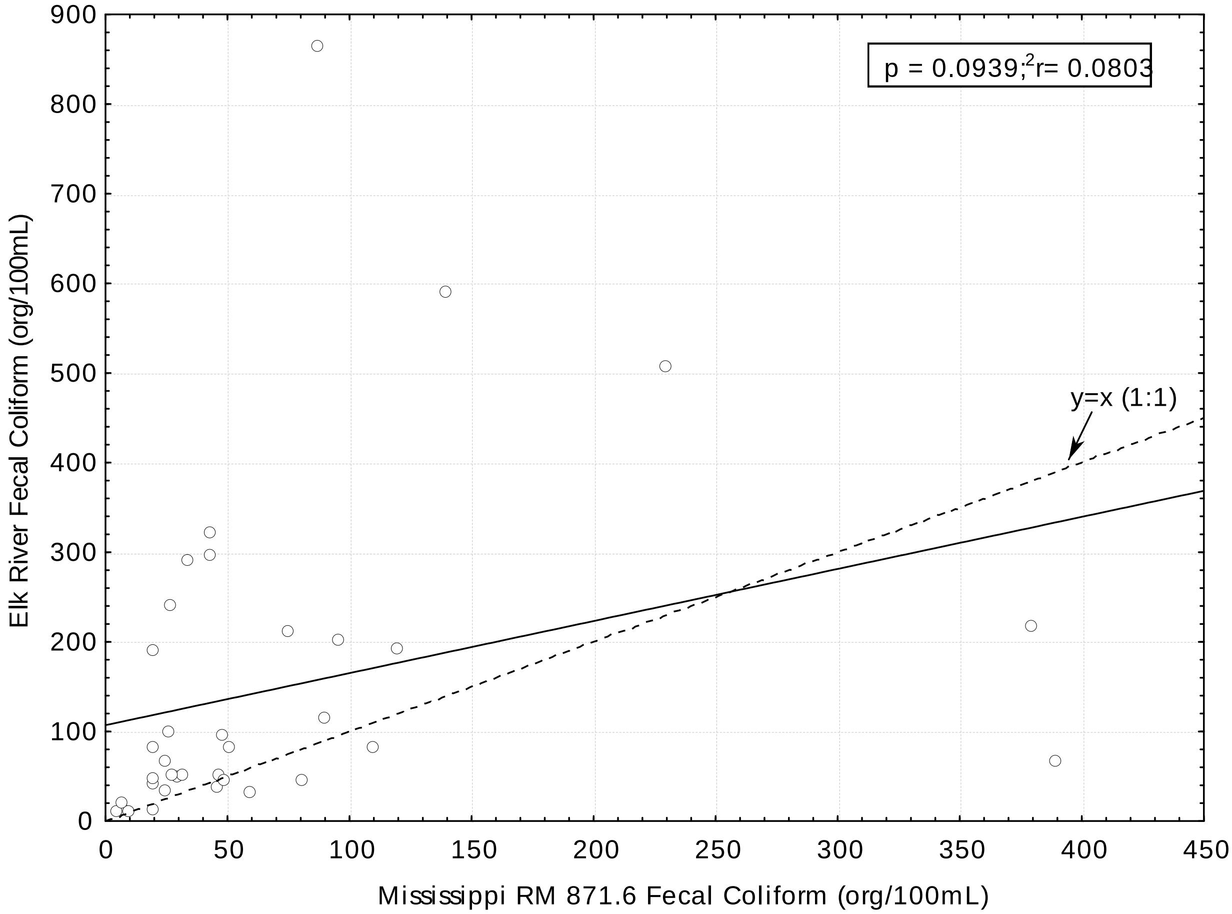

Figure 30. Relationship between Mississippi RM 871.6 and the Elk River upstream of Lake Orono for fecal coliform data taken on the same day.

Two Mississippi River AUIDs not listed for bacteria impairment are 07010203-503 downstream of Elk River and 07010206-567 downstream of the Elk and Crow Rivers; these AUIDs are between two AUIDs known to be impaired (07010203-510 and 07010206-568). Bacteria data are unavailable for the non-listed AUIDs; it is possible that the Crow and Elk River bacteria concentrations contributing to the significant increase in bacteria at RM 871.6 (within the downstream impaired AUID) contribute to the impairment status of the downstream AUID and may be impaired themselves. Data are needed for the non-listed Mississippi River AUIDs.

Flow data were not available adjacent to this RM871.6, but precipitation and *E. coli* data are compared in Figure 31. *E. coli* concentrations at RM 871.6 appear to be highest during periods of both high and low local precipitation. High bacteria concentrations during periods of low local precipitation may be due to local dry weather flows or inflow from upstream Mississippi River reaches and their tributaries and watersheds.

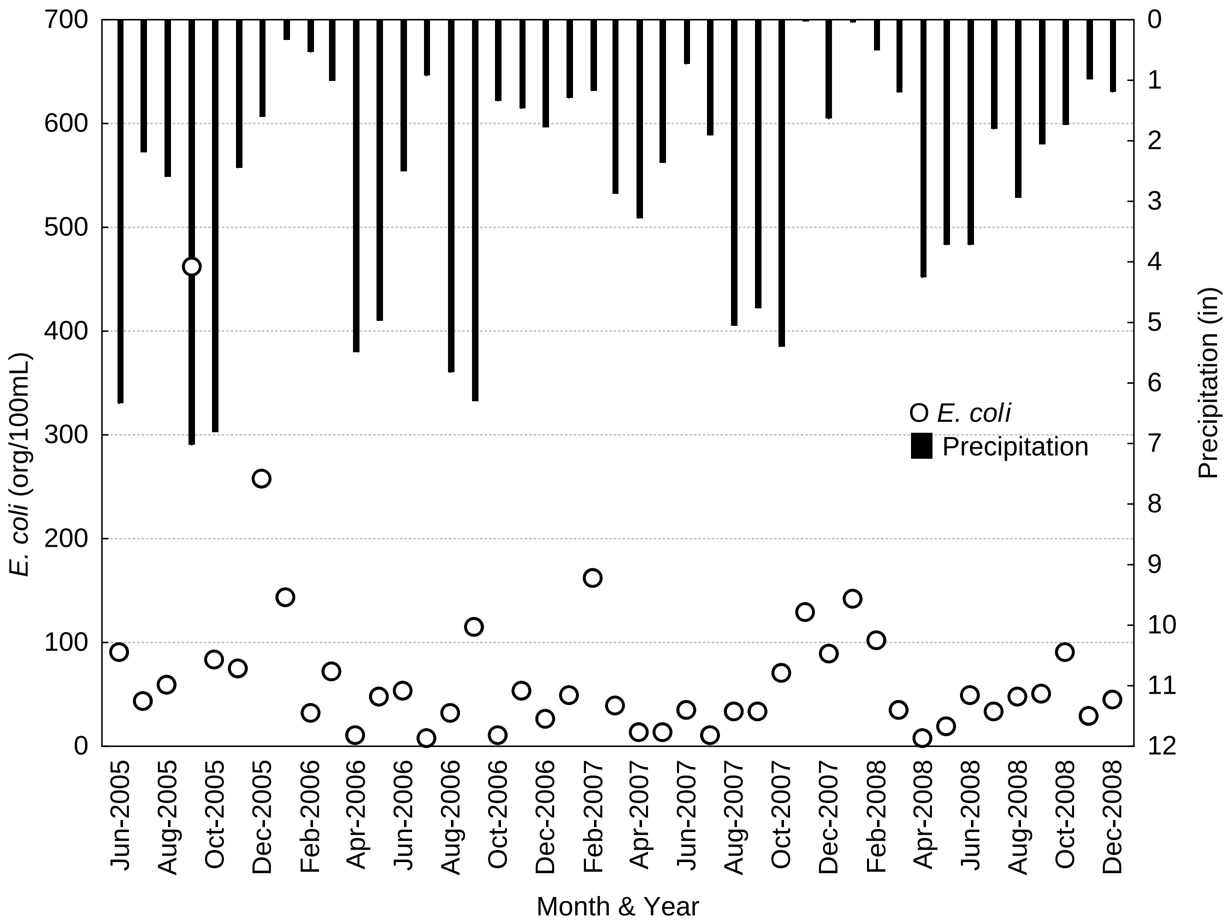

Figure 31. *E. coli* geometric means and total precipitation at RM 871.6.

AUID 07010206-509 (Impaired)

The following Mississippi RMs are within AUID 07010206-509 (Figure 32) which is known to be impaired:

- 863.0
- 862.8
- 859.1
- 859.0
- 858.8
- 858.5
- 857.6
- 857.5
- 855.0
- 854.9

These RMs will be discussed from page 68 to page 81. Bacteria data and related statistics for these RMs (by month and year and by month across all years) can be found in Appendix A (*E. coli*) and Appendix B (fecal coliform).

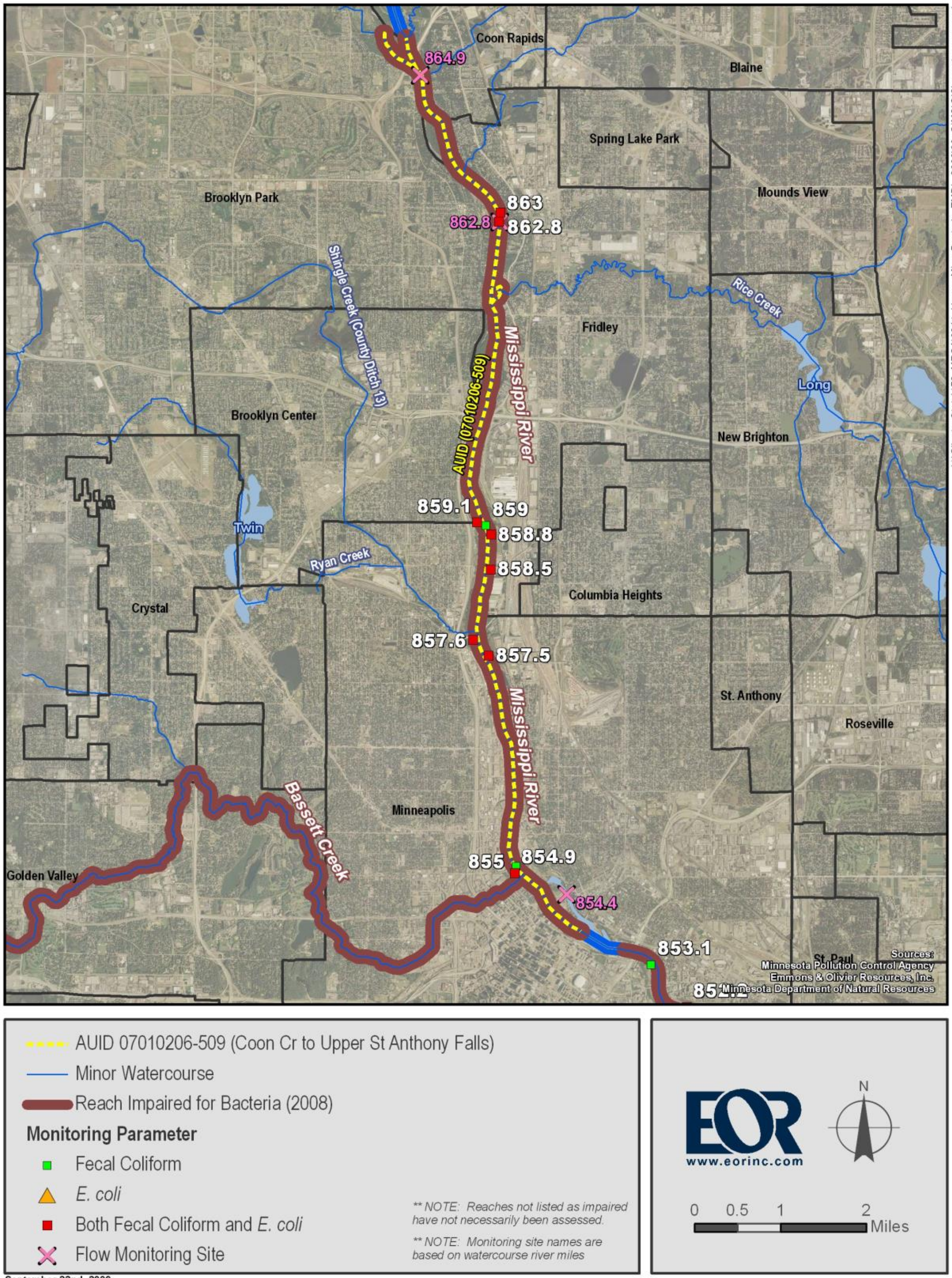

Figure 32. Mississippi River AUID 07010206-509 and mainstem bacteria and flow monitoring sites.

Mississippi RM 863.0

Mississippi RM 863.0 is the upstream-most site within impaired AUID 07010206-509. Figure 33 illustrates geometric mean *E. coli* concentrations by month and year as compared to flow and precipitation. In early 2008, *E. coli* concentrations were highest and at the same time precipitation was lowest during the 3-year time period shown. Flow appears to roughly pattern local precipitation.

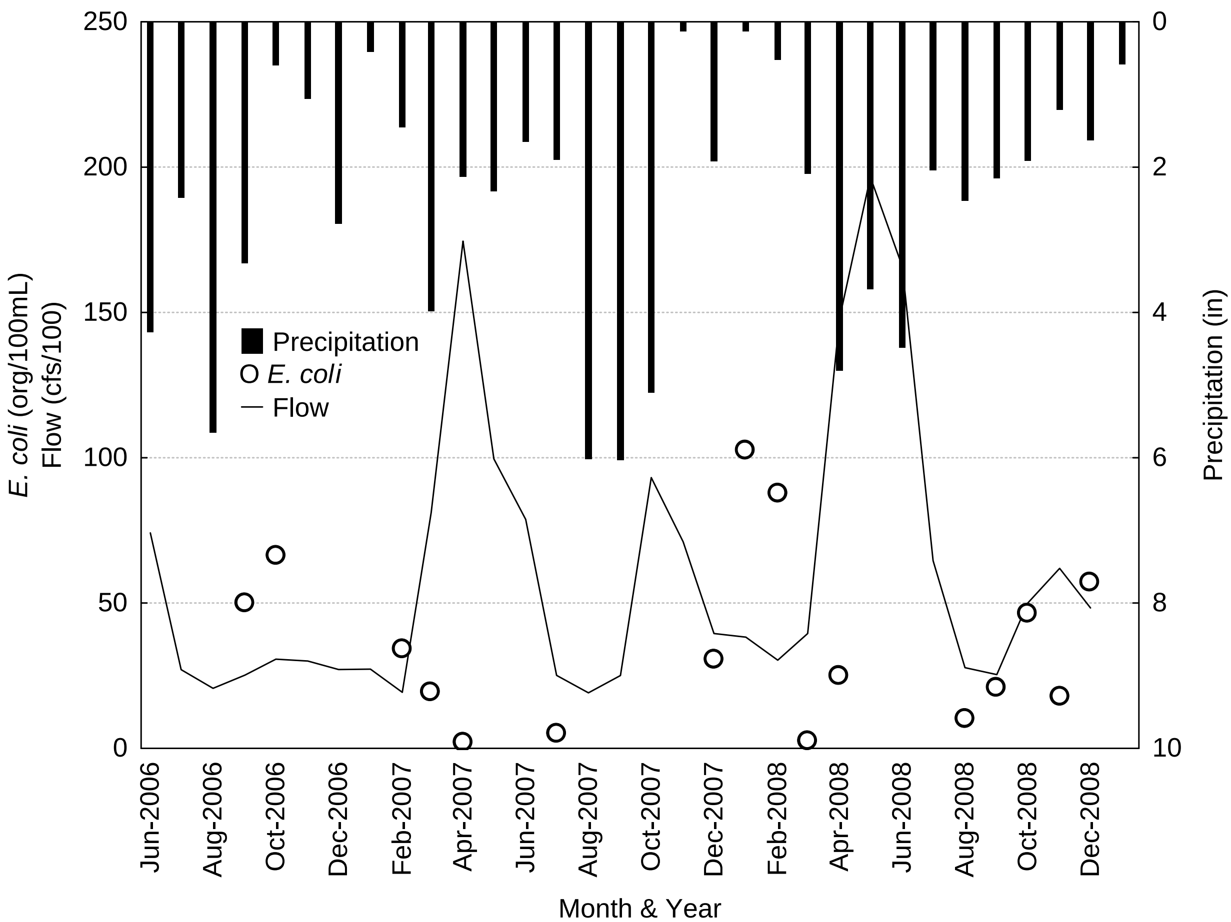

Figure 33. *E. coli* geometric means, mean flow and total precipitation at RM 863.0.

Figure 34 illustrates the LDC analysis where monitored *E. coli* loading was compared to hypothetical loading at the standard concentration (126 org/100mL). A total of 9.7% (3/31) of monitored data exceeds the standard loading. All three exceedances occur during dry conditions, twice in January and once in December.

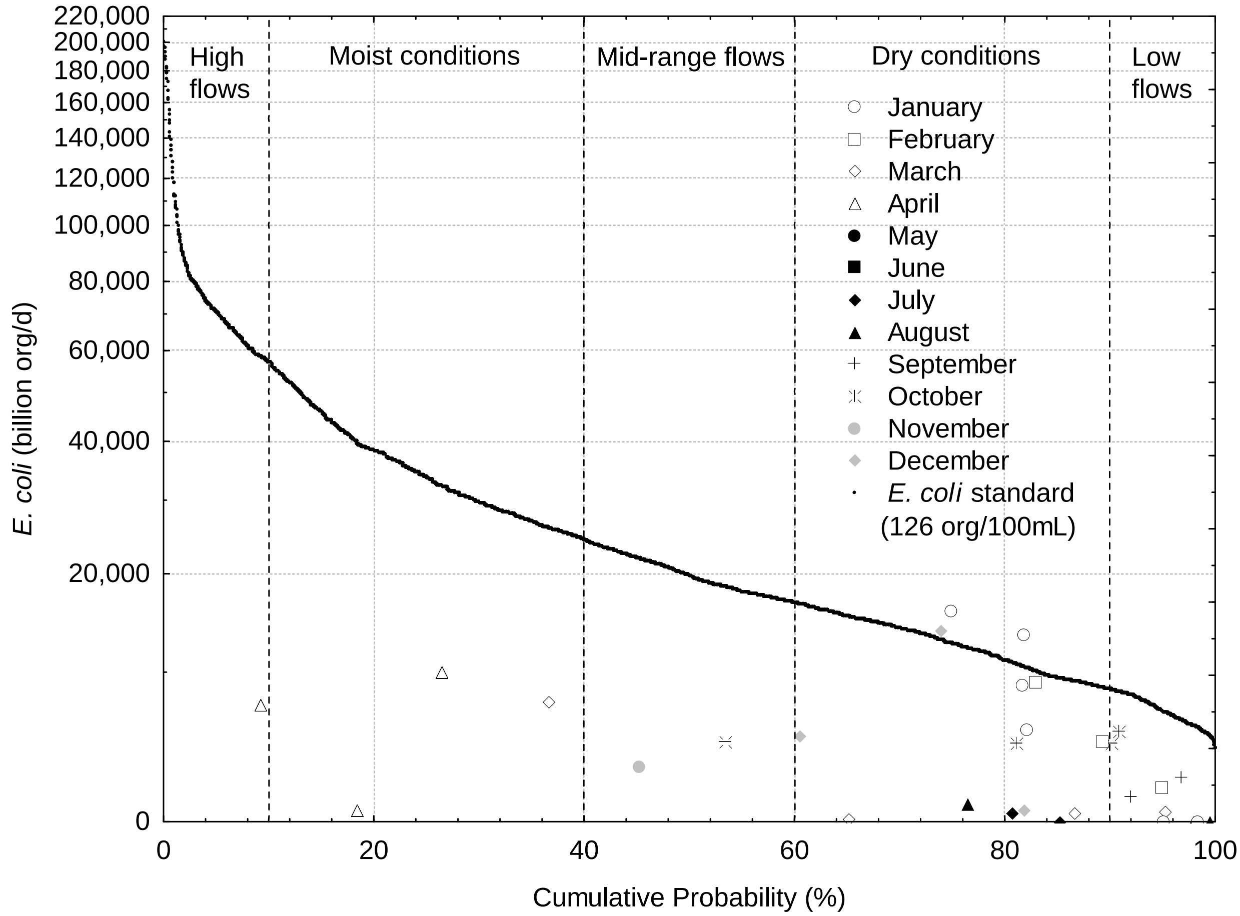

Figure 34. Load duration curve for *E. coli* at RM 863.0.

Mississippi RM 862.8

Figure 35 illustrates geometric mean *E. coli* concentrations by month and year at RM 862.8 as compared to flow and precipitation. *E. coli* concentrations appear higher in general in 2005 and 2006 than 2007 and 2008. Flow appears roughly to follow precipitation patterns.

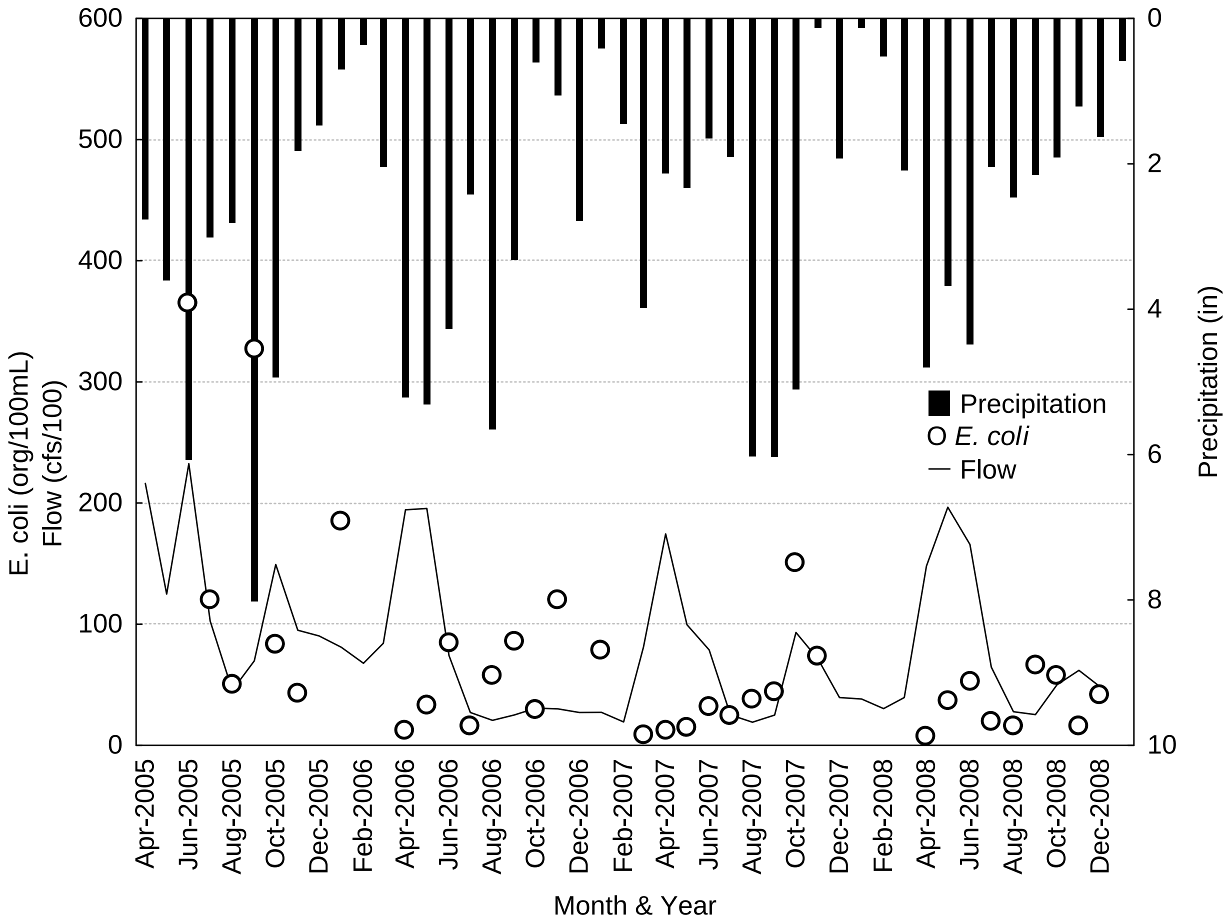

Figure 35. *E. coli* geometric means, mean flow and total precipitation at RM 862.8.

Figure 36 illustrates the LDC analysis where monitored *E. coli* loading was compared to hypothetical loading at the standard concentration (126 org/100mL). A total of 18% (19/107) of monitored data exceeds the standard loading. Exceedances are experienced from May through November and once in January.

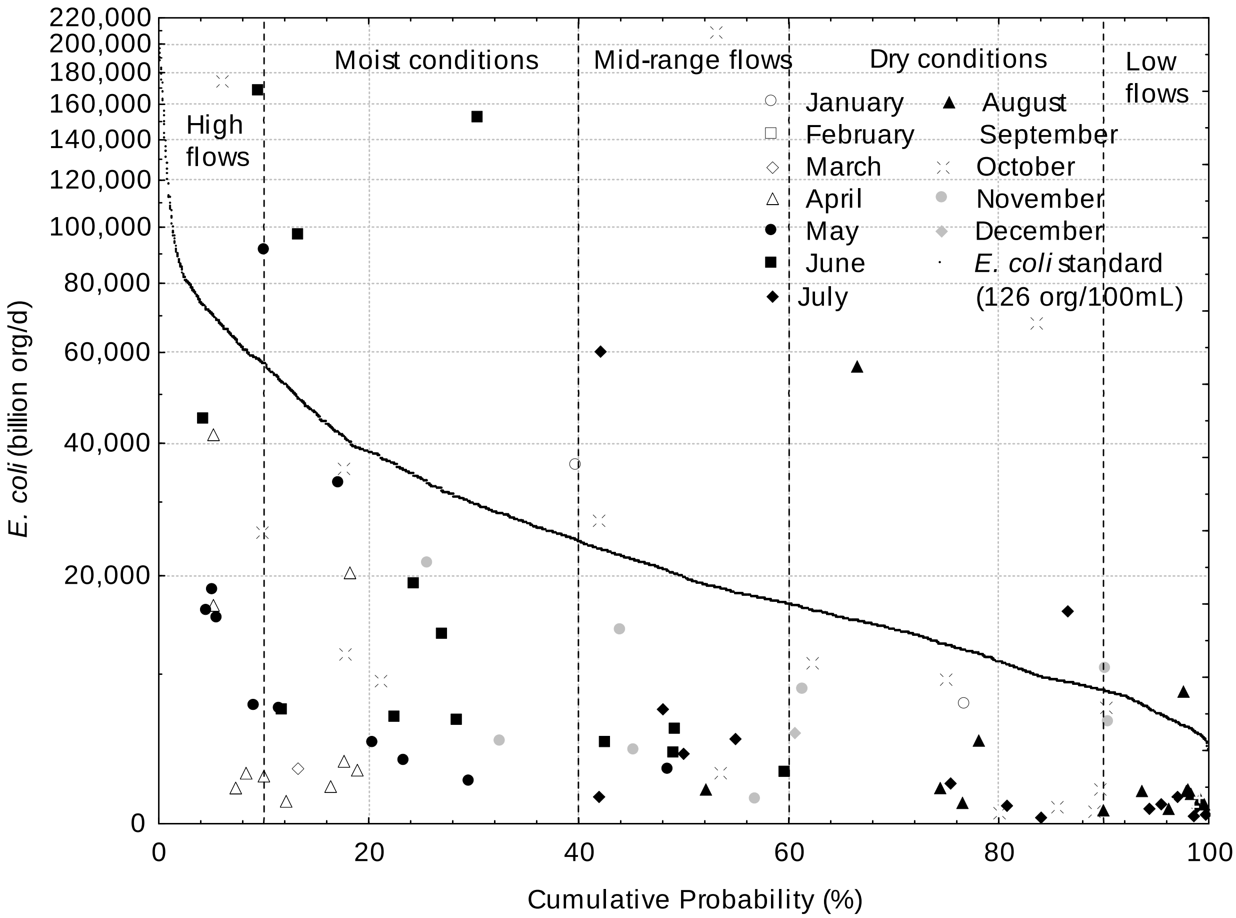

Figure 36. Load duration curve for *E. coli* at RM 862.8.

Mississippi RM 859.1

Mississippi RM 859.1 experiences six jumps in *E. coli* and fecal coliform concentrations from the adjacent upstream site at RM 862.8. Jumps occurred in August through October with the exception of a single jump in April. RM 862.8 and 859.1 are separated by Rice Creek (RM 862.0) but bacteria data are not available for Rice Creek. Figure 37 and Figure 38 illustrate geometric mean *E. coli* and corresponding monthly precipitation. In 2006 through 2008, *E. coli* concentrations appear to be higher in the fall than in the respective spring.

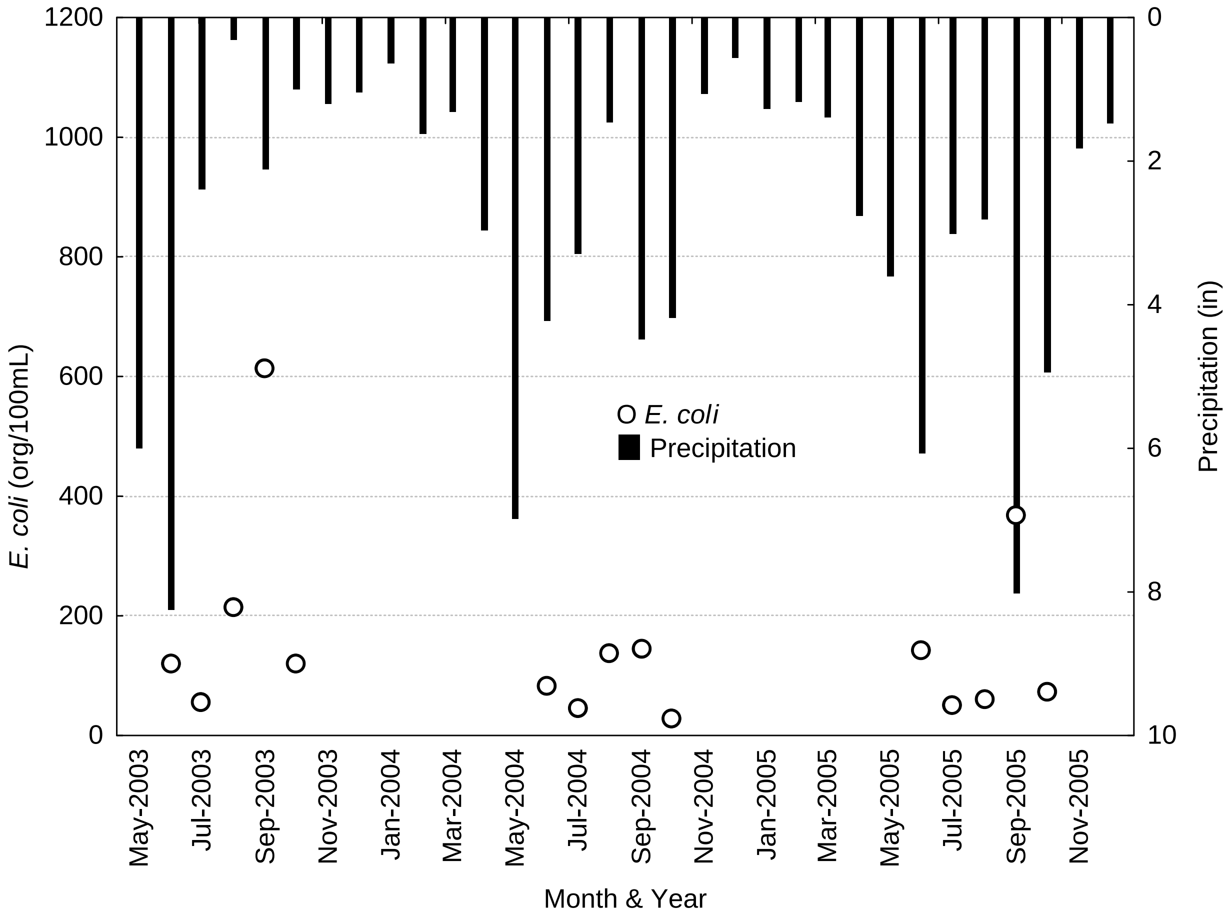

Figure 37. *E. coli* geometric means and total precipitation at RM 859.1 from 2003-2005.

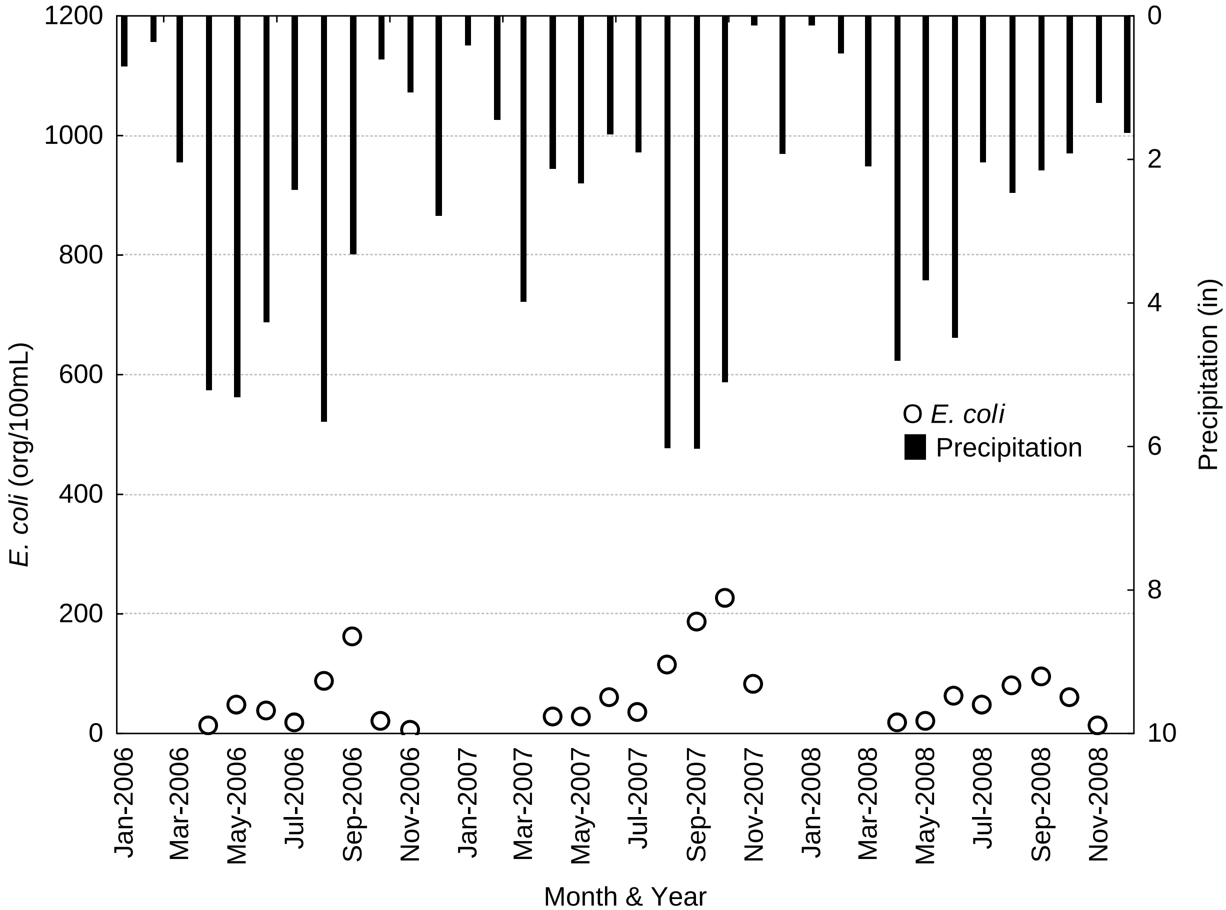

Figure 38. *E. coli* geometric means and total precipitation at RM 859.1 from 2006-2008.

Mississippi RM 859.0

There are fecal coliform data available but no *E. coli* data available for this site. Table B - 1 and Table B - 2 in Appendix B identify the only fecal coliform data available for this site. Ten samples were taken in total from July through September in the year 2002. In August, the geometric mean exceeds that of the former fecal coliform standard of 200 org/100mL.

Mississippi RM 858.8

Flow data for Mississippi RM 858.8 was not available for this study. Figure 39 and Figure 40 illustrate geometric mean by month and year *E. coli* concentrations as compared to precipitation (total by month and year). *E. coli* concentrations tend to increase leading into early fall (see also Table A - 2). However, data for this site are scarce; only one sample was taken for any given month with the exception of two in October 2006.

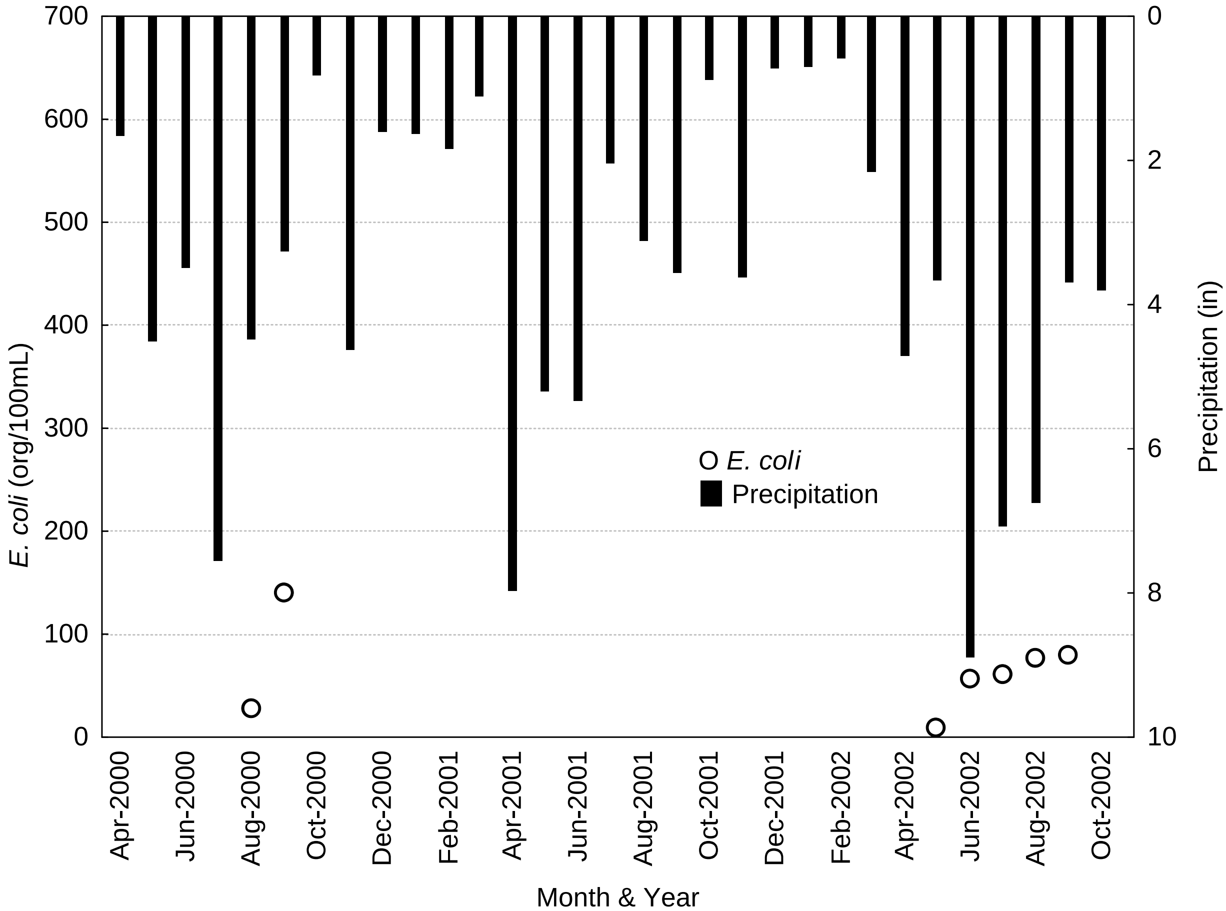

Figure 39. *E. coli* geometric means and total precipitation at RM 858.8 from 2000-2002.

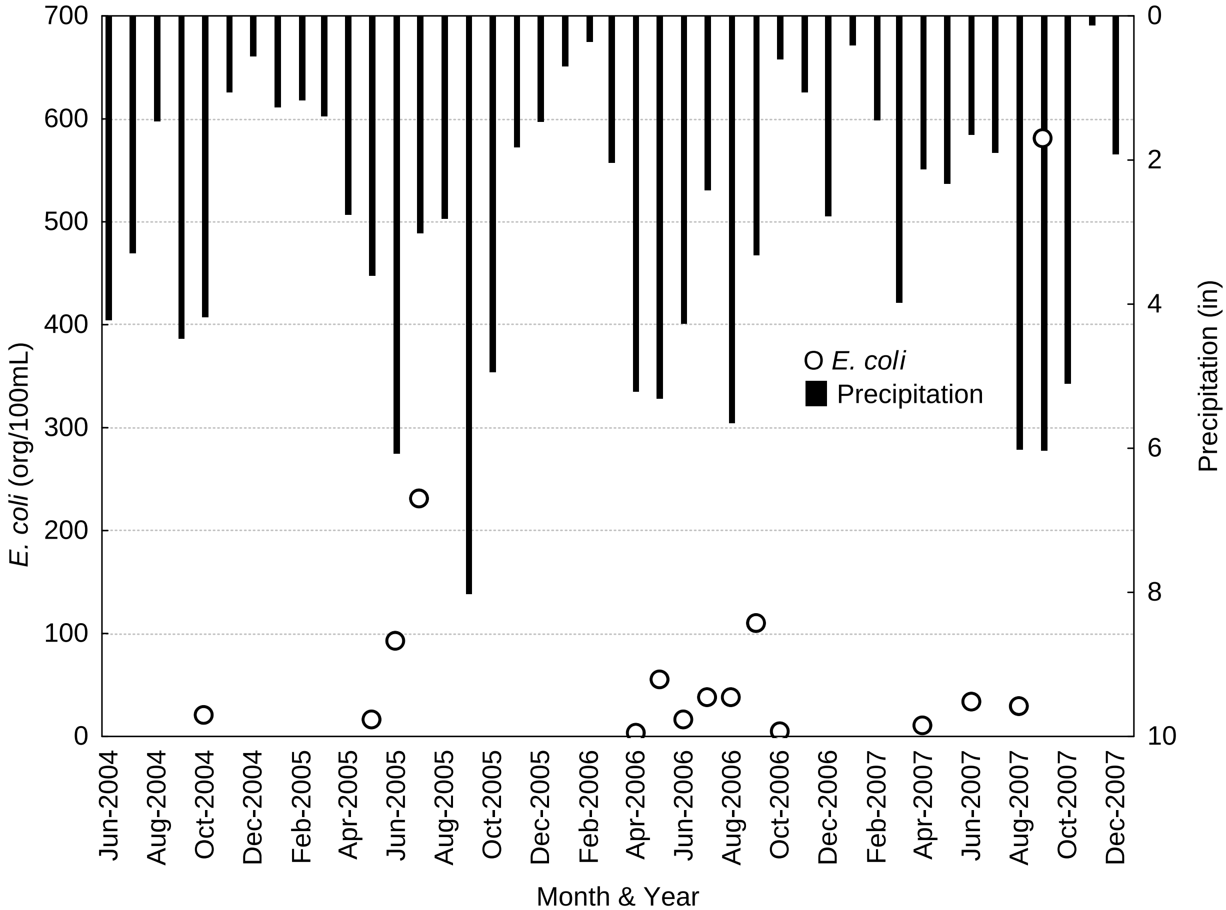

Figure 40. *E. coli* geometric means and total precipitation at RM 858.8 from 2004-2007.

Mississippi RM 858.5

Mississippi RM 858.5 experiences four jumps in fecal coliform concentrations from upstream RM 862.8. Fecal coliform jumps occur once each month from December through March. Rice Creek (RM 862.0), for which bacteria data are unavailable, enters the Mississippi River between RM 862.8 and 858.5. No data are available for *E. coli* at this RM.

Fecal coliform data at RM 858.5 is available from 1999 through 2008 with no fewer than 24 samples taken during any single month. Data are shown in Table B - 1 and Table B - 2 in Appendix B. Geometric means of data summarized by month across all years never exceed the former fecal coliform standard of 200 org/100mL. Concentrations during the months of August and September exceed those of May and June. September and January, respectively, have the highest concentrations.

Mississippi RM 857.6

Mississippi RM 857.6 experiences five jumps in bacteria concentrations from upstream RM 858.8 (*E. coli*) and 858.5 (fecal coliform) during late summer and fall (August through October). Shingle Creek (County Ditch 13) (RM 857.7) enters the Mississippi River immediately upstream of RM 857.6. Flow data were not available for RM 857.6 for this study. Figure 41 and Figure 42 illustrate geometric mean by month and year *E. coli* concentrations as compared to precipitation (total by month and year) for two different time periods. *E. coli* concentrations generally increase into the fall. In September 2005 high precipitation corresponds with a spike in *E. coli* concentration above 800 org/100mL.

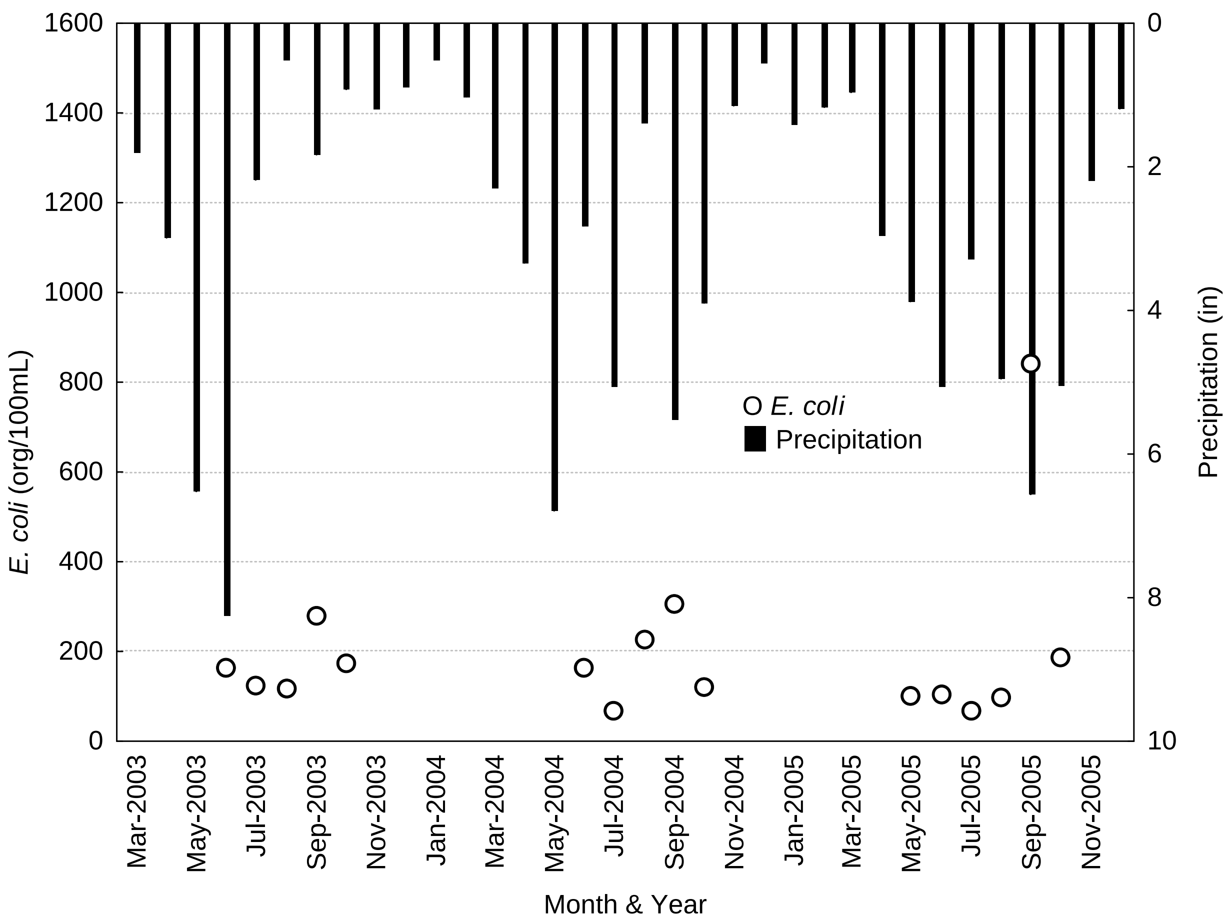

Figure 41. *E. coli* geometric means and total precipitation at RM 857.6 from 2003 through 2005.

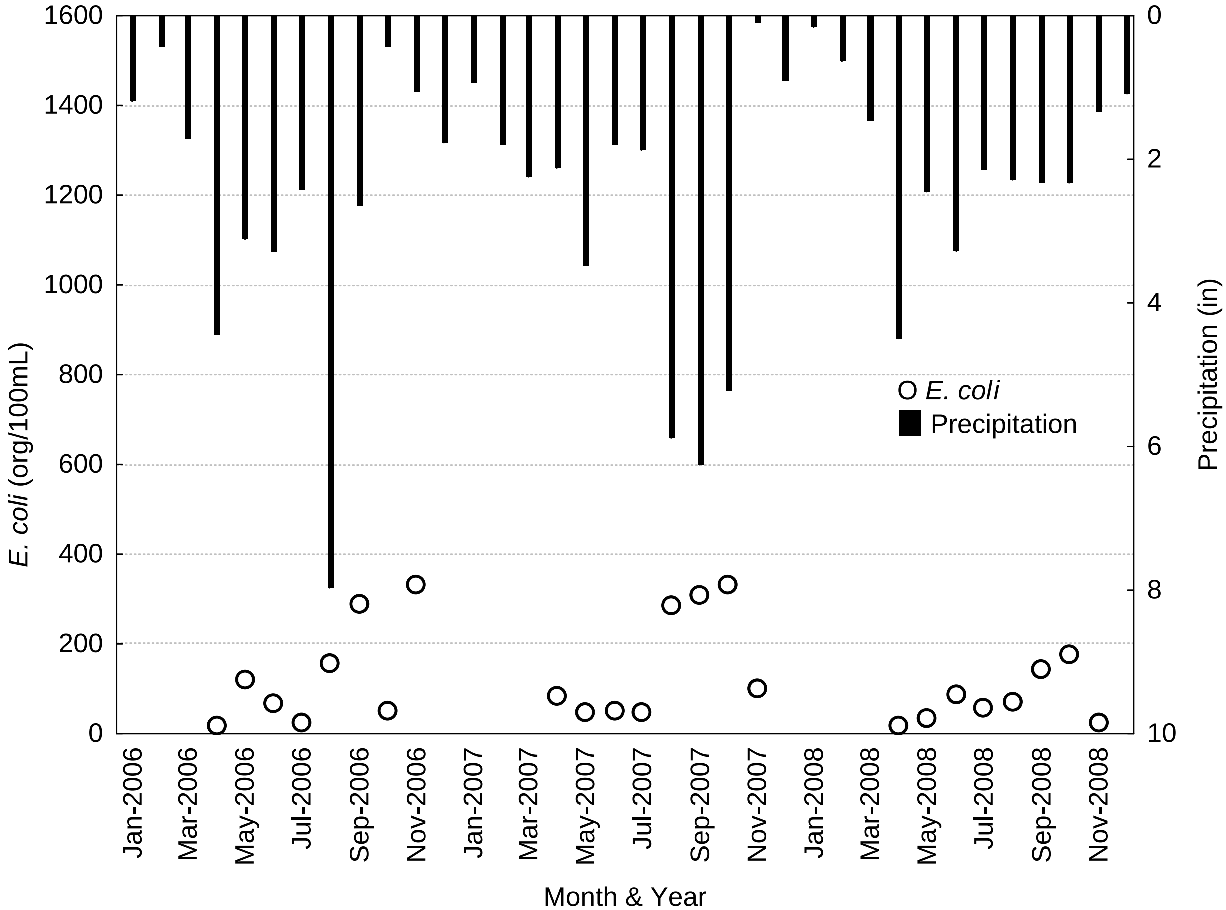

Figure 42. *E. coli* geometric means and total precipitation at RM 857.6 from 2006 through 2008.

Mississippi RM 857.5

Flow data were not available for RM 857.5 for this study. Figure 43 illustrates geometric mean by month and year *E. coli* concentrations as compared to precipitation (total by month and year) for two different time periods. Given the limited time period of available data, trends are inconclusive, though mean concentrations appear low.

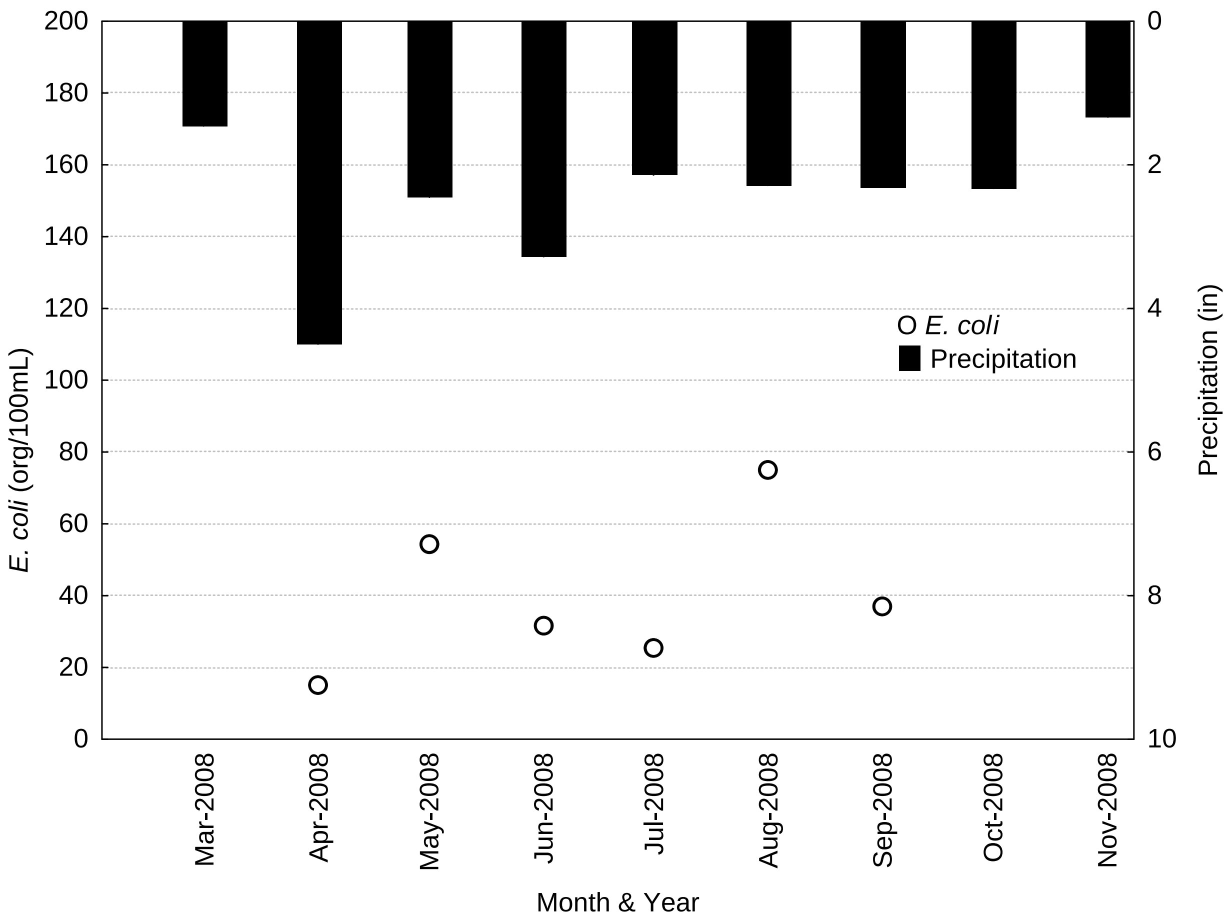

Figure 43. *E. coli* geometric means and total precipitation at RM 857.5.

Mississippi RM 855.0

There are fecal coliform data available but no *E. coli* data available for this site. No jumps in fecal coliform concentrations were experienced between this RM and adjacent upstream RMs. Table B - 1 and Table B - 2 in Appendix B identify the only fecal coliform data available for this site. Ten samples were taken in total from July through September in the year 2002. In both July and August, the geometric mean exceeds that of the former fecal coliform standard of 200 org/100mL.

Mississippi RM 854.9

Figure 44 and Figure 45 illustrate geometric mean *E. coli* concentrations by month and year at RM 854.9 as compared to flow and precipitation during the periods from 2003 through 2005 and 2006 through 2008, respectively. *E. coli* concentrations are generally higher in the fall than in the spring especially for the period after 2004. Flow data are sparse and inconclusive.

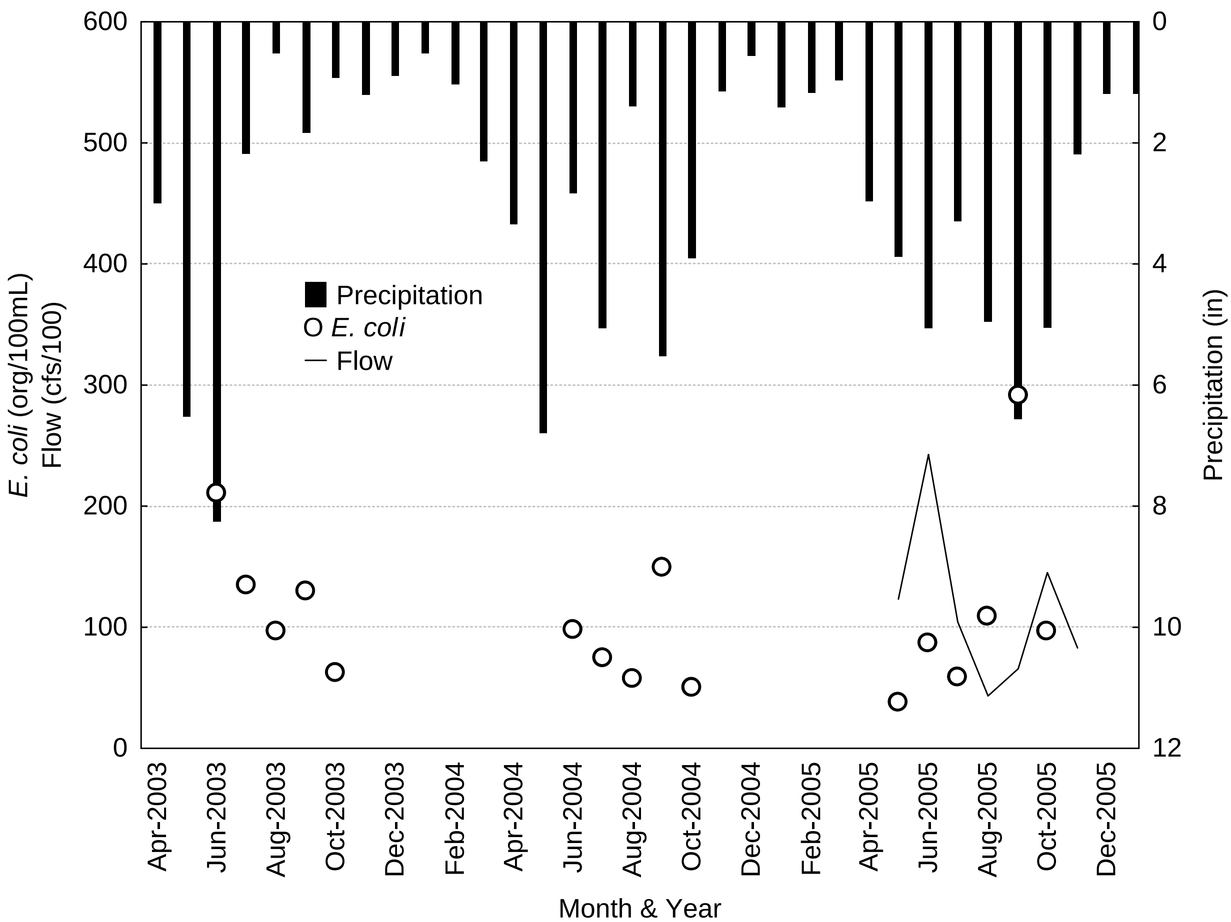

Figure 44. *E. coli* geometric means, mean flow and total precipitation at RM 854.9 from 2003-2005.

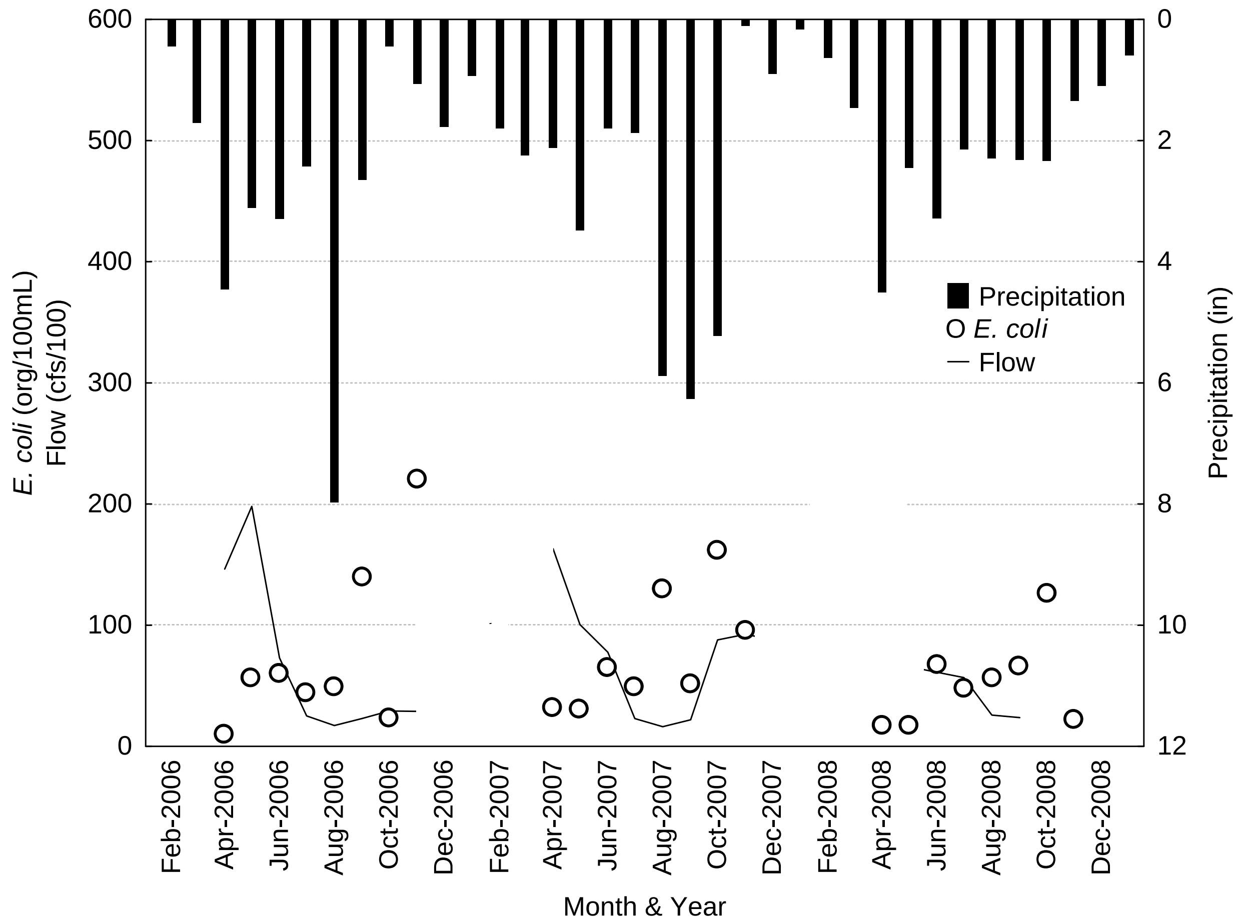

Figure 45. *E. coli* geometric means, mean flow and total precipitation at RM 854.9 from 2006-2008.

Figure 46 illustrates the LDC analysis where monitored *E. coli* loading was compared to hypothetical loading at the standard concentration (126 org/100mL). A total of 24% (35/146) of monitored data exceeds the standard loading. Exceedances are experienced mostly in late summer and fall (28 in August through October) with five exceedances in May and June. Fall exceedances never occurred during high flows.

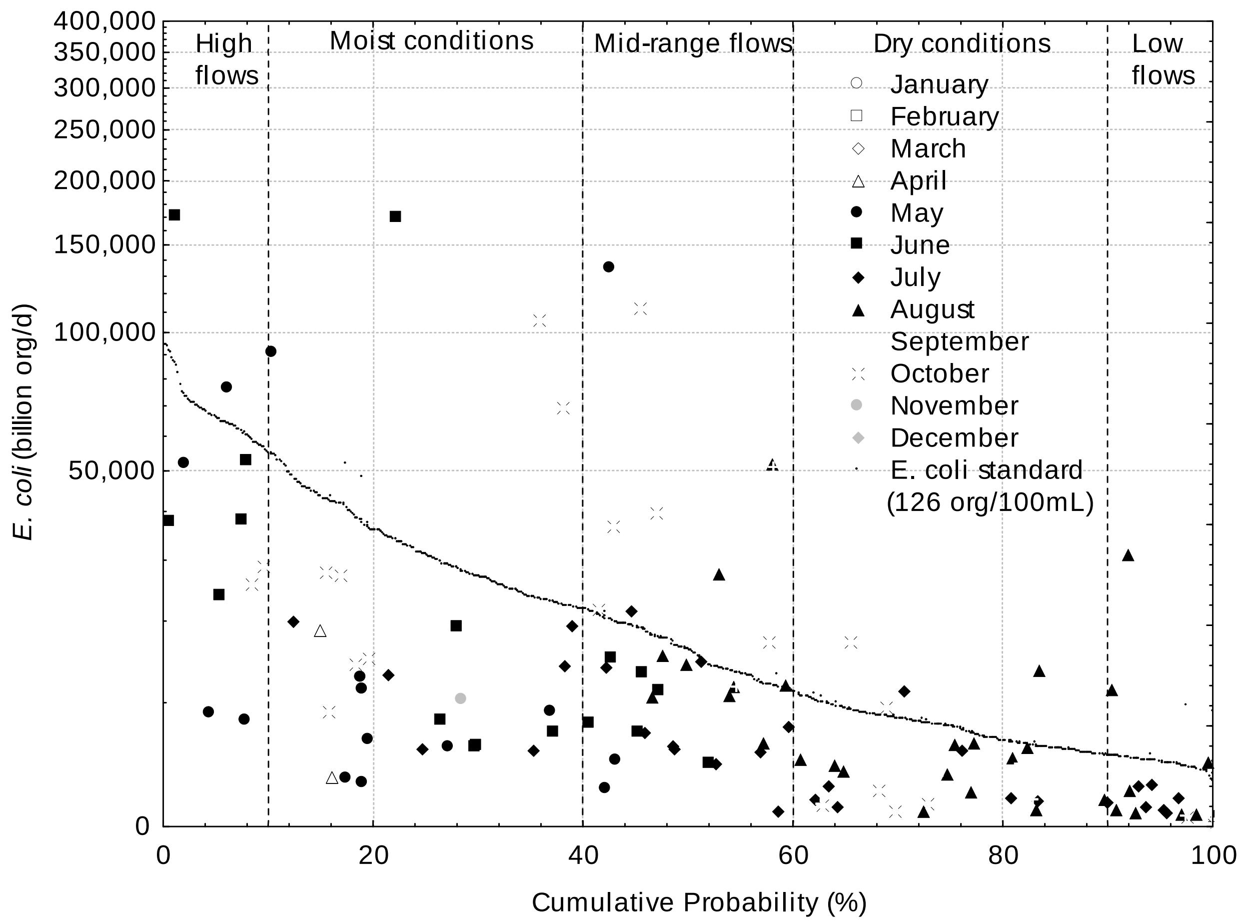

Figure 46. Load duration curve for *E. coli* at RM 854.9.

AUID 07010206-503 (Impaired)

The following Mississippi RMs are within AUID 07010206-503 (Figure 47) which is known to be impaired:

- 853.1
- 852.2
- 849.9
- 848.1
- 847.7

These RMs will be discussed from page 84 to page 95. Bacteria data and related statistics for these RMs (by month and year and by month across all years) can be found in Appendix A (*E. coli*) and Appendix B (fecal coliform).

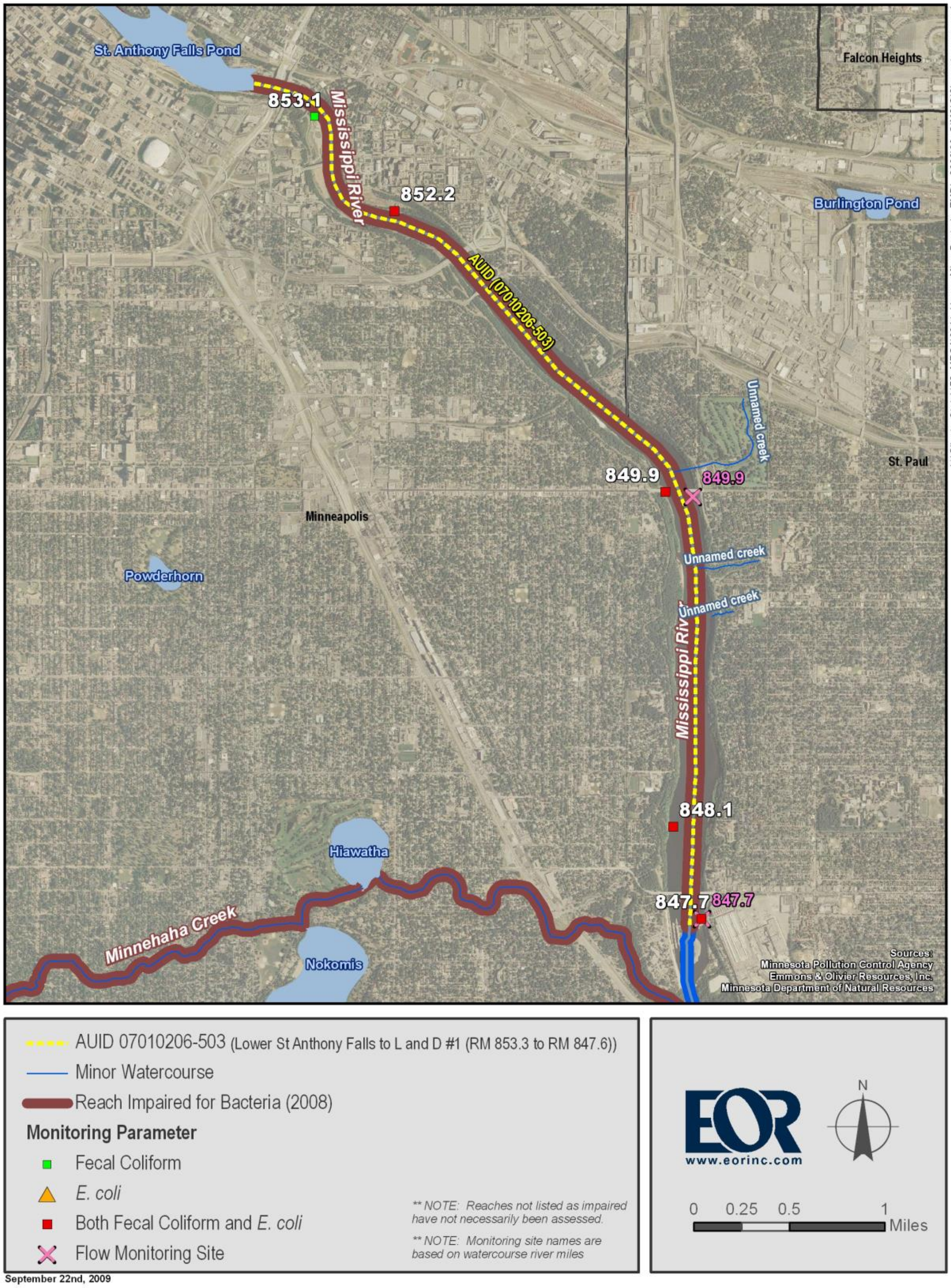

Figure 47. Mississippi River AUID 07010206-503 and mainstem bacteria and flow monitoring sites.

Mississippi RM 853.1

There are fecal coliform data available but no *E. coli* data available for this site. Bassett Creek enters the Mississippi River at RM 854.8. No jumps in fecal coliform data were experienced between RM 854.9 and 853.1, but only 10 samples were taken within July, August and September of 2002 during the entire 10-year study period at RM 853.1. Data indicate that in all three months the former fecal coliform standard of 200 org/100mL is exceeded. Fecal coliform data are available in Table B - 1 and Table B - 2 in Appendix B.

Mississippi RM 852.2

E. coli data are available for RM 852.2 from 2003 through 2008 as compared to none at RM 853.1. No jumps in *E. coli* concentrations are experienced between RM 852.2 and the adjacent upstream *E. coli* monitoring location at RM 854.9 despite the entrance of Bassett Creek into the Mississippi River at RM 854.8.

Figure 48 and Figure 49 illustrate geometric mean *E. coli* concentrations by month and year as compared to flow and precipitation during the periods from 2003 through 2005 and 2006 through 2008, respectively. Wet fall weather appears to correspond with high fall *E. coli* concentrations. Flow data are sparse and inconclusive.

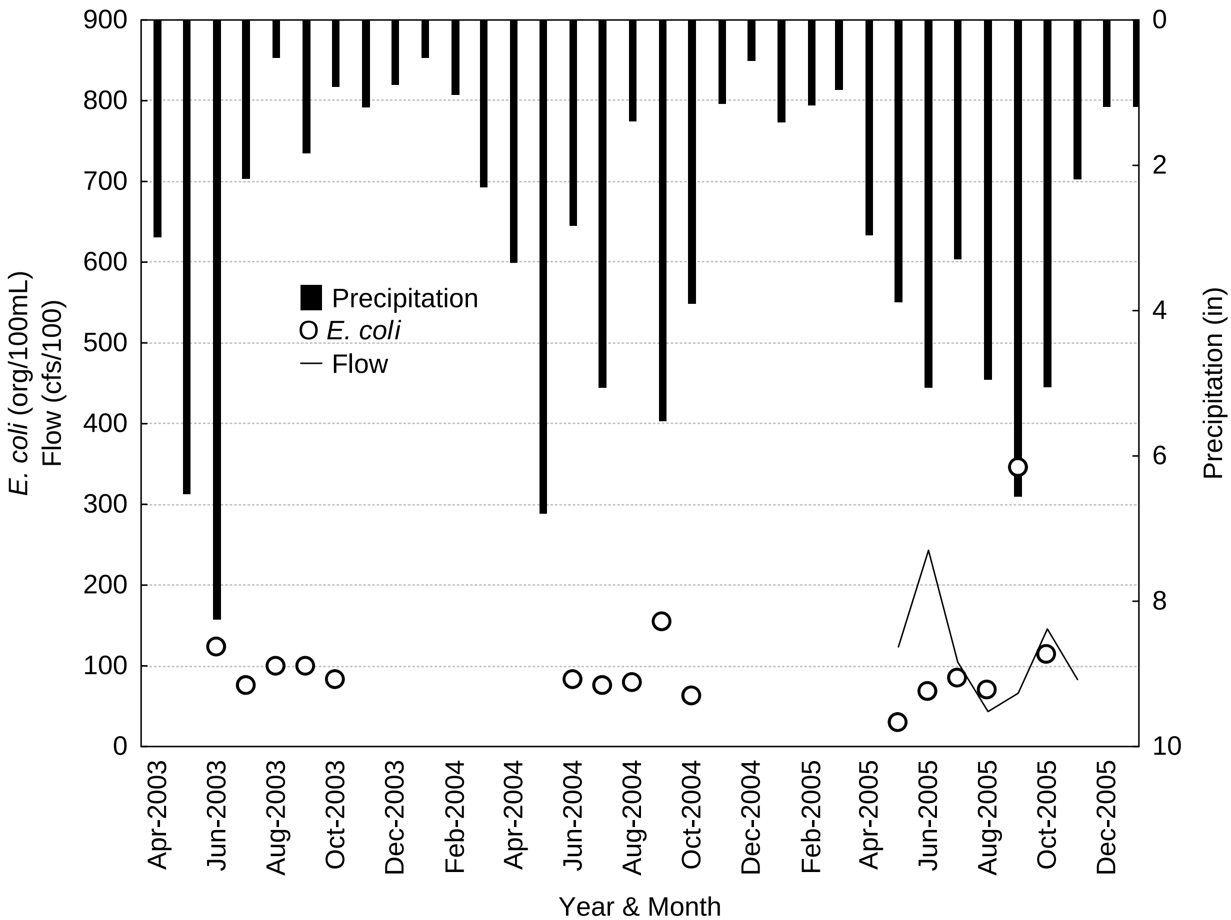

Figure 48. *E. coli* geometric means, mean flow and total precipitation at RM 852.2 from 2003-2005.

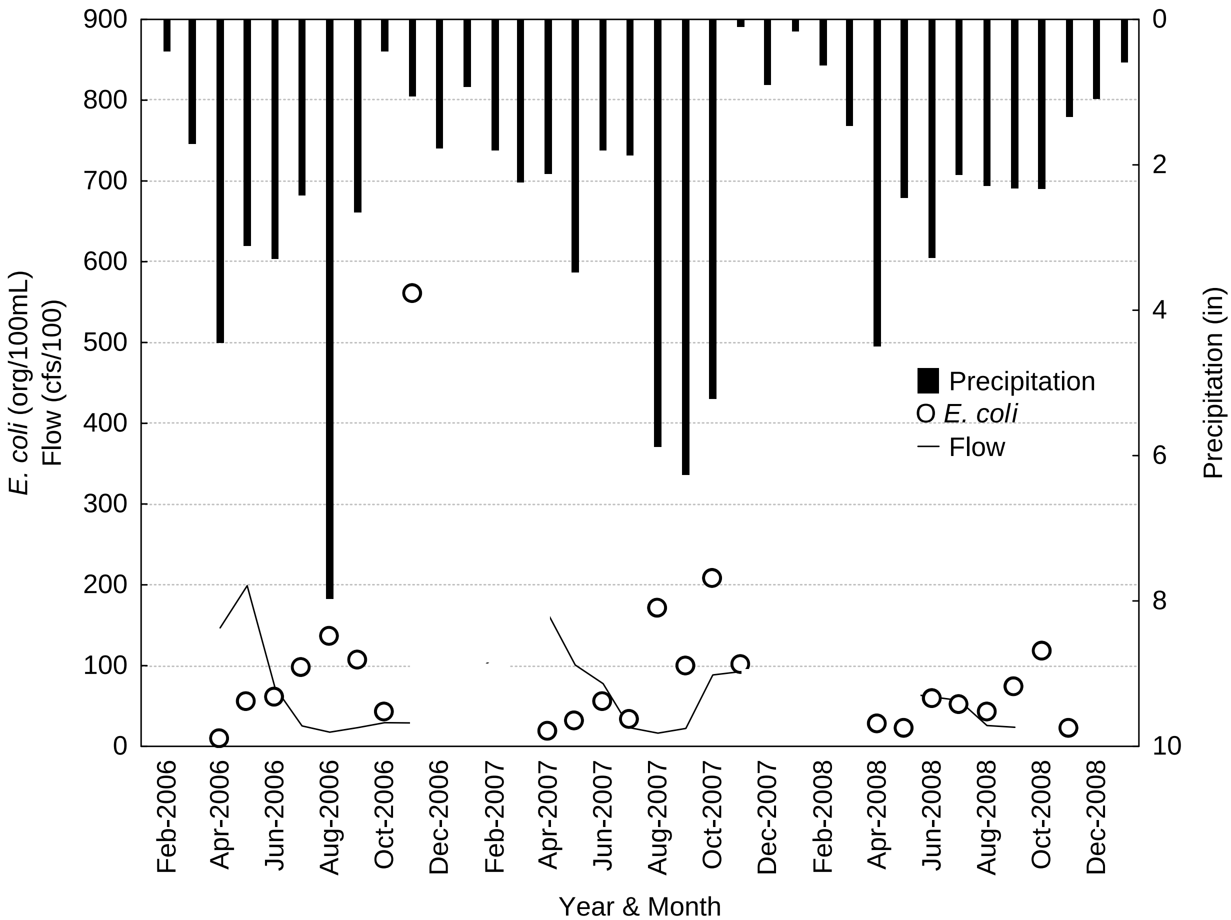

Figure 49. *E. coli* geometric means, mean flow and total precipitation at RM 852.2 from 2006-2008.

Figure 50 illustrates the LDC analysis where monitored *E. coli* loading was compared to hypothetical loading at the standard concentration (126 org/100mL). A total of 27% (39/144) of monitored data exceeds the standard loading. Exceedances are experienced mostly in late summer and fall (34 in July through October, 11 in September) with five occurrences in the spring, similar to that of adjacent upstream site at RM 854.9. Exceedances appear to occur at all flow conditions.

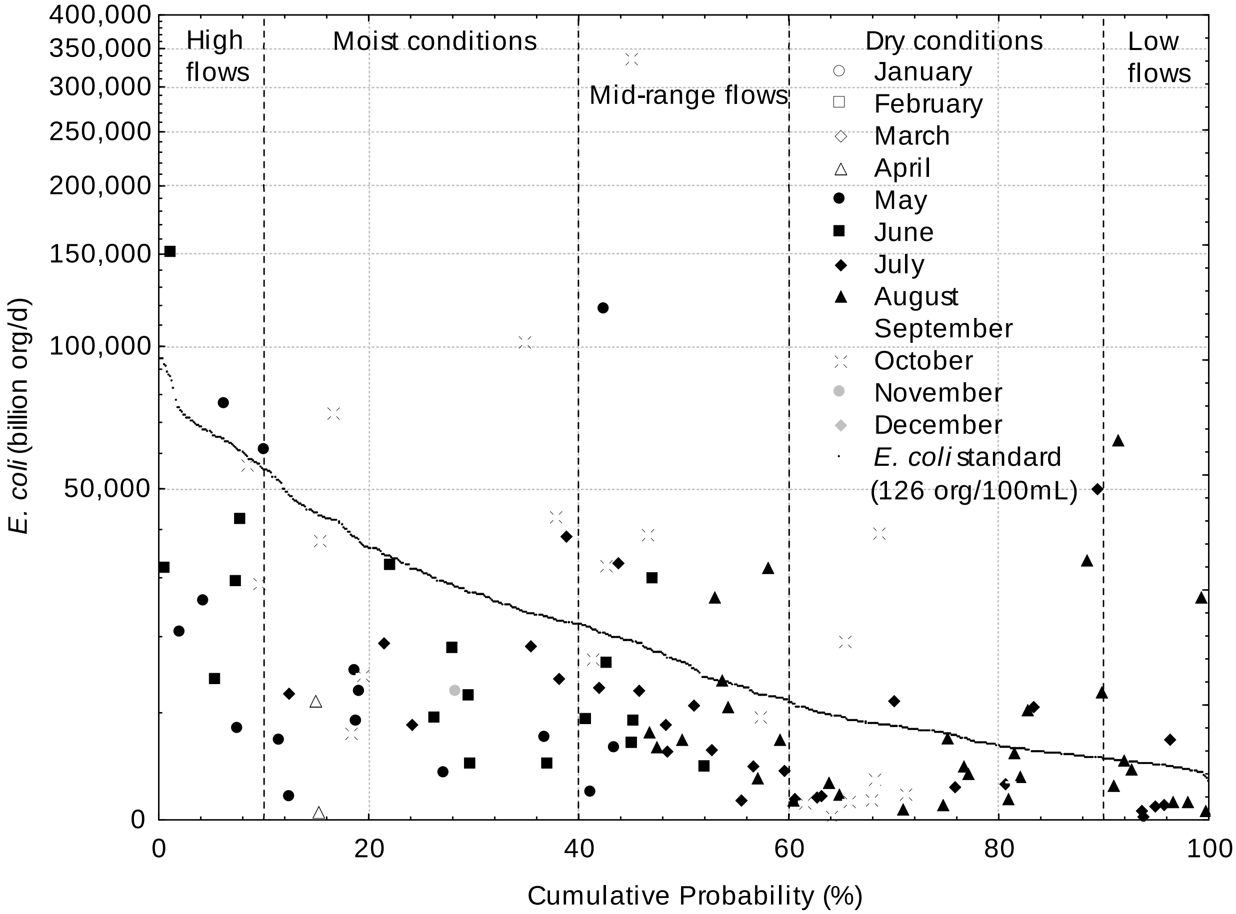

Figure 50. Load duration curve for *E. coli* at RM 852.2.

Mississippi RM 849.9

Figure 51 and Figure 52 illustrate geometric mean *E. coli* concentrations by month and year as compared to flow and precipitation. High *E. coli* concentrations occur at the full range of precipitation amounts. Flow data are not available in the winter but appear to pattern local precipitation trends with the exception of August 2006 when local precipitation was relatively high and Mississippi River flow was low. In this case, August 2006 *E. coli* concentration did experience an increase from the month prior.

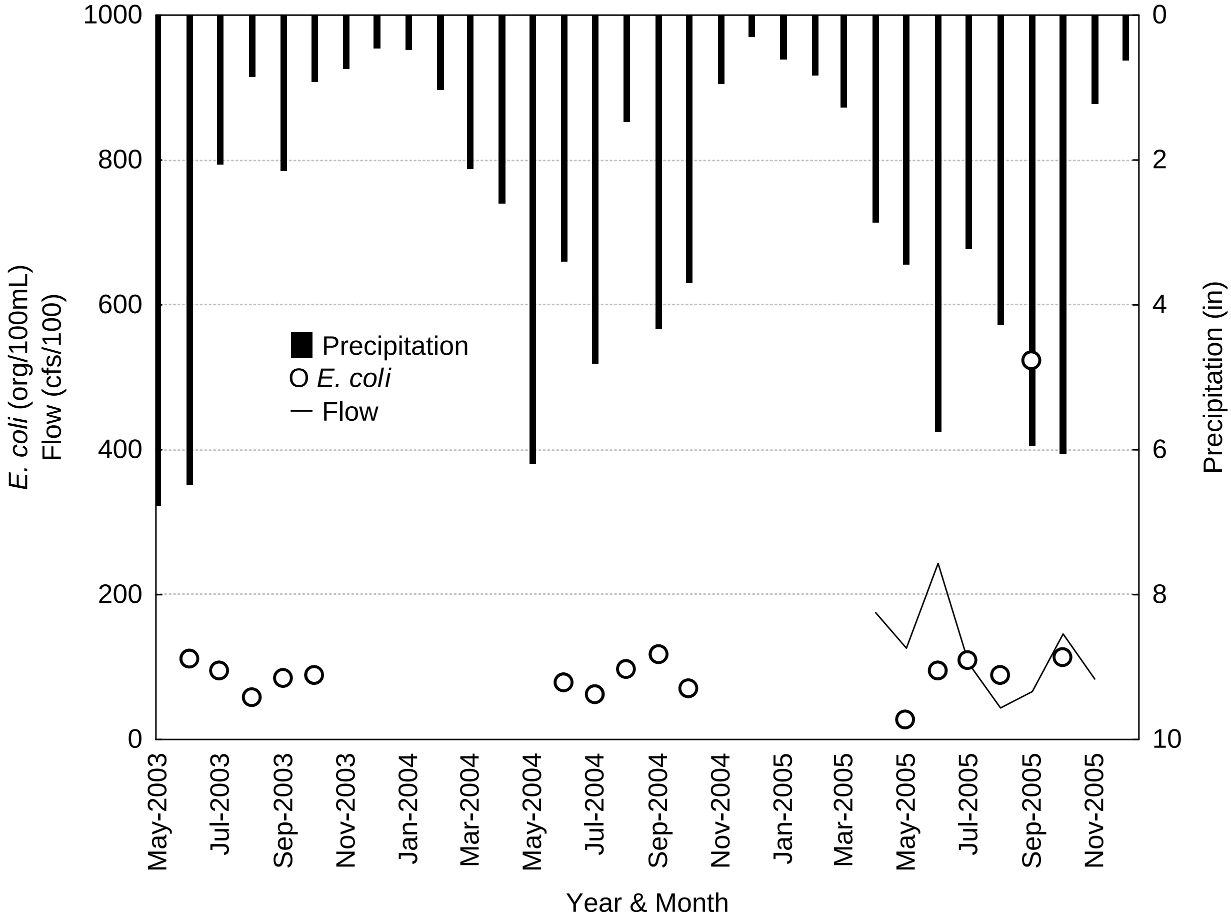

Figure 51. *E. coli* geometric means, mean flow and total precipitation at RM 849.9 from 2003-2005.

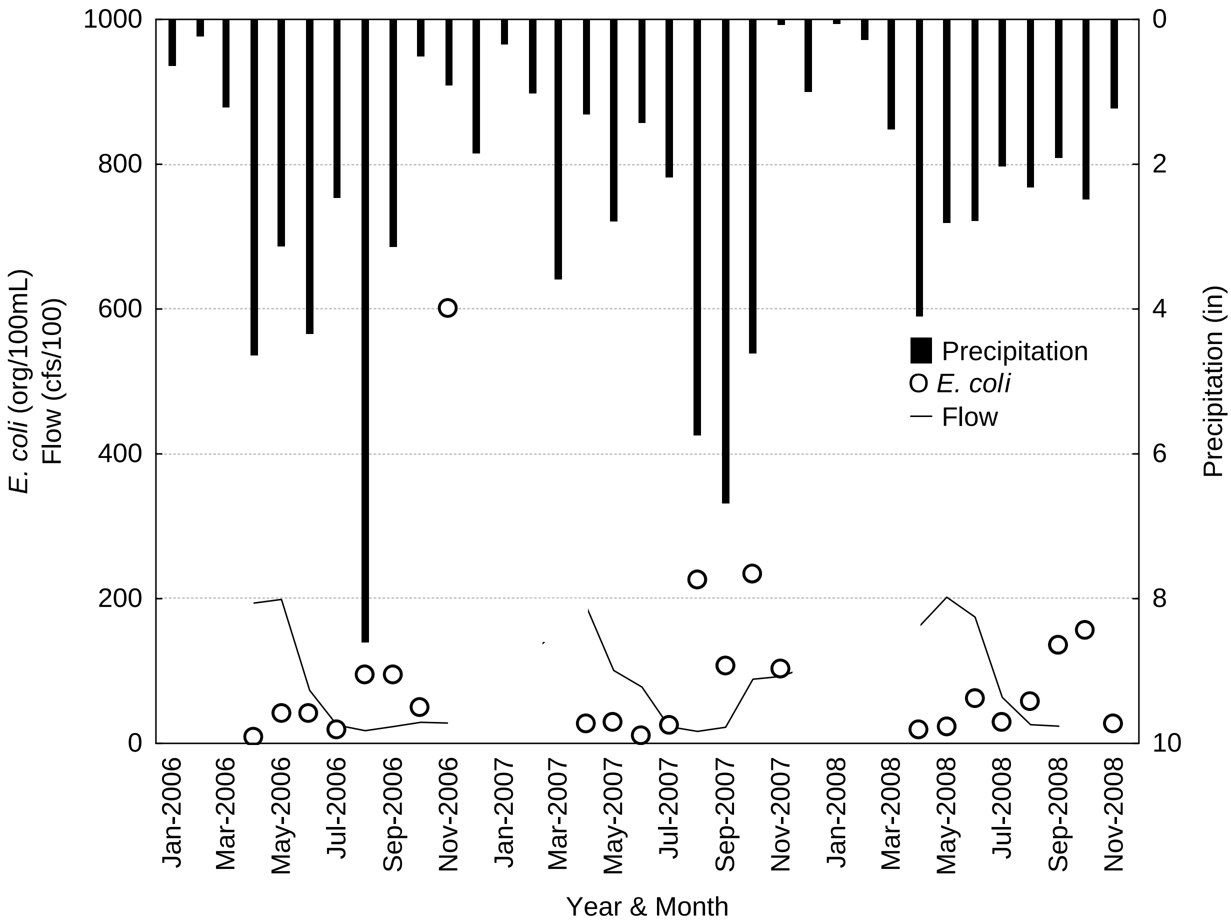

Figure 52. *E. coli* geometric means, mean flow and total precipitation at RM 849.9 from 2006- 2008.

Figure 53 illustrates the LDC analysis where monitored *E. coli* loading was compared to hypothetical loading at the standard concentration (126 org/100mL). A total of 41/174 (24%) of monitored data exceeds the standard loading. Similar to adjacent RM 852.2, the majority of exceedances are experienced in late summer and fall (36 in July through October, 23 in August and September alone) with five exceedances in spring. Fall exceedances occur mostly during mid-range flows, dry conditions, and low flows.

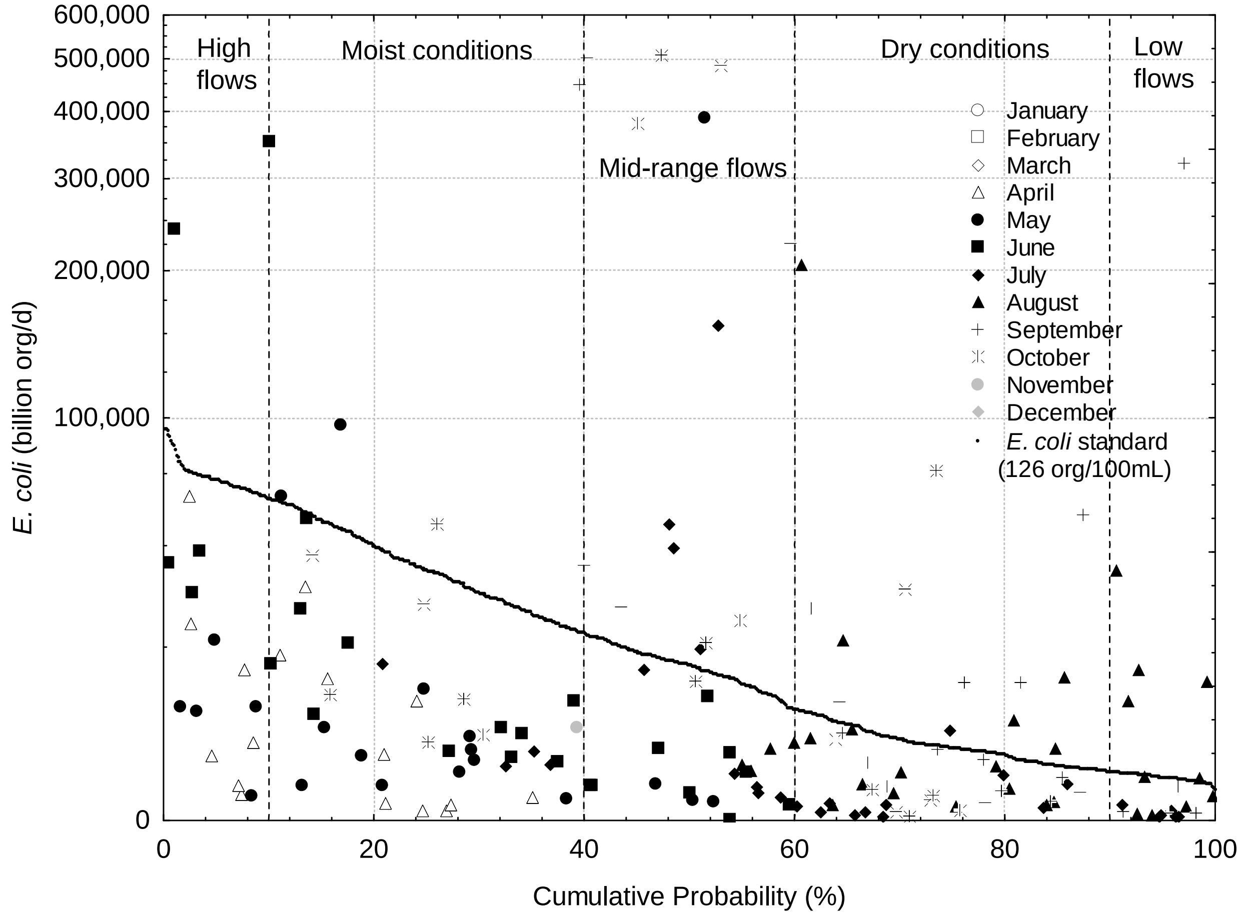

Figure 53. Load duration curve for *E. coli* at RM 849.9.

Mississippi RM 848.1

Figure 54 and Figure 55 illustrate geometric mean *E. coli* concentrations by month and year as compared to flow and precipitation during the periods from 2003 through 2005 and 2006 through 2008, respectively. *E. coli* concentrations do not appear to correspond to precipitation patterns but stay relatively low with the exception of one major spike in September 2005. Flow data are not available in the winter but appear to pattern local precipitation trends with the exception of August 2006 and August 2007 when local precipitation was relatively high and Mississippi River flow was low. *E. coli* concentrations did increase with these two events.

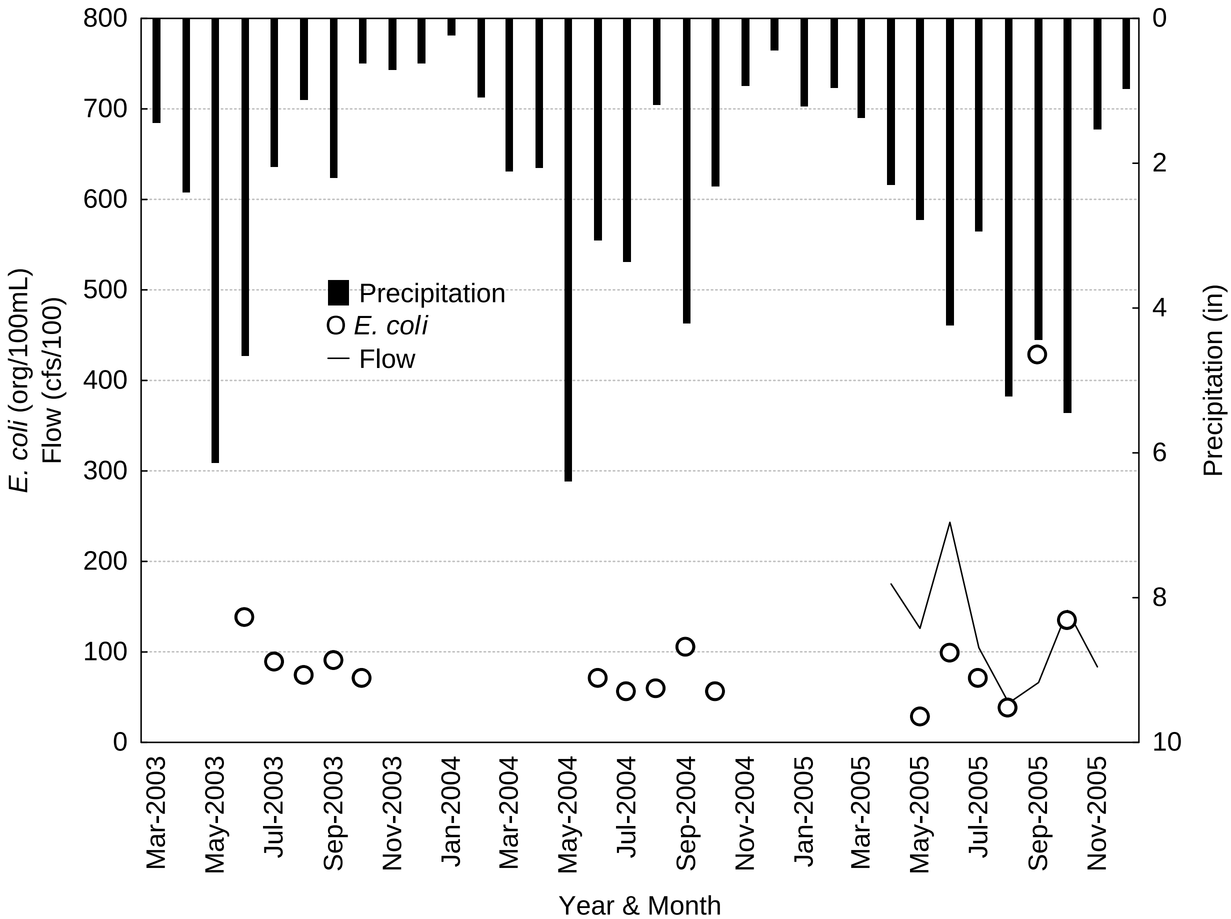

Figure 54. *E. coli* geometric means, mean flow and total precipitation at RM 848.1 from 2003-2005.

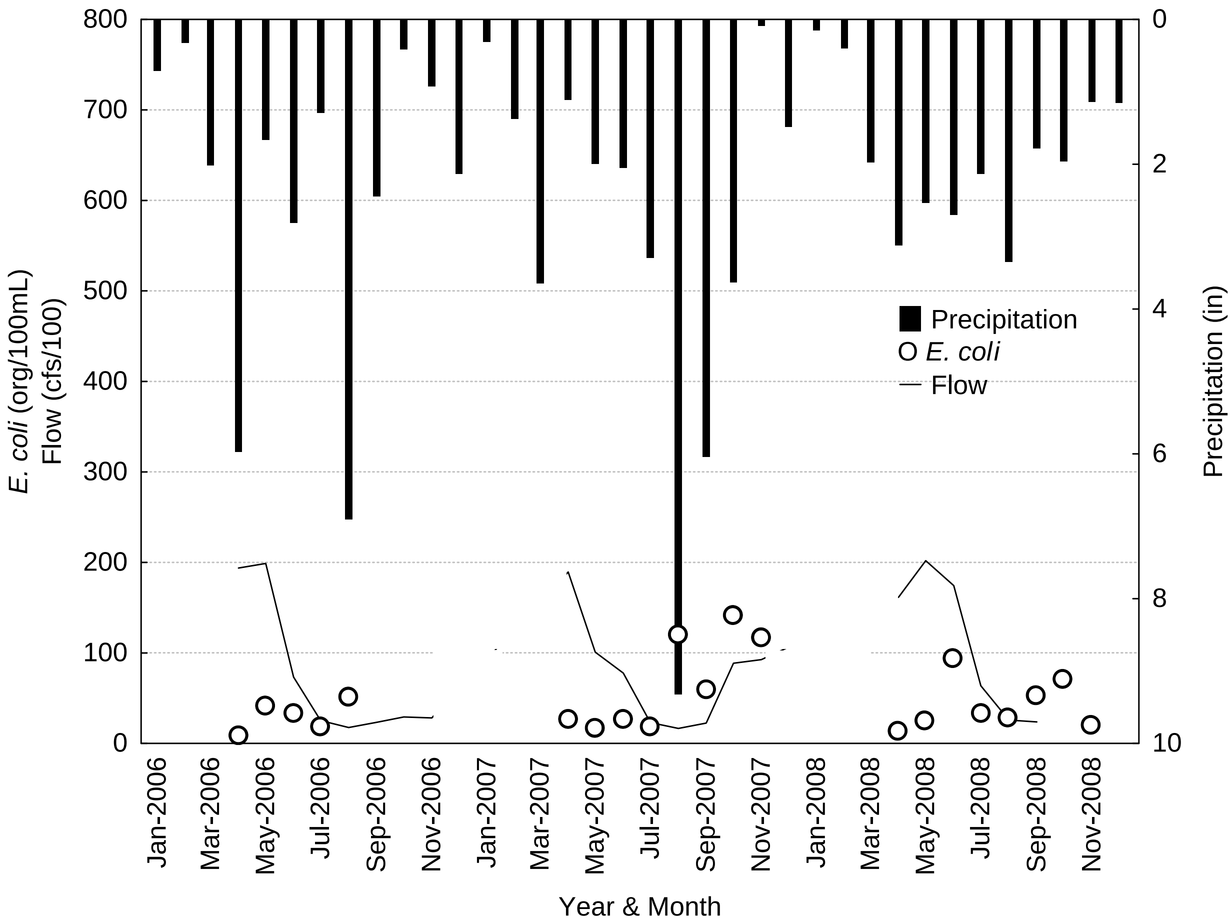

Figure 55. *E. coli* geometric means, mean flow and total precipitation at RM 848.1 from 2006-2008.

Figure 56 illustrates the LDC analysis where monitored *E. coli* loading was compared to hypothetical loading at the standard concentration (126 org/100mL). A total of 17% (27/157) of monitored data exceeds the standard loading. Similar to nearby RM 852.2 and 849.9, the majority of exceedances are experienced in late summer and fall (22 in July through October, 8 in September alone). Fall exceedances occurred during mid-range flows, dry conditions, and low flows. Data highlight a June 2008 occurrence of extremely high *E. coli* during high flows; this is somewhat evident in Figure 55 where the June 2008 geometric mean is higher than any other geometric mean of the same year. A total of 6 exceedances occurred in the spring.

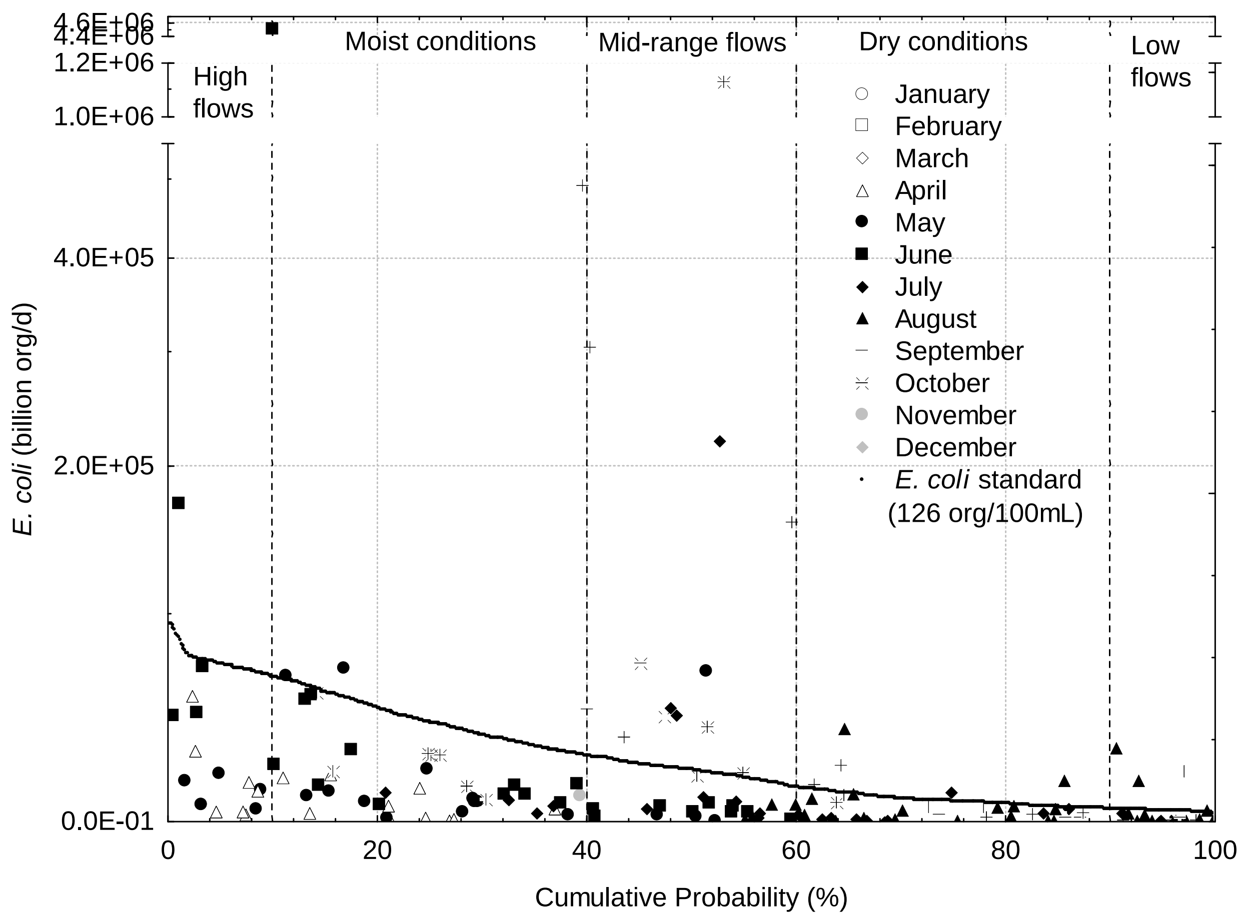

Figure 56. Load duration curve for *E. coli* at RM 848.1.
Note scale breaks in y-axis.

Mississippi RM 847.7

Figure 57 illustrates geometric mean *E. coli* concentrations by month and year as compared to flow and precipitation. Flow data do not always pattern precipitation and fall *E. coli* concentrations exceed those of the spring. January 2008 exhibits a high *E. coli* concentration.

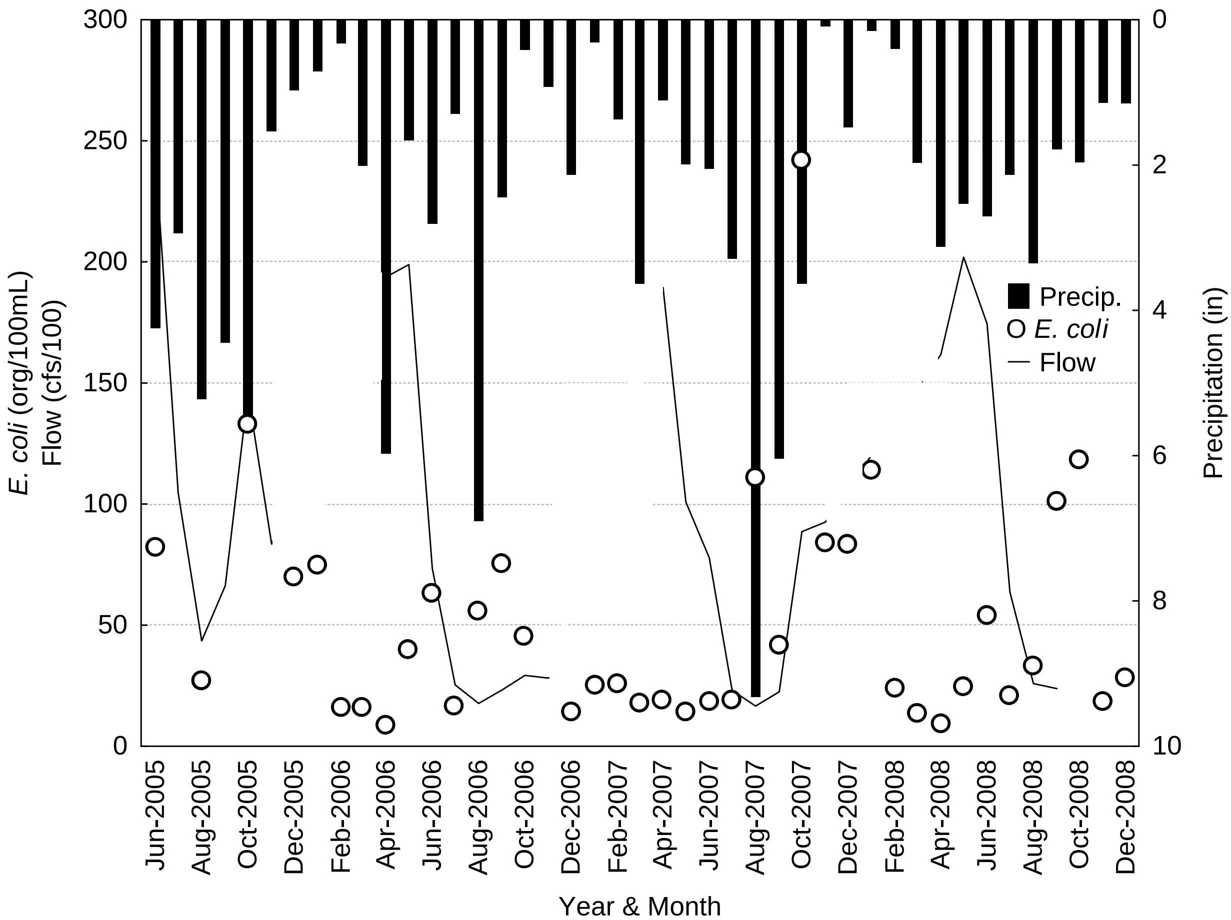

Figure 57. *E. coli* geometric means, mean flow and total precipitation at RM 847.7.

Figure 58 illustrates the LDC analysis where monitored *E. coli* loading was compared to hypothetical loading at the standard concentration (126 org/100mL). A total of 21% (20/95) of monitored data exceeds the standard loading. Similar to nearby upstream RM 848.1, 849.9, and 852.2, the majority of exceedances (18) occur from July through October. The balance (2) occur in June. No winter exceedances occur.

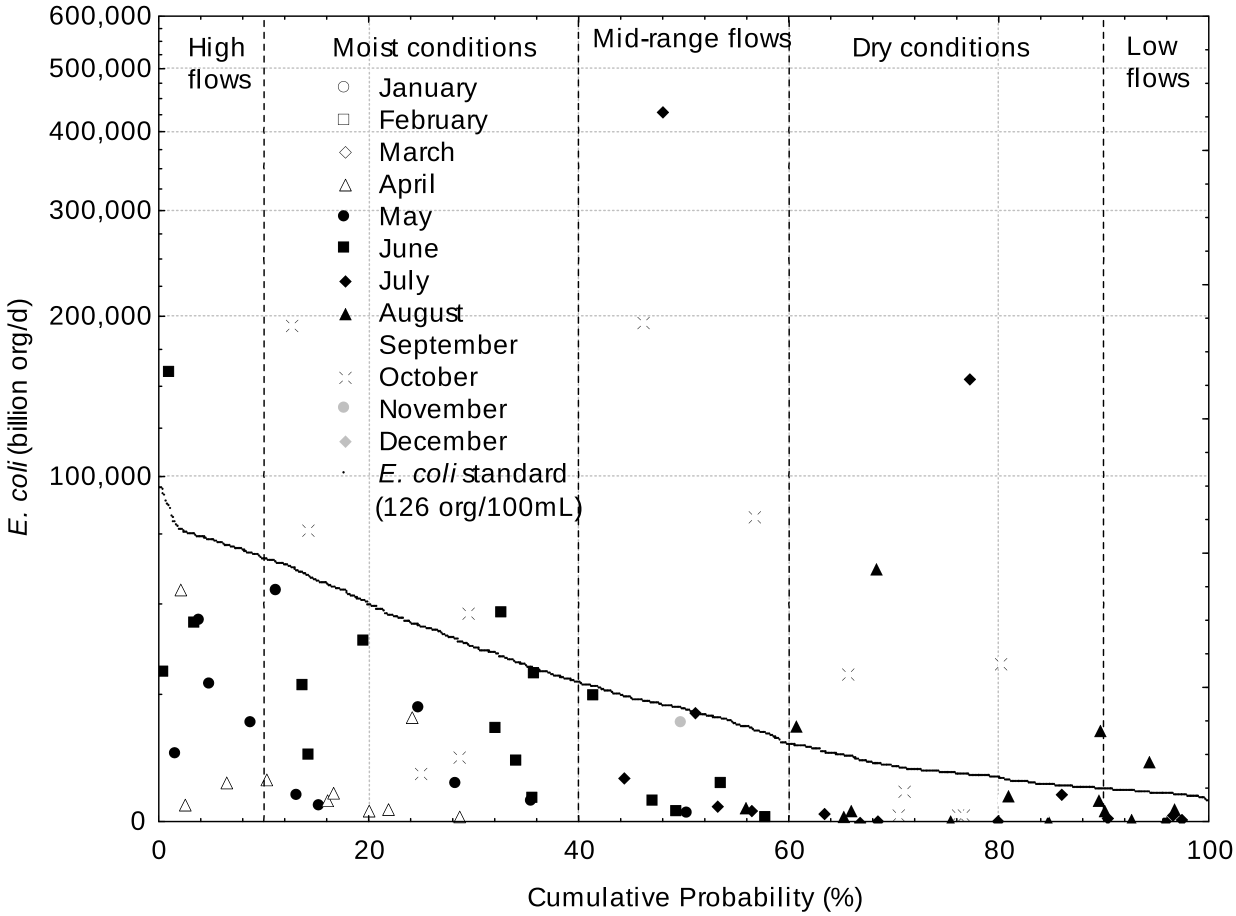

Figure 58. Load duration curve for *E. coli* at RM 847.7.

AUID 07010206-505 (Impaired)

The following Mississippi RMs are within AUID 07010206-505 (Figure 59) which is known to be impaired:

- 839.7
- 839.1
- 836.8

These RMs will be discussed from page 98 to page 103. Bacteria data and related statistics for these RMs (by month and year and by month across all years) can be found in Appendix A (*E. coli*) and Appendix B (fecal coliform).

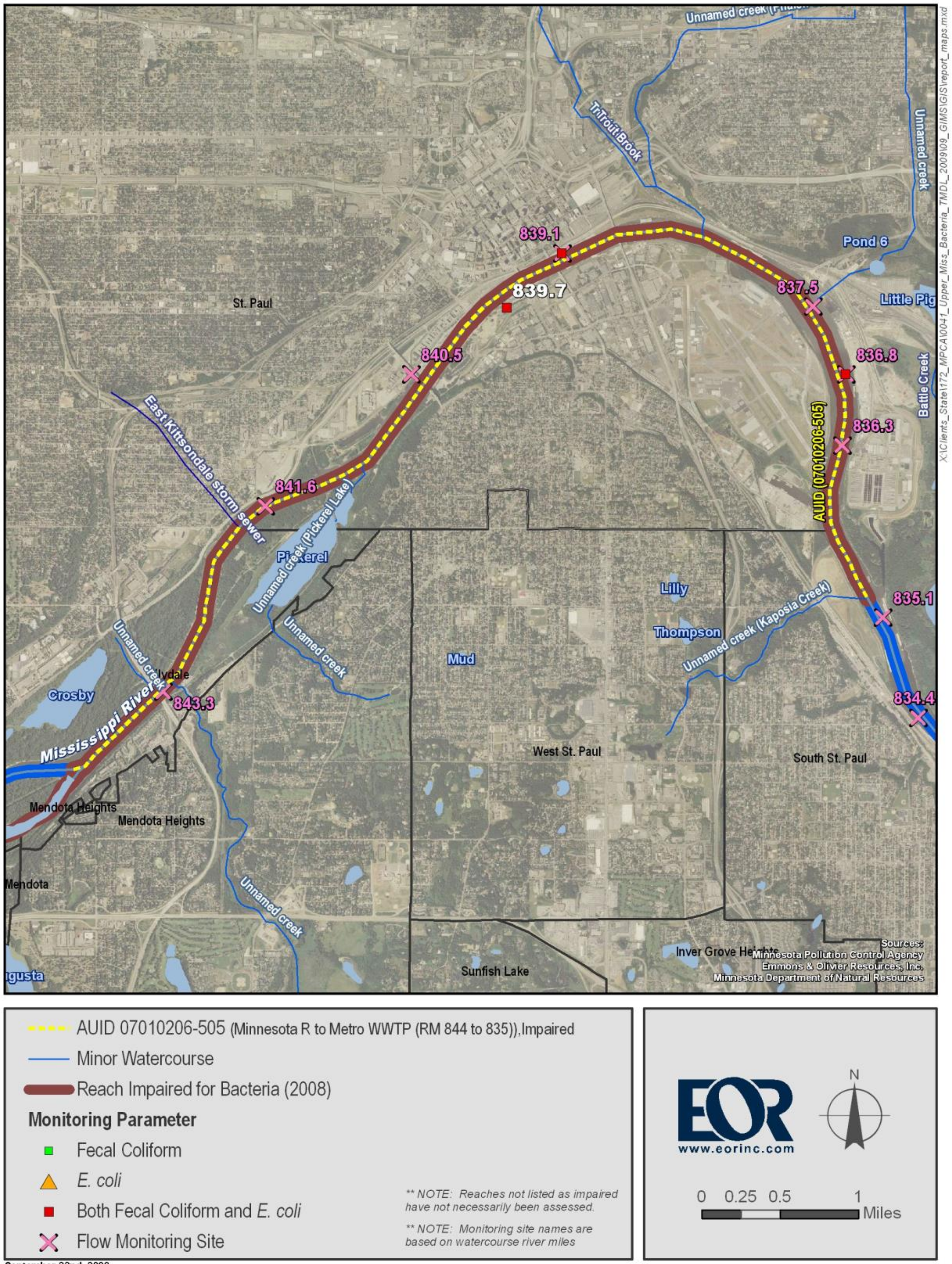

Figure 59. Mississippi River AUID 07010206-505 and mainstem bacteria and flow monitoring sites.

Mississippi RM 839.7

Figure 60 and Figure 61 illustrate geometric mean *E. coli* concentrations by month and year as compared to flow and precipitation. Precipitation data are not continuous and *E. coli* data are sparse. Flow data appear to pattern local precipitation. *Section 3.F. Surrogates Analysis* identifies for this RM a positive correlation between *E. coli* and TSS (R-squared value of 0.3006, p-value of 0.0524).

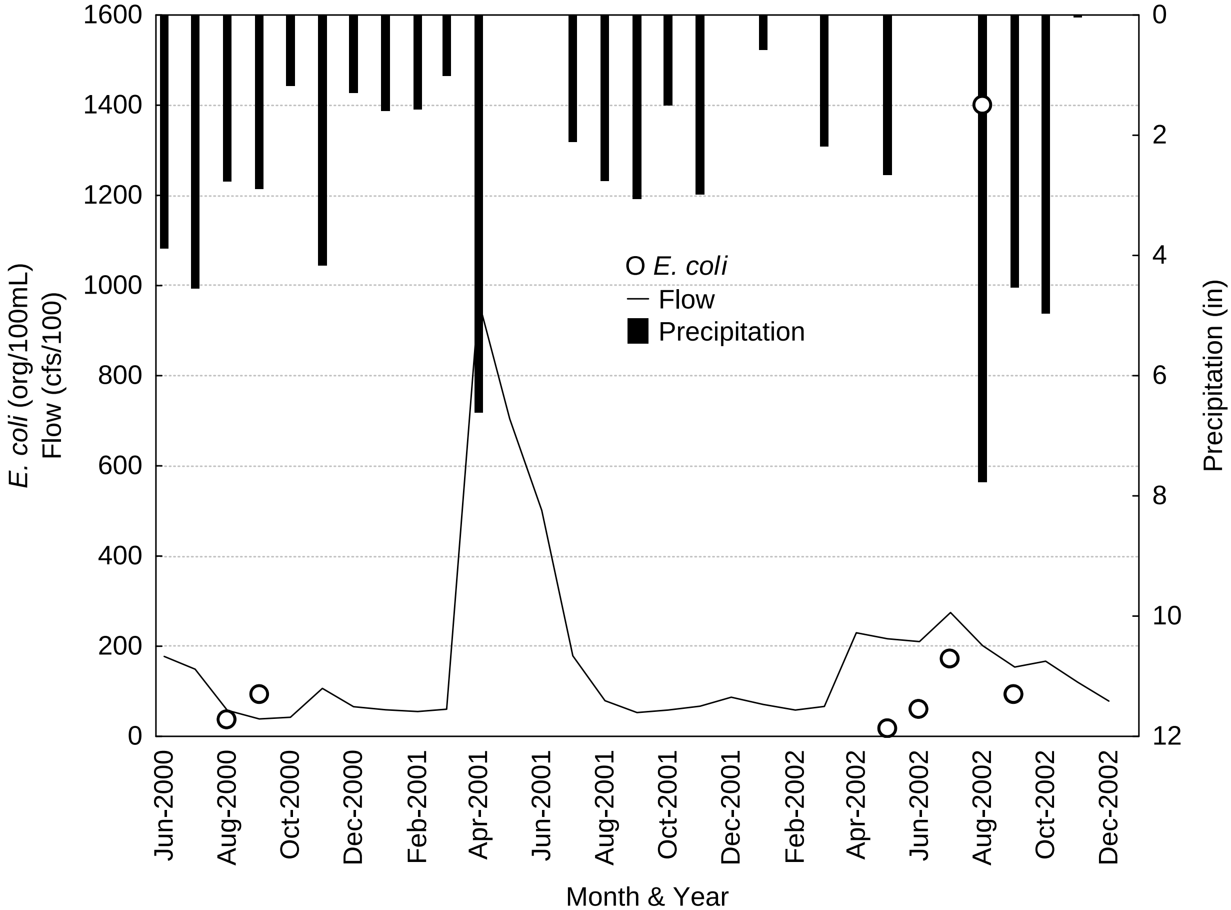

Figure 60. *E. coli* geometric means, mean flow and total precipitation at RM 839.7 from 2000-2002. Precipitation data unavailable from the following months: 2001 - May, June & December; 2002 - February, April, June, July & December.

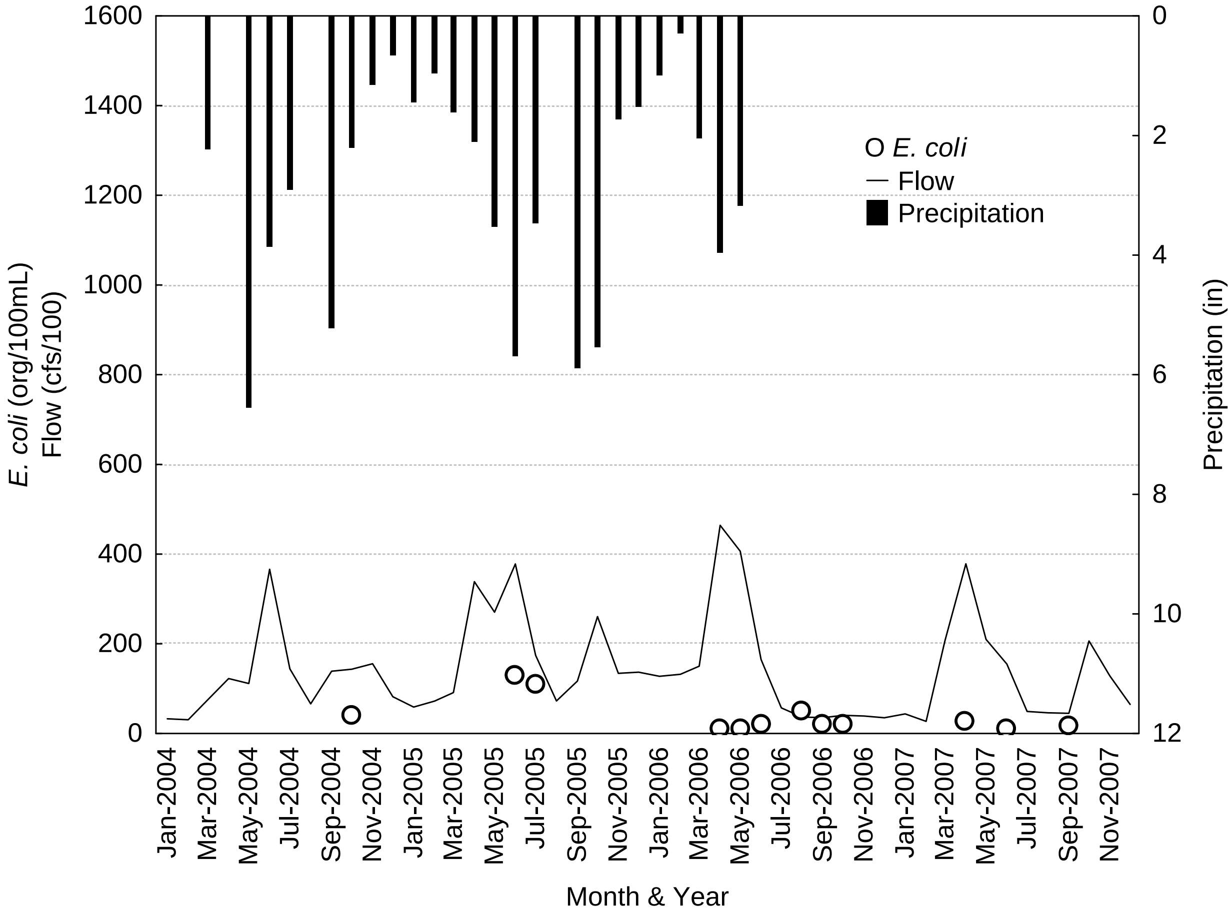

Figure 61. *E. coli* geometric means, mean flow and total precipitation at RM 839.7 from 2004-2007. Precipitation data unavailable from the following months: 2004 – January, February, April & August; 2005 – August; 2006 – after May.

Figure 62 illustrates the LDC analysis where monitored *E. coli* loading was compared to hypothetical loading at the standard concentration (126 org/100mL). A total of 13% (3/24) of monitored data exceeds the standard loading. The three exceedances from the sparse data set occur in June, July and August at high flows and moist conditions.

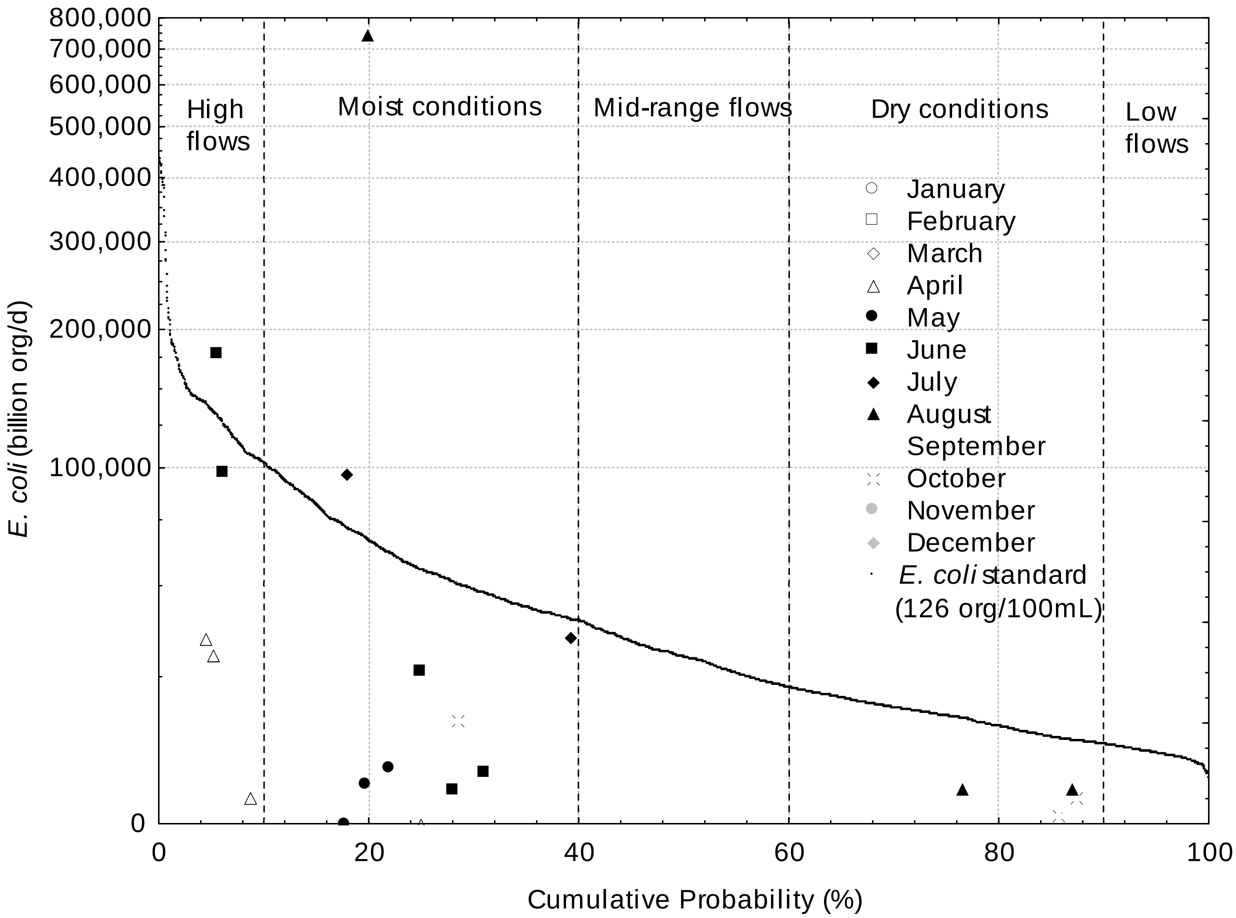

Figure 62. Load duration curve for *E. coli* at RM 839.7.

Mississippi RM 839.1

Mississippi RM 839.1 experiences two jumps in fecal coliform concentration from the adjacent upstream monitoring site at RM 847.7. Increases occur during the winter time, a rarity in this analysis but also exhibited at RM 858.5 and RM 831.0. Two main tributaries and one storm sewer outfall from a portion of the City of St. Paul enter the Mississippi River between RM 847.7 and RM 839.1: Minnehaha Creek (RM 847.1), the Minnesota River (RM 843.9) and East Kittsondale stormsewer outfall (RM 841.6).

Figure 63 illustrates geometric mean *E. coli* concentrations by month and year as compared to flow and precipitation for 2005 through 2006. The single year of *E. coli* data precludes year to year comparisons. Similar to adjacent upstream RM 839.7, flow data appear to pattern precipitation and fall *E. coli* concentrations exceed those of spring. And as with RM 839.7, winter also exhibits a slight increase in *E. coli* concentrations as compared to the three prior months. Figure 64 illustrates mean *E. coli* concentrations by month and year as compared to flow for 2007 through 2008; precipitation data was unavailable for that time period.

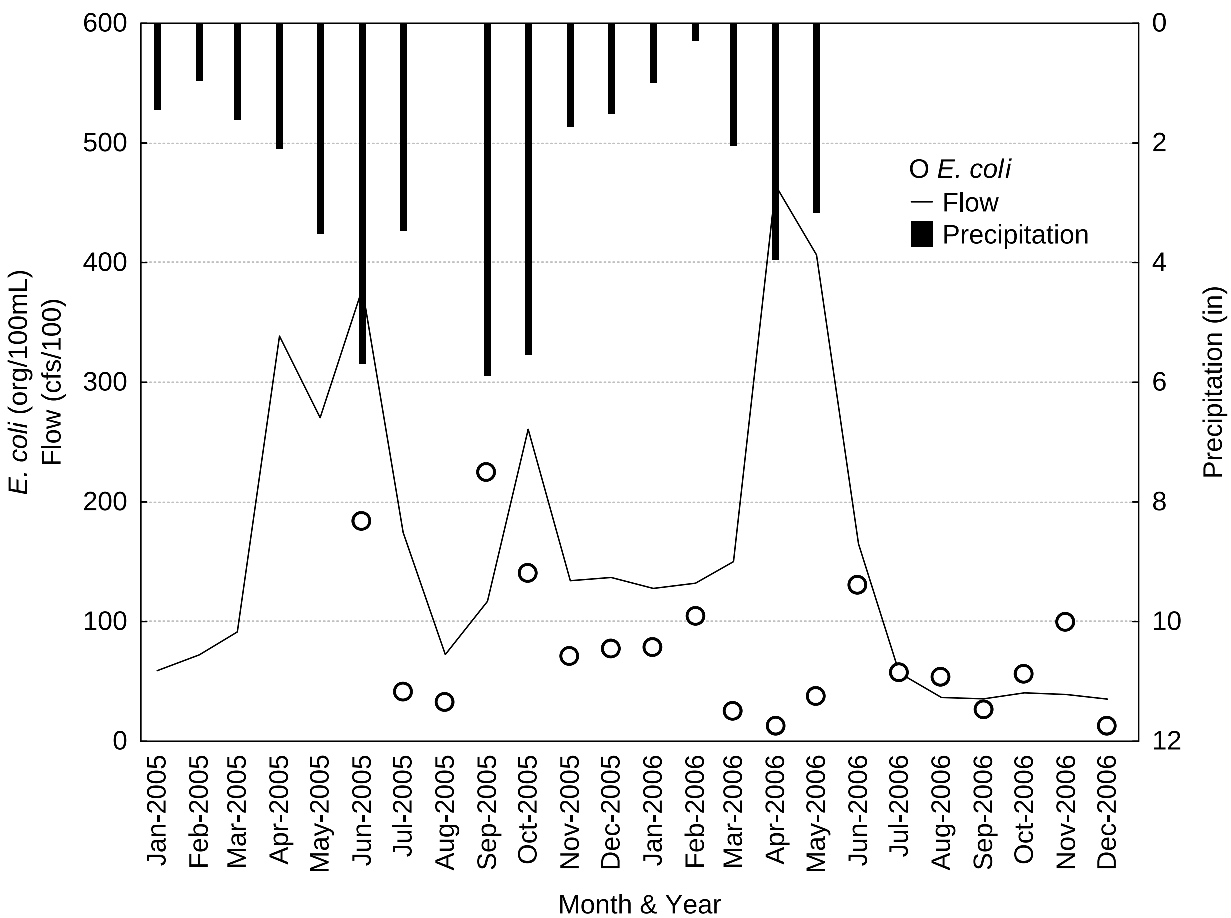

Figure 63. *E. coli* geometric means, mean flow and total precipitation at RM 839.1; precipitation data unavailable in August 2005 and after May 2006.

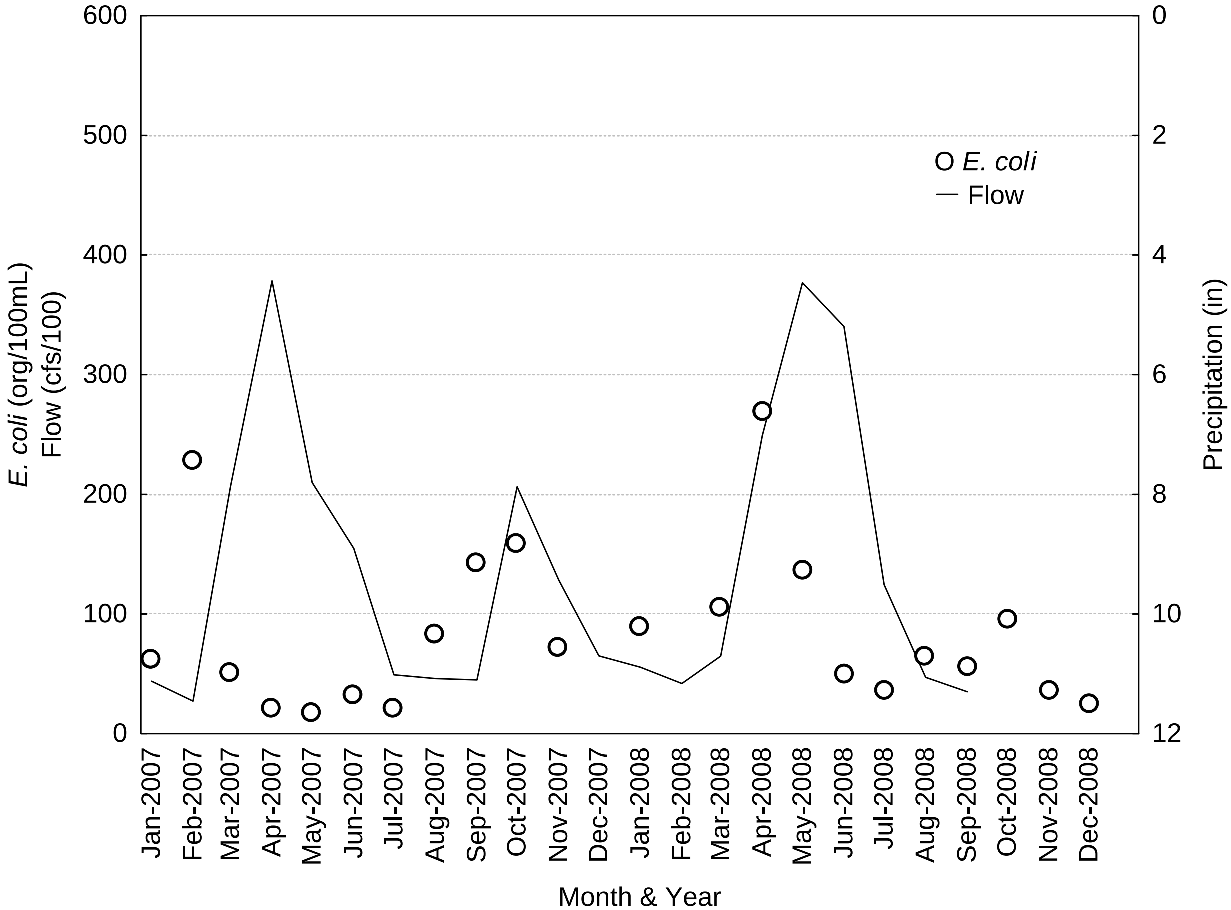

Figure 64. *E. coli* geometric means and mean flow at RM 839.1 from 2007-2008.

Figure 65 illustrates the LDC analysis where monitored *E. coli* loading was compared to hypothetical loading at the standard concentration (126 org/100mL). A total of 25% (31/125) of monitored data exceeds the standard loading. Exceedances are experienced from April through November and two in February. The top most exceedances in any single month occur in August (4), September (5) and October (8); April through June experience three exceedances each. The two February exceedances occur once at moist conditions and once at low flows.

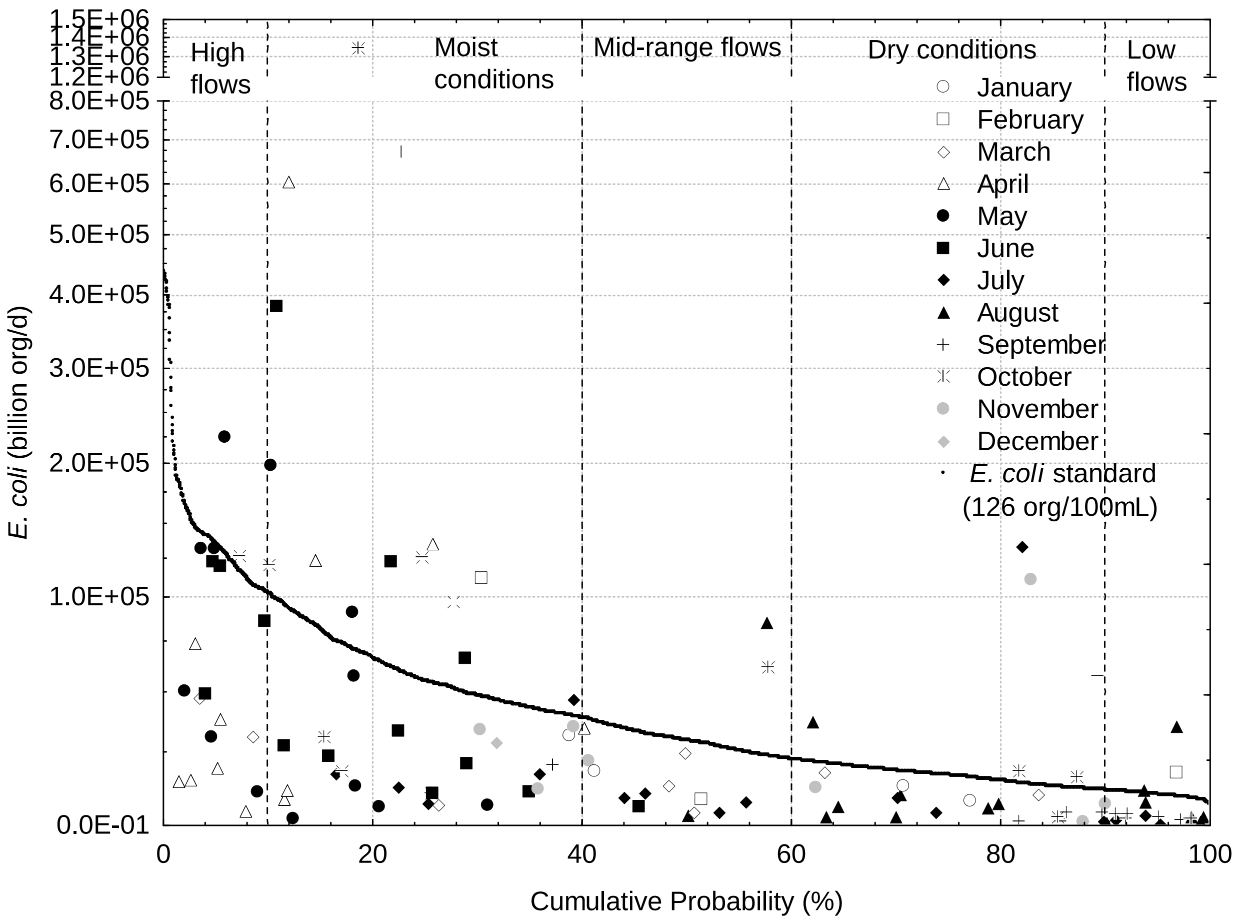

Figure 65. Load duration curve for *E. coli* at RM 839.1.
Note scale break in y-axis.

Mississippi RM 836.8

Flow and *E. coli* data at this site were not collected during the same time periods, which precluded an LDC analysis. Tables in Appendix A and B identify the bacteria concentrations at the site. *E. coli* data were only taken during the winter months of 2007 and 2008 with a total of 12 samples. Similarly, fecal coliform data (2000, 2003, 2007 and 2008) were almost exclusively taken during winter months and a total of 16 samples were taken. Data aggregated across all years indicate that the *E. coli* standard (126 org/100mL) and the former fecal coliform standard (200 org/100mL) were never exceeded.

AUID 07010206-504 (Not Listed as Impaired)

Figure 66 identifies AUID 07010206-504 and RM 831.0, the only RM within the AUID. Bacteria data and related statistics for M 831.0 (by month and year and by month across all years) can be found in Appendix A (*E. coli*) and Appendix B (fecal coliform).

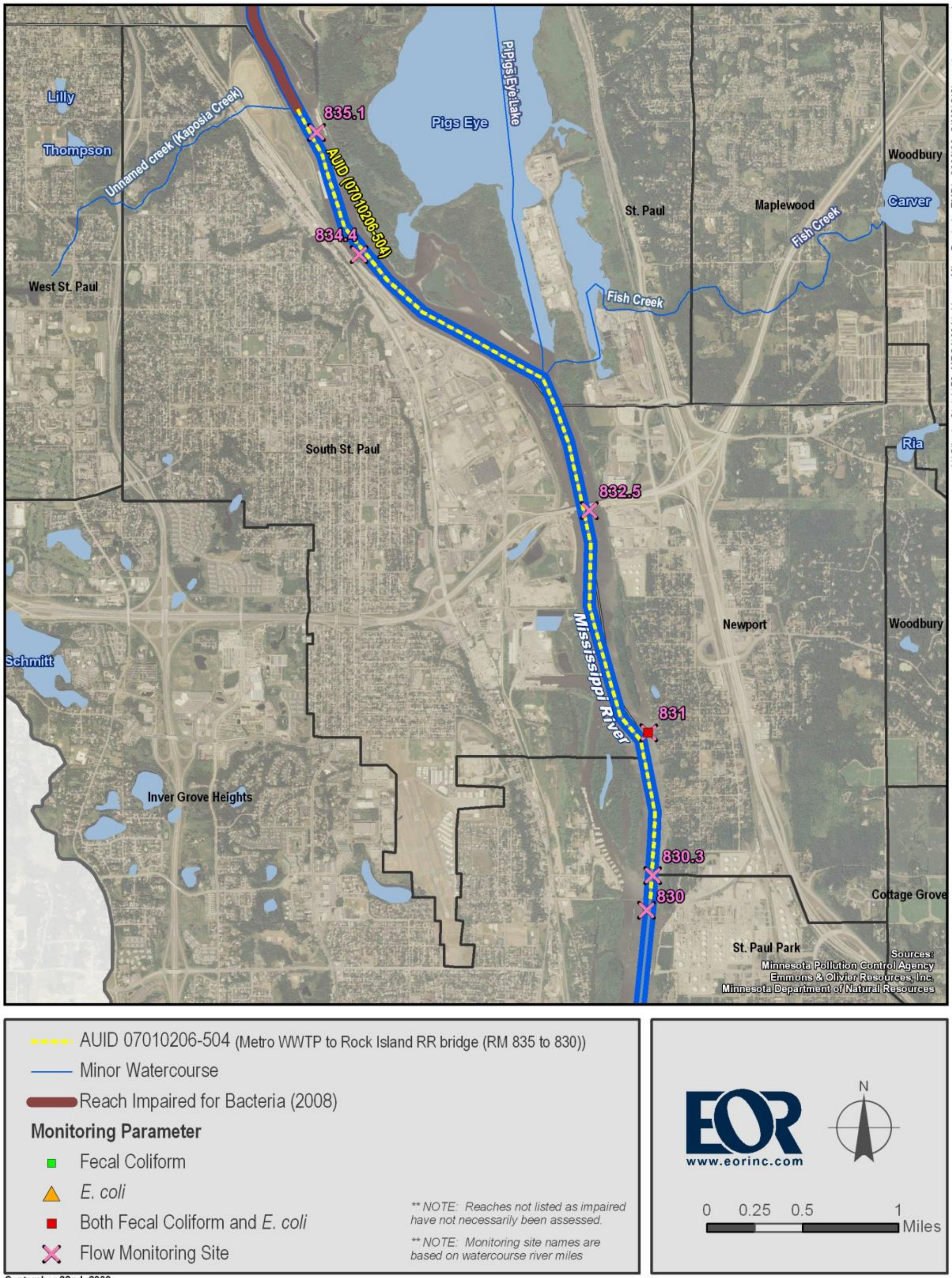

Figure 66. Mississippi River AUID 07010206-504 and mainstem bacteria and flow monitoring sites.

Mississippi RM 831.0

Mississippi RM 831.0 is within AUID 07010206-504 which is not listed as impaired. The site experiences two jumps in fecal coliform concentration from adjacent upstream monitoring site at RM 836.8. As was exhibited with increases at RM 858.5 and 839.1, increases occur during the winter time. In all cases where fecal coliform data at RM 831.0 exceed that of RM 836.8, they also exceed that of RM 839.1. During the winter time, *E. coli* and fecal coliform concentrations increase steadily from monitoring locations between RM 847.7 and RM 831.0; this is not the case during the spring, summer, or fall.

Battle Creek flows into Pigs Eye Lake (Mississippi River backwater) and meets the Mississippi River mainstem at approximately the same location as Fish Creek (RM 833.3). Only *E. coli* data are available for Battle Creek and Fish Creek. A small creek, Kaposia Creek, discharges to the Mississippi at RM 835.4, but no bacteria data are available from the creek.

Figure 67 illustrates geometric mean *E. coli* concentrations by month and year as compared to flow and precipitation from 2005 through 2006. Though flow data are not continuous, it appears to pattern local precipitation. *E. coli* concentrations do not appear to pattern local precipitation based on this single year of data. Precipitation and flow data were not available from 2007 through 2008. Figure 68 illustrates only geometric mean *E. coli* concentrations for that time period.

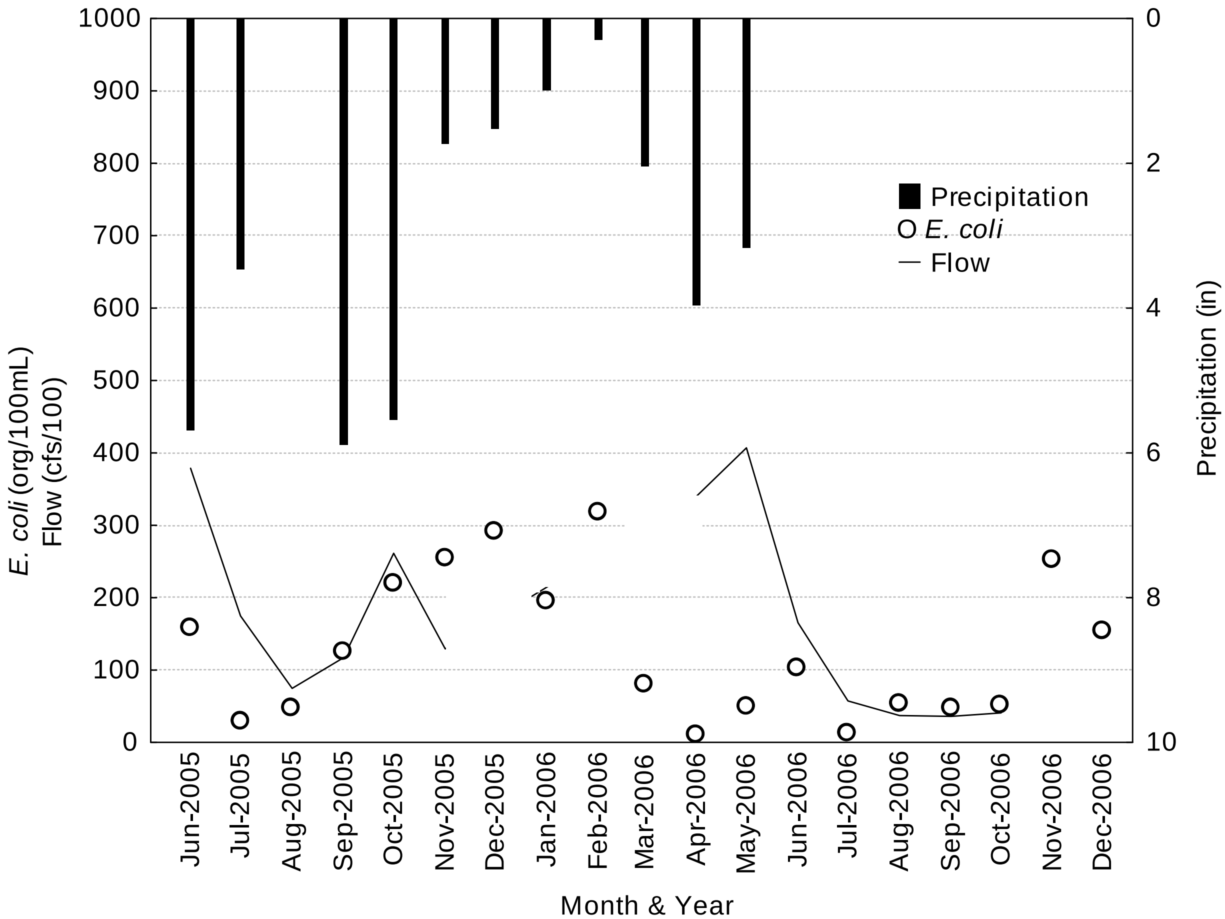

Figure 67. *E. coli* geometric means, mean flow and total precipitation at RM 831.0 from 2005-2006; precipitation data unavailable from the following months: 2005 – August; 2006 – June through October.

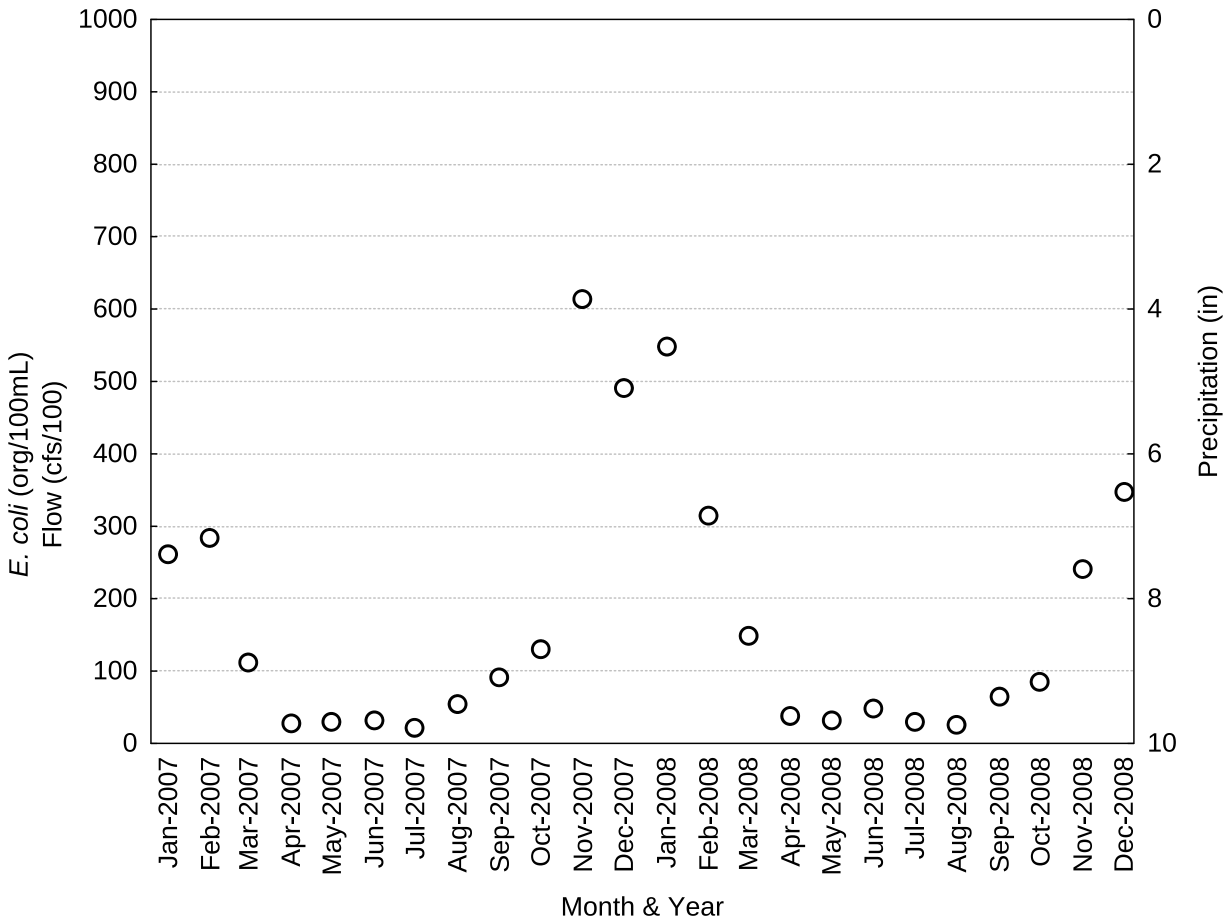

Figure 68. *E. coli* geometric means at RM 831.0 from 2007-2008.

Figure 69 illustrates the LDC analysis where monitored *E. coli* loading was compared to hypothetical loading at the standard concentration (126 org/100mL). In this case, flow data were not available immediately adjacent to the water quality monitoring site. USGS gauge station 5331000 at RM 840.5 was added to all tributary flows available between it and the water quality site at RM 831.0. Added tributary flows were Trout Brook and Phalen Creek storm sewers (RM 838.3) and Battle and Fish Creeks (RM 833.3) entering the Mississippi at the river miles bracketed. Using this method, values calculated for *E. coli* loading are less reliable. However, the relationship between monitored *E. coli* data and the standard remain valid. A total of 26% (11/43) of monitored data exceed the standard loading. Exceedances are experienced in May, June, and August through November and at all flow conditions except low flows.

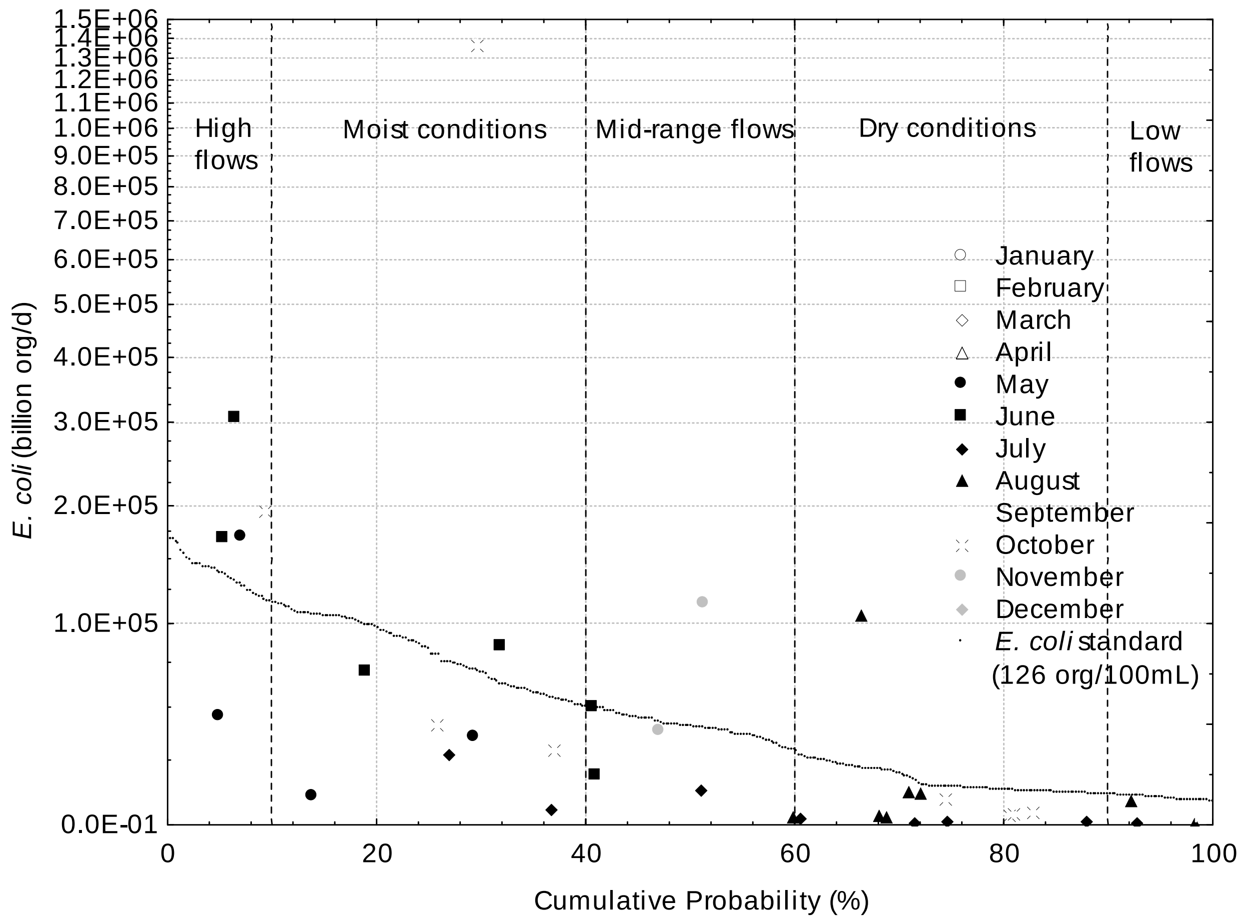

Figure 69. Load duration curve for *E. coli* at RM 831.0.

AUID 07010206-502 (Not Listed as Impaired)

The following Mississippi RMs are within AUID 07010206-502 (Figure 70) and will be discussed from page 112 to page 122:

- 826.7
- 826.4
- 821.8
- 815.6
- 815.2

Bacteria data and related statistics for these RMs (by month and year and by month across all years) can be found in Appendix A (*E. coli*) and Appendix B (fecal coliform).

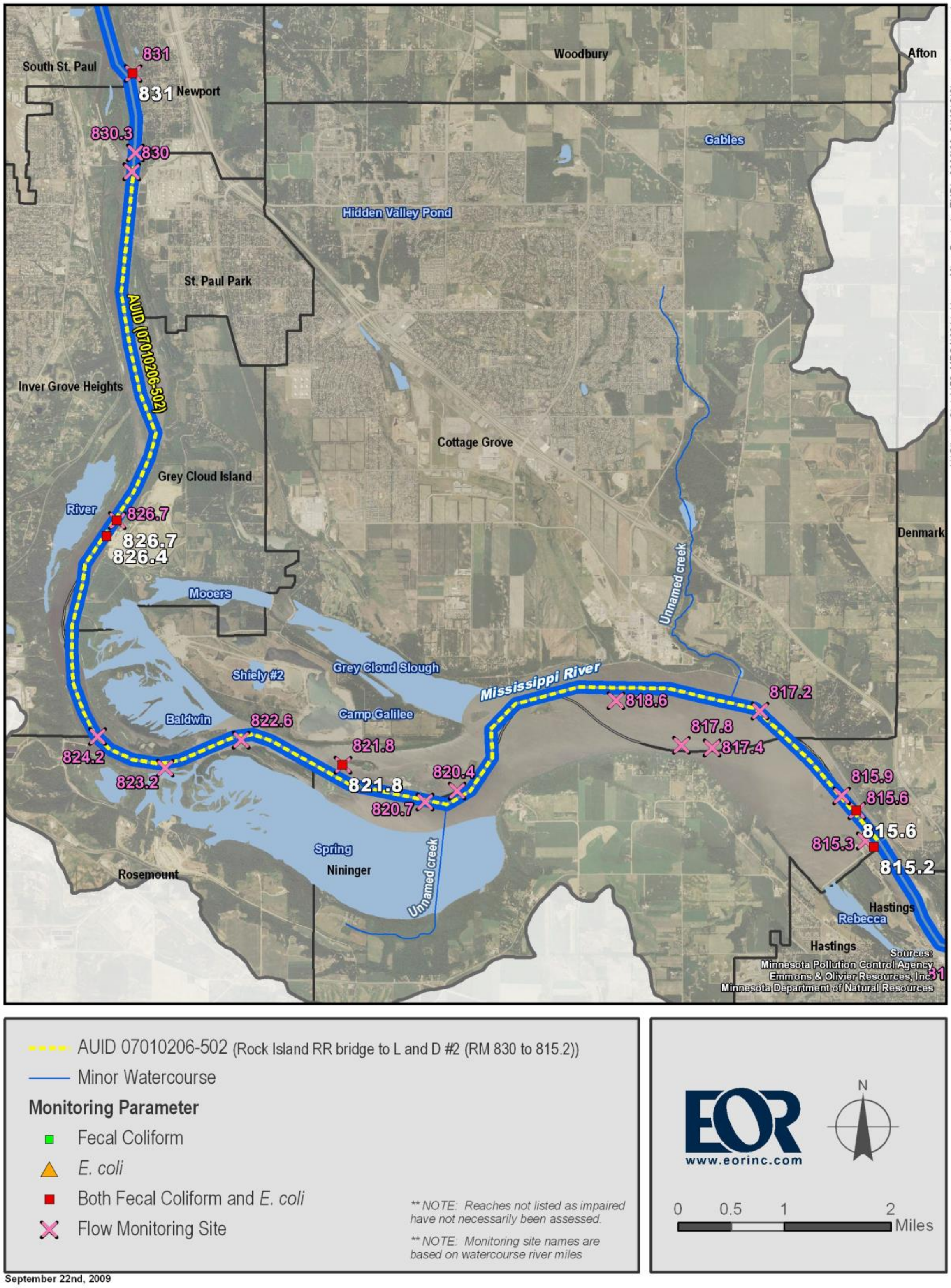

Figure 70. Mississippi River AUID 07010206-502 and mainstem bacteria and flow monitoring sites.

Mississippi RM 826.7

Mississippi RM 826.7 is within AUID 07010206-502, which is not listed as impaired. Since flow data were not available for this site for this study, Figure 71 illustrates only precipitation and geometric means of *E. coli* concentrations. Concentrations generally peak during the fall and occasionally into winter when precipitation is generally not at its peak for the respective year.

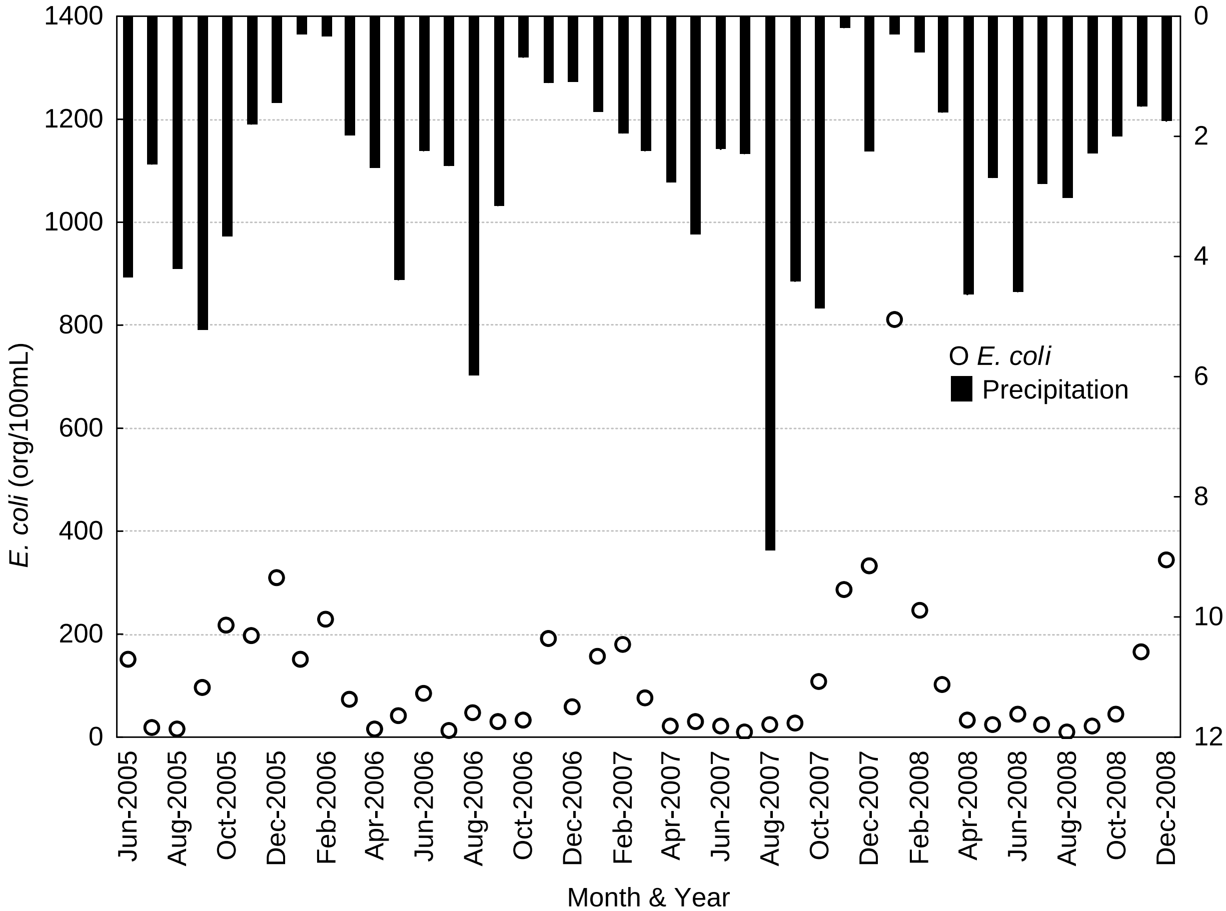

Figure 71. *E. coli* geometric means and total precipitation at RM 826.7.

Mississippi RM 826.4

Flow data were not available for RM 826.4 for this study. Figure 72 and Figure 73 illustrate precipitation (total by month and year) and geometric mean by month and year *E. coli* concentrations. Data are sporadic and inconclusive. However, with the exception of one August 2002 spike, *E. coli* concentrations tend to be low, especially since 2004.

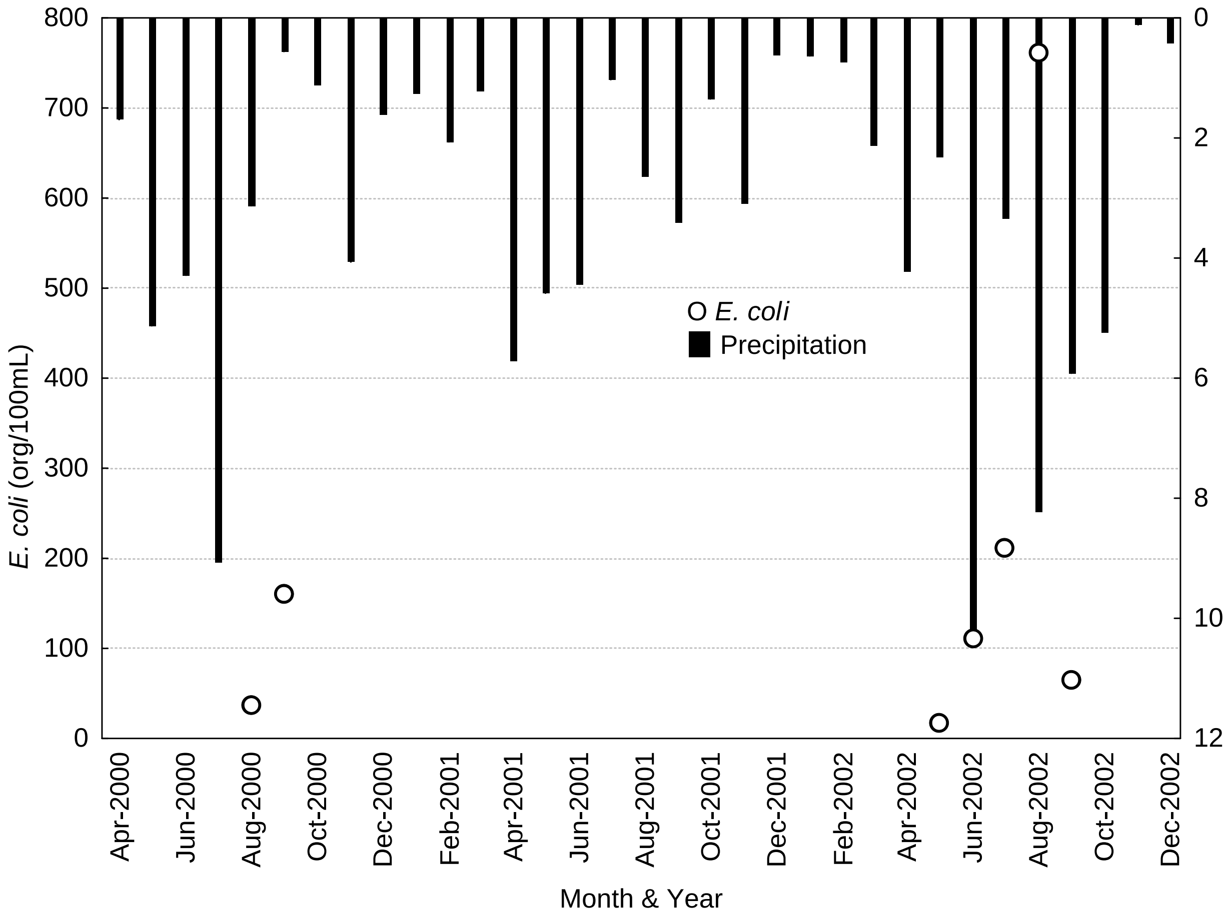

Figure 72. *E. coli* geometric means and total precipitation at RM 826.4 from 2000-2002.

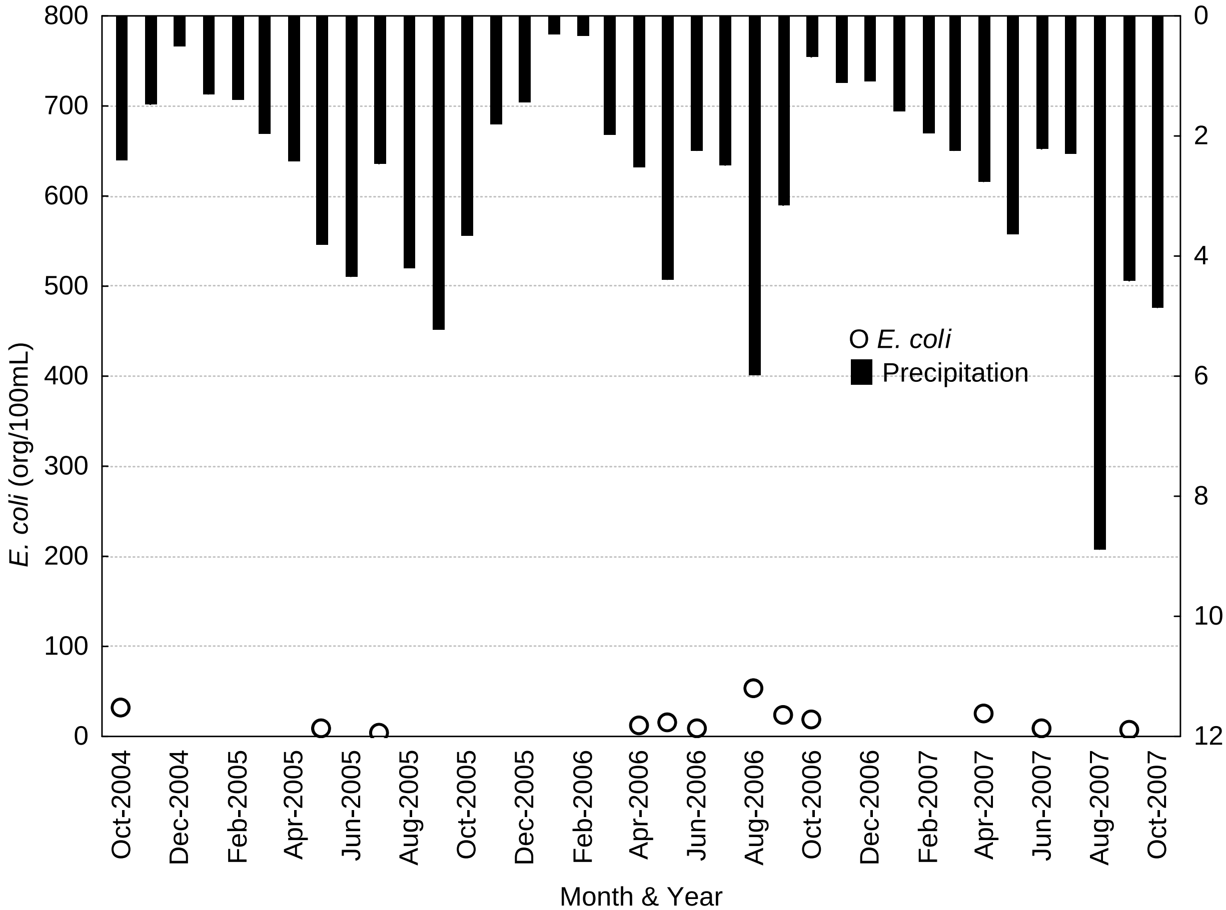

Figure 73. *E. coli* geometric means and total precipitation at RM 826.4 from 2004-2007.

Mississippi RM 821.8

Mississippi RM 821.8 also exhibits low geometric mean by month and year *E. coli* concentrations like its adjacent upstream site (RM 826.4). Figure 74 illustrates precipitation (total by month and year) and mean by month and year *E. coli* concentrations. Trends related to *E. coli* response to precipitation are inconclusive.

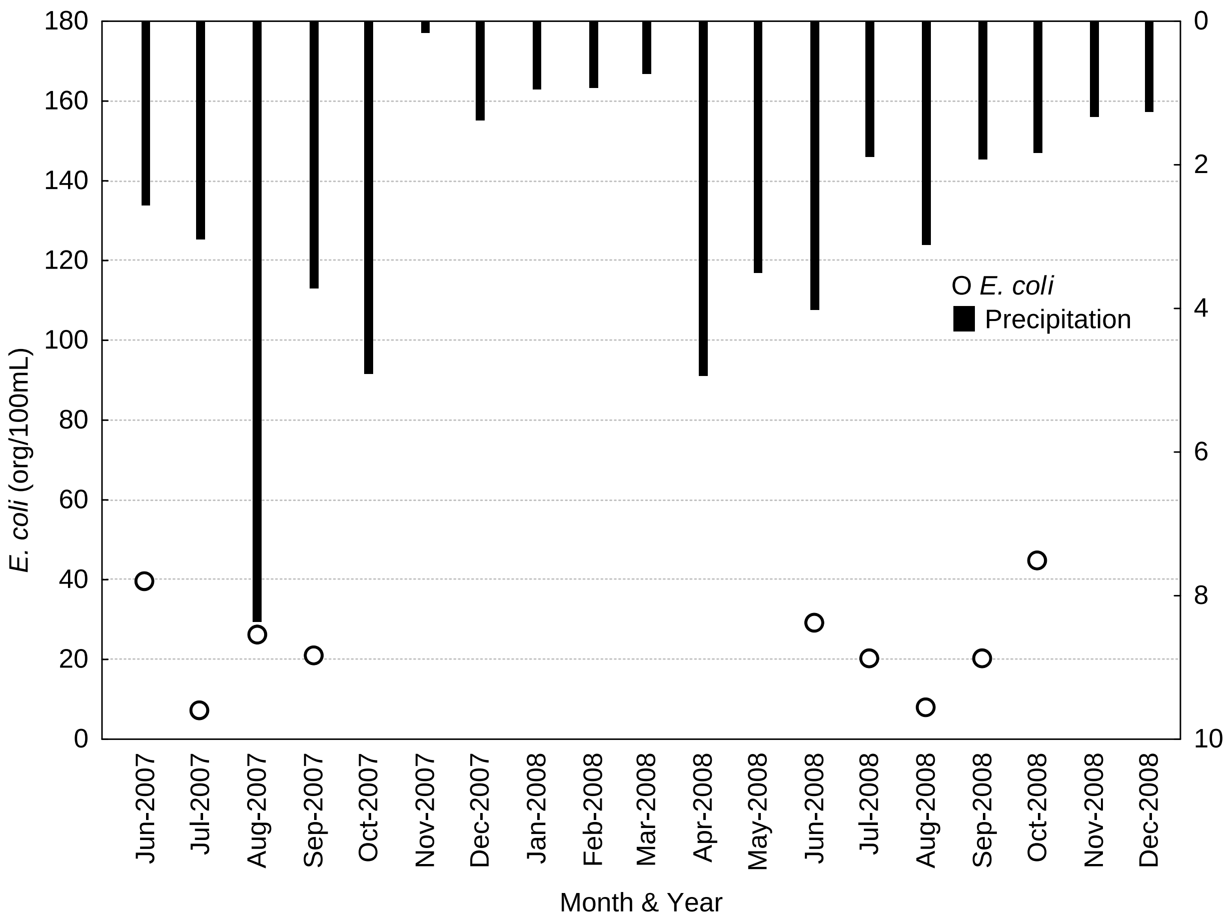

Figure 74. *E. coli* geometric means and total precipitation at RM 821.8.

Mississippi RM 815.6

Mississippi RM 815.6 experiences one jump in fecal coliform concentration from the adjacent upstream site at RM 821.8 in October. Two unnamed creeks are between RM 821.8 and RM 815.6 and enter the Mississippi River at RM 820.8 and RM 817.2. The former unnamed creek enters Spring Lake, Mississippi River backwater. No bacteria data are available for either of these Mississippi River inputs.

Figure 75 and Figure 76 illustrate geometric mean *E. coli* concentrations by month and year as compared to flow and precipitation, where available. *E. coli* concentrations appear higher at low precipitation, especially during the winter of 2007-2008. As occurred at RM 848.1 (and similarly at 849.9), flow appears to pattern local precipitation patterns with the exception of August 2007 when local precipitation was relatively high and Mississippi River flow was low. This event does not appear to cause a substantive increase in *E. coli* concentration.

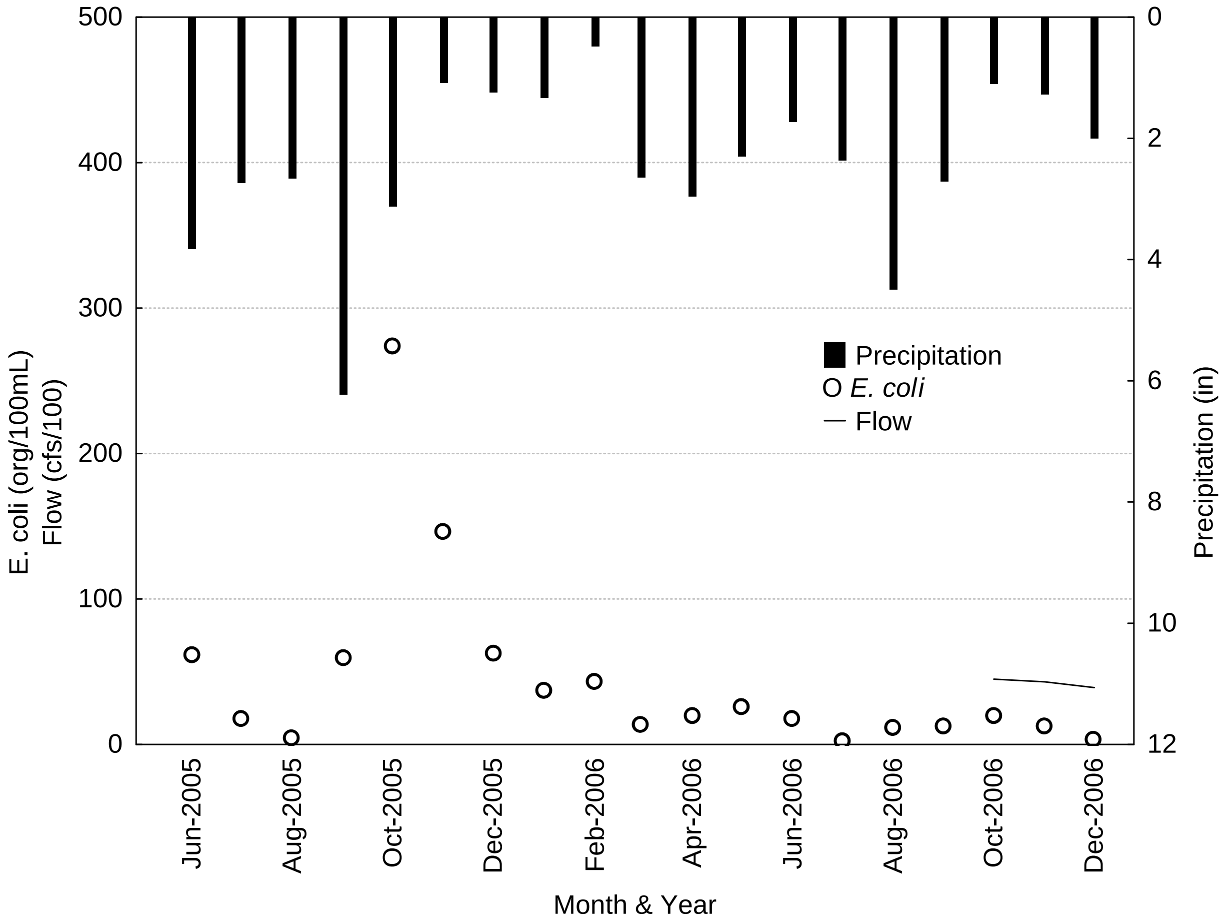

Figure 75. *E. coli* geometric means, mean flow and total precipitation at RM 815.6 from 2005-2006.

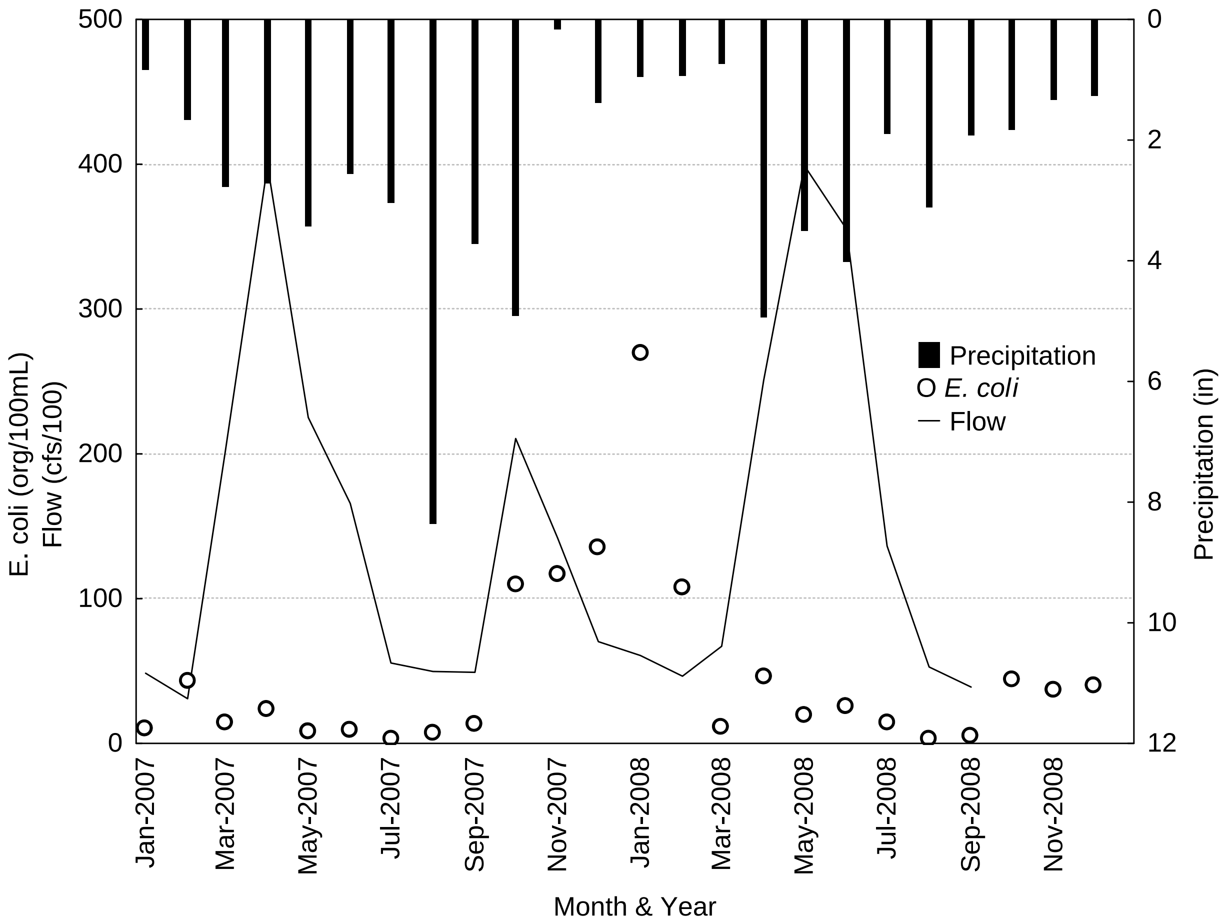

Figure 76. *E. coli* geometric means, mean flow and total precipitation at RM 815.6 from 2007 to 2008.

Figure 77 illustrates the LDC analysis for RM 815.6 where monitored *E. coli* loading was compared to hypothetical loading at the standard concentration (126 org/100mL). A total of 6.3% (5/80) of monitored data exceeds the standard loading. Exceedances are experienced from October through January. The top most exceedance in any single month occurs in January with two exceedances. No exceedances occur at either high or low flows.

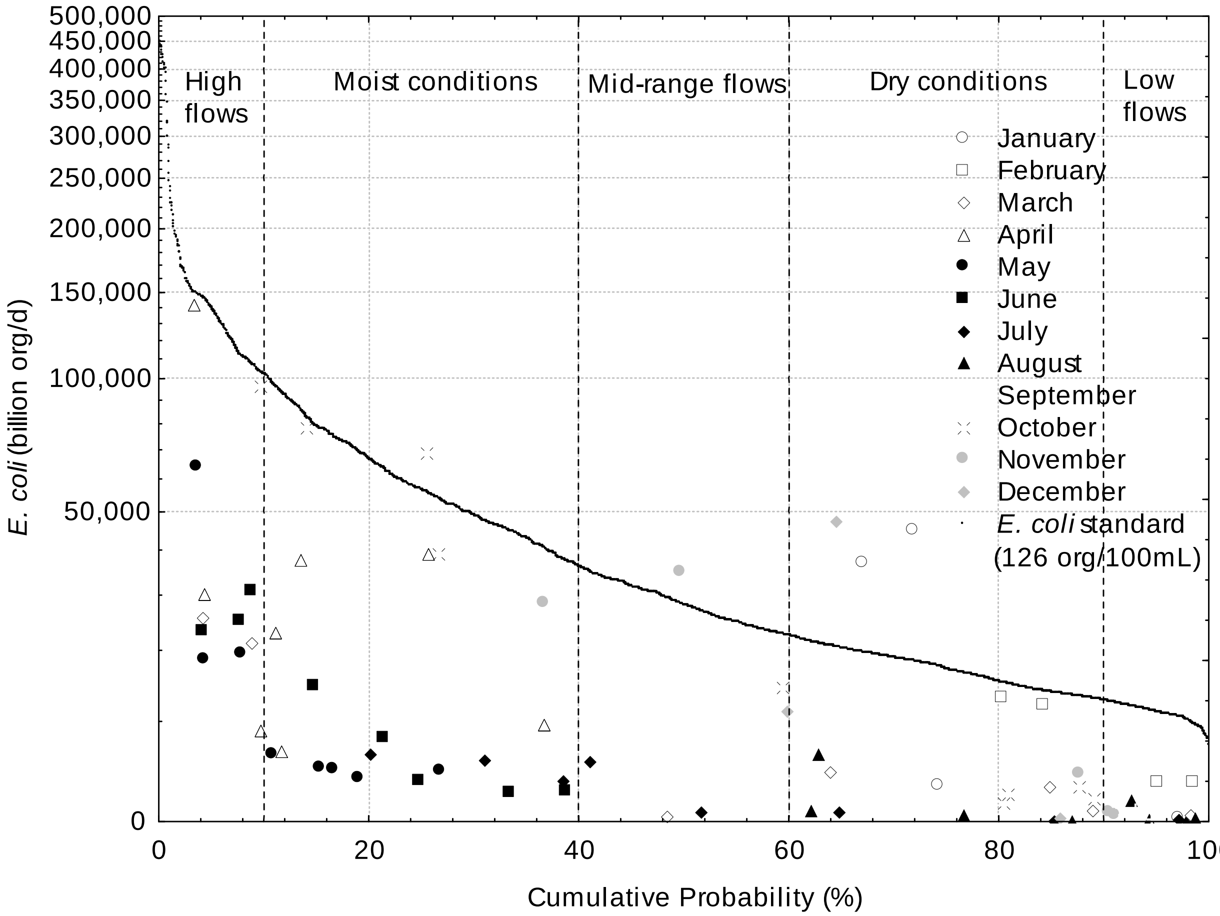

Figure 77. Load duration curve for *E. coli* at RM 815.6.

Mississippi RM 815.2

Figure 78 through Figure 80 illustrate geometric mean *E. coli* concentrations by month and year as compared to flow and precipitation for the years 2000, 2002, and 2006-2007, respectively. Flow data appear to pattern local precipitation data with the exception of August 2007. As at RM 815.6 and 848.1, this month experienced high amounts of local precipitation that was not reflected in Mississippi River flow. No *E. coli* data are available for this month so findings related to bacteria are inconclusive.

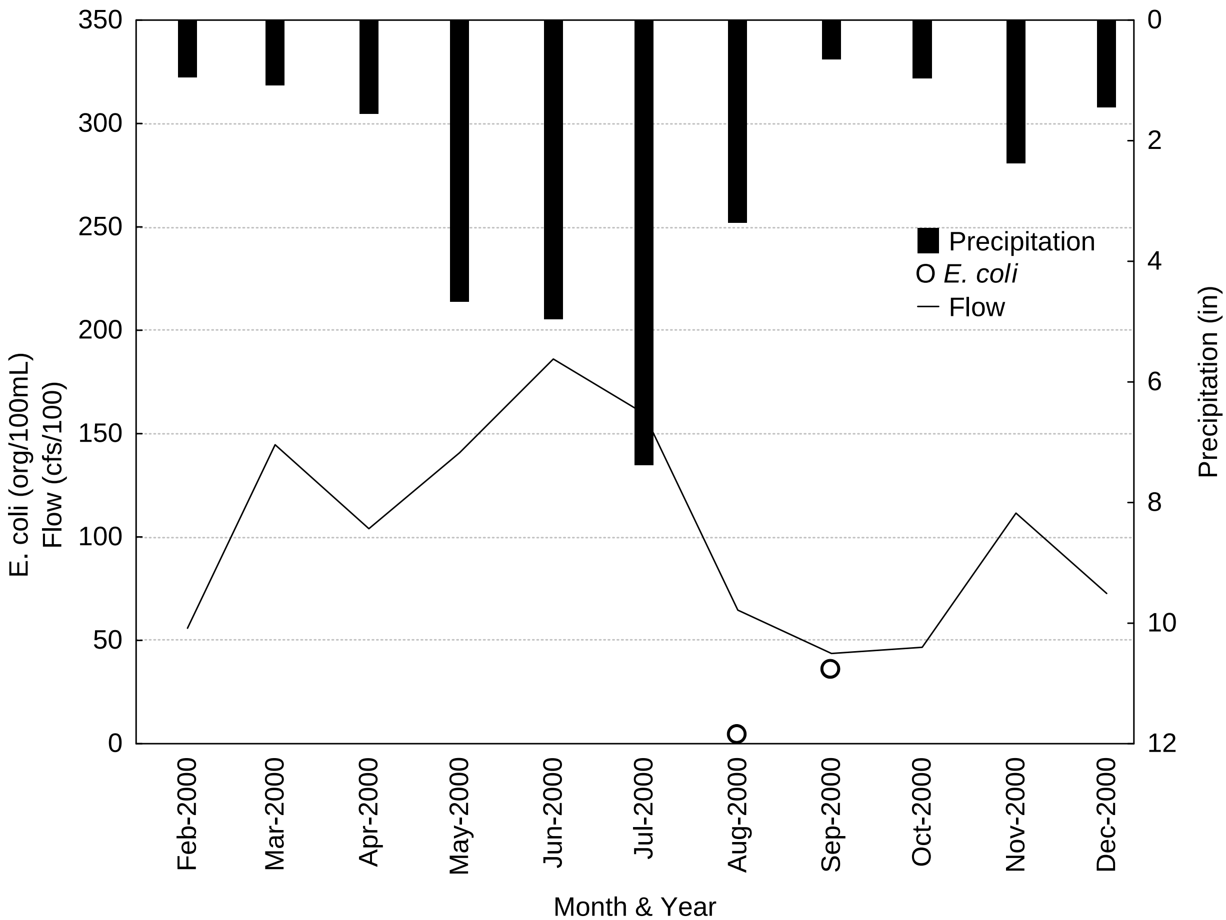

Figure 78. *E. coli* geometric means, mean flow and total precipitation at RM 815.2 in 2000.

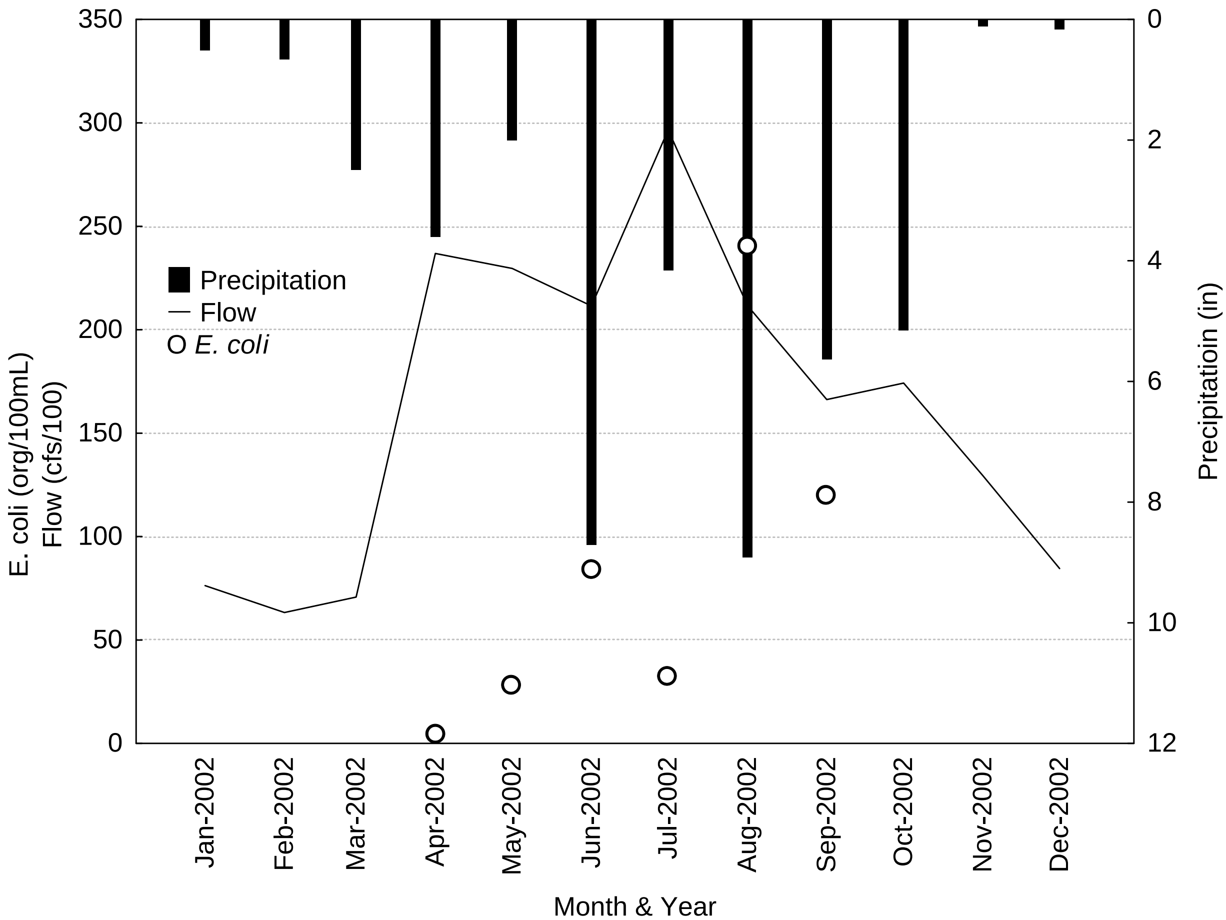

Figure 79. *E. coli* geometric means, mean flow and total precipitation at RM 815.2 in 2002.

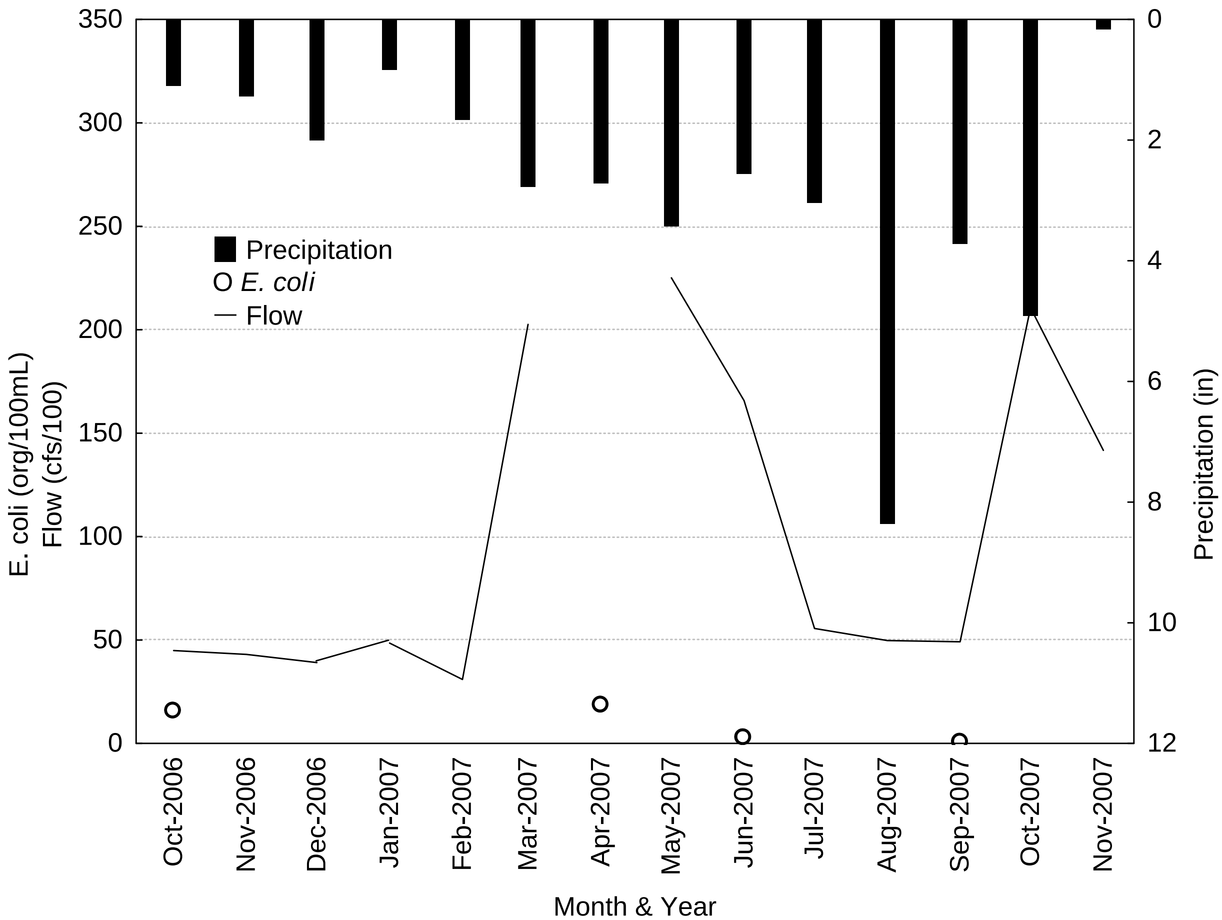

Figure 80. *E. coli* geometric means, mean flow and total precipitation at RM 815.2 from 2006-2007.

Figure 81 illustrates the LDC analysis where monitored *E. coli* loading was compared to hypothetical loading at the standard concentration (126 org/100mL). A total of only 7.7% (1/13) of monitored data exceed the standard loading. The only exceedance from the sparse data set occurred in August at moist conditions.

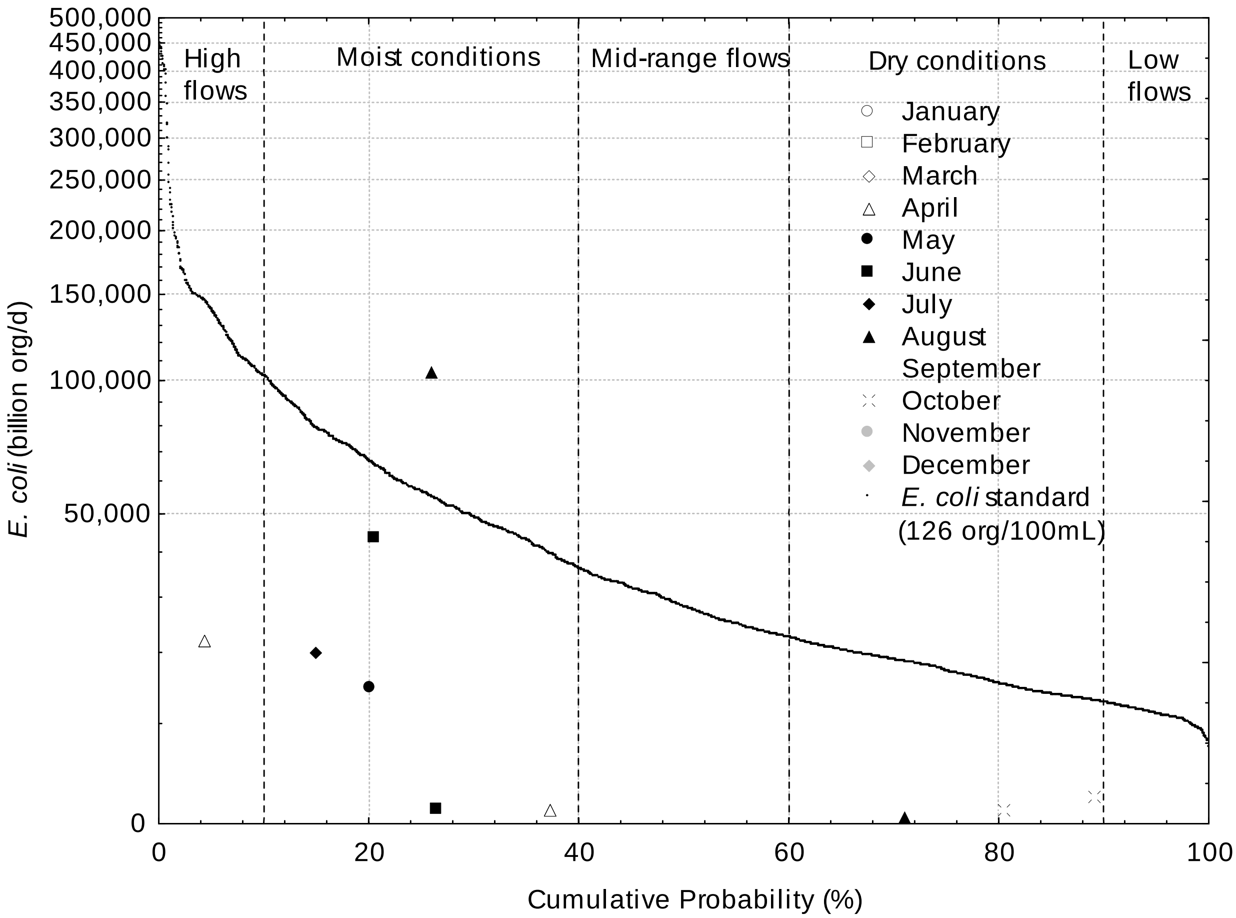

Figure 81. Load duration curve for *E. coli* at RM 815.2.

AUID 07010206-501 (Not Listed as Impaired)

The following Mississippi RMs are within AUID 07010206-501 (Figure 82) and will be discussed from page 125 to page 125:

- 813.9
- 812.8

No *E. coli* data was available for these RMs for this study. Fecal coliform data and related statistics for these RMs (by month and year and by month across all years) can be found in Appendix B.

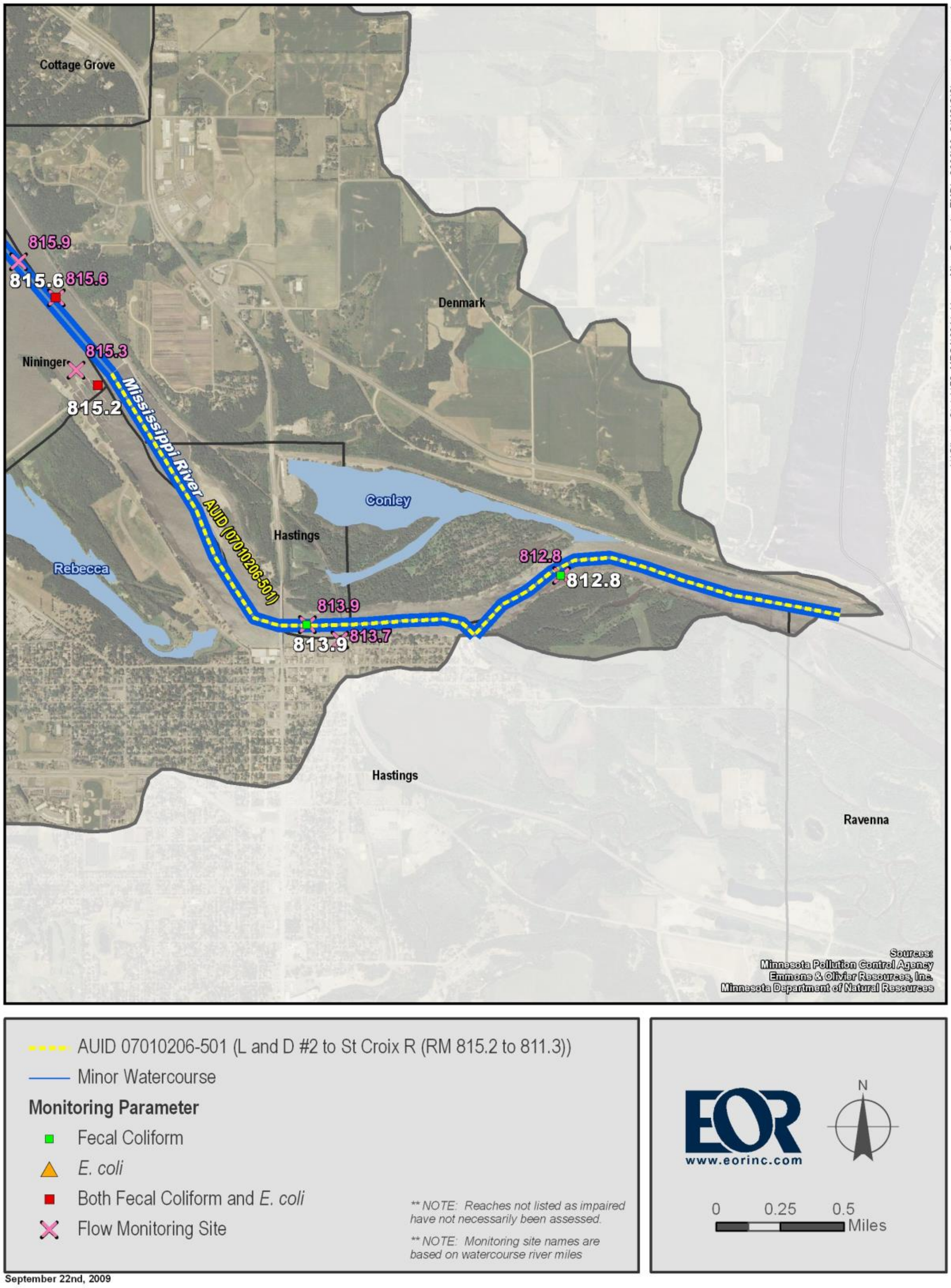

Figure 82. Mississippi River AUID 07010206-501 and mainstem bacteria and flow monitoring sites.

Mississippi RM 813.9

There are fecal coliform data available but no *E. coli* data available for this site. No jumps in fecal coliform concentrations were experienced between RM 813.9 and adjacent upstream RMs. Fecal coliform data are shown in Table B - 1 and Table B - 2 in Appendix B. A total of 18 fecal coliform samples were taken in 1999 (11 samples), 2000 (6 samples) and 2003 (1 sample) during the months of May and July through October. The geometric means of monthly concentrations exceed the former fecal coliform standard of 200 org/100mL on July 1999 and September 2000. Geometric means aggregated across all years exhibit no exceedances above the former standard.

Mississippi RM 812.8

There are fecal coliform data available but no *E. coli* data available for this site. No jumps in fecal coliform concentrations were experienced between RM 813.9 and adjacent upstream RMs. Fecal coliform data are shown in Table B - 1 and Table B - 2 in Appendix B. A total of 18 fecal coliform samples were taken in 1999 (11 samples), 2000 (6 samples) and 2003 (1 sample) during the months of May and July through October. The geometric means of monthly concentrations exceed the former fecal coliform standard of 200 org/100mL on July 1999 and September 2000. Geometric means aggregated across all years exhibit no exceedances above the former standard.

AUID Temporal Trends

The same method that was used for jumps in bacteria concentrations between Mississippi RMs, was used to identify temporal jumps (in this case, increases *or* decreases) in bacteria concentrations between adjacent years for each AUID. The log of the bacteria data more closely fit a normal distribution; therefore, data were log transformed prior to analysis. Temporal jumps were identified where the 95% confidence interval for a given year exceeds *or* is less than that of the adjacent year (where the confidence interval does not overlap). Table 13 summarizes the AUIDs that experienced temporal jumps in bacteria concentrations (*E. coli* and fecal coliform) between adjacent years and the years that the temporal jumps occurred. The table also illustrates results of combining all sites along the entire mainstem. Fecal coliform data availability was greater than that of *E. coli* data. Among other possible explanations, this is one reason that *E. coli* temporal jumps are fewer in number than fecal coliform temporal jumps. Relatively common among AUIDs is a decrease in *E. coli* and fecal coliform concentration in the years 2006 and 2008 as compared to the year before. Increases are less common but occur twice in 2005.

Table 13. Jumps in annual mean *E. coli* and fecal coliform from prior year on the mainstem of the Mississippi River grouped by AUID and listed from upstream to downstream.

AUID	Listed as Impaired? Y/N	Year			
		E. coli		Fecal coliform	
		Increase	Decrease	Increase	Decrease
07010203-574	N			2004, 2007	2003, 2006
07010203-510	Y				2001
07010206-568	Y		2006		2003
07010206-509	Y		2004, 2006		2006, 2008
07010206-503	Y		2006	2005	2006, 2008
07010206-502	N				2006
All AUIDs	N/A		2004, 2006, 2008	2005	2000, 2006, 2008

Of the 11 Mississippi mainstem AUIDs for which *E. coli* data are available, the following five AUIDs experience no temporal jumps (increases or decreases) between mean annual concentrations irrespective of chronological order and only throughout the bracketed period for which data was available (none of these AUIDs are listed as impaired):

- 07010201-501 [2007-2008]
- 07010201-502 [2007-2008]
- 07010203-574 [2000, 2002, 2003-2004]
- 07010206-502 [2000, 2002, 2004-2008]
- 07010206-504 [2005-2008]

In chronological order by year, AUIDs 07010203-510 and 07010206-505 which are known to be impaired experience no temporal jumps in mean annual *E. coli* concentration. Available *E. coli* data for AUID 07010203-510 include 2000-2002 and 2004-2007. Available *E. coli* data for AUID 07010206-505 include 2000, 2002 and 2005-2008.

E. TRIBUTARIES AND STORM SEWERS

An LDC analysis was conducted for *E. coli* on the downstream-most monitoring site of tributaries to the Mississippi River and storm sewer outfalls. LDC analyses were limited to those sites having both *E. coli* and flow data available for this study for all or portions of the study period from 1999 through 2008. Not all tributaries have both flow and *E. coli* data as is discussed in greater detail in *Section 5. Data Gaps*. Geometric means and summary statistics for those sites having *E. coli* data but no flow data or having only fecal coliform data are summarized in Table D - 1 of Appendix D. Figure 83 and Figure 84 illustrate the *E. coli* and flow monitoring sites used for tributary LDC analyses in the northern and southern sections of the study area, respectively. Tributary data presented here are ordered from upstream to downstream based on where the tributary enters the Mississippi River. Mississippi RMs are in parenthesis in section headings. Storm sewer data are those which were made available for this study by Capitol Region Watershed District. LDCs are developed based on the water quality standard for *E. coli*, but storm sewers are not regulated under this standard; it is applied herein for reference purposes only.

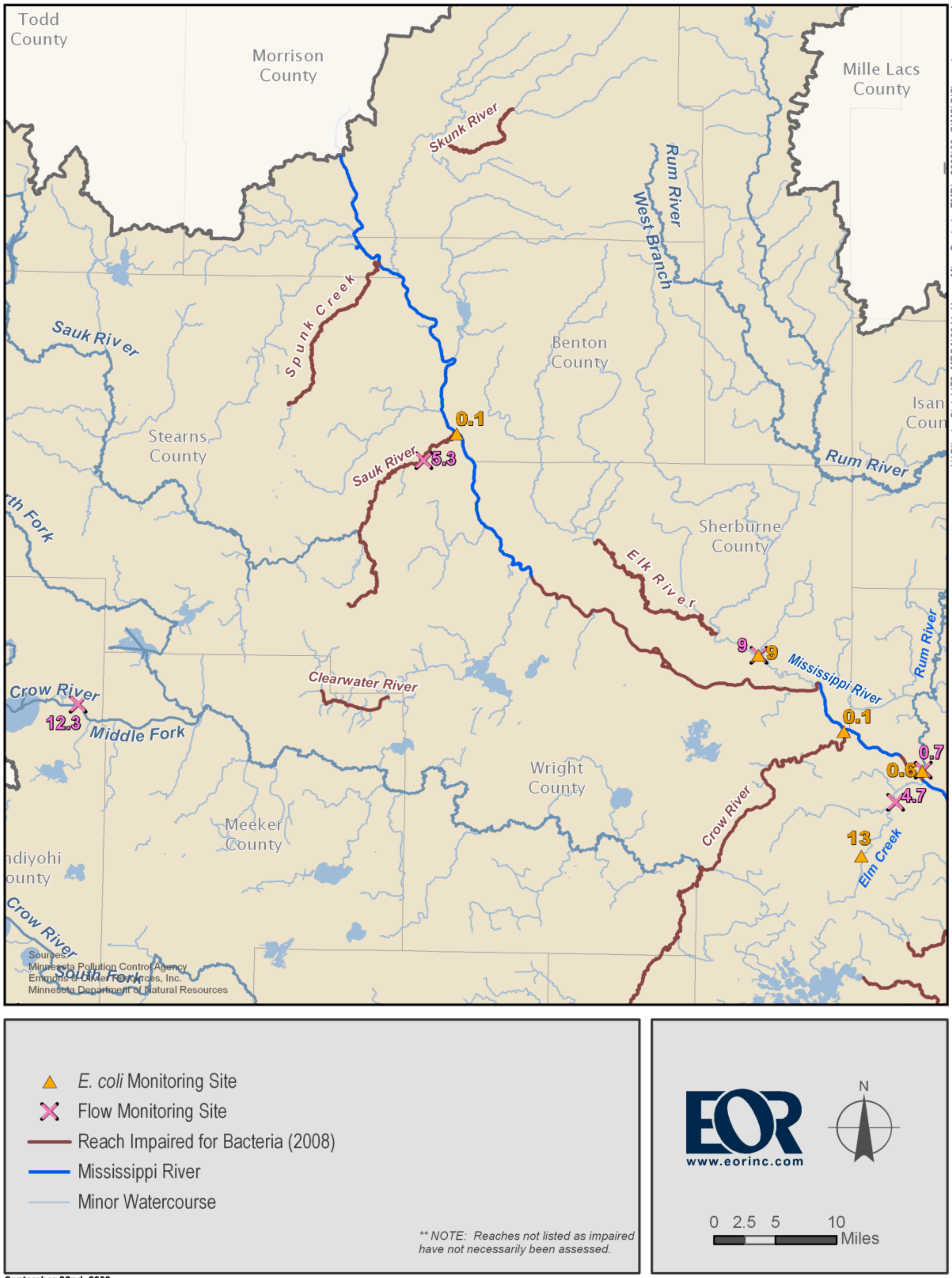

Figure 83. Downstream-most monitoring sites of tributaries having *E. coli* and flow data in the northern portion of the study area.

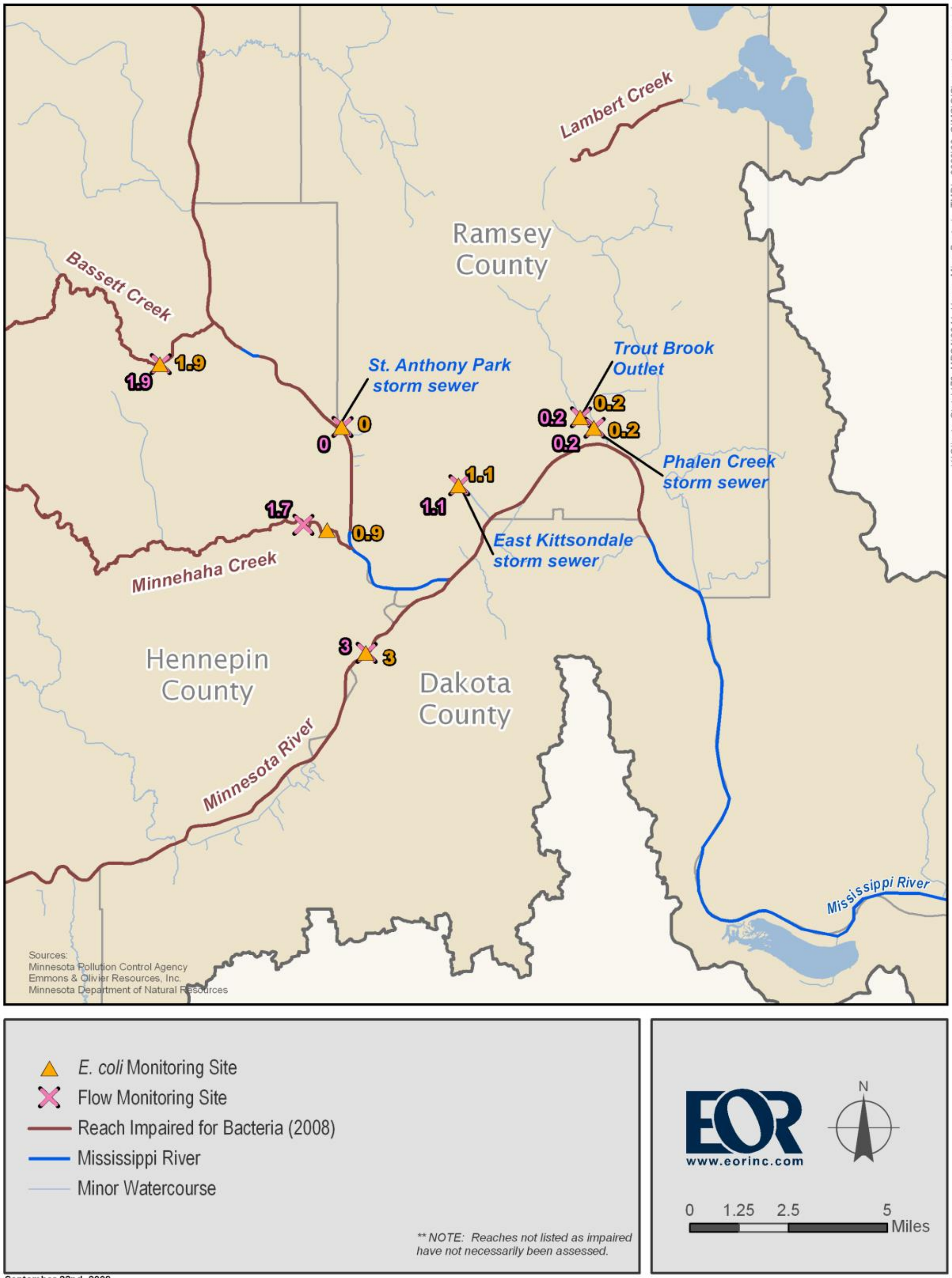

Figure 84. Downstream-most monitoring sites of tributaries having *E. coli* and flow data in the southern portion of the study area.

Table 14 is the summary of the LDC analyses of the tributaries for which data were available for this study at a downstream location. Data are presented from upstream to downstream along the Mississippi River based on where the tributary enters the Mississippi River. The Minnesota River and Bassett Creek are the only tributaries having both *E. coli* and flow data in the winter; these tributaries experience 31% and 22% of exceedances in the winter, respectively. The highest overall percent exceedances are experienced by, in decreasing order, East Kittsondale storm sewer (92%), Minnehaha Creek (76%), Trout Brook outlet (70%), and Elm Creek (58%). Storm sewers appear to be a high contributor of bacteria to the Mississippi River. Summer is the season with the most exceedances at 46% (99/215). Fall exceedances make up 39% (83/215) of the total number of exceedances experienced.

Table 14. Tributary and storm sewer *E. coli* summary of exceedances; concentrations above the standard of 126 org/100mL.

AUID	Waterbody	Reach Description	Mississippi RM where Tributary Enters Mississippi River	Percent Exceedances	Total Exceedances	Total *E. coli* Measurements	Exceedances by Month												Percent Exceedances by Season (No. Exceedances / Total Exceedances)			
							1	2	3	4	5	6	7	8	9	10	11	12	Winter (12-2)	Spring (3-5)	Summer (6-8)	Fall (9-11)
07010202-501	**Sauk River**	Mill Cr to Mississippi R	930.1	9%	5	53	0/0	0/0	0/2	0/9	1/10	1/9	1/7	0/7	2/5	0/4	0/0	0/0	N/A	20%	40%	40%
07010203-548	**Elk River**	St Francis R to Orono Lk	884.6	33%	4	12	0/0	0/0	0/0	0/2	0/2	0/3	0/1	2/2	2/2	0/0	0/0	0/0	N/A	0%	50%	50%
07010204-502	**Crow River**	S Fk Crow R to Mississippi R	879.5	9%	2	23	0/0	0/0	0/0	0/4	0/3	0/4	0/3	1/3	1/3	0/3	0/0	0/0	N/A	0%	50%	50%
07010207-555	**Rum River**	Trott Bk to Madison/Rice St in Anoka	871.3	29%	5	17	0/0	0/0	0/0	0/0	0/0	2/3	0/2	0/4	2/3	1/3	0/2	0/0	N/A	N/A	40%	60%
07010206-508	**Elm Creek**	Headwaters (Lk Medina 27-0146-00) to Mississippi R	871.1	58%	23	40	0/0	0/0	0/0	0/1	0/5	0/4	6/6	5/6	7/7	4/6	1/5	0/0	N/A	0%	48%	52%
07010206-538	**Bassett Creek**	Medicine Lk to Mississippi R	854.8	23%	9	39	0/1	0/2	2/4	0/5	0/3	0/4	2/4	1/3	0/3	2/4	0/3	2/3	22%	22%	33%	22%
N/A	**St. Anthony Park Storm Sewer**	N/A	850.3	54%	13	24	0/0	0/0	0/0	0/0	2/3	1/4	2/4	2/4	4/4	2/4	0/1	0/0	N/A	15%	38%	46%
07010206-539	**Minnehaha Creek**	Lk Minnetonka to Mississippi R	847.1	76%	45	59	0/0	0/0	0/0	0/0	0/1	8/10	6/12	11/13	13/13	6/9	1/1	0/0	N/A	0%	56%	44%
07020012-505	**Minnesota River**	RM 22 to Mississippi R	843.9	26%	35	134	5/6	5/6	4/11	0/12	0/12	6/16	1/14	3/16	4/16	4/16	2/5	1/4	31%	11%	29%	29%
N/A	**East Kittsondale Storm Sewer**	N/A	841.6	92%	34	37	0/0	0/0	0/0	4/4	3/4	5/6	6/6	6/6	4/5	5/5	1/1	0/0	N/A	21%	50%	29%
N/A	**Phalen Creek Storm Sewer**	N/A	838.3	42%	14	33	0/0	0/0	0/0	1/2	0/3	1/4	3/6	4/6	3/5	2/6	0/1	0/0	N/A	7%	57%	36%
N/A	**Trout Brook Outlet**	N/A	838.3	70%	26	37	0/0	0/0	0/0	1/2	2/4	2/6	5/6	6/6	4/5	6/7	0/1	0/0	N/A	12%	50%	38%

Sauk River (RM 930.1)

Sauk River enters the Mississippi River at RM 930.1. Several reaches of the Sauk River (AUIDs 07010202-501 and 07010202-537) are known to be impaired for aquatic recreation due to fecal coliform. Data from the most-downstream site were used in the LDC analysis shown in Figure 85. A total of 9.0% (5/53) of monitored data exceeds the standard loading. Exceedances are distributed during the months of May through July and September.

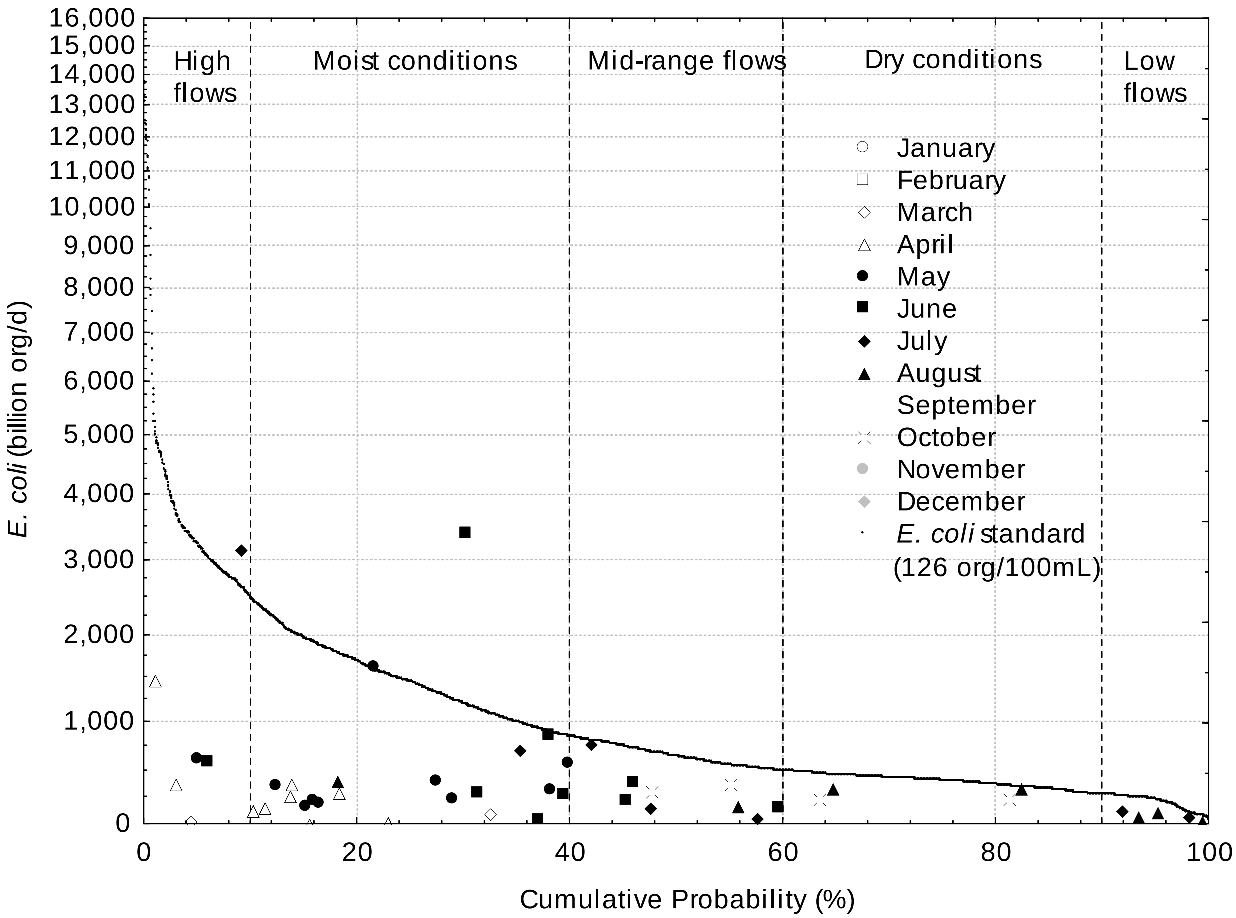

Figure 85. Load duration curve for *E. coli* at Sauk River.

Elk River (RM 884.6)

The Elk River LDC analysis is shown in Figure 86. A total of 33% (4/12) of monitored data exceeds the standard loading but only 12 samples were taken. The four exceedances are distributed evenly between August and September and occur during mid-range to low flows.

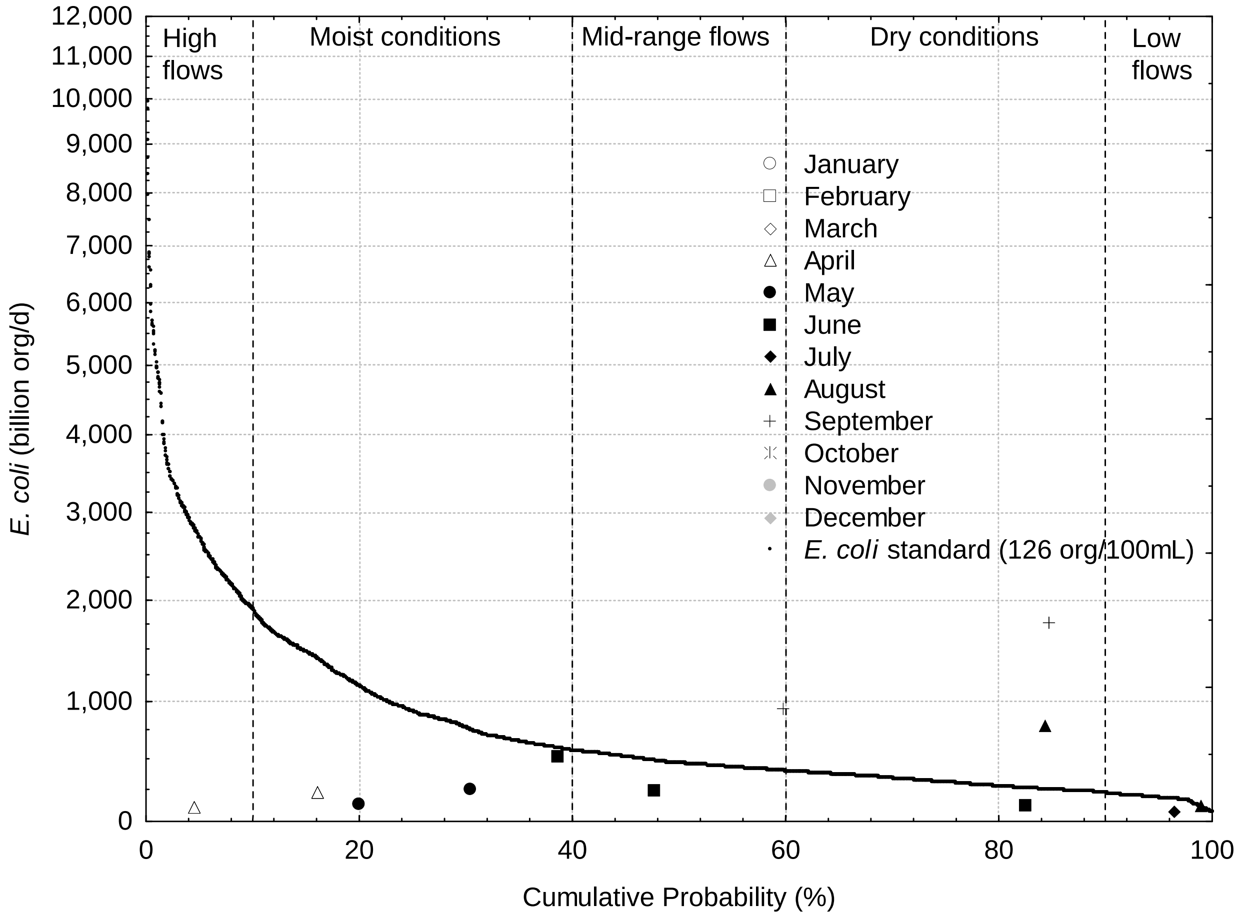

Figure 86. Load duration curve for *E. coli* at Elk River.

Crow River (RM 879.5)

A total of 9.0% (2/23) of monitored data exceeds the standard loading (Figure 87). The Crow River (AUIDs 07010204-502 and 07010205-508) is known to be impaired for aquatic recreation due to fecal coliform. As with the adjacent upstream tributary, Elk River, exceedances are distributed evenly between August and September.

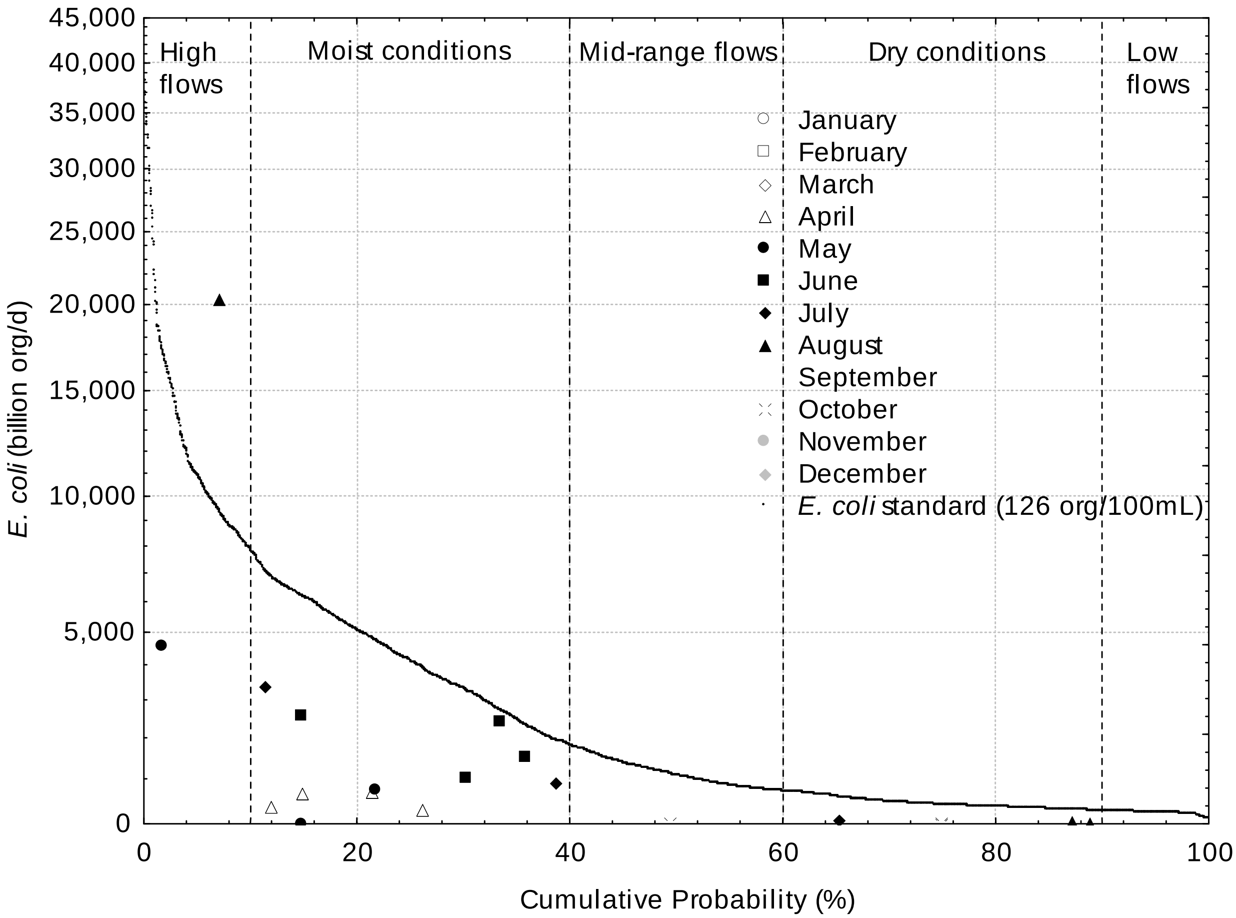

Figure 87. Load duration curve for *E. coli* at Crow River.

Rum River (RM 871.3)

The Rum River enters the Mississippi River at RM 871.3. A total of 29% (5/17) of monitored data exceeds the standard loading (Figure 88). The five exceedances occur in June, September and October during high flows or moist conditions.

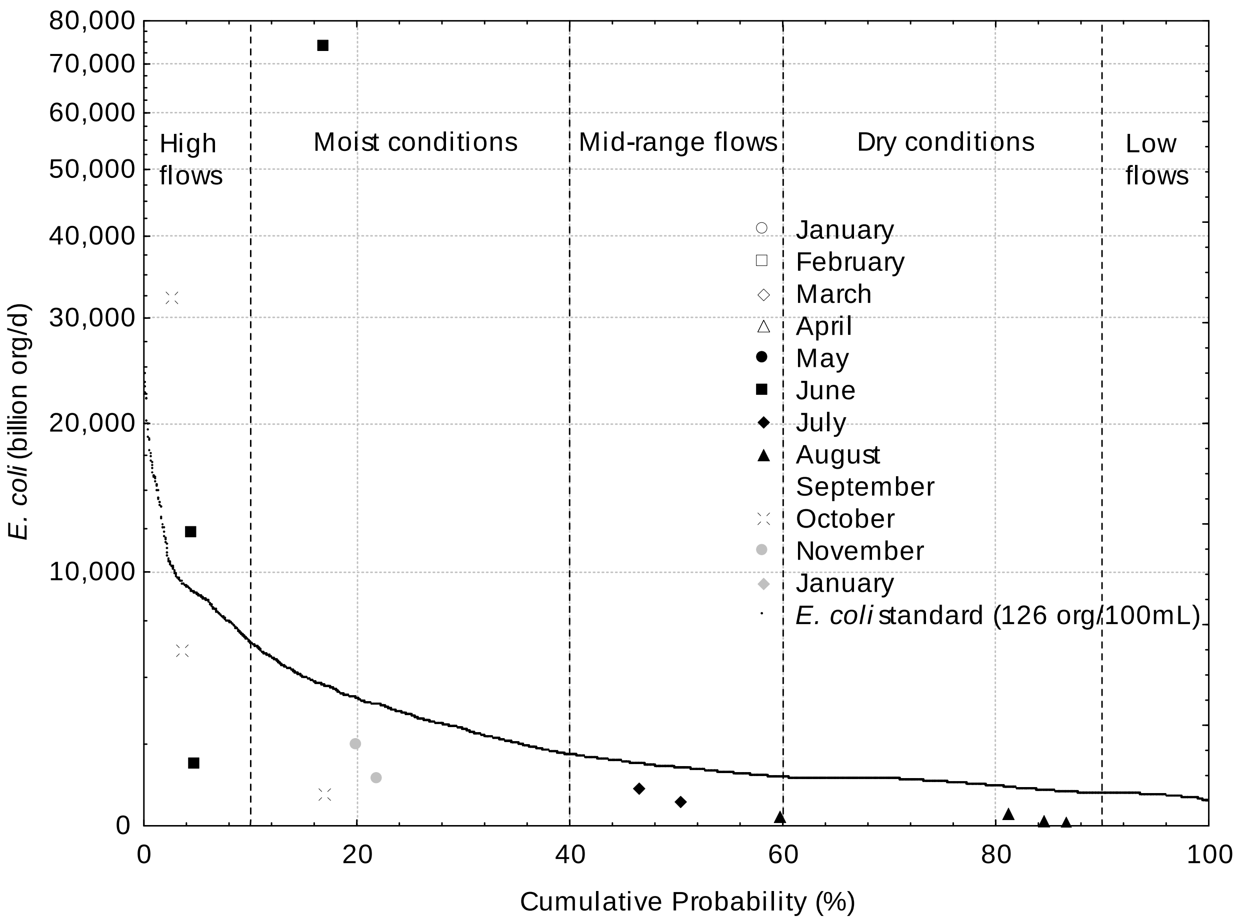

Figure 88. Load duration curve for *E. coli* at Rum River.

Elm Creek (RM 871.1)

Elm Creek enters the Mississippi River at RM 871.1 only 0.2 miles downstream from where the Rum River enters. A total of 58% (23/40) of monitored data exceeds the standard loading (Figure 89). Exceedances are relatively evenly distributed from July through October with one exceedance occurring in November.

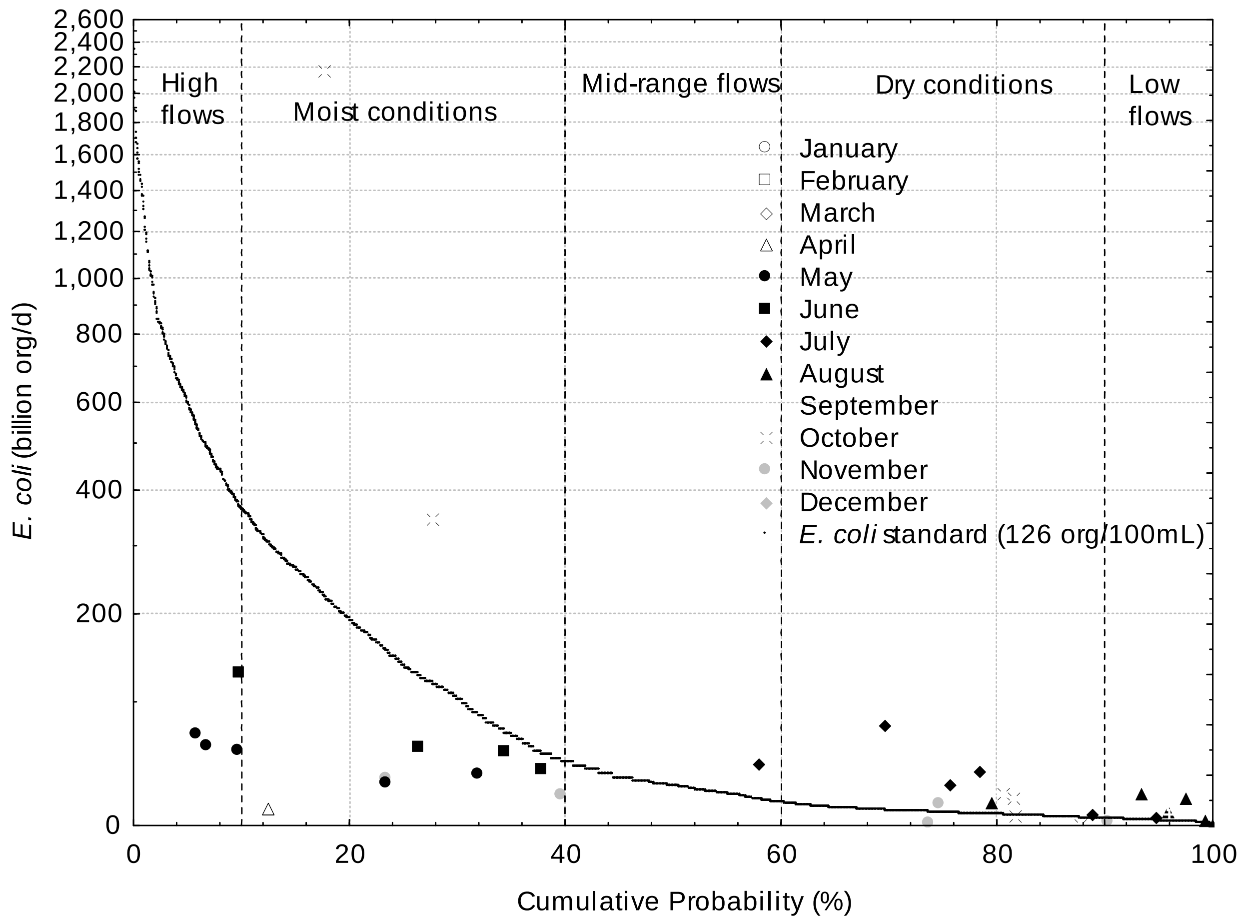

Figure 89. Load duration curve for *E. coli* at Elm Creek.

Bassett Creek (RM 854.8)

Bassett Creek (AUID 07010206-538) is known to be impaired for aquatic recreation due to fecal coliform. A total of 23% (9/39) samples taken at the downstream-most site of Bassett Creek resulted in exceedances according to the LDC analysis presented in Figure 90. Only five exceedances are well above the curve of *E. coli* loading at the standard concentration.

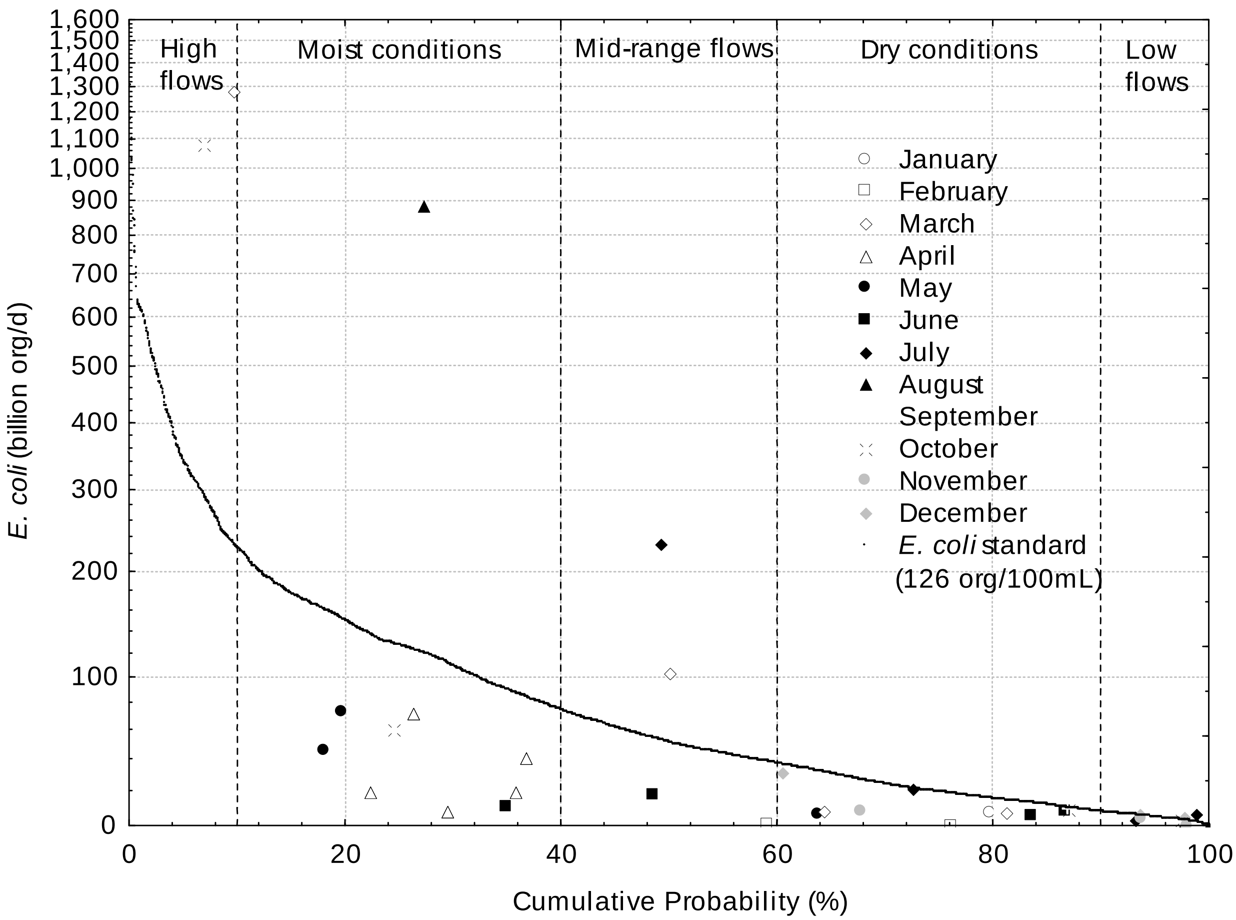

Figure 90. Load duration curve for *E. coli* at Bassett Creek.

St. Anthony Park Storm Sewer Outfall (RM 850.3)

At the St. Anthony Park Storm Sewer Outfall, a total of 54% (13/24) of monitored data exceeds the standard loading. The urban subwatershed appears to contribute to *E. coli* concentrations in the Mississippi River. Exceedances occur during all but low flow regimes from May through October (Figure 91).

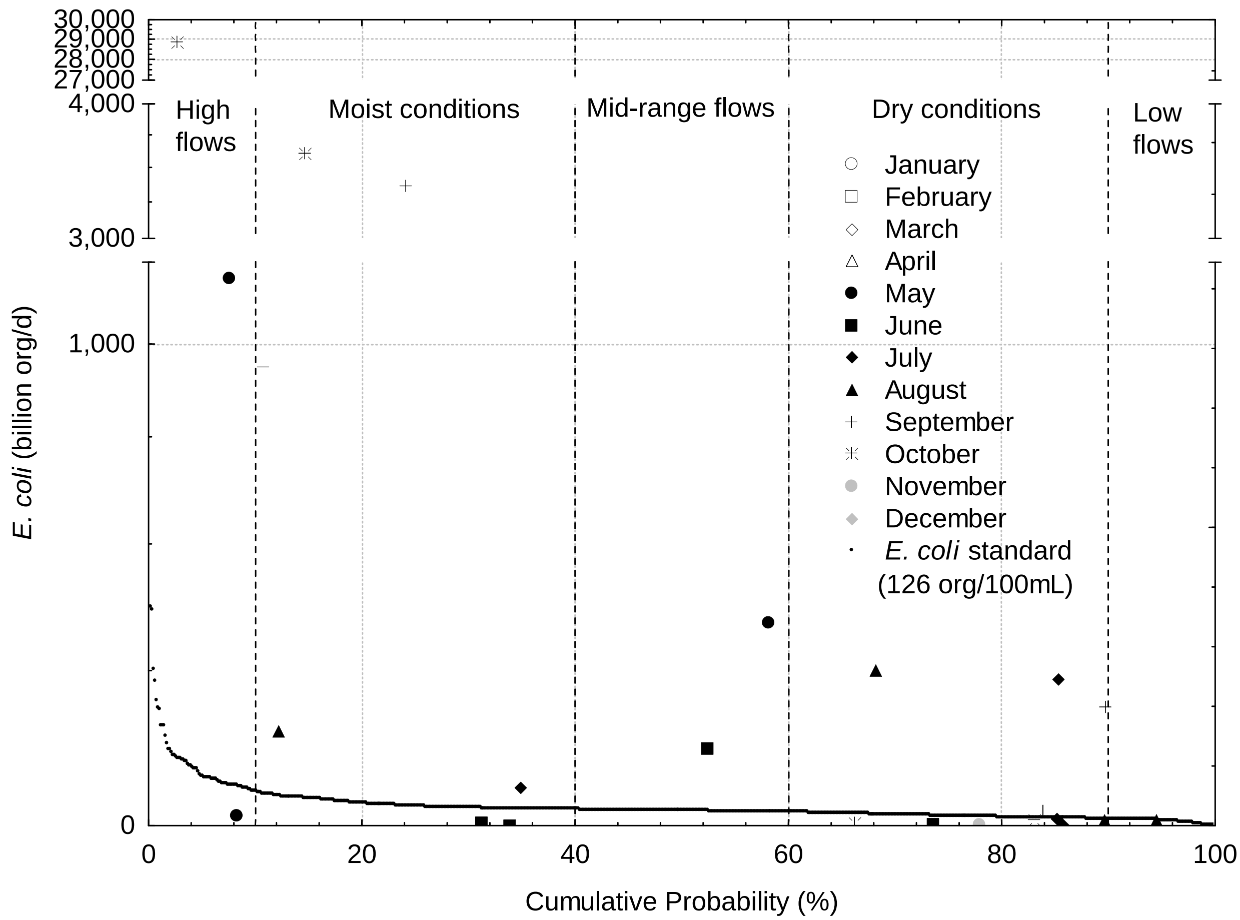

Figure 91. Load duration curve for *E. coli* at St. Anthony Park storm sewer outfall.
Note scale breaks in y-axis.

Minnehaha Creek (RM 847.1)

Minnehaha Creek (AUID 07010206-539) is known to be impaired for aquatic recreation due to fecal coliform. A total of 76% (45/59) of monitored data exceeds the standard loading at the downstream-most site of Minnehaha Creek (Figure 92). Exceedances are distributed during the months of June through October. The majority of exceedances occur during August and September with a total of 24 exceedances.

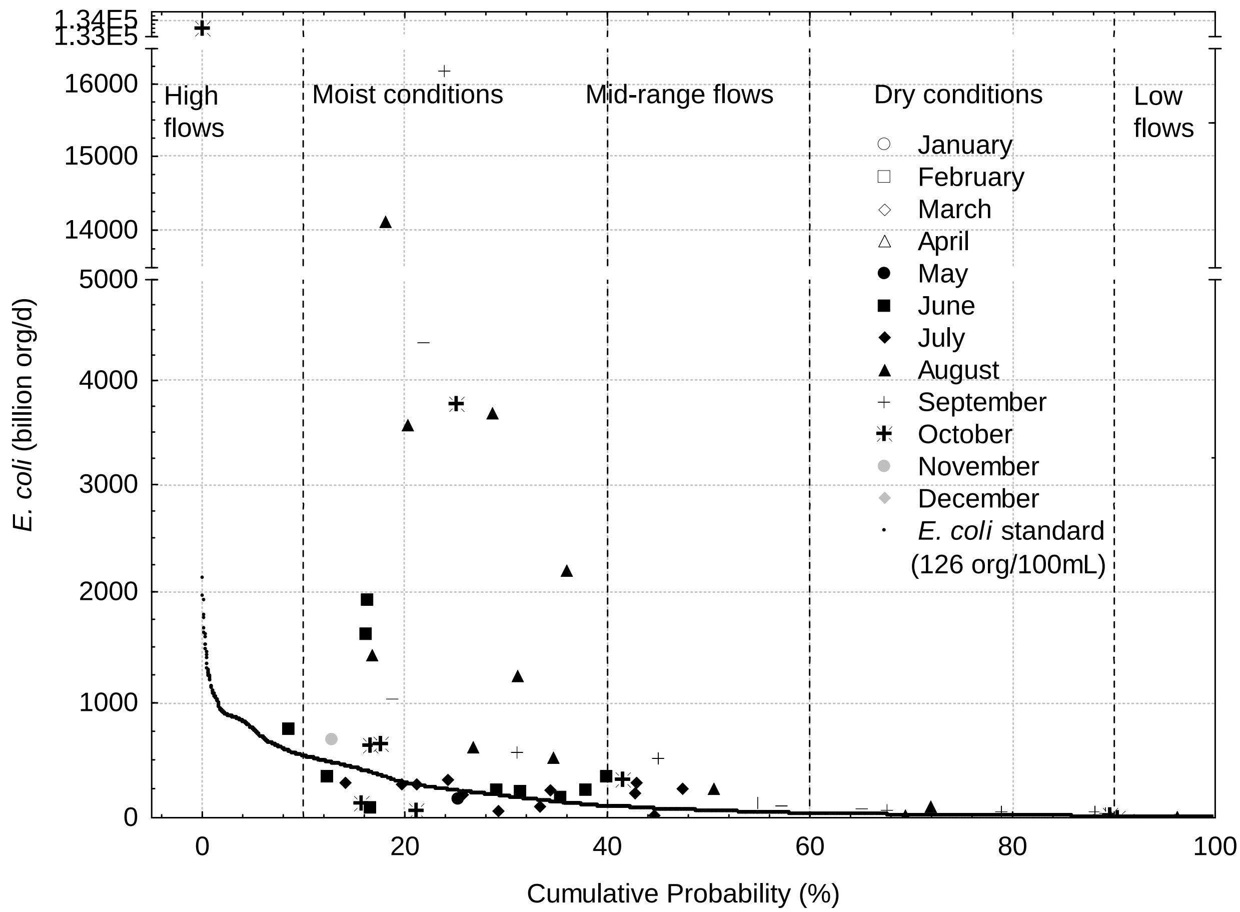

Figure 92. Load duration curve for *E. coli* at Minnehaha Creek.
Note scale breaks in y-axis.

Minnesota River (RM 843.9)

The Minnesota River within the study area (AUID 07020012-505) is known to be impaired for aquatic recreation due to fecal coliform. The river experiences exceedances during every month except for April and May when high flows are most common (Figure 93). In particular, January and February each have 5 exceedances. A total of 26% (35/134) of monitored data exceeds the standard loading.

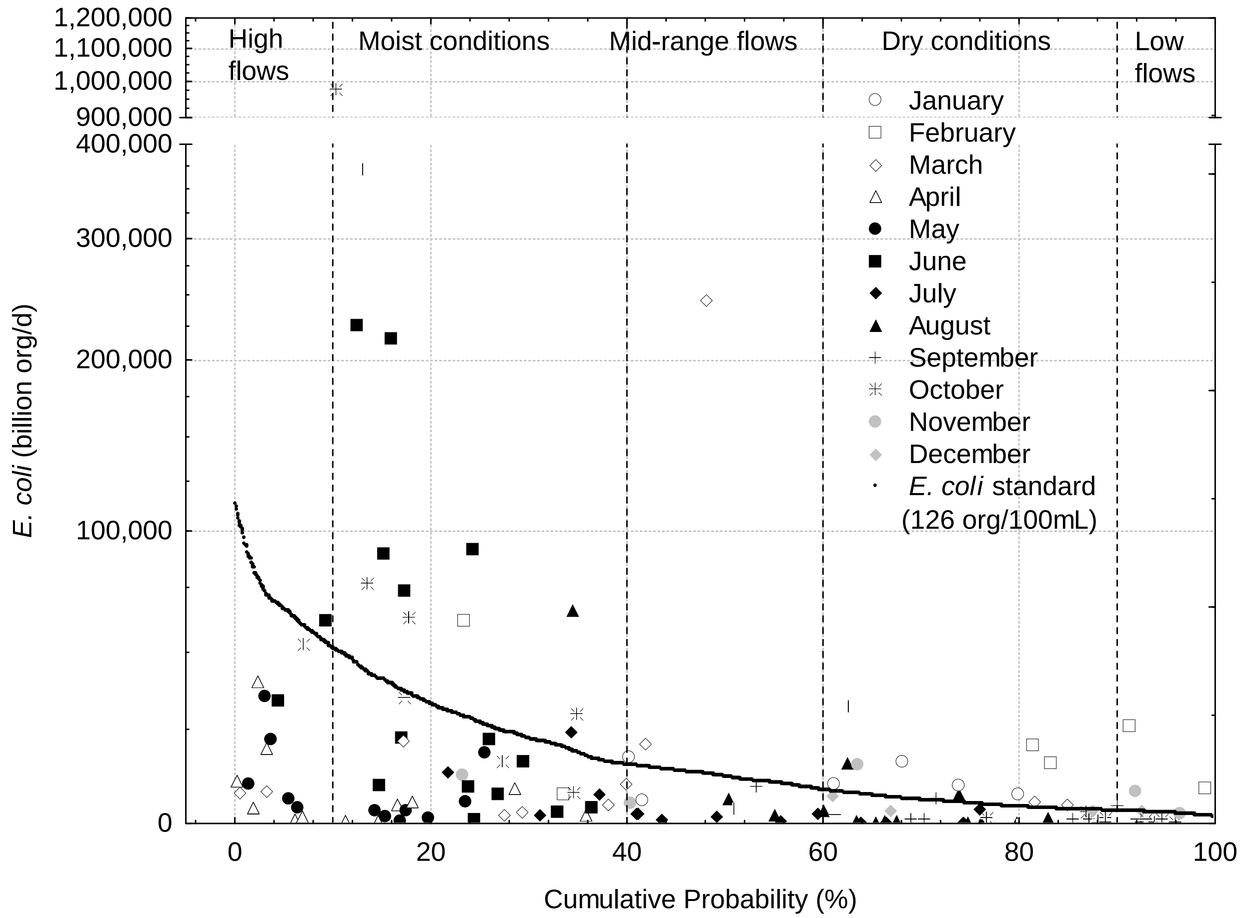

Figure 93. Load duration curve for *E. coli* at Minnesota River.
Note scale breaks in y-axis.

East Kittsondale Storm Sewer (RM 841.6)

East Kittsondale storm sewer enters the Mississippi River at RM 841.6; however, this particular monitoring point is located 1.1 miles upstream of the outfall and experiences additional inflows prior to discharge (see Table C - 1 in Appendix C). The single site for which there is data on this storm sewer experiences 92% (34/37) exceedances, the highest of all tributaries for which data are available (Figure 94). Minnehaha Creek follows in second at 76% exceedances. Exceedances occur in April through November peaking with six each in July and August.

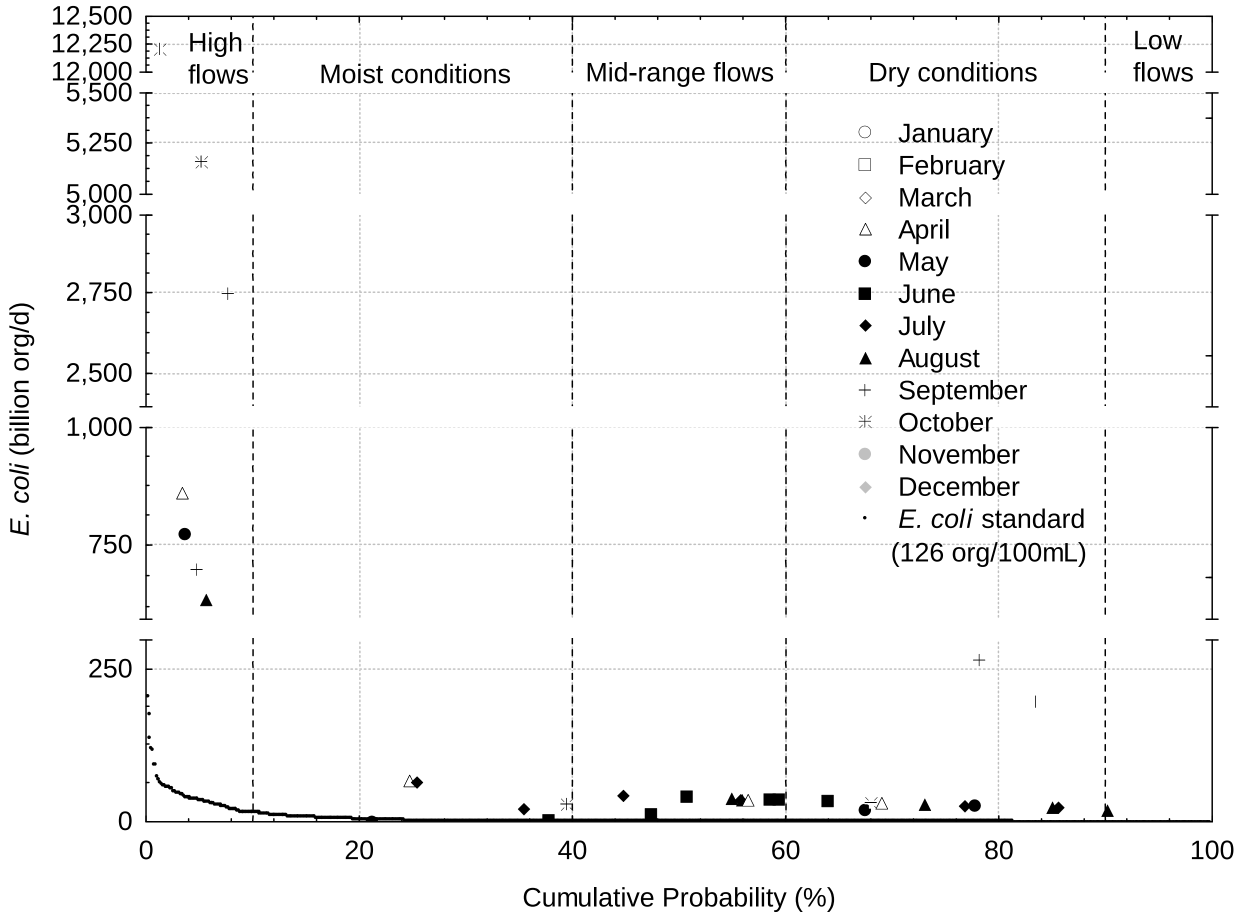

Figure 94. Load duration curve for *E. coli* at East Kittsondale storm sewer upstream of outfall to Mississippi River.
Note scale breaks in y-axis.

Phalen Creek Storm Sewer (RM 838.3)

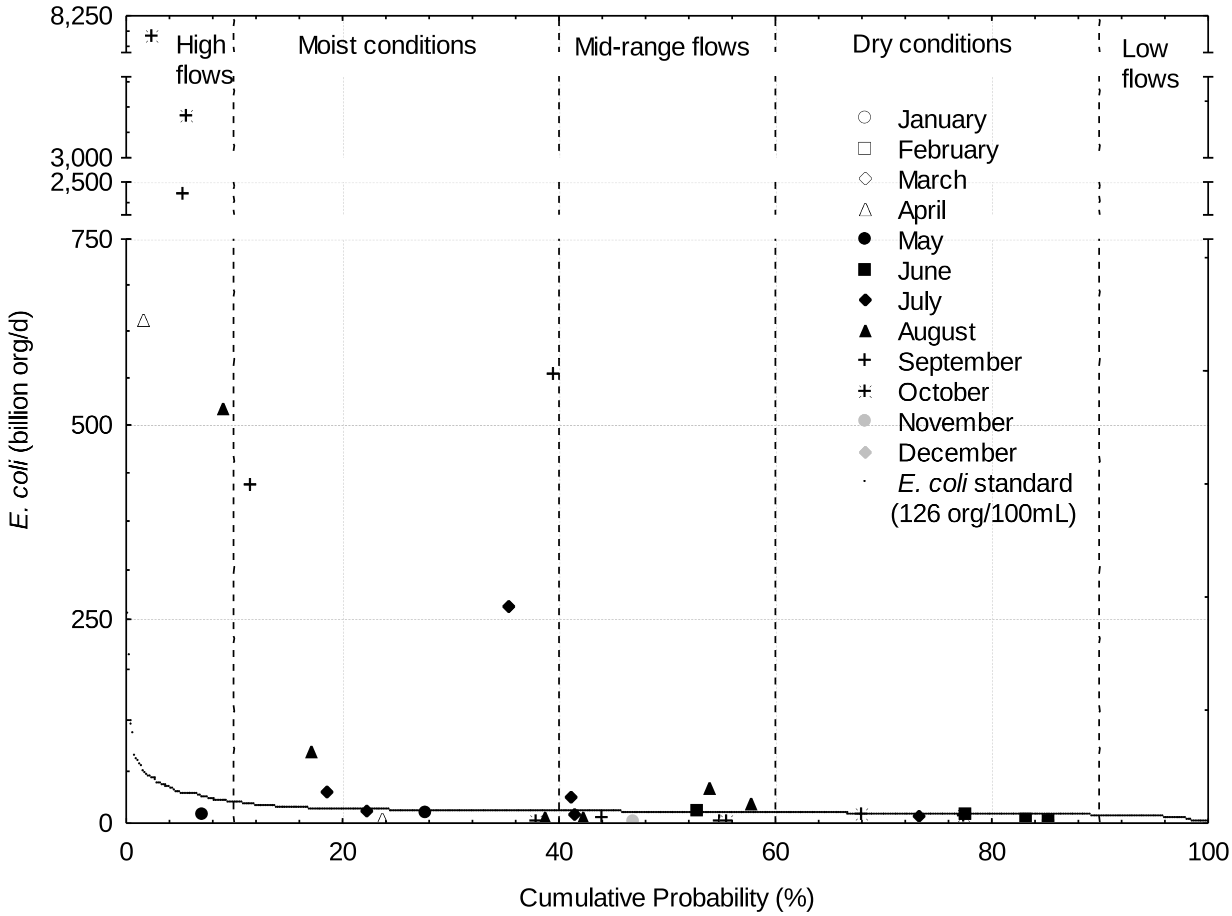

Figure 95Figure 95 illustrates the LDC analysis for Phalen Creek storm sewer. A total of 42% (14/33) of monitored data exceeds the standard loading. The monthly timing of exceedances show no apparent trend and occur during April (1), and June through October (13).

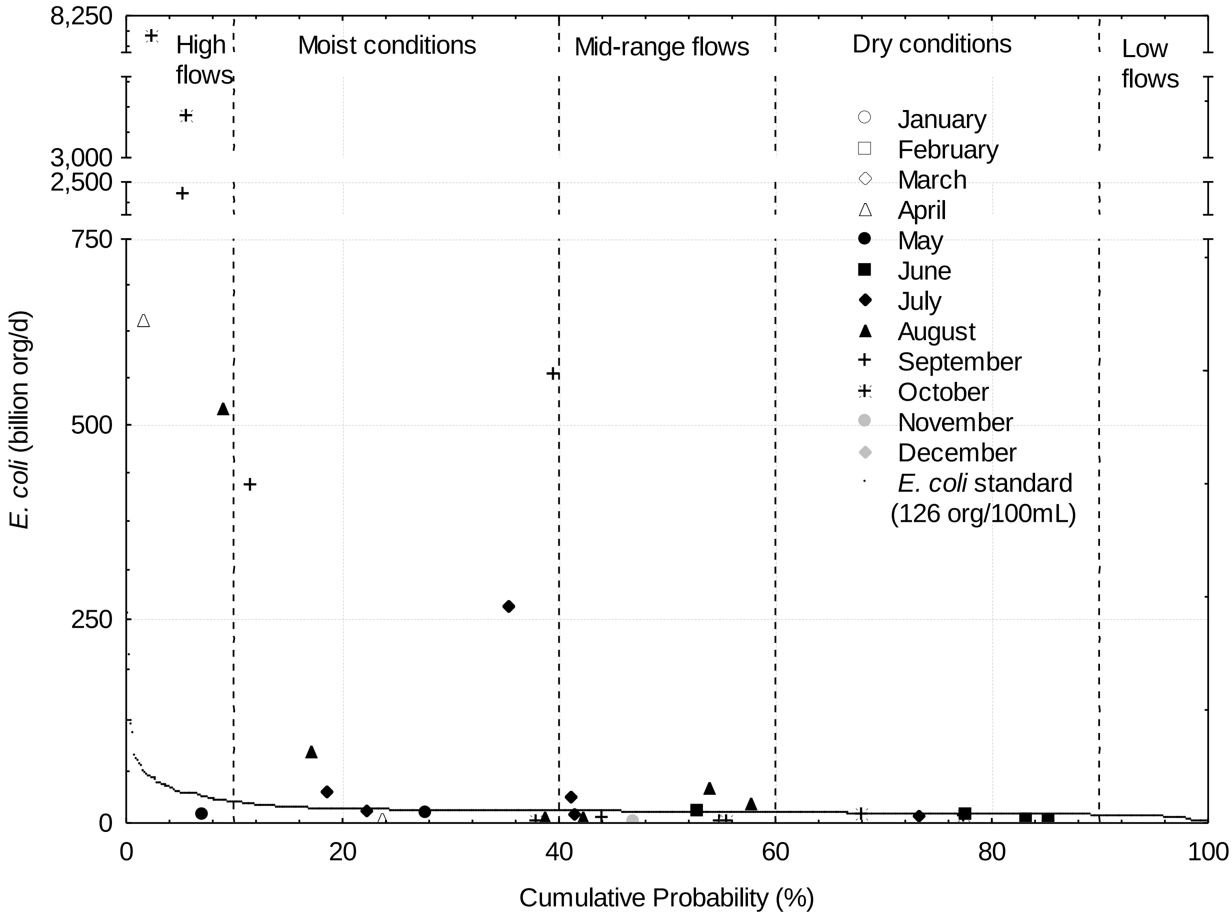

Figure 95. Load duration curve for *E. coli* at Phalen Creek storm sewer.
Note scale breaks in y-axis.

Trout Brook Storm Sewer (RM 838.3)

Trout Brook storm sewer enters the Mississippi River within the same tenth of a mile as Phalen creek storm sewer. Trout Brook experiences the third highest percent of exceedances as shown in the LDC analysis (Figure 96). A total of 70% (26/37) of monitored data exceeds the standard loading. Exceedances are experienced in April through October with increasing occurrences into the fall; 16 occur in August through October.

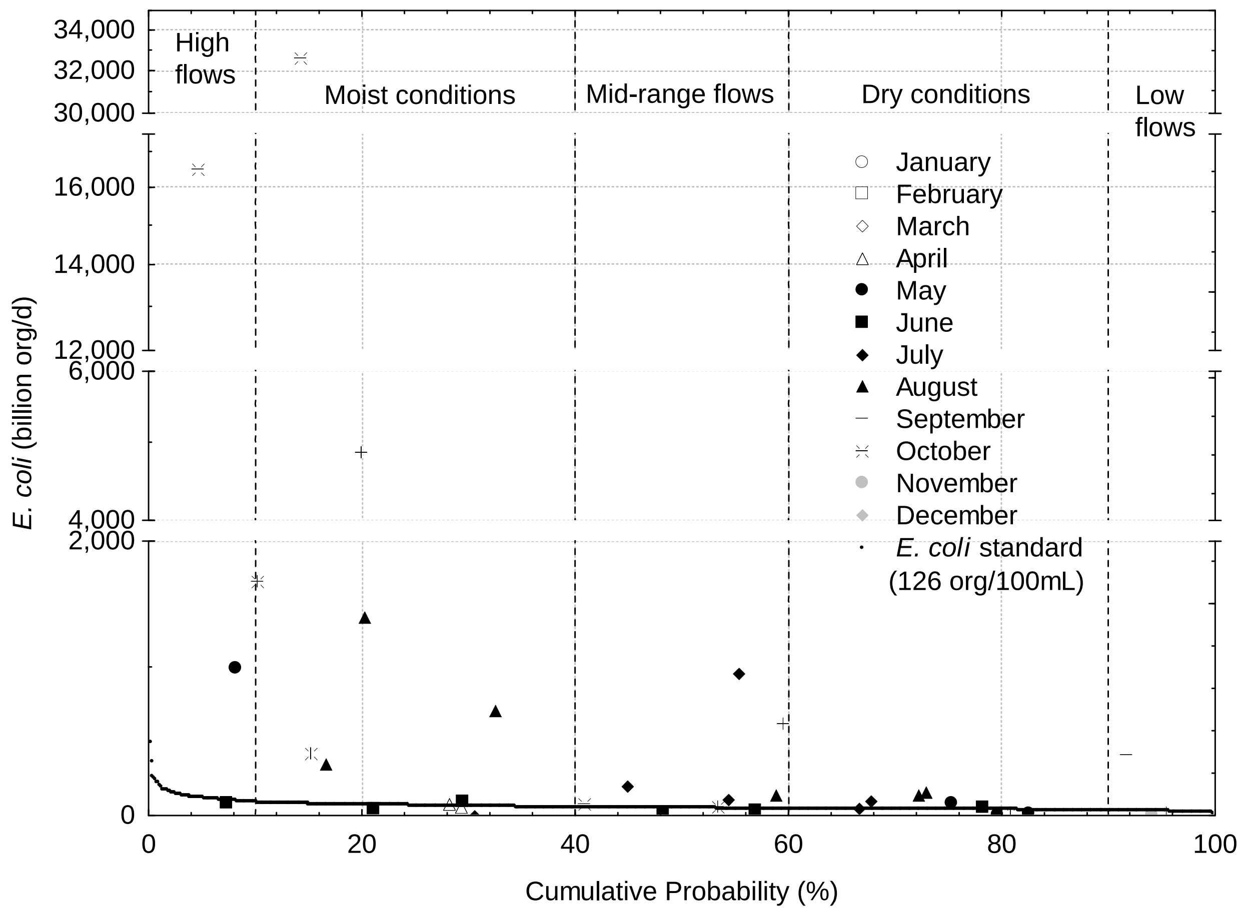

Figure 96. Load duration curve for *E. coli* at Trout Brook storm sewer.
Note scale breaks in y-axis.

F. Surrogates Analysis

It is apparent that *E. coli* monitoring data are not available at all monitoring sites where water quality data are collected. However, a few parameters that are commonly collected, in particular, temperature, turbidity, total suspended solids (TSS), and total phosphorus (TP), are known to affect *E. coli* concentrations. For the purposes of this study, data from the Mississippi mainstem were queried for sites having both *E. coli* data as well as temperature or turbidity. Temperature and turbidity were assumed to be the most likely candidates as surrogates (see *Literature Summary of Bacteria - Environmental Associations* available soon as part of this overall project). The five sites having the longest dataset within the study period from 1999 through 2008 were used to conduct correlation analyses in order to determine if there is a possibility that either temperature, TSS, or turbidity could serve as a surrogate for *E. coli*. Surrogates could then be used at monitoring stations for which *E. coli* data are limited or unavailable.

Temperature

Table 15 summarizes the results of the correlation analysis between *E. coli* and temperature. *E. coli* and temperature data were paired in three ways to identify the differences in results. Raw data were paired by the date of the sample. Mean temperatures and geometric mean *E. coli* were summarized and paired in two ways: by month and year and by month across all years. R-squared values are very low in all cases except that of data paired by month across all years. However, none of the correlations are statistically significant.

Table 15. Surrogates correlation analysis between *E. coli* and temperature.

	Data paired by date				Data paired by month and year				Data paired by month across all years			
Mississippi River Site (RM)	R-squared value	p-value	No. of data points	Pos. (+) or Neg. (-) Corre-lation	R-squared value	p-value	No. of data points	Pos. (+) or Neg. (-) Corre-lation	R-squared value	p-value	No. of data points	Pos. (+) or Neg. (-) Corre-lation
859.1	0.0000	0.9120	289	+	0.0219	0.3824	37	+	0.1525	0.3864	7	+
857.6	0.0001	0.8838	298	+	0.0000	0.9922	40	-	0.0493	0.5971	8	+
854.9	0.0029	0.3487	300	+	0.0007	0.8709	39	+	0.1814	0.2928	8	+
852.2	0.0032	0.3822	244	+	0.0492	0.2305	31	-	0.0286	0.6890	8	+
849.9	0.0001	0.9066	278	-	0.0280	0.3222	37	-	0.0001	0.9853	8	+
848.1	0.0008	0.6930	198	+	0.0045	0.7507	25	+	0.1089	0.4699	7	+

Figure 97 and Figure 98 illustrate two of the correlations paired by date. Figure 99 illustrates one of the correlations paired by month across all years. Data are spread in a narrow vertical band along low *E. coli* values and the scarce high *E. coli* measurements tend to pull the linear fit in one direction or another.

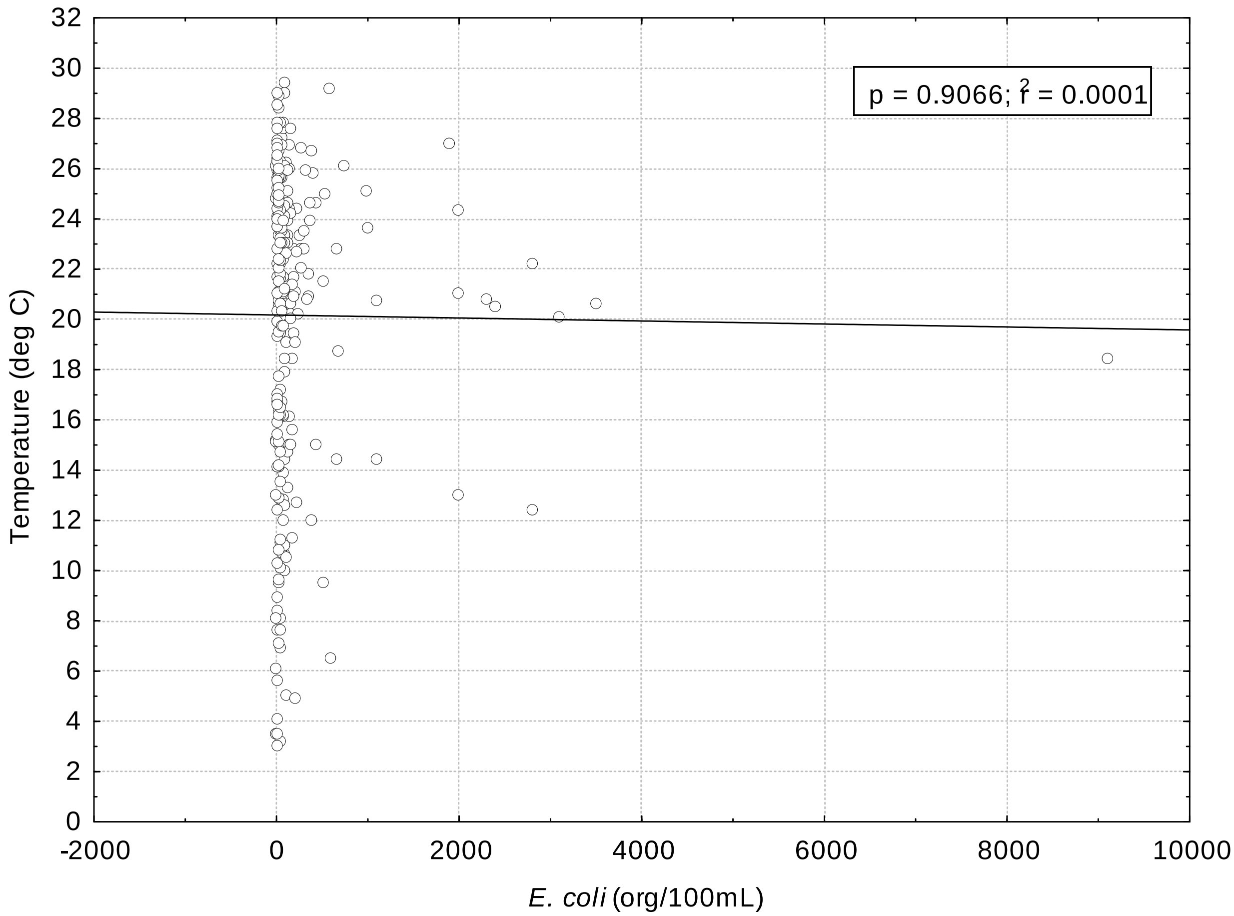

Figure 97. Correlation between daily temperature and *E. coli* at RM 849.9.

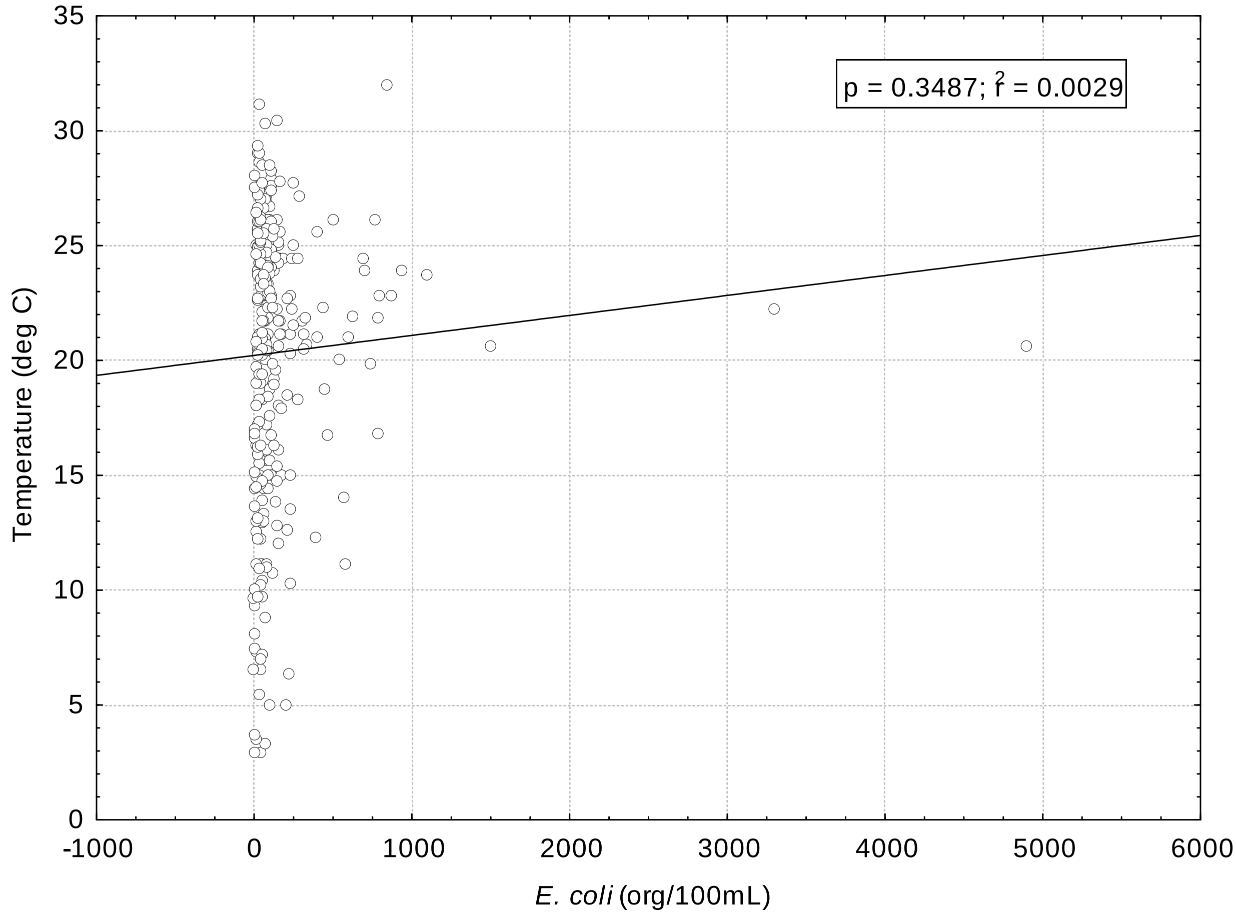

Figure 98. Correlation between daily temperature and *E. coli* at RM 854.9.

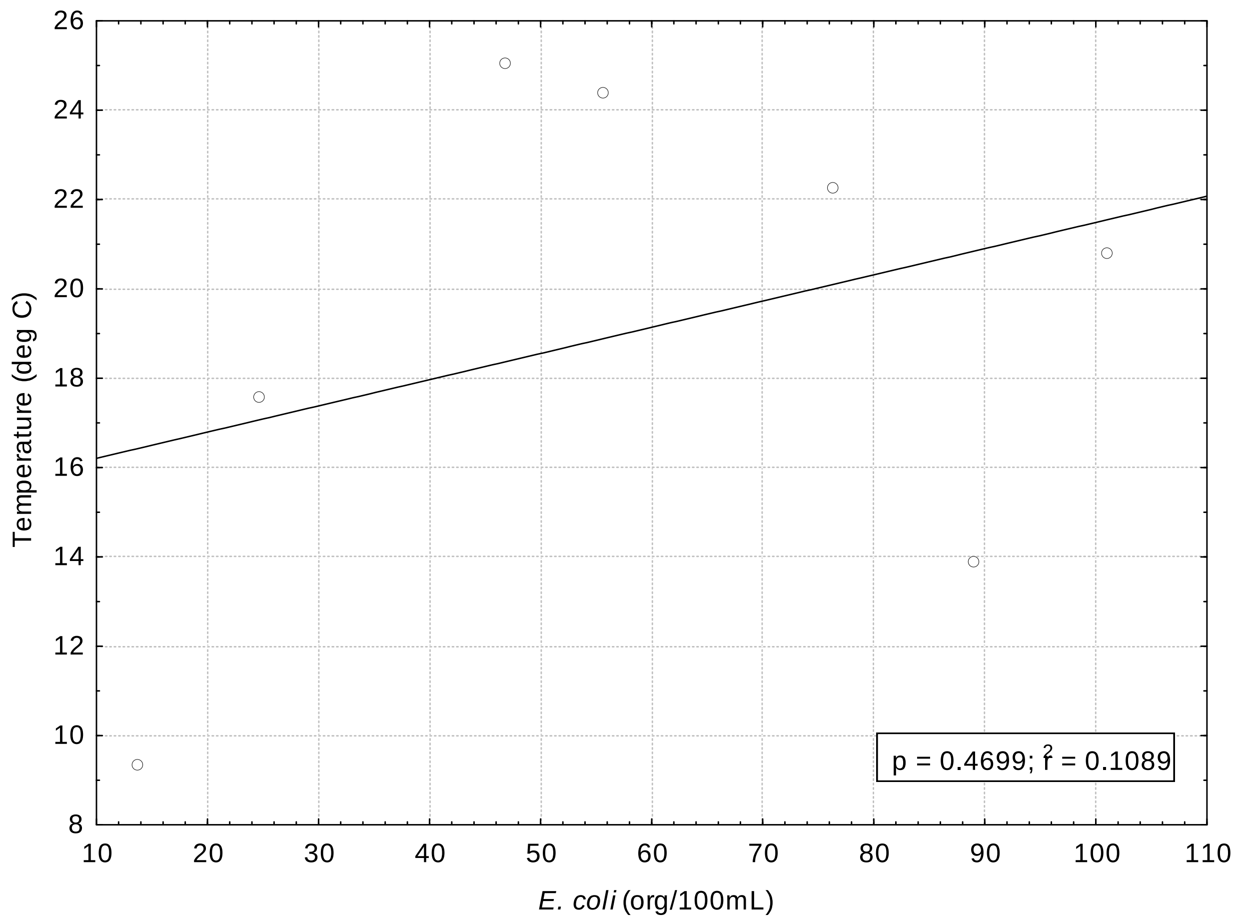

Figure 99. Correlation between temperature (mean) and *E. coli* (geometric mean) paired by month across all years at RM 848.1.

Total Suspended Solids (TSS)

Table 16 summarizes the results of the correlation analysis between *E. coli* and TSS. R-squared values are higher than that of the temperature analysis, and two of the correlations (RM 953.5 and 896.9) are statistically significant at the 95% confidence level (p-value < 0.05). However, one of these two correlations shows a positive correlation while the other shows a negative. Figure 100 and Figure 101 illustrate these two correlations.

Table 16. Surrogates correlation analysis between *E. coli* and TSS.

Mississippi River Site (RM)	R-squared value	p-value	No. of data points	Pos. (+) or Neg. (-) Correlation
953.5	0.3348	0.0119	18	-
914.0	0.0088	0.7022	16	+
896.9	0.3166	0.0121	17	+
858.8	0.0101	0.7222	15	+
839.7	0.3006	0.0524	13	+
815.2	0.0875	0.3044	14	+

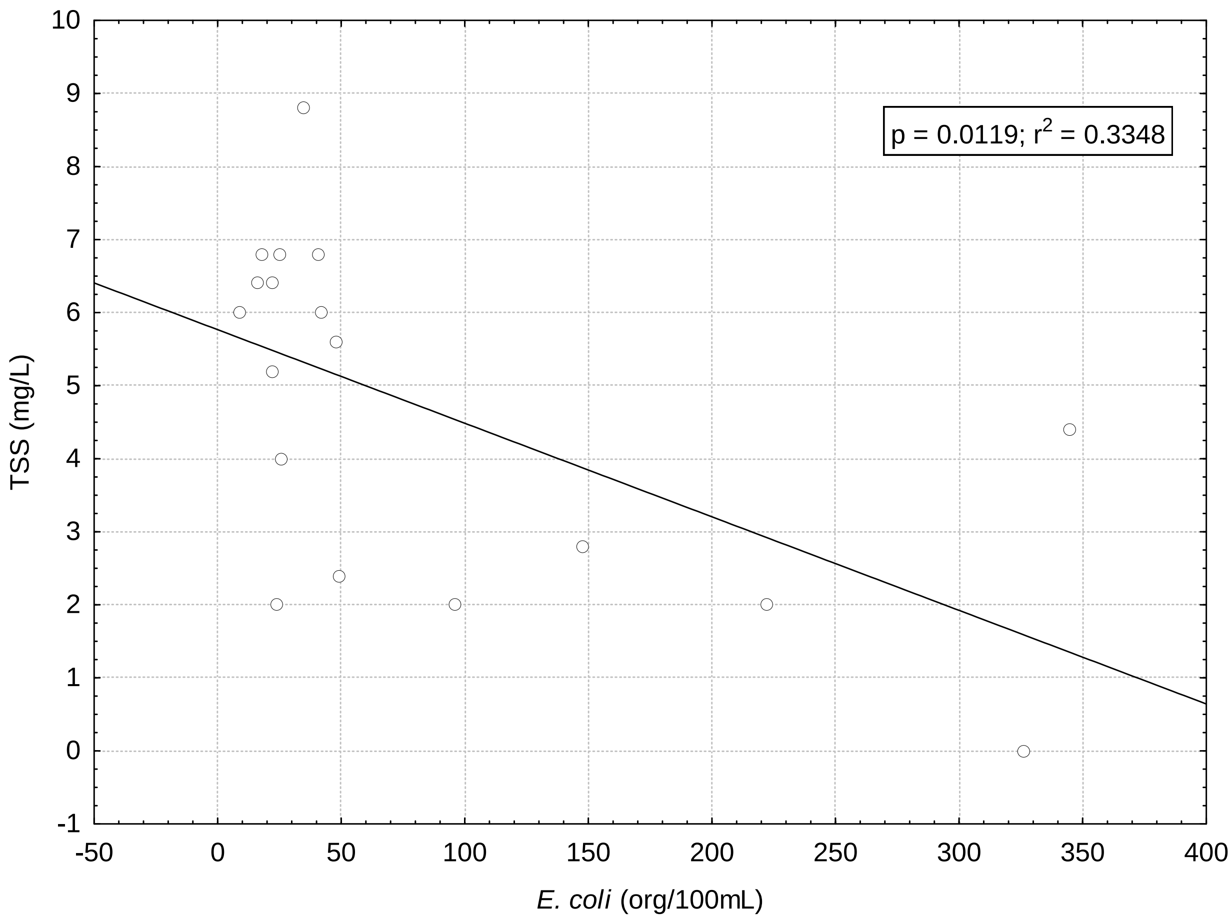

Figure 100. Correlation of daily TSS and *E. coli* at RM 953.5.

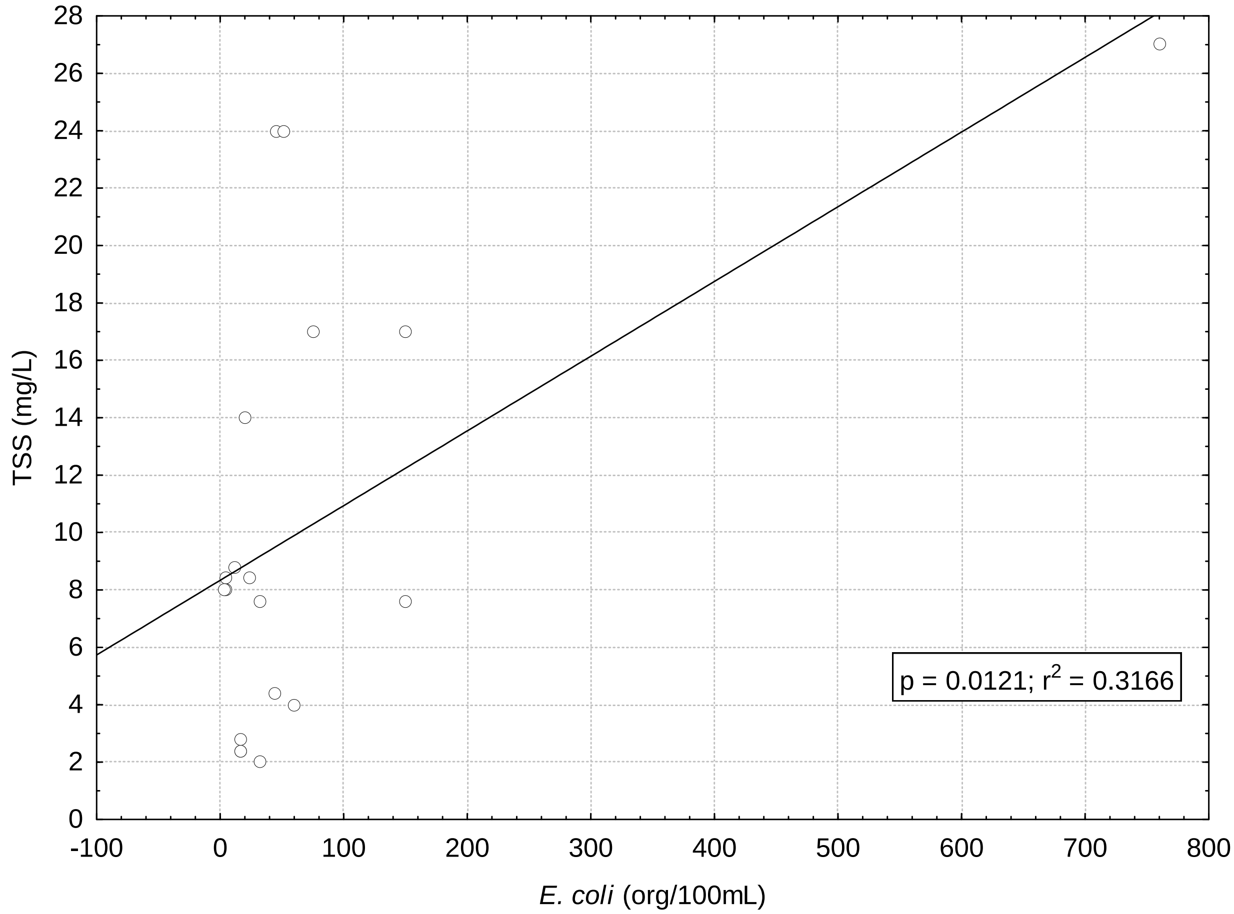

Figure 101. Correlation of daily TSS and *E. coli* at RM 896.9.

<u>Turbidity</u>

Table 17 summarizes results from the correlation analysis between *E. coli* and turbidity. None of the correlations were statistically significant. At any single RM, the highest R-squared value was 0.1071 at RM 839.7. Data indicate that turbidity alone is not a surrogate for *E. coli*.

Table 17. Surrogates correlation analysis between *E. coli* and turbidity.

Mississippi River Site (RM)	R-squared value	p-value	No. of data points	Pos. (+) or Neg. (-) Correlation
953.5	0.0659	0.3558	15	-
896.9	0.0289	0.4736	20	+
858.8	0.0157	0.6205	18	-
839.7	0.1071	0.1998	17	+
826.4	0.0074	0.7611	15	+
815.2	0.0015	0.8902	15	+

Figure 102 through Figure 104 illustrate the correlation at three of the Mississippi RMs. Data are more spread and scarcer than data in the temperature correlation analysis. Figure 104 illustrates that a single data point pulled this R-squared value into the higher positive territory.

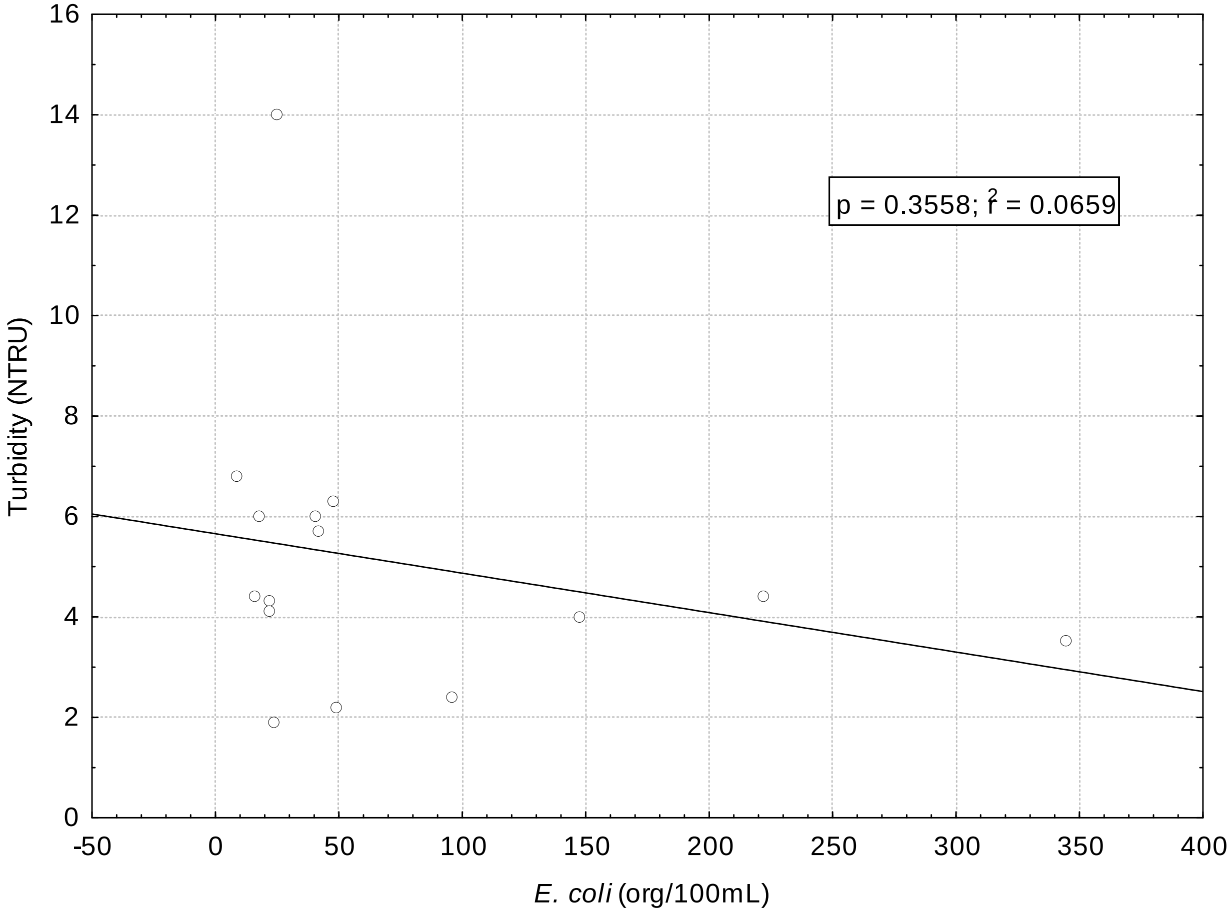

Figure 102. Correlation of daily turbidity and *E. coli* at RM 953.5.

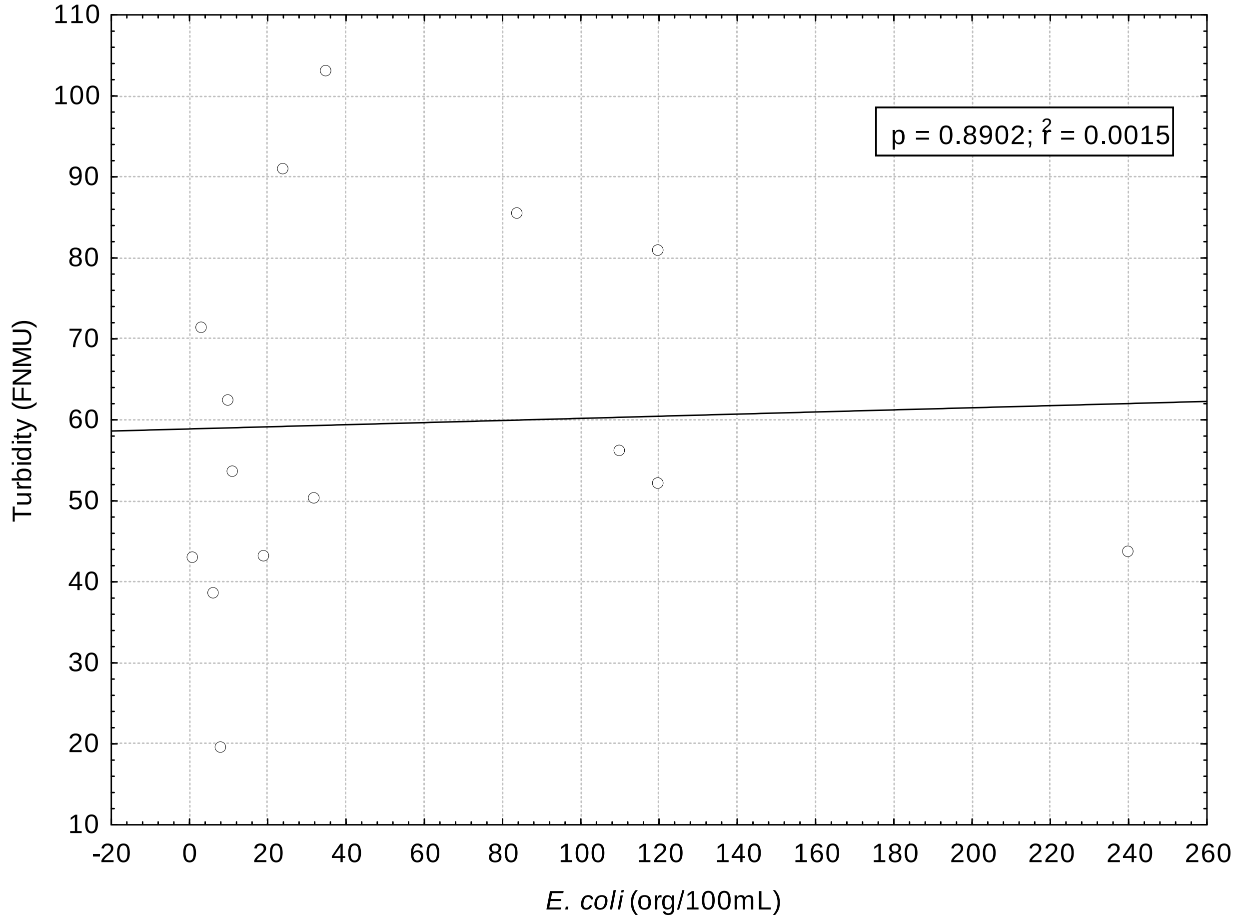

Figure 103. Correlation between daily turbidity and *E. coli* at RM 815.2.

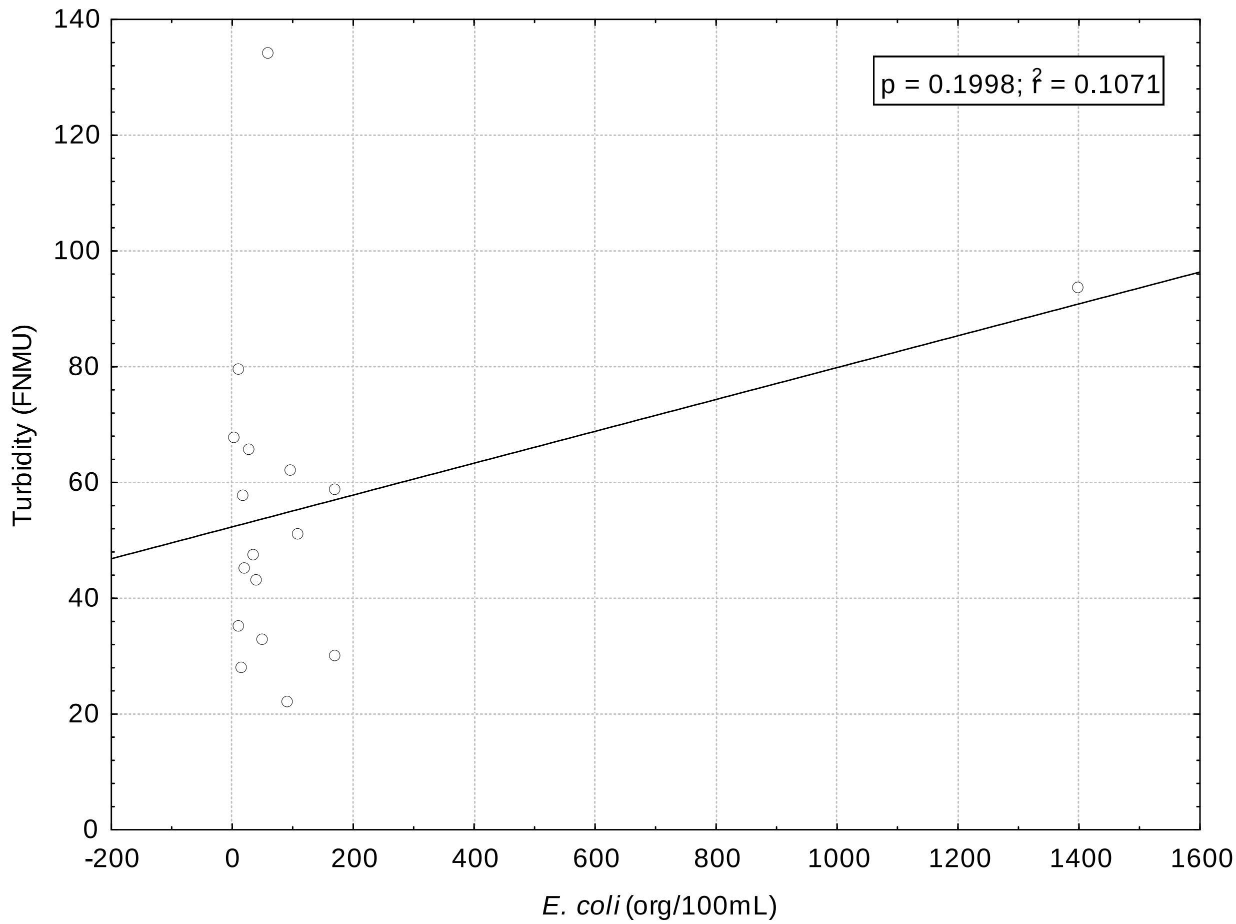

Figure 104. Correlation between daily turbidity and *E. coli* at RM 839.7.

G. WATER QUALITY ANALYSIS SUMMARY

The following list represents a compilation of the preliminary trends and findings from the water quality analysis on data available from all or portions of the period of study from 1999 through 2008 (See *Section 3.D. Mississippi Mainstem: Analysis by River Mile* and *Section 3.E. Tributaries and Storm Sewers* for summary tables). Findings are preliminary due to the variability of the data including frequency, seasonality, and collection and analysis protocols.

- Data at individual RMs often show increasing bacteria concentrations into the fall: RM 929.4, 859.1, 858.8, 857.6, 854.9, 852.2, 847.7, 839.1 and 826.7. In several cases, this trend appears only after 2004.
- High winter concentrations are not uncommon among sites having winter data. In particular, RM 863.0 and 815.6 experience high winter concentrations. Data from a downstream site on the Minnesota River also experiences high winter concentrations. Several water quality monitoring sites do not have winter data.
- Bacteria concentrations along the Mississippi River mainstem peak around the metropolitan area.
- Increases in bacteria concentrations between adjacent monitoring sites along the Mississippi River mainstem mainly occur in late summer and fall and never occur in the spring. Mississippi RMs 858.5, 839.1, and 831.0 experience increases in bacteria concentrations between adjacent monitoring sites only during winter months.
- Tributary sites tend to experience more exceedances above the *E. coli* standard than Mississippi River mainstem sites.
- Storm sewer data available from only four sites (out of hundreds of outfalls to the Mississippi River in the project area) exhibit high *E. coli* concentrations and experience some of the greatest percent exceedances of all monitoring sites.
- Exceedances in *E. coli* concentrations above the standard (126 org/100mL) are experienced under all flow regimes demonstrating no clear pattern; this suggests a mix of bacteria sources including, but not limited to, the possibility that in-stream processes are significant. The lack of trends is especially apparent, and expected, on mainstem, large river data; it is a function of the inherent convergence of a variety of bacteria sources and flow regimes from both local and regional watersheds.
- Data indicate that neither temperature, TSS nor turbidity alone is a surrogate for *E. coli*.
- Annual trends in geometric mean bacteria concentrations of AUIDs indicate a relatively common decrease in *E. coli* and fecal coliform concentration in the years 2006 and 2008 as compared to the year before. Increases are less common.

4. SOURCE ASSESSMENT

The different types of potential sources of bacteria from fecal contamination are presented in this section, along with a description and qualitative analysis of these sources in the study area. If further data collection regarding the sources is warranted in future phases of this project, **potential next steps** are presented for each source. In some cases, the potential next steps apply to **priority watersheds**; these priority watersheds will be defined in future phases and will depend on multiple factors, such as the following:

- If a bacteria TMDL study is already in progress for the watershed, the watershed will not be considered a priority since source assessment data should be already being assembled for the study.
- If available monitoring data suggest that the watershed serves as a substantial source of bacteria to the Mississippi River, the watershed will be considered a priority watershed.
- Watersheds that are located relatively close to the Mississippi River and are directly connected to the river will be considered priority watersheds due to the likelihood that bacteria from the watershed in question reach the river.

The following sources of data were used to compile the potential source assessment:

- MPCA Delta Database (information provided through the MPCA Data Desk), which provides permitted and registered sources.
- Small Community Wastewater Needs in Minnesota (MPCA 2008)
- Metropolitan Council Environmental Services Interceptor Services GIS
- USDA National Agricultural Statistics Service land cover database
- DNR designated Wildlife Management Areas

The Incident Management Application (IMA) Report database is available through the MPCA. This database includes all complaints and incidents that are reported to the MPCA related to illicit and permitted discharges (air and water), wastewater bypasses, sewage back ups, permit violations, equipment failures, infrastructure abandonments, among other types of incidents. The database includes reports from 1999 to present with over 17,000 records from all over the State of Minnesota.

Potential Next Steps: Query the Incident Management Activity Report database to narrow down the incidents related to bacteria contamination in priority watersheds of the study area.

A. HUMANS

Fecal coliform is present in human waste and can be input to surface waters from illegal or leaky sanitary sewer connections, poorly functioning septic systems, and poorly functioning wastewater treatment facilities (WWTFs). Individual sewage treatment systems that are not functioning properly allow untreated or partially treated sewage to go directly into waterways on a regular basis while emergency bypasses from wastewater treatment facilities are an occasional source of bacteria and other pollutants. Preventing inadequately treated human waste from entering waterways should be a high priority, as human pathogens are found to be highly communicable.

Subsurface Sewage Treatment Systems (SSTS)

A survey was distributed to Minnesota counties in 2006 with the purpose of developing a listing of small communities with wastewater needs. Data available for the current status of non-sanitary sewer based treatment systems in the state is limited to what was reported in the survey results (*Small Community Wastewater Needs in Minnesota*, MPCA 2008) along with individual county, township, and Metropolitan Council databases if they exist. The *Small Community Wastewater Needs in Minnesota* report presents results of the survey; these survey results have not been ground-truthed.

The small community wastewater needs survey recognized a small community as a cluster of five or more homes and businesses, on lots typically less than one acre in size, suspected or known to be in need of effective wastewater treatment. Wastewater treatment areas of concern could be due to no treatment system, straight pipes and other surfacing systems, old systems, poor soils, or small lots. Eight of the counties that have area contributing to the study area do not have data for small community needs. These counties comprise approximately 24% of the study (Upper Mississippi Bacteria TMDL project) area and are shown in gray in Figure 105. The survey identified 141 communities as having some type of wastewater need.

The *Small Community Wastewater Needs in Minnesota* report includes a 12-year history of wastewater implementations throughout the state; the database of implemented wastewater improvements is updated annually. Three un-sewered communities implemented wastewater improvements within the study area between 1997 and 2008 (Figure 105).

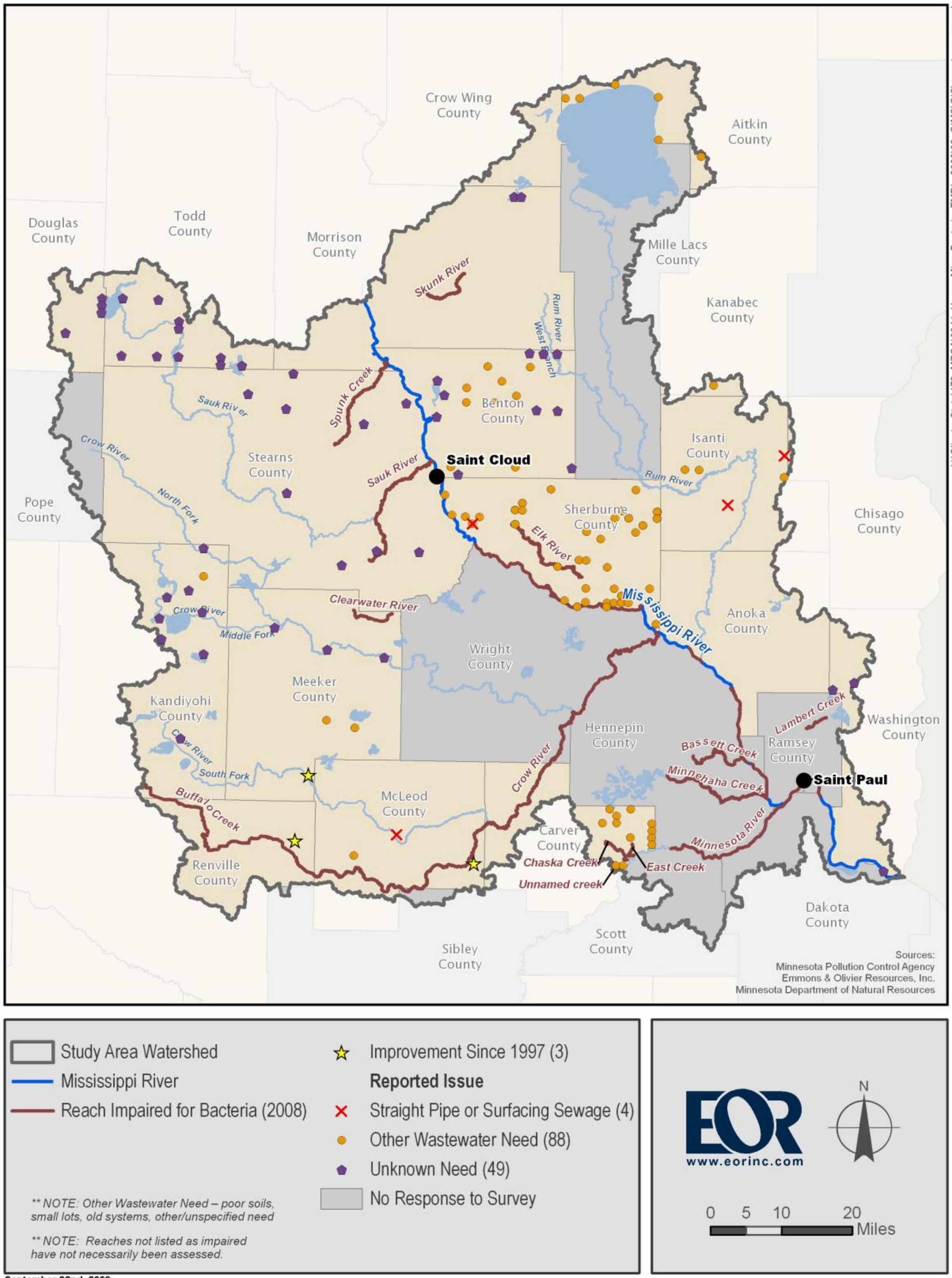

Figure 105. Small Community Wastewater Needs
Data from *Small Community Wastewater Needs in Minnesota* (MPCA 2008).

Individual & Community Septic Systems

According to the 2007 American Housing Survey, twenty-two percent of households in the Midwest depend on onsite or small community cluster systems to treat wastewater. In many cases, these systems are installed and forgotten until problems arise. Residential lots in small communities throughout Minnesota cannot accommodate modern septic systems that meet the requirements of current codes due to small lot size and/or inadequate soils. Development pressures in lake communities add to the problem as well as cabins that occupy a large footprint on small lake lots. In addition, many small communities are characterized by outdated, malfunctioning septic systems serving older residences. Small lots, poor soils, and inadequate septic system designs and installations may be implicated in bacterial contamination of groundwater but the link to surface water contamination is tenuous. Within the Upper Mississippi watershed, of the 141 communities identifying some type of wastewater need, 137 communities reported wastewater needs due to poor soils, small lots, aged systems, or other unspecified needs. The community of Long Lake in Sherburne County reported surfacing sewage as of the 2008 survey. Community septic systems that discharge greater than 10,000 gallons per day are required to obtain an NPDES discharge permit. Fifteen permitted community systems are identified in the study area (Figure 106).

Potential Next Steps: Determine degree of small community needs for counties with no data in priority subwatersheds. Ground truth high priority needs in priority subwatersheds.

Straight Pipes

The use of straight pipes to convey sewage away from homes was the first infrastructure step toward sewage treatment in individual, community, and municipal systems. In agricultural regions, where the land has been drained for crop production, drain tile lines were commonly used to convey sewage away from homes and businesses to the edge of town, combining sewage with ground and surface water. This resulted in the “community” straight pipes that occur in Minnesota. Straight pipes pose an imminent threat to public health as they convey raw sewage from homes and businesses directly to surface water. Community straight pipes are more commonly found in agricultural cross-road communities. Within the Upper Mississippi watershed, the communities of Biscay in McLeod County, Long Lake and Lake Francis in Isanti County reported wastewater needs due to straight pipe systems as of 2008 (Figure 105).

Potential Next Steps: Identify straight pipe systems in counties for which no data have been collected. Determine degree of small community wastewater needs due to straight pipes in priority subwatersheds that could be directly contributing raw sewage. Ground truth high priority needs in priority subwatersheds.

Septage Application

A state subsurface sewage treatment system (SSTS) license applicable to the type of work being performed is required for any business that conducts work to design, install, repair, maintain, operate, or inspect all or part of an SSTS. A license is also required to land spread septage and operate a sewage collection system discharging to an SSTS. Disposal contractors are required to properly treat and disinfect septage through processing or lime stabilization. Treated septage may then be disposed of onto agricultural and forest lands. EPA Standards Section 503 provides general requirements, pollutant limits, management practices, and operational standards for the final use or disposal of septage generated during the treatment of domestic sewage in a treatment works. The management practices require that septage application remain greater than 10 meters from waters of the United States, as defined in 40 CFR 122.2, unless otherwise permitted. To prevent septage from entering wetlands or other waters of the United States, septage may not be applied to sites that are flooded, frozen, or snow-covered. Standards for the density of fecal coliform in the septage are as follows: Fecal coliform shall be less than 1000 MPN (most probable number) per gram of total solids (dry weight basis), or the density of *Salmonella sp.* bacteria shall be less than three MPN per four grams of total solids (dry weight basis) at the time it is used or disposed, at the time it is prepared for sale or give away in a bag or other container for application to the land, or at the time the septage or material derived from septage is prepared to meet the requirements in 503.10 (b), (c), (e), or (f).

> **Potential Next Steps**: Contact local units of government within priority subwatersheds to inventory application codes or ordinances, methods of tracking and reporting, and compliance with regulatory standards and protocols.

Municipal Wastewater

There are 96 wastewater treatment facilities (WWTFs) located within the study area (Figure 106). WWTFs are required to test fecal coliform bacteria levels in effluent on a weekly basis. Dischargers to class 2 waters are required to disinfect from April through October, and dischargers to class 7 waters are required to disinfect from May through October. Wastewater disinfection is required during all months for dischargers within 25 miles of a water intake for a potable water supply system (Min. Rules Ch. 7053.0215, subp. 1). The geometric mean for all samples collected in a month must not exceed 200 cfu/100 ml fecal coliform bacteria.

<u>Wastewater Treatment Facility Bypasses & Violations</u>

WWTF bypasses are emergency discharges of partially treated or untreated sewage. They occur during periods of heavy precipitation, when WWTFs become overloaded and typically last from a few hours to a few days. Violations are recorded if a WWTF's effluent exceeds the 200 cfu/100 ml fecal coliform bacteria.

> **Potential Next Steps**: Determine number and location of WWTFs that are greater than 25 miles from potable water supplies and are therefore not required to disinfect year round. Review WWTF permitted discharge limits and any records of WWTF bypasses and violations within priority subwatersheds.

Figure 106. Existing Wastewater Treatment Facilities and Community Septic Systems
Data from MPCA Data Desk.

Combined Sewer Overflow

Combined Sewer Overflows (CSO) occur when heavy rain or melting snow causes sanitary sewers, which are normally diverted to the wastewater treatment plant, to overflow into stormwater drainpipes and out to the Mississippi River. This allows sewage to mix with runoff from buildings, parking lots, and streets and flow untreated into the Mississippi River. The occurrence of a CSO can result in adversely affecting downstream use of the resource. Up to 1984 an estimated 4.6 billion gallons of untreated sewage and stormwater overflowed into the Mississippi River annually; on average it was estimated that discharges were occurring once every three days (American City and County 1996). CSOs have become relatively rare in Minneapolis and St. Paul. Both cities have been actively working on sewer separation since the 1960s. Federal and state mandates issued require that the two cities eliminate CSOs to the river. Of the original 34 overflow regulators (monitoring and flow control devices), there are eight remaining. In 1985, federal-state-city funding financed the CSO elimination program and a statutory 10-year deadline was established. When the federal grant funding program ended in 1991, the city of St. Paul and the state increased their funding to cover the shortfall and continued the program (American City and County 1996). According to MCES Interceptor Services GIS (March 2008), only one regulator remains in St. Paul at Third and Commercial Streets. The remaining combined sewers in Minneapolis are the most difficult and costly to remedy. Minneapolis has a target year of 2014 to eliminate all combined sewers (City of Minneapolis 2009).

Events of CSO overflows are recorded by MCES (Table 18). Information is available from MCES on the timing, quantity, and location of each overflow event as well. Although no overflows occurred in 2007, some CSOs are expected to occur during heavy rainfall events due to the fact that excessive inflow and infiltration (I and I) is discharged to the existing sanitary sewer system that is not designed to collect and transfer inflow and infiltration.

Table 18. Minneapolis/St. Paul Combined Sewer Overflow Events

Year	Number of Events	CSO Volume
1984	77 events	> 1 billion gallons
1998	5 events	2 million gallons
1999	5 events	25 million gallons
2000	7 events	57 million gallons
2001	3 events	40 million gallons
2002	3 events	1 million gallons
2003	5 events	7.96 million gallons
2004	4 events	2.2 million gallons
2005	7 events	3.1 million gallons
2006	5 events	431,000 gallons
2007	0 events	0 gallons
2008	0 events	0 gallons

(MCES, March 2008 Environment Committee Presentation)

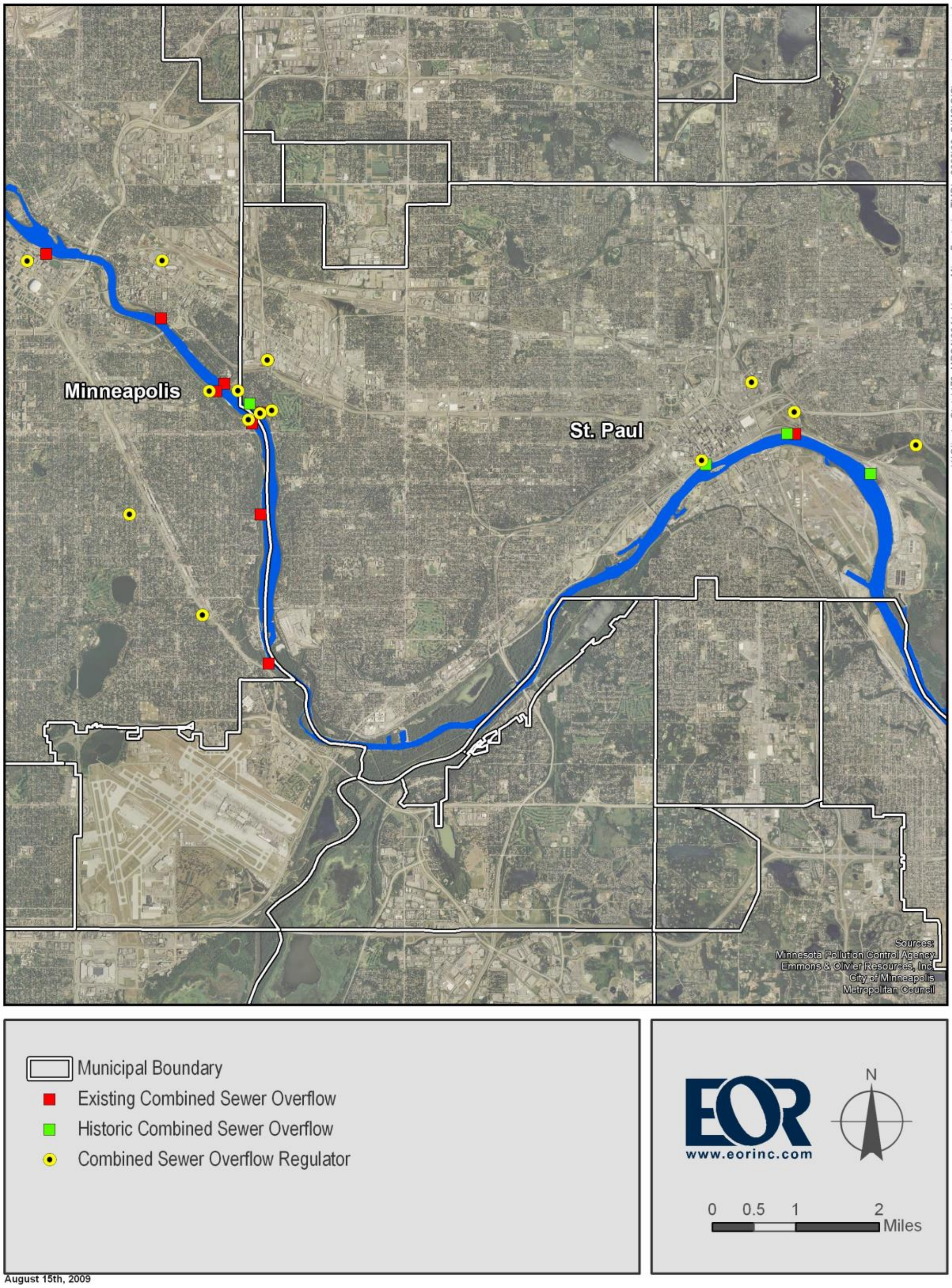

Figure 107. CSO Regulator Locations

Leaking Sanitary Sewers

Aging sanitary sewers have been shown to be leaky, with stormwater often entering into the sanitary sewer conveyance system (referred to as inflow and infiltration, or I&I). Considering the vulnerability of the sanitary sewers to I&I, it is also possible that untreated sewage inside of the pipes is leaking from the pipes into the ground and potentially entering the stormsewer conveyance system. This phenomenon was suggested as a cause of extensive human fecal contamination in separated storm drain systems in Santa Barbara, CA (Sercu *et al*. 2009).

Potential Next Steps: Investigate the potential for untreated sewage to enter stormsewer conveyance systems in sewered communities with aging infrastructure.

Biosolids

Application of biosolids from WWTFs follows the same regulations as septage application from SSTSs (see *Section 4.A. Septage Application*). However, whereas septage application is not highly tracked, the application of biosolids from WWTFs is highly regulated, monitored, and tracked.

Potential Next Steps: Investigate biosolids application sites within priority watersheds to determine if biosolids represent a substantial bacteria source to the impaired reaches.

B. LIVESTOCK

Feedlots

Animal waste containing fecal bacteria can be transported in stormwater to surface waters. The primary goal of the state feedlot program is to ensure that surface waters are not contaminated by the runoff from feedlots, manure storage or stockpiles, and cropland with improperly applied manure.

A feedlot is defined as an area intended for the confined holding of animals, where manure may accumulate, and where vegetative cover can not be maintained within the enclosure due to the density of animals. Feedlots that either (a) have a capacity of 1,000 animal units or more, or (b) meet or exceed the EPA's Concentrated Animal Feeding Operation (CAFO) threshold, are required to apply for coverage under an NPDES/SDS permit for livestock production from the MPCA. The permit requires that the feedlots have zero discharge to surface water and therefore should not be a contributing source of bacteria. However, they are included in the potential source inventory considering that not all permitted feedlots may be meeting the permit's conditions.

Feedlots with greater than 50 animal units, or greater than 10 animal units in shoreland areas, are required to register with the State of Minnesota. Estimates of the numbers of animal units in registered feedlots are available from the MPCA. All NPDES-permitted feedlots are also registered with the state. Feedlots with fewer than 1,000 animal units but greater than 50 animal units (or 10 animal units in shoreland areas) are registered with the state but not permitted (through the NPDES program).

Based on MPCA's feedlot database, there are an estimated 30 NPDES-permitted open feedlots and 7,541 registered open feedlots not requiring NPDES coverage within the study area.

Potential Next Steps: Review NPDES-permitted feedlots for discharge violations and identify probable issues with non-permitted feedlot activities in priority subwatersheds and within close proximity to surface water and conveyances to waters of the state. Areas near known bacteria exceedances should be prioritized.

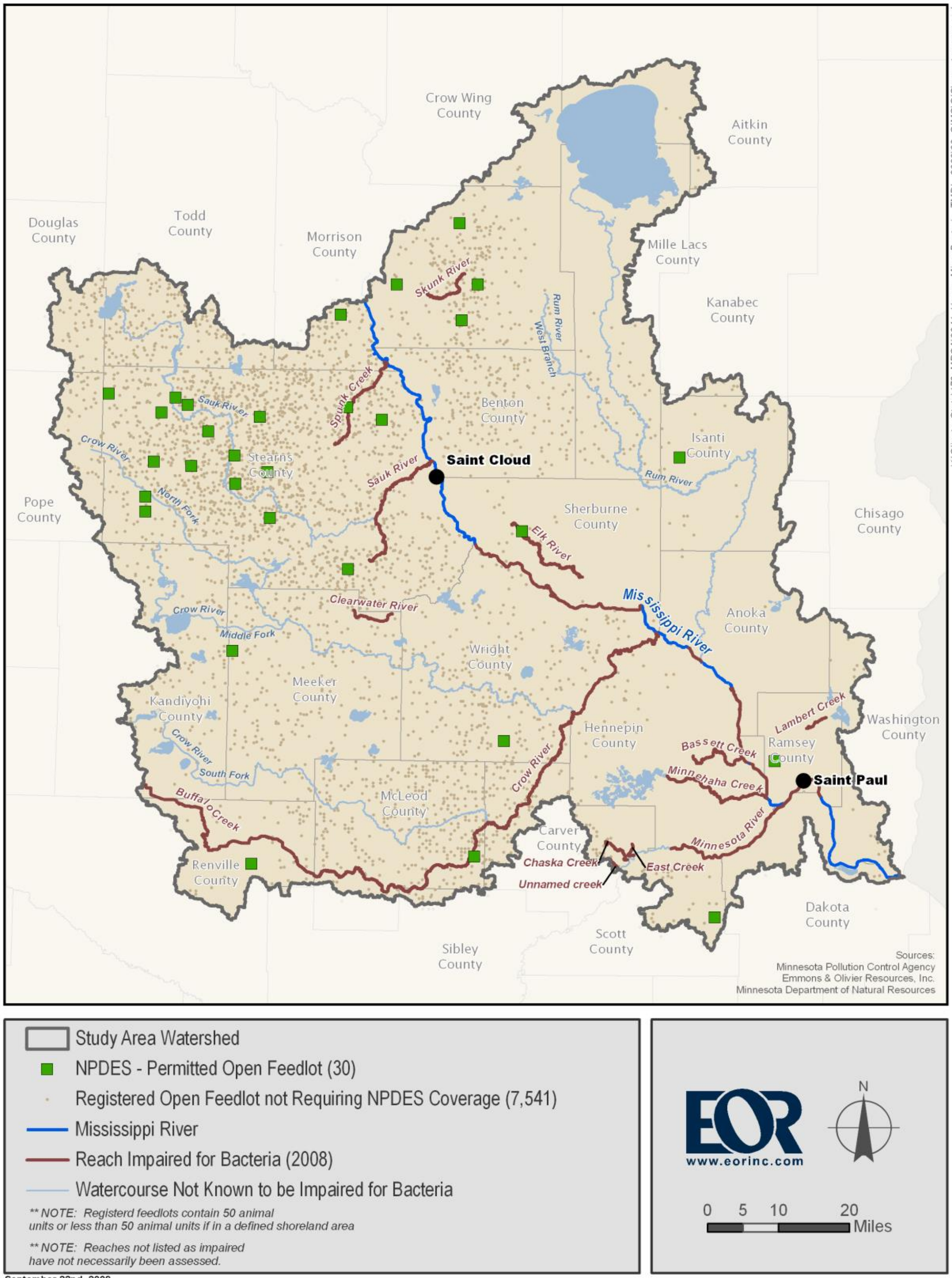

Figure 108. Registered Feedlots
Data from MPCA Data Desk

Pasture (Grazing livestock)

Pastured areas are those where grass or other growing plants are used for grazing and where the concentration of animals allows a vegetative cover to be maintained during the growing season. Pastures are neither permitted nor registered with the state.

Land cover data provide the distribution of pastured land in the study area (Figure 109). This indicates the areas that *potentially* have pastured animals; however, much of the area labeled as pasture may not be grazed. Areas with registered feedlots (Figure 108) also contain land cover identified as pasture; there could be overlap in that livestock could be both a part of a registered feedlot and also be grazed on pasture.

Vegetative buffers along waterways mitigate the impact that pastured livestock have on surface water quality. Agricultural land uses adjacent to lakes, rivers, and streams require a buffer strip of permanent vegetation that is 50 feet wide unless the areas are part of a resource management system plan (MN Rule 6120.330 Subp. 7). Additionally, for any new ditches or ditch improvements, the land adjacent to public ditches must include a buffer strip of permanent vegetation that is usually 16.5 feet wide on each side (MN Statute 103E.021).

Potential Next Steps: Review pasture areas that may be grazed and do not overlap with existing feedlot locations within priority subwatersheds and within close proximity and/or known animal access to surface water and conveyances to waters of the state. Establish methodology to determine non-registered grazing animal densities in priority subwatersheds.

Figure 109. Land Cover Defined as Pasture
Land cover data from USDA, National Agricultural Statistics Service, 2008 Minnesota Cropland Data Layer

Field-Applied Manure

Livestock manure is often either surface applied or incorporated into farm fields as a fertilizer and soil amendment. This land application of manure has the potential to be a substantial source of fecal contamination, entering waterways from overland runoff and drain tile intakes. MN Rules Chapter 7020 contains manure application setback requirements (Table 19). These setback requirements are largely based on research related to phosphorus transport, and not bacterial transport, and the effectiveness of these current setbacks on bacterial transport to surface waters is not known.

Research being conducted in southern MN shows high concentrations of fecal bacteria leaving fields with incorporated manure and open tile intakes (Scott Matteson, personal communication).

Table 19. Manure Application Setback Distances for Minnesota
Minimum setbacks near waters (counties can be more restrictive than MN Rule 7020).
Table adapted from "Fecal Coliform TMDL Assessment for 21 Impaired Streams in the Blue Earth River Basin," (Minnesota State University, Mankato, Water Resources Center, June 2007)

Waterbody Type	Surface Application	Incorporation within 24 hrs.
Lake, stream	300'*	25'**
Wetlands (10+ ac.)	300'*	25'**
Ditches (without berms)	300'*	25'**
Open tile intakes	300'	0
Well, quarry	50'	50'
Sinkhole (w/o berms)		
Downslope	50'	50'
Upslope	300'	50'

*100' vegetated buffer can be used instead of 300' setback for non-winter applications (50' buffer for wetlands/ditches).
**No long-term phosphorus build-up within 300'

Potential Next Steps: Investigate the land application of manure in priority watersheds, including where it is applied, how much, and what methods are used. Identifying locations and appropriate widths of buffers along water courses adjacent to land-applied manure fields should be considered. Follow-up on research being conducted in southern MN.

C. PETS

Like humans and livestock, domestic pets can contribute fecal coliform to a watershed when their waste is not properly managed. When this occurs, bacteria can be introduced to waterways from:

- Dog parks
- Residential yard runoff (spring runoff after winter accumulation)

- Rural areas where there are no pet cleanup ordinances

Although these sources may be only minor contributors of fecal coliform on a watershed scale, the location of them in the immediate vicinity of a waterway could result in significant contributions to local areas. However, it is generally thought that these sources may be only minor contributors of fecal contamination on a watershed scale.

Potential Next Steps: The American Veterinary Medical Association estimates there are 0.66 cats and 0.58 dogs per household in the United States. The density of pets can be approximated by population density in the study area for priority subwatersheds and for those locations within close proximity to surface water and conveyances to waters of the state.

D. WILDLIFE

Fecal coliform can be contributed to surface water by wildlife from dwelling in waterbodies, within conveyances to waterbodies, or when their waste is carried to storm inlets, creeks, and lakes during storm runoff events. Figure 110 displays DNR designated Wildlife Management Areas and open water within the study area. These areas provide wildlife habitat encouraging congregation and could be potential sources of higher fecal coliform due to the high densities of animals. There are likely many other areas within the project area where wildlife congregates. It has been suggested that surface water in areas near power plants may remain open throughout the winter, offering a gathering place for waterfowl and resulting in fecal contamination.

A distinction can be made between sources from wildlife that live and dwell in surface water such as waterfowl and semi-aquatic mammals, where there is a daily source of bacteria input directly to waters, and wildlife that dwell in upland areas such as deer, where input of bacteria to waterbodies is primarily precipitation driven.

In urban areas, wildlife such as raccoons, rats and feral cats often find adequate habitat within storm sewer systems where bacteria from scat can accumulate over time until a runoff event flushes.

Potential Next Steps: Determine wildlife densities within priority subwatersheds and degree to which congregation areas may be sources of bacterial impairment. Determine degree to which urban storm sewer dwelling wildlife is contributing bacteria through inventory or other means.

September 22nd, 2009

Figure 110. Potential Wildlife Congregating Areas, based on Wildlife Management Areas
Data from Minnesota DNR, February 2006

E. Urban Stormwater

Urban stormwater contains many of the bacteria sources already presented in this discussion (e.g. municipal wastewater, pets, and wildlife). It is discussed here as a separate topic due to the extent of the bacteria impairment in the urban portions of the study area.

Fecal bacteria and associated pathogen loads in urban stormwater are directly conveyed to streams and rivers via impervious surfaces, storm drains, and storm sewer networks. Urban stormwater often acts as the conveyance for all of the potential sources in this assessment. Fecal bacteria concentrations in stormwater runoff from urban areas can be as great as or greater than those found in cropland runoff, grazed pasture runoff, and feedlot runoff (USEPA 2001).

Community systems within the study area that serve a population of at least 10,000 and systems with a population of at least 5,000 and discharging to valuable or polluted waters may be required to obtain a Municipal Separate Storm Sewer System (MS4) permit. This permit requires a range of actions to reduce the impact of stormwater from these communities on downstream waterbodies. Since there are likely to be multiple sources of bacteria contributing to the impairment, reductions may be needed from all contributing sources (both regulated and non-regulated entities).

Sources of bacteria in urban stormwater are:

- Leakage from sanitary sewers
- Domestic pets
- Wildlife
- Inflow and infiltration
- Combined sewer overflows

Potential Next Steps: Literature review on fecal contamination in urban stormwater; source tracking field studies (using tools such as identification of Bacteroidales (specifically the genus *Bacteroides)* specific to humans, livestock, and wildlife; human-specific viruses; human pharmaceuticals, fluoride or caffeine in pilot areas).

F. Sediments

It has traditionally been assumed that *E. coli* and fecal coliform found in surface waters indicates fecal contamination from warm-blooded animals (generally mammals and birds). However, recent research has demonstrated the existence of populations of *E. coli* that persist and replicate in forest soils (Byappanahalli et al. 2006) and in sediments of surface waters (Ishii et al. 2006). The *E. coli* strains in these situations have been shown to be distinct from strains originating from sources of fecal contamination. *E. coli* persisting in sediments can be resuspended into the water column under high flow events. This confounds the use of *E. coli* as an indicator of fecal contamination.

Potential Next Steps: Literature review on bacteria growth and die-off in sediments (in progress).

G. Other Hot-Spots

Studies suggest that bacteria concentrations may increase in areas with slow flowing water and/or high temperature, such as ponds and dammed portions of the river.

Potential Next Steps: Investigate, through literature review, GIS exercise, and/or field study, the effect of dams and ponding on bacteria concentrations.

5. DATA GAPS

Two categories of data gaps were identified that currently hinder the ability to assess all of the surface waters within the study area with respect to bacteria levels (fecal coliform and/or *E. coli*), and that hinder the ability to complete bacteria TMDLs and implementation plans for the listed reaches within the entire study area. These two categories of data gaps are 1) *E. coli* and fecal coliform monitoring data gaps, and 2) data gaps regarding sources of *E. coli* in particular and fecal contamination in general. These two categories are discussed here.

A. *E. COLI* AND FECAL COLIFORM MONITORING DATA GAPS

Data identified herein as gaps may be the result of sources not accessed through this study. As described in *Section 3.A. Database Development*, data were sought from a breadth of resources, but the responses may have been incomplete.

The water quality database was reviewed to examine the coverage of the data set with respect to the following categories: 1) reaches along the stretch of the Mississippi River within the project area, and 2) tributaries to the Mississippi River (only the AUID of the tributary directly adjacent to the Mississippi River). These categories focus on the mainstem impairments in identifying reaches along the river or tributary inputs to the river that have not yet been assessed. We identified the AUIDs within these categories for which we do not have either fecal coliform or *E. coli* data (Table 20) as well as those AUIDs within these categories for which we have fecal coliform data but not *E. coli* data (Table 21); these are the existing data gaps. Figure 111 maps these data gaps. Recall that Table D - 1 in Appendix D includes geometric means and associated statistics for the downstream-most site of those tributaries having only fecal coliform data.

Table 20. Mississippi River mainstem and adjacent tributaries with no *E. coli* or fecal coliform data.

AUID	Stream Name	Reach Description	County	Municipality / Township	Watershed Organization
07010201-505	Mississippi River	Platte R to Little Rock Cr	Benton, Morrison, Stearns	Brockway Township, Langola Township, Rice City, Two Rivers Township, Watab Township	NA
07010201-508	Mississippi River	Spunk Cr to Platte R	Benton, Morrison	Langola Township, Two Rivers Township	NA
07010201-509	Mississippi River	Two R to Spunk Cr	Benton, Morrison	Langola Township, Two Rivers Township, Bellevue Township	NA
07010201-513	Mississippi River	Little Rock Cr to Sartell Dam	Benton, Stearns	Le Sauk Township, Sartell City, Sauk Rapids Township, Watab Township, Brockway Township	NA
07010201-514	Mississippi River	Sartell Dam to Watab R	Stearns	Sartell City	NA
07010201-516	Little Two River	Headwaters to Mississippi R	Morrison	Bellevue Township, Elmdale City, Elmdale Township, Swan River Township, Swanville Township, Two	NA
07010201-555	Unnamed spring (Smart's Creek)	Headwaters to Mississippi R	Stearns	Brockway Township	NA
07010201-569	Hazel Creek	Unnamed ditch to Mississippi R	Morrison	Two Rivers Township	NA
07010201-577	Little Rock Creek	Little Rock Lk to Mississippi R	Benton, Stearns	Watab Township	NA
07010203-503	Mississippi River	Elk R to Crow R	Sherburne, Wright	Elk River City, Otsego Township	NA
07010203-513	Mississippi River	St Cloud Dam to Clearwater R	Sherburne, Stearns	Clear Lake Township, Haven Township, Lynden Township, St. Cloud City, Clear Lake Township	NA
07010203-525	Elk River	Orono Lk to Mississippi R	Sherburne, Wright	Elk River City, Otsego Township	NA
07010203-528	Unnamed creek	T121 R23W S19, south line to Mississippi R	Sherburne, Wright	Elk River City, Otsego Township	NA
07010203-554	Fish Creek	Fish Lk to Mississippi R	Sherburne, Wright	Clear Lake Township, Clearwater Township	NA
07010203-557	Silver Creek	Locke Lk to Mississippi R	Wright	Clear Lake Township, Silver Creek Township	NA
07010203-562	Johnson Creek (St Augusta	T123 R28W S15, south line to Mississippi R	Stearns	St. Augusta City, St. Cloud City	NA
07010203-572	Plum Creek	Warner Lk to Mississippi R	Stearns	Lynden Township	NA
07010203-575	Mississippi River	CSAH 7 in St Cloud to St Cloud Dam	Sherburne, Stearns	St. Cloud City	NA
07010206-510	Mississippi River	Rum R to Elm Cr	Anoka, Hennepin	Anoka City, Champlin City	West Mississippi River, Elm Creek
07010206-511	Mississippi River	Elm Cr to Coon Rapids Dam	Anoka, Hennepin	Anoka City, Champlin City, Coon Rapids City, Brooklyn Park City	Lower Rum River, Six Cities, West Mississippi River, Elm Creek
07010206-512	Mississippi River	Coon Rapids Dam to Coon Cr	Anoka, Hennepin	Coon Rapids City	Six Cities, West Mississippi River
07010206-513	Mississippi River	Upper St Anthony Falls to Lower St Anthony Falls	Hennepin	Minneapolis City	Mississippi River
07010206-514	Mississippi River	L & D #1 to Minnesota R	Hennepin, Ramsey	Fort Snelling Unorganized, Minneapolis City, St. Paul City	Minnehaha Creek, Capitol Region
07010206-530	Coon Creek	Unnamed cr to Mississippi R	Anoka, Ramsey	Andover City, Coon Rapids City, Ham Lake City	Coon Creek, Six Cities
07010206-534	Unnamed stream	Pigs Eye Lk to Mississippi R	Ramsey	St. Paul City	Lower Mississippi River, Ramsey/Washington/Metro
07010206-542	Unnamed creek	Unnamed cr to Mississippi R	Dakota, Ramsey	Lilydale City, Mendota Heights City, St. Paul City	Capitol Region, Lower Mississippi River
07010206-557	County Ditch 17	Headwaters to Mississippi R	Anoka	Blaine City, Coon Rapids City, Fridley City	Six Cities, Lower Rum River, Elm Creek
07010206-567	Mississippi River	Crow R to NW city limits of Anoka	Anoka, Hennepin, Sherburne, Wright	Dayton City, Ramsey City, Elk River City, Otsego Township	Elm Creek
07010206-586	Rice Creek	Locke Lk to Mississippi R	Anoka	Fridley City	Rice Creek
07010206-590	Unnamed creek	Pickerel Lk to Mississippi R	Ramsey	St. Paul City	Lower Mississippi River
07010206-597	Unnamed creek	Within Mississippi R Polygon	Washington	Cottage Grove City	South Washington
07010206-608	Fish Creek	Unnamed (North Star) Lk to Mississippi R	Ramsey	St. Paul City	Lower Mississippi River, Ramsey/washington/metro
07010206-621	Trout Brook	Unnamed ditch to Mississippi R	Ramsey	St. Paul City	Capitol Region, Lower Mississippi River
07010206-661	Unnamed creek	Headwaters to Mississippi R	Hennepin, Ramsey	Minneapolis City, St. Paul City	Capitol Region

Table 21. Mississippi River mainstem and adjacent tributaries with fecal coliform data but no *E. coli* data.

Waterbody	AUID	Reach Description	Mississippi RM of Entry into Mississippi River	Flow Data Available? (Y/N)	Flow Station ID
Two River	07010201-523	North & South Two R to Mississippi R	953.5	N	N/A
Spunk Creek*	07010201-525	Lower Spunk Lk to Mississippi R	949.7	N	N/A
Watab River	07010201-528	Rossier Lk to Mississippi R	932.5	N	N/A
Clearwater River	07010203-511	Clearwater Lk to Mississippi R	914.4	N	N/A
Shingle Creek	07010206-506	Headwaters (Eagle Cr/Bass Cr) to Mississippi R	857.7	Y	5288705
Mississippi River	07010206-501	L & D #2 to St Croix R (RM 815.2 to 811.3)	N/A	Y	5331580

*Listed as impaired

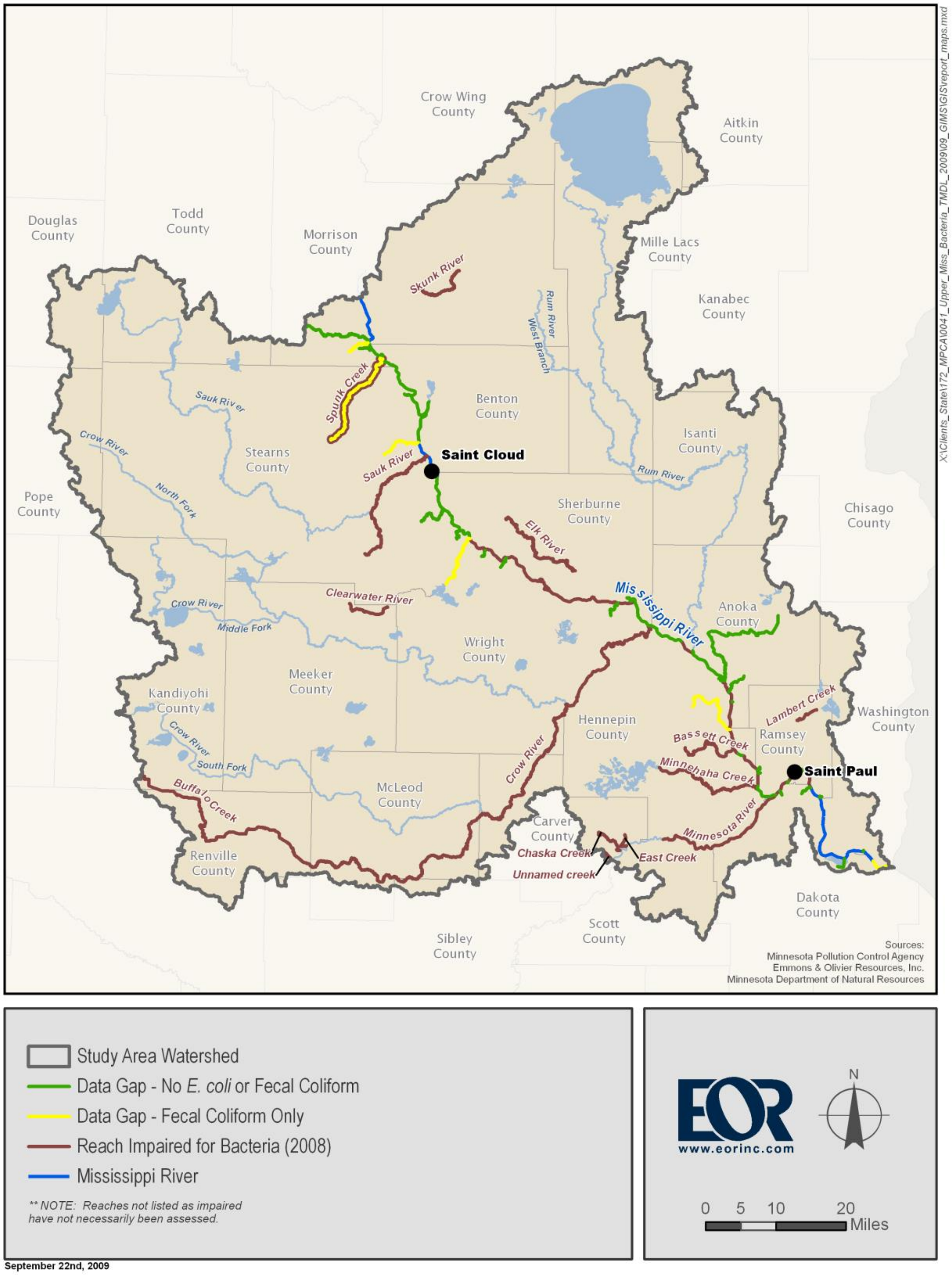

Figure 111. Mississippi River mainstem and adjacent tributary reach data gaps: those reaches missing both *E. coli* and fecal coliform data and those reaches having fecal coliform data but not *E. coli* data.

There are numerous other AUIDs within the entire study area (not just the Mississippi River and its directly adjacent tributaries) for which there are no fecal coliform or *E. coli* data (Figure 112). It is not realistic to aim to collect monitoring data on every AUID within the study area. The individual TMDL projects on the major tributaries known to be impaired will investigate sources of *E. coli* in the watersheds of the tributaries to the impaired waters. The type of data collected, similar to data presented in *Section 4. Source Assessment* of this report, may provide sufficient information for an understanding of these minor upstream tributaries and prioritizing future monitoring.

Figure 112. Mississippi River mainstem and tributary data gaps within the whole study area; those missing both *E. coli* and fecal coliform data.

Table 22 identifies those Mississippi River mainstem RMs that have *E. coli* data but have fewer than 5 samples in any given month from April through October.

Table 22. Mississippi River mainstem RMs having *E. coli* data from April through October and having at least one month with fewer than five samples; table identifies number of samples per month.

AUID	Reach Description	RM	Month						
			4	5	6	7	8	9	10
07010201-501	End HUC 07010104 (below Swan R) to Two R	953.5	4	3	4	2	3	2	1
07010201-502	Watab R to Sauk R	930.2	4	3	4	2	3	2	1
07010203-574	Sauk R to CSAH 7 in St Cloud	929.4	3	4	4	4	3	3	3
		928.4	4	4	4	15	31	33	31
07010203-510	Clearwater R to Elk R	914.0	3	4	4	4	3	3	4
		896.9	3	4	4	3	2	2	4
07010206-568	NW city limits of Anoka to Rum R	871.7			2	2	2	2	
07010206-509	Coon Cr to Upper St Anthony Falls	863.0	3			2	3	2	4
		858.8	2	3	4	3	4	4	3
		857.5	2	3	3	3	2	3	
07010206-505	Minnesota R to Metro WWTP (RM 844.0 to 835.0)	839.7	3	2	5	2	3	4	4
		836.8*							
07010206-502	Rock Island RR bridge to L & D #2 (RM 830.0 to 815.2)	826.4	3	3	3	2	3	4	3
		821.8			4	7	6	6	2
		815.2	4	3	4	2	3	4	3

* Data available only November through March

The data gaps highlighted in the above figures and tables are numerous. A few specific *E. coli* data gaps are particularly evident in the water quality analysis and precluded some possible conclusions. These are discussed below.

Winter Data

Table 9 highlights the scarcity of winter *E. coli* data along the mainstem of the Mississippi River and it is likely that *E. coli* data throughout the project area exhibit similar seasonal trends. *E. coli* and fecal coliform concentrations increase steadily from RM 847.7 to RM 831.0 during the winter time, which is not the case during the spring, summer, or fall. In addition, RM 858.5 and 839.1 experience bacteria increases from upstream monitoring sites during the winter. This characteristic might be evident at other locations but data are not available to determine this. Even though the aquatic recreation standard does not apply during the winter months, winter bacteria sources are relevant due to the potential survival of bacteria in sediments of downstream waterbodies (see Section 4F, *Source Assessment: Sediments*). Winter bacteria sources are also relevant to source water protection efforts.

Mississippi River AUIDs 07010203-503, 07010206-567, and 07010206-513

Bacteria data were unavailable for this study for the non-listed adjacent AUIDs 07010203-503 (between Elk River and the Crow River) and 07010206-567 (downstream of the Crow River). These are sandwiched between two AUIDs known to be impaired (07010203-510 and 07010206-568) and data indicate it is possible that the Crow River in particular contributes to the jump at RM 871.6 within the adjacent downstream impaired AUID. Similarly, AUID 07010206-513 is also between two AUIDS known to be impaired (07010206-509 and 07010206-503) and is not listed as impaired for lack of data.

Rice Creek

Rice Creek enters the Mississippi River at RM 862.0. Jumps in *E. coli* and fecal coliform concentrations from RM 862.8 to both 859.1 and 858.5 may be the result of Rice Creek inputs, but bacteria data were not available for Rice Creek for this study.

Unnamed Creeks at Mississippi RM 820.8 and 817.2

Two unnamed creeks enter the Mississippi River above RM 815.6, which experienced a jump in fecal coliform concentration from the adjacent upstream site at RM 821.8. Discharge at RM 820.8 is from Spring Lake. No bacteria data are available for either of these Mississippi River inputs.

Paired Monitoring Sites

The majority of tributary data are not collected on the same day as data from adjacent mainstem Mississippi River sites. It is useful to examine relative concentrations of the tributaries and mainstem from data collected on the same day.

Storm sewers

It is apparent from this water quality analysis that storm sewers can have high *E. coli* concentrations. However, data from only four storm sewers were available for this study. In order to provide perspective, the City of St. Paul alone has approximately 60 storm sewer outfalls that discharge to the Mississippi River. The Cities of St. Cloud, Sauk Rapids and Sartell have approximately 38, 8 and 15 storm sewer outfalls to the Mississippi River, respectfully.

B. FLOW MONITORING DATA GAPS

An LDC analysis was conducted for *E. coli* on mainstem Mississippi River sites and the downstream-most monitoring site of all tributaries and storm sewer outfalls for which data were available for this study. LDC curves inform the state and potential bacteria source of any monitoring site and/or waterbody by accounting for flow. Not all mainstem Mississippi River sites or tributaries have both flow and *E. coli* data. Some waterbodies have insufficient flow data, meaning either no flow at all or having flow data on reaches too far separated from the monitoring location (e.g. multiple unaccounted tributary inputs preclude use of the flow data). Those tributaries without *E. coli* data are identified above. Table 23 and Table 24 identify those mainstem reaches and tributaries that have *E. coli* monitoring data but insufficient flow data. Analysis on Mississippi River reaches could use upstream and downstream flow data. However, this is not possible for tributaries with no flow data; therefore, the priority would be to obtain flow records for tributaries that have *E. coli* data but no flow data as identified in Table 24. It is possible that records could exist but were not available for this study. Appendix A and Appendix B includes geometric means and associated statistics of all bacteria data on Mississippi River mainstem RMs. Table D - 1 in Appendix D includes geometric means and associated statistics for the downstream-most site of those tributaries having *E. coli* data with insufficient flow data.

Table 23. Existing Mississippi River *E. coli* monitoring locations with insufficient flow data.

<table>
<tr><th>RM</th><th>AUID</th><th>Impaired?</th></tr>
<tr><td>914.0</td><td>07010203-513</td><td></td></tr>
<tr><td>896.9</td><td>07010203-510</td><td>Y</td></tr>
<tr><td>871.7</td><td rowspan="2">07010206-568</td><td rowspan="2">Y</td></tr>
<tr><td>871.6</td></tr>
<tr><td>859.1</td><td rowspan="5">07010206-509</td><td rowspan="5">Y</td></tr>
<tr><td>858.8</td></tr>
<tr><td>857.6</td></tr>
<tr><td>857.5</td></tr>
<tr><td>854.9</td></tr>
<tr><td>826.7</td><td>07010206-502</td><td></td></tr>
<tr><td>826.4</td><td>07010206-502</td><td></td></tr>
<tr><td>821.8</td><td>07010206-502</td><td></td></tr>
</table>

Table 24. Tributaries with *E. coli* data at least at a downstream site but with no flow data.

Waterbody	AUID	Mississippi RM of Entry into Mississippi River
Platte River	07010201-545	947.5
Unnamed Ditch (Pleasant Creek)	07010206-594	864.9
Unnamed Creek (Beltline Interceptor)	07010206-616	837.2
Battle Creek (US of Pigs Eye Lake)*	07010206-592	833.2

* Flow data not available after 2006, *E. coli* data not available prior to 2008.

C. Source Tracking

Analysis of the available *E. coli* data in the Upper Mississippi River basin allows determination of the relationship between *E. coli* levels and weather patterns, flows, and time of year. However, this analysis does not show a consistent pattern to indicate a cause of the elevated *E. coli* levels or to determine the source of the *E. coli*. This lack of a clear pattern does not provide the kind of information needed to guide implementation to ultimately reduce bacteria levels in the Upper Mississippi River. A data gap exists regarding the source of bacteria in the Upper Mississippi River Basin. Data collection for bacterial source analysis will be helpful to guide implementation and provide for stakeholder support of the TMDL and the subsequent implementation plan.

Bacterial source analysis can be targeted to key problem areas in order to identify if the elevated *E. coli* levels are caused by human, animal, or other sources. This information will allow the development of an implementation plan directed at addressing the relevant sources identified such as leaking septic tanks, bird populations on the river, or livestock.

6. MONITORING RECOMMENDATIONS

Monitoring recommendations were developed to address the data gaps presented in the previous section. Continued monitoring of waterbodies with a history of *E. coli* data will prove useful for source tracking work. Continued monitoring of these sites will also provide data for future listing and delisting assessments and impacts of BMP implementation.

The principle of the following monitoring recommendations is to establish a comprehensive monitoring plan. Currently, a lot of data are being collected. However, data are collected at various frequencies, on various years, months, and dates, and could benefit from a coordinated plan. A comprehensive plan would entail paired tributary/mainstem or upstream/downstream monitoring sites to be monitored on the same day to better study relationships between sites, spatial coverage throughout the study area, and seasonal coverage at strategic monitoring sites.

A. *E. COLI* MONITORING

E. coli data gaps inform the monitoring recommendations for water quality analysis of the Upper Mississippi River within the project area. Monitoring recommendations provided in this subsection are developed for the sole purpose of MPCA assessment of waters for listing and delisting.

Sampling locations

The recommended monitoring locations were selected to directly address the data gaps outlined in *Section 5. Data Gaps*.

E. coli data should be collected at the following locations:

- Mississippi River AUIDs and adjacent tributary AUIDs with no *E. coli* or fecal coliform data (Table 20) with additional attention paid to those AUIDs having fecal coliform data but no *E. coli* data (Table 21). These AUIDs are identified in Figure 111 on page 175.
- Table 22 identifies those RMs with fewer than 5 samples per month of *E. coli* data that could be added to the monitoring plan dependant upon the scope, resources, and desired MPCA assessments for listing or delisting; these are not identified in Figure 111 on page 175.

Additional parameters monitored

In addition to collecting *E. coli* data, the following parameters should also be collected where feasible. Flow data are needed in order to calculate loads and to examine how *E. coli* varies with flow regime. The additional parameters listed below have been shown to positively relate to bacteria concentrations in surface waters (see *Literature Summary of Bacteria - Environmental Associations* completed as part of this overall project):

- Flow (continuous)
- Turbidity and TSS
- Temperature (continuous)
- Nutrients
- Conductivity

Protocols for sample collection

If an entity plans on sampling over the next few years, MPCA recommends following the statewide sampling protocols and guidelines that have already been established for monitoring *E. coli* in streams (*Guidance Manual for Assessing the Quality of Minnesota Surface Waters for Determination of Impairment: 305(b) Report and 303(d) List* available at http://www.pca.state.mn.us/publications/wq-iw1-04.pdf). Since it has been shown that monitoring data vary based on the field protocols being used, it will be helpful for monitoring entities to use standardized field protocols.

Analysis

The analytical methods approved by the EPA and MPCA for stream assessments and recommended for monitoring protocol can be found in Appendix D of the *Volunteer Service Monitoring Guide* found at http://www.pca.state.mn.us/water/monitoring-guide.html. In addition, a list of MDH certified laboratories can be found at http://www.health.state.mn.us/divs/phl/cert/allcertlabs.html. Since it has been shown that monitoring data vary based on the laboratory protocols being used, it will be helpful for monitoring entities to use standardized laboratory protocols.

Reporting

All *E. coli* data (and other associated water quality data) should be submitted to STORET within one year of data collection. Flow data collection should be coordinated with MPCA and DNR in order to be submitted to the Minnesota Department of Natural Resources (DNR) and made available on the DNR/MPCA Cooperative Stream Gaging Website (http://www.dnr.state.mn.us/waters/csg/index.html).

Frequency of sampling

For future MPCA assessments for listing or delisting, sampling frequency should occur at least 5 times per month from April through October. For the purposes of identifying *E. coli* concerns for drinking water impairments or source assessment, winter monitoring should be conducted at recommended monitoring locations (Table 20 through Table 22) and at existing monitoring locations where winter monitoring is not yet conducted.

Timing of sampling

Monitoring should consider the timing of sampling. If high winter *E. coli* concentrations are a concern and/or priority for MPCA or MDH, winter sampling could be part of the monitoring program protocol since winter sampling is currently scarce.

Samples should be collected under different hydrologic conditions to be able to assess the waterbody during low, medium, and high flows. Two of the five monthly samples should occur during baseflow. At least one a month should occur during a storm event. A storm sample should be verified by checking that flows are actually elevated above baseflow.

Who will be conducting monitoring

Implementation of a comprehensive monitoring plan is only as good as the participation among local entities and, equally important, coordination between them. Coordinating same-day sampling, in particular, can be difficult. Monitoring partners should understand the importance of following the recommended monitoring protocols in order for the program to be effective.

The monitoring program will be driven by local entities that are already conducting *E. coli* and flow monitoring, along with those entities that are interested in expanding their monitoring program. MPCA should respond to participation requests by determining how they could best achieve the goals (spatial and temporal) of this plan.

Measurement of progress

Progress will be measured by the coverage of data for major waterbodies such that waters can be assessed for listing or delisting according to MPCA protocol.

B. BMP Effectiveness Monitoring

Monitoring of existing BMPs may be informative to gauge their effectiveness at removing bacteria. However, an inventory of BMPs to address bacterial contamination from fecal matter was not completed for this phase of the project. Information from stakeholders regarding BMP implementation within the watershed will be gathered and BMP effectiveness monitoring will be recommended in future project phases.

C. Source Tracking

Background

E. coli and fecal coliform measurements indicate the contamination of waters by fecal materials, but these measurements cannot provide further identification of the specific source of the contamination. *E. coli* readings can be elevated due to pollution of waters with feces from birds, pets, wildlife, and agriculturally raised animals in addition to pollution with human fecal matter through leaking sanitary sewer lines or failing individual sewage treatment systems. In addition, it has been found that *E. coli* can multiply in the sediments.

In order to efficiently guide implementation actions, the source of the elevated *E. coli* readings should be identified. A number of methods exist that can be used to further identify the source of contamination. These methods include testing for:

- Human-specific *Bacteroidales*
- *Bacteroidales* specific to common animals and birds
- Human-specific viruses such as adenovirus, enterovirus, and norovirus
- Human pharmaceuticals, caffeine, or fluoride
- *E. coli* that are most common in cattle
- Veterinary antibiotics

Bacteroidales are anaerobic bacteria that are abundant in human and animal feces. The DNA sequences of *Bacteroidales* differ in different host species, so the source of the fecal matter can be differentiated. In addition there are certain *Bacteroidales* that are common to all hosts. Because *Bacteroidales* are anaerobic bacteria, they cannot survive long in the environment and can therefore be used to identify recent contamination of waterbodies. Their specificity to certain hosts also allows the identification of likely sources, human and non-human. This information can guide implementation more clearly than the presence of *E. coli* by directing actions to reduce the identified sources. For example, the presence of human-related *Bacteroidales* suggests that repair of potential leaking septic systems or sanitary sewer lines is necessary. Although *Bacteroidales* are a good tool for tracking sources of fecal contamination, the quantities of these bacteria can not be directly related to *E. coli* concentrations.

Bacteroidales analyses are conducted using polymerase chain reaction (PCR) to identify the presence or absence of the specific *Bacteroidales*, or using quantitative PCR to estimate the initial quantity of specific *Bacteroidales*. Quantitative assays are currently available for *Bacteroidales* specific to humans, dogs, cows, pigs, gulls, geese, and chicken, and horses (Bambic and Wuertz 2009). In addition, qualitative presence/absence assays are available for *Bacteroidales* specific to certain wildlife. These assays, while found to be reliable, are not yet standardized to one common method.

Human-specific viruses such as adenovirus, enterovirus, and norovirus are another indicator that can be used to determine if the *E. coli* or fecal coliform measurements are from a human source. The presence of any of these viruses suggests a human source for the fecal contamination. In addition, the presence of these viruses suggests a higher risk to human health from water contact and identifies the location as a high priority for implementation actions.

The presence of human pharmaceuticals, caffeine, or fluoride could also be measured and would be an indication of a human source. However, the persistence of these compounds may vary from that of *E. coli*.

Certain agricultural sources could be identified through testing for *E. coli* that are associated most strongly with cattle or by testing for veterinary antibiotics. The presence of these sources would suggest implementation of activities that limit the transport of manures off of agricultural sites.

Incorporation into Monitoring Plan

As a separate task of this project, microbial source tracking methods will be investigated, with the intent of incorporating the microbial source tracking recommendations into the overall monitoring plan. Based on the water quality analysis conducted herein, the following are initial monitoring ideas that will be considered for possible incorporation into the monitoring plan:

- Paired monitoring sites:

  Monitoring on the same day at a pair and/or group of monitoring sites can help identify tributaries that contribute *E. coli*, identify how the Mississippi interacts with tributaries and/or inform the state of a Mississippi River reach with no existing *E. coli* data. Those tributaries identified for monitoring sites could be paired with the following existing mainstem monitoring sites to better understand how they affect *E. coli* levels in the Mississippi River. Recommended paired monitoring sites to be monitored on the same day for *E. coli* are the following (see also Figure 113):

  - RM 857.6 and Shingle Creek* (RM 0.7)
  - RM 831.0 and Fish Creek (RM 0.2), Battle Creek (RM 2.2), and Pigs Eye Lake°
  - RM 871.6 and Crow River (RM 12.3)
  - RM 914.0 and Clearwater River* (RM 0.3)
  - RM 928.4 and Sauk River (RM 0.2)

    *No *E. coli* data at existing site
    °New site recommendation

  It is recommended that if an *E. coli* monitoring site does not exist upstream of the tributary of interest, include one where feasible.
- Storm sewers: It is apparent from this water quality analysis that storm sewers can have high *E. coli* concentrations. Additional monitoring of storm sewers is recommended starting with those having the highest flow volumes.

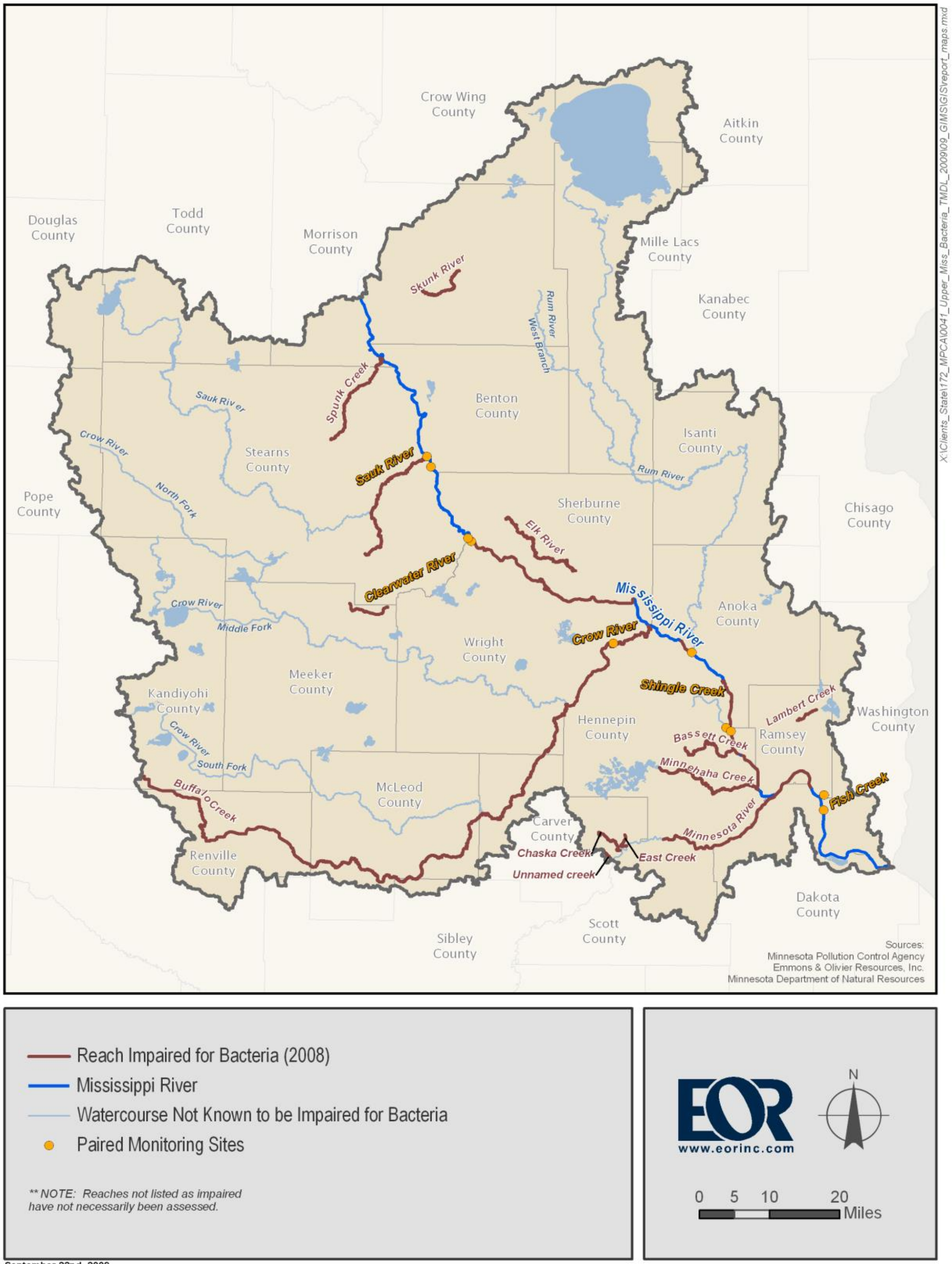

Figure 113. Paired sites recommended for same-day monitoring.

D. Pathogen Monitoring

Where the technology exists, waterborne pathogens could be directly monitored. Potential pathogens include C*ryptosporidium*, *Giardia*, *Salmonella*, and norovirus. Monitoring could be paired with *E. coli* to determine the relationships between these pathogens and the indicator bacteria.

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8. APPENDICES

A. *E. coli* Data Summary

Table A - 1. Mississippi River *E. coli* data summary by RM by month across all years.

AUID	RM	Month	Geometric Mean	N	Minimum	Maximum	25th Percentile	Median (50th Percentile)	75th Percentile
07010201-501	953.5	3	66	1	66	66	66	66	66
		4	22	4	9	48	16	24	37
		5	23	3	16	35	16	22	35
		6	31	4	18	42	23	35	42
		7	29	2	9	96	9	53	96
		8	73	3	24	326	24	49	326
		9	226	2	148	345	148	247	345
		10	25	1	25	25	25	25	25
		11	222	1	222	222	222	222	222
07010201-502	930.2	1	260	1	260	260	260	260	260
		3	47	1	47	47	47	47	47
		4	13	4	9	26	10	11	19
		5	12	3	6	23	6	12	23
		6	70	4	31	214	39	63	147
		7	23	2	12	44	12	28	44
		8	227	3	104	816	104	138	816
		9	225	2	155	326	155	241	326
		10	19	1	19	19	19	19	19
		11	82	1	82	82	82	82	82
07010203-574	929.4	4	4	3	1	12	1	6	12
		5	13	4	6	32	8	13	24
		6	97	4	19	450	58	103	280
		7	45	4	30	80	34	42	63
		8	83	3	20	650	20	44	650
		9	174	3	80	300	80	220	300
		10	62	3	39	120	39	52	120
	928.4	1	102	4	91	130	92	96	115
		2	99	4	81	110	91	105	110
		3	120	4	54	210	87	135	180
		4	16	4	2	55	8	29	50
		5	10	4	8	14	8	10	13
		6	34	4	7	140	18	38	94
		7	12	15	2	99	3	5	78
		8	8	31	1	92	4	6	20
		9	15	33	4	68	8	14	22
		10	12	31	1	162	8	11	19
		11	30	34	3	100	24	31	54
		12	67	35	31	150	51	72	82
07010203-510	914.0	4	12	3	1	370	1	5	370
		5	9	4	4	23	4	10	20
		6	61	4	13	500	24	48	280
		7	29	4	16	45	20	32	43
		8	145	3	52	980	52	60	980
		9	70	3	44	110	44	72	110
		10	22	4	12	33	16	26	33
	896.9	4	8	3	3	20	3	9	20
		5	8	4	4	20	4	8	16
		6	96	4	29	760	41	64	418
		7	32	3	12	60	12	45	60
		8	81	3	32	150	32	110	150
		9	54	3	24	150	24	44	150
		10	21	4	16	32	16	20	28

Table A - 1. Continued

AUID	RM	Month	Geometric Mean	N	Minimum	Maximum	25th Percentile	Median (50th Percentile)	75th Percentile
07010206-568	871.7	6	487	2	270	880	270	575	880
		7	215	2	42	1100	42	571	1100
		8	68	2	36	130	36	83	130
		9	170	2	100	290	100	195	290
	871.6	1	95	8	32	326	60	102	142
		2	70	5	26	161	38	85	122
		3	41	11	10	146	18	49	75
		4	11	12	2	185	5	8	20
		5	25	12	9	435	13	22	34
		6	51	15	21	231	37	49	74
		7	13	15	3	92	5	13	24
		8	42	14	11	260	26	34	59
		9	84	16	14	2420	33	53	130
		10	41	16	5	2420	14	30	108
		11	62	8	14	159	40	74	110
		12	93	5	26	517	45	89	128
07010206-509	863.0	1*		6	0	162	0	87	157
		2	64	3	34	113	34	68	113
		3	7	4	1	37	4	8	24
		4	11	3	2	39	2	16	39
		7*		2	0	5	0	3	5
		8*		3	0	10	0	0	10
		9	32	2	21	50	21	36	50
		10	56	4	32	82	43	61	75
		11	18	1	18	18	18	18	18
		12	42	4	7	135	23	62	110
	862.8	1	121	2	79	185	79	132	185
		3	8	1	8	8	8	8	8
		4	12	10	3	75	6	8	30
		5	27	11	10	201	16	19	33
		6	58	13	17	649	26	36	77
		7	25	15	5	326	12	22	36
		8	35	14	11	475	17	33	42
		9	86	16	20	727	43	60	150
		10	67	16	7	1414	24	71	128
		11	49	8	10	154	24	74	88
		12	42	1	42	42	42	42	42
	859.1	4	19	19	3	120	7	17	50
		5	29	20	3	770	16	25	39
		6	81	50	18	5200	33	67	130
		7	42	57	7	280	23	41	64
		8	114	55	18	9500	46	94	230
		9	246	52	30	3800	77	205	570
		10	74	44	3	2440	28	80	155
		11	25	4	5	130	9	32	91
	858.8	4	5	2	3	10	3	7	10
		5	19	3	8	55	8	16	55
		6	41	4	16	92	25	45	74
		7	81	3	38	230	38	60	230
		8	39	4	28	76	29	34	57
		9	163	4	80	580	95	125	360
		10	7	3	3	20	3	7	20
	857.6	4	28	19	7	560	10	17	73
		5	57	21	3	6300	28	40	100
		6	111	51	8	8000	48	82	180
		7	65	58	7	630	31	56	130
		8	134	55	20	2900	68	100	280
		9	294	51	52	5500	150	240	430
		10	152	50	10	3600	66	152	270
		11	94	4	24	330	50	103	230

* Zeros in dataset preclude calculation of the geometric mean.

Table A - 1. Continued

AUID	RM	Month	Geometric Mean	N	Minimum	Maximum	25th Percentile	Median (50th Percentile)	75th Percentile
07010206-509 Cont'd	857.5	4	15	2	7	32	7	20	32
		5	54	3	24	180	24	37	180
		6	31	3	8	324	8	12	324
		7	25	3	4	215	4	19	215
		8	75	2	31	180	31	106	180
		9	37	3	19	67	19	39	67
	854.9	4	18	20	2	160	9	13	48
		5	31	21	7	840	15	25	44
		6	106	51	13	4900	47	80	180
		7	72	59	10	940	38	72	110
		8	79	55	16	790	44	64	112
		9	122	53	9	1500	78	110	210
		10	71	51	2	792	37	62	150
		11	82	4	22	220	34	123	210
07010206-503	852.2	4	18	20	2	140	10	18	37
		5	33	21	5	730	17	35	46
		6	81	51	13	4100	40	80	130
		7	67	58	10	1200	35	60	130
		8	89	56	14	1600	44	75	125
		9	122	53	33	1400	62	96	210
		10	90	49	5	2200	40	84	160
		11	106	4	22	560	39	118	370
	849.9	4	16	20	3	110	6	15	43
		5	29	21	5	2400	13	23	33
		6	65	51	1	3500	28	48	110
		7	52	58	5	990	22	49	120
		8	85	54	14	1900	38	61	210
		9	127	53	15	9100	58	100	210
		10	104	49	7	3100	38	92	160
		11	113	4	26	600	38	130	405
	848.1	4	14	20	2	92	6	17	33
		5	25	21	2	420	13	25	32
		6	76	50	10	8700	32	48	120
		7	47	56	2	1400	21	54	90
		8	56	52	9	2500	19	48	105
		9	101	46	16	2200	46	83	180
		10	89	38	16	7200	46	82	110
		11	65	3	20	280	20	48	280
	847.7	1	55	8	11	172	26	70	127
		2	21	5	9	37	15	26	28
		3	15	11	5	59	10	13	28
		4	12	12	3	90	6	12	18
		5	25	11	6	106	9	21	64
		6	46	16	6	231	22	50	106
		7	29	15	1	2420	7	14	101
		8	45	14	4	770	10	52	166
		9	108	15	16	2420	51	78	307
		10	112	16	14	1050	22	148	469
		11	94	6	15	1414	22	87	214
		12	36	5	14	83	17	46	70

Table A - 1. Continued

AUID	RM	Month	Geometric Mean	N	Minimum	Maximum	25th Percentile	Median (50th Percentile)	75th Percentile
07010206-505	839.7	4	15	3	4	31	4	28	31
		5	13	2	10	16	10	13	16
		6	46	5	11	170	19	60	96
		7	137	2	110	170	110	140	170
		8	135	3	36	1400	36	49	1400
		9	40	4	16	91	18	56	91
		10	25	3	11	40	11	36	40
	839.1	1	76	4	61	99	62	76	94
		2	135	3	37	291	37	228	291
		3	46	8	15	106	27	47	98
		4	41	12	5	816	12	27	148
		5	44	13	3	246	17	38	121
		6	72	14	22	488	36	61	114
		7	37	16	7	1203	21	32	46
		8	53	16	10	462	19	46	113
		9	75	16	11	1414	31	42	295
		10	108	16	13	2420	39	143	260
		11	74	9	13	1023	36	73	88
		12	29	3	13	77	13	25	77
	836.8	1	76	2	39	147	39	93	147
		2	101	3	65	198	65	80	198
		3	106	3	29	613	29	67	613
		11	86	1	86	86	86	86	86
		12	104	3	43	285	43	93	285
07010206-504	831.0	1	303	6	131	687	248	282	435
		2	304	6	261	345	285	300	345
		3	112	11	14	818	26	137	347
		4	22	12	5	66	11	25	49
		5	35	12	12	166	18	31	63
		6	63	14	12	291	29	69	127
		7	20	16	8	91	13	16	36
		8	43	16	4	613	16	40	101
		9	73	15	21	613	33	48	152
		10	106	17	30	2420	50	76	211
		11	299	10	114	1300	210	282	399
		12	330	6	153	866	261	284	461
07010206-502	826.7	1	266	6	108	1010	140	193	649
		2	216	6	130	276	186	234	276
		3	82	11	18	270	26	110	192
		4	21	12	4	91	12	15	46
		5	31	13	7	152	22	24	62
		6	52	14	14	238	27	47	115
		7	13	15	4	62	10	14	20
		8	18	17	1	411	7	12	54
		9	32	15	6	172	10	29	104
		10	77	17	13	2420	29	59	130
		11	202	10	54	707	116	212	277
		12	248	6	58	613	178	317	365
	826.4	4	15	3	11	24	11	12	24
		5	12	3	8	16	8	15	16
		6	19	3	8	110	8	8	110
		7	29	2	4	210	4	107	210
		8	112	3	36	760	36	52	760
		9	36	4	7	160	15	44	112
		10	22	3	15	32	15	23	32
	821.8	6	34	4	18	52	24	39	50
		7	13	7	2	33	6	16	30
		8	14	6	5	108	6	12	23
		9	20	6	9	66	12	18	36
		10	45	2	40	50	40	45	50

Table A - 1. Continued

AUID	RM	Month	Geometric Mean	N	Minimum	Maximum	25th Percentile	Median (50th Percentile)	75th Percentile
07010206-502 Cont'd	815.6	1	47	6	5	308	23	41	236
		2	59	6	24	108	40	62	108
		3	13	10	2	28	7	19	25
		4	27	12	8	118	12	28	68
		5	17	13	7	72	8	16	26
		6	21	14	7	81	9	22	45
		7	6	15	1	28	3	10	15
		8	6	17	1	48	2	5	12
		9	14	15	2	91	6	14	37
		10	73	17	13	1300	30	73	119
		11	51	10	6	488	29	46	140
		12	42	6	3	291	17	63	96
	815.2	4	14	4	4	35	10	18	27
		5	11	3	4	28	4	12	28
		6	24	4	3	120	7	48	102
		7	16	2	8	32	8	20	32
		8	18	3	4	240	4	6	240
		9	19	4	1	120	15	33	78
		10	30	3	10	110	10	24	110

Table A - 2. Mississippi River *E. coli* data summary by RM by year by month.

AUID	RM	Year	Month	Geometric Mean	N	Minimum	Maximum	25th Percentile	Median (50th Percentile)	75th Percentile
07010201-501	953.5	2007	4	14	2	9	22	9	16	22
			5	19	2	16	22	16	19	22
			6	31	3	18	42	18	41	42
			7	96	1	96	96	96	96	96
			8	34	2	24	49	24	37	49
			9	226	2	148	345	148	247	345
			10	25	1	25	25	25	25	25
			11	222	1	222	222	222	222	222
		2008	3	66	1	66	66	66	66	66
			4	35	2	26	48	26	37	48
			5	35	1	35	35	35	35	35
			6	28	1	28	28	28	28	28
			7	9	1	9	9	9	9	9
			8	326	1	326	326	326	326	326
07010201-502	930.2	2007	4	11	2	11	11	11	11	11
			5	12	2	6	23	6	15	23
			6	92	3	46	214	46	80	214
			7	44	1	44	44	44	44	44
			8	291	2	104	816	104	460	816
			9	225	2	155	326	155	241	326
			10	19	1	19	19	19	19	19
			11	82	1	82	82	82	82	82
		2008	1	260	1	260	260	260	260	260
			3	47	1	47	47	47	47	47
			4	15	2	9	26	9	18	26
			5	12	1	12	12	12	12	12
			6	31	1	31	31	31	31	31
			7	12	1	12	12	12	12	12
			8	138	1	138	138	138	138	138
07010203-574	929.4	2000	7	30	1	30	30	30	30	30
			8	44	1	44	44	44	44	44
			9	80	1	80	80	80	80	80
		2001	10	52	1	52	52	52	52	52
		2002	5	16	1	16	16	16	16	16
			6	450	1	450	450	450	450	450
			7	45	1	45	45	45	45	45
			8	20	1	20	20	20	20	20
			9	300	1	300	300	300	300	300
		2005	4	12	1	12	12	12	12	12
			5	32	1	32	32	32	32	32
			6	96	1	96	96	96	96	96
			7	80	1	80	80	80	80	80
		2006	4	6	1	6	6	6	6	6
			5	6	1	6	6	6	6	6
			6	110	1	110	110	110	110	110
			7	38	1	38	38	38	38	38
			10	68	2	39	120	39	80	120
		2007	4	1	1	1	1	1	1	1
			5	10	1	10	10	10	10	10
			6	19	1	19	19	19	19	19
			8	650	1	650	650	650	650	650
			9	220	1	220	220	220	220	220

Table A - 2. Continued

AUID	RM	Year	Month	Geometric Mean	N	Minimum	Maximum	25th Percentile	Median (50th Percentile)	75th Percentile
07010203-574 Cont'd	928.4	2007	4	49	2	44	55	44	50	55
			5	9	2	8	11	8	10	11
			6	81	2	47	140	47	94	140
			7	13	2	2	91	2	47	91
			8	39	2	30	52	30	41	52
			9	40	2	31	52	31	42	52
			10	74	1	74	74	74	74	74
			11	69	2	63	75	63	69	75
			12	105	2	74	150	74	112	150
		2008	1	110	2	93	130	93	112	130
			2	105	2	100	110	100	105	110
			3	80	2	54	120	54	87	120
			4	5	2	2	13	2	8	13
			5	11	2	8	14	8	11	14
			6	14	2	7	28	7	18	28
			7	12	13	2	99	4	5	61
			8	7	29	1	92	4	6	19
			9	14	31	4	68	8	13	21
			10	11	30	1	162	8	11	19
			11	28	32	3	100	22	31	49
			12	66	33	31	133	51	68	82
07010203-510	914.0	2000	7	40	1	40	40	40	40	40
			8	60	1	60	60	60	60	60
			9	72	1	72	72	72	72	72
		2001	10	32	1	32	32	32	32	32
		2002	5	16	1	16	16	16	16	16
			6	500	1	500	500	500	500	500
			7	45	1	45	45	45	45	45
			8	52	1	52	52	52	52	52
			9	110	1	110	110	110	110	110
		2004	10	12	1	12	12	12	12	12
		2005	4	370	1	370	370	370	370	370
			5	4	1	4	4	4	4	4
			6	60	1	60	60	60	60	60
			7	16	1	16	16	16	16	16
		2006	4	1	1	1	1	1	1	1
			5	23	1	23	23	23	23	23
			6	35	1	35	35	35	35	35
			7	24	1	24	24	24	24	24
			10	26	2	20	33	20	27	33
		2007	4	5	1	5	5	5	5	5
			5	4	1	4	4	4	4	4
			6	13	1	13	13	13	13	13
			8	980	1	980	980	980	980	980
			9	44	1	44	44	44	44	44

Table A - 2. Continued

AUID	RM	Year	Month	Geometric Mean	N	Minimum	Maximum	25th Percentile	Median (50th Percentile)	75th Percentile
07010203-510 Cont'd	896.9	2000	8	110	1	110	110	110	110	110
			9	44	1	44	44	44	44	44
		2001	10	16	1	16	16	16	16	16
		2002	5	4	1	4	4	4	4	4
			6	760	1	760	760	760	760	760
			7	45	1	45	45	45	45	45
			8	32	1	32	32	32	32	32
			9	150	1	150	150	150	150	150
		2004	10	16	1	16	16	16	16	16
		2005	4	20	1	20	20	20	20	20
			5	4	1	4	4	4	4	4
			6	52	1	52	52	52	52	52
			7	60	1	60	60	60	60	60
		2006	4	9	1	9	9	9	9	9
			5	20	1	20	20	20	20	20
			6	29	1	29	29	29	29	29
			7	12	1	12	12	12	12	12
			10	27	2	23	32	23	28	32
		2007	4	3	1	3	3	3	3	3
			5	12	1	12	12	12	12	12
			6	75	1	75	75	75	75	75
			8	150	1	150	150	150	150	150
			9	24	1	24	24	24	24	24
07010206-568	871.7	2002	6	487	2	270	880	270	575	880
			7	215	2	42	1100	42	571	1100
			8	68	2	36	130	36	83	130
			9	170	2	100	290	100	195	290
	871.6	2005	6	90	3	43	231	43	74	231
			7	43	2	20	91	20	56	91
			8	59	4	33	130	41	54	95
			9	461	3	93	2420	93	435	2420
			10	83	3	40	326	40	44	326
			11	75	2	49	114	49	82	114
			12	257	2	128	517	128	323	517
		2006	1	142	3	82	326	82	108	326
			2	31	2	26	38	26	32	38
			3	71	2	70	73	70	72	73
			4	10	4	2	48	5	12	32
			5	48	5	15	435	26	36	40
			6	53	3	40	77	40	49	77
			7	7	5	3	14	3	11	12
			8	32	3	11	260	11	11	260
			9	115	4	27	1300	33	84	715
			10	10	5	5	19	7	11	12
			11	53	2	31	89	31	60	89
			12	26	1	26	26	26	26	26
		2007	1	48	3	32	96	32	37	96
			2	161	1	161	161	161	161	161
			3	39	4	10	146	22	41	98
			4	13	5	2	185	6	8	23
			5	12	3	10	17	10	11	17
			6	34	4	21	70	23	31	54
			7	9	5	3	24	5	13	16
			8	32	3	26	40	26	33	40
			9	33	4	14	83	23	33	58
			10	70	5	16	347	41	42	172
			11	129	2	105	159	105	132	159
			12	89	1	89	89	89	89	89

Table A - 2. Continued

AUID	RM	Year	Month	Geometric Mean	N	Minimum	Maximum	25th Percentile	Median (50th Percentile)	75th Percentile
07010206-568 Cont'd	871.6 Cont'd	2008	1	141	2	137	146	137	142	146
			2	102	2	85	122	85	104	122
			3	34	5	17	88	18	22	75
			4	7	3	4	16	4	6	16
			5	19	4	9	31	12	23	31
			6	48	5	27	75	47	50	53
			7	33	3	11	92	11	36	92
			8	47	4	23	196	27	33	115
			9	50	5	27	130	33	44	62
			10	90	3	17	2420	17	18	2420
			11	28	2	14	58	14	36	58
			12	45	1	45	45	45	45	45
07010206-509	863.0	2006	7*		1	0	0	0	0	0
			8*		1	0	0	0	0	0
			9	50	1	50	50	50	50	50
			10	67	2	54	82	54	68	82
		2007	1		4	0	162	0	53	134
			2	34	1	34	34	34	34	34
			3	19	2	10	37	10	24	37
			4	2	1	2	2	2	2	2
			7	5	1	5	5	5	5	5
			8*		1	0	0	0	0	0
			12	31	2	7	135	7	71	135
		2008	1	103	2	67	157	67	112	157
			2	88	2	68	113	68	91	113
			3	2	2	1	6	1	4	6
			4	25	2	16	39	16	28	39
			8	10	1	10	10	10	10	10
			9	21	1	21	21	21	21	21
			10	47	2	32	68	32	50	68
			11	18	1	18	18	18	18	18
			12	57	2	39	84	39	62	84
	862.8	2005	6	365	1	365	365	365	365	365
			7	120	2	44	326	44	185	326
			8	51	4	13	475	17	37	264
			9	327	3	70	727	70	687	727
			10	84	3	32	326	32	56	326
			11	42	2	22	82	22	52	82
		2006	1	185	1	185	185	185	185	185
			4	13	3	6	30	6	11	30
			5	33	5	13	201	16	28	33
			6	85	3	26	649	26	36	649
			7	16	5	5	30	13	20	23
			8	58	3	27	183	27	39	183
			9	86	4	25	461	35	77	285
			10	29	5	7	866	10	12	28
			11	120	2	93	154	93	124	154
		2007	1	79	1	79	79	79	79	79
			3	8	1	8	8	8	8	8
			4	13	5	3	75	4	6	64
			5	14	3	10	19	10	16	19
			6	32	4	22	70	24	26	48
			7	25	5	11	219	12	15	22
			8	38	3	34	42	34	37	42
			9	44	4	20	127	26	39	86
			10	151	5	36	1414	96	108	148
			11	73	2	68	79	68	74	79
		2008	4	8	2	6	10	6	8	10
			5	36	3	17	99	17	28	99
			6	53	5	17	248	23	54	77
			7	20	3	8	36	8	26	36
			8	16	4	11	31	12	15	24
			9	66	5	41	172	49	50	72
			10	57	3	20	108	20	86	108
			11	16	2	10	25	10	18	25
			12	42	1	42	42	42	42	42

* Zeros in dataset preclude calculation of geometric mean.

Table A - 2. Continued

AUID	RM	Year	Month	Geometric Mean	N	Minimum	Maximum	25th Percentile	Median (50th Percentile)	75th Percentile
07010206-509 Cont'd	859.1	2003	6	119	16	18	5200	42	95	255
			7	54	19	14	260	40	52	73
			8	215	15	46	1080	74	178	610
			9	613	16	44	3800	165	920	2550
			10	119	13	46	2440	68	96	134
		2004	6	83	9	32	220	46	82	130
			7	45	9	10	240	20	54	78
			8	136	9	36	9500	42	56	230
			9	144	9	50	450	94	110	280
			10	27	2	23	32	23	28	32
		2005	6	141	5	68	330	68	112	330
			7	51	7	22	170	22	52	64
			8	59	10	18	160	28	63	100
			9	367	6	78	1100	200	360	1100
			10	72	6	18	510	36	58	130
		2006	4	14	6	3	73	5	16	23
			5	48	6	13	170	22	44	160
			6	36	7	18	70	25	32	66
			7	18	7	7	46	8	22	30
			8	87	8	40	140	72	85	125
			9	161	7	70	360	120	150	230
			10	20	8	3	150	9	21	59
			11	5	1	5	5	5	5	5
		2007	4	29	6	7	120	15	30	50
			5	27	8	3	770	15	25	35
			6	60	5	23	410	27	42	70
			7	36	8	15	120	23	30	58
			8	115	6	38	460	38	120	240
			9	185	6	50	3800	58	73	690
			10	225	7	55	640	160	210	380
			11	82	2	52	130	52	91	130
		2008	4	18	7	7	80	7	15	52
			5	20	6	12	37	12	20	28
			6	62	8	32	235	37	49	101
			7	48	7	16	280	24	36	80
			8	80	7	20	370	22	70	270
			9	95	8	30	300	56	104	155
			10	59	8	10	1210	12	57	230
			11	12	1	12	12	12	12	12
	858.8	2000	8	28	1	28	28	28	28	28
			9	140	1	140	140	140	140	140
		2002	5	8	1	8	8	8	8	8
			6	56	1	56	56	56	56	56
			7	60	1	60	60	60	60	60
			8	76	1	76	76	76	76	76
			9	80	1	80	80	80	80	80
		2004	10	20	1	20	20	20	20	20
		2005	5	16	1	16	16	16	16	16
			6	92	1	92	92	92	92	92
			7	230	1	230	230	230	230	230
		2006	4	3	1	3	3	3	3	3
			5	55	1	55	55	55	55	55
			6	16	1	16	16	16	16	16
			7	38	1	38	38	38	38	38
			8	38	1	38	38	38	38	38
			9	110	1	110	110	110	110	110
			10	5	2	3	7	3	5	7
		2007	4	10	1	10	10	10	10	10
			6	33	1	33	33	33	33	33
			8	29	1	29	29	29	29	29
			9	580	1	580	580	580	580	580

Table A - 2. Continued

AUID	RM	Year	Month	Geometric Mean	N	Minimum	Maximum	25th Percentile	Median (50th Percentile)	75th Percentile
07010206-509 Cont'd	857.6	2003	6	163	17	22	8000	66	120	220
			7	121	19	27	630	56	110	280
			8	114	15	23	2900	58	76	170
			9	278	16	120	2800	162	225	385
			10	172	13	84	540	130	160	240
		2004	6	164	9	46	1400	78	100	410
			7	65	9	10	260	28	68	220
			8	224	9	68	2900	82	230	310
			9	303	8	90	650	245	345	425
			10	117	6	44	520	66	108	160
		2005	5	100	1	100	100	100	100	100
			6	102	5	32	330	68	72	210
			7	65	7	18	170	30	86	130
			8	95	10	23	390	42	69	280
			9	840	6	180	5500	270	860	2100
			10	185	6	45	3200	46	168	280
		2006	4	17	6	7	73	10	16	18
			5	120	6	42	610	48	87	370
			6	67	7	36	150	48	52	110
			7	22	7	7	38	15	30	33
			8	157	8	90	440	99	140	225
			9	289	7	150	460	210	310	420
			10	51	8	10	430	18	43	165
			11	330	1	330	330	330	330	330
		2007	4	84	6	8	560	15	101	500
			5	46	8	3	6300	26	32	41
			6	51	5	8	490	38	40	58
			7	46	8	15	370	21	40	76
			8	284	6	82	1400	130	325	330
			9	306	6	52	4300	140	195	730
			10	329	8	45	3300	145	330	720
			11	99	2	76	130	76	103	130
		2008	4	17	7	7	58	8	12	44
			5	32	6	10	150	23	31	35
			6	85	8	20	720	48	85	110
			7	56	8	24	170	37	50	85
			8	68	7	20	180	44	92	110
			9	143	8	74	400	110	130	170
			10	174	9	20	3600	44	230	270
			11	24	1	24	24	24	24	24
	857.5	2008	4	15	2	7	32	7	20	32
			5	54	3	24	180	24	37	180
			6	31	3	8	324	8	12	324
			7	25	3	4	215	4	19	215
			8	75	2	31	180	31	106	180
			9	37	3	19	67	19	39	67

Table A - 2. Continued

AUID	RM	Year	Month	Geometric Mean	N	Minimum	Maximum	25th Percentile	Median (50th Percentile)	75th Percentile
07010206-509 Cont'd	854.9	2003	6	211	17	37	4900	76	170	320
			7	135	19	25	940	70	100	240
			8	96	15	20	770	48	70	150
			9	130	16	72	580	81	140	160
			10	62	13	30	176	42	62	90
		2004	6	98	9	27	560	56	92	140
			7	74	9	25	170	35	90	160
			8	57	9	23	330	42	52	64
			9	150	9	60	440	78	90	310
			10	50	8	22	120	41	48	64
		2005	5	38	1	38	38	38	38	38
			6	88	5	46	250	52	78	110
			7	58	7	23	140	30	52	110
			8	110	10	52	550	64	105	110
			9	292	7	98	1500	100	170	1100
			10	97	6	46	740	52	60	130
		2006	4	10	6	3	36	7	11	13
			5	57	6	17	210	17	65	150
			6	60	7	28	94	39	80	88
			7	44	8	17	84	35	47	64
			8	49	8	25	150	27	43	82
			9	140	7	76	320	88	130	210
			10	24	8	2	230	12	20	88
			11	220	1	220	220	220	220	220
		2007	4	32	6	5	98	13	48	75
			5	30	8	8	840	12	24	40
			6	65	5	27	630	35	40	47
			7	48	8	21	170	30	37	85
			8	130	6	25	790	25	200	290
			9	52	6	9	540	12	35	400
			10	162	8	27	570	82	205	335
			11	96	2	46	200	46	123	200
		2008	4	18	8	2	160	9	13	49
			5	18	6	7	44	10	19	32
			6	67	8	13	450	35	61	130
			7	48	8	10	120	41	46	80
			8	57	7	16	130	24	60	110
			9	66	8	22	210	43	59	115
			10	127	8	24	792	39	150	350
			11	22	1	22	22	22	22	22

Table A - 2. Continued

AUID	RM	Year	Month	Geometric Mean	N	Minimum	Maximum	25th Percentile	Median (50th Percentile)	75th Percentile
07010206-503	852.2	2003	6	123	17	25	4100	46	94	150
			7	75	19	17	280	48	70	130
			8	99	15	42	1500	48	74	110
			9	99	16	40	300	66	107	136
			10	82	13	24	680	54	84	100
		2004	6	84	9	18	310	48	92	130
			7	75	9	27	230	30	68	144
			8	78	10	27	340	40	99	110
			9	154	9	64	450	76	160	280
			10	62	6	40	120	40	59	84
		2005	5	30	1	30	30	30	30	30
			6	67	5	27	220	44	60	88
			7	84	7	32	220	35	80	210
			8	70	10	18	340	36	56	130
			9	345	7	120	1400	150	240	930
			10	113	6	25	2200	50	82	120
		2006	4	10	6	2	18	10	13	15
			5	56	6	17	150	35	49	140
			6	61	7	22	210	26	60	100
			7	97	7	23	1200	30	46	230
			8	135	8	44	850	76	115	215
			9	107	7	60	320	62	86	210
			10	42	8	5	570	19	28	154
			11	560	1	560	560	560	560	560
		2007	4	18	6	3	48	8	27	46
			5	31	8	5	730	15	29	41
			6	54	5	40	120	40	44	56
			7	34	8	10	170	21	31	53
			8	170	6	28	1600	42	147	790
			9	98	6	33	1400	45	46	210
			10	208	7	100	540	110	220	270
			11	100	2	56	180	56	118	180
		2008	4	28	8	8	140	14	33	45
			5	22	6	10	46	13	24	38
			6	58	8	13	360	29	60	117
			7	52	8	16	90	40	60	82
			8	43	7	14	120	20	40	78
			9	74	8	40	350	42	64	95
			10	118	9	10	2000	40	80	260
			11	22	1	22	22	22	22	22

Table A - 2. Continued

AUID	RM	Year	Month	Geometric Mean	N	Minimum	Maximum	25th Percentile	Median (50th Percentile)	75th Percentile
07010206-503 Cont'd	849.9	2003	6	110	17	18	3500	33	74	200
			7	95	19	32	540	52	74	200
			8	57	15	14	750	23	54	82
			9	84	16	15	440	54	84	145
			10	87	13	28	670	48	78	120
		2004	6	78	9	20	740	44	74	130
			7	61	9	7	430	38	50	130
			8	97	9	20	1100	52	55	210
			9	117	9	50	340	74	78	220
			10	69	5	25	390	25	60	110
		2005	5	27	1	27	27	27	27	27
			6	95	5	42	350	62	68	122
			7	109	7	22	990	32	110	280
			8	87	10	18	1900	44	68	90
			9	523	7	110	2300	170	310	2000
			10	114	6	35	3100	36	75	110
		2006	4	8	6	3	18	5	10	13
			5	41	6	8	220	23	30	130
			6	41	7	17	100	18	46	68
			7	19	7	5	84	7	18	41
			8	95	8	15	580	40	110	255
			9	94	7	40	340	46	76	280
			10	48	8	7	1100	13	34	275
			11	600	1	600	600	600	600	600
		2007	4	27	6	5	110	17	32	50
			5	28	8	10	2400	12	16	23
			6	11	5	1	28	15	18	27
			7	25	8	10	160	12	19	55
			8	226	6	44	1000	88	285	510
			9	106	6	18	9100	22	62	160
			10	233	8	27	2800	100	165	1105
			11	102	2	50	210	50	130	210
		2008	4	18	8	3	80	8	25	44
			5	22	6	5	50	17	24	46
			6	62	8	25	680	34	50	72
			7	28	8	8	320	17	24	30
			8	56	6	24	220	32	40	120
			9	134	8	30	1300	73	115	215
			10	156	9	26	3000	60	100	160
			11	26	1	26	26	26	26	26

Table A - 2. Continued

AUID	RM	Year	Month	Geometric Mean	N	Minimum	Maximum	25th Percentile	Median (50th Percentile)	75th Percentile
07010206-503 Cont'd	848.1	2003	6	138	16	18	7100	37	86	325
			7	88	19	25	580	52	72	220
			8	74	13	18	2500	27	54	86
			9	90	16	33	300	63	88	110
			10	70	13	16	670	52	80	96
		2004	6	70	9	20	460	35	70	120
			7	55	9	12	460	25	62	108
			8	59	9	10	850	23	45	62
			9	105	9	40	370	58	80	220
			10	56	2	32	98	32	65	98
		2005	5	28	1	28	28	28	28	28
			6	99	5	46	250	64	110	117
			7	71	7	15	1400	28	32	260
			8	38	10	9	420	18	41	64
			9	428	7	110	2200	140	220	1400
			10	134	6	30	7200	45	78	120
		2006	4	8	6	3	27	5	7	12
			5	40	6	12	160	22	29	130
			6	32	7	12	68	22	34	48
			7	18	7	2	110	10	12	82
			8	51	8	18	140	30	55	90
		2007	4	27	6	5	92	17	32	50
			5	17	8	2	420	9	15	24
			6	26	5	10	55	25	25	32
			7	18	7	5	180	5	15	64
			8	119	6	16	720	16	230	410
			9	59	6	16	580	18	34	240
			10	140	8	82	380	82	111	250
			11	116	2	48	280	48	164	280
		2008	4	13	8	2	43	5	20	33
			5	24	6	10	64	12	28	35
			6	93	8	18	8700	36	56	100
			7	32	7	10	280	12	26	56
			8	28	6	12	120	14	14	110
			9	52	8	26	90	39	49	80
			10	71	9	18	613	40	60	100
			11	20	1	20	20	20	20	20

Table A - 2. Continued

AUID	RM	Year	Month	Geometric Mean	N	Minimum	Maximum	25th Percentile	Median (50th Percentile)	75th Percentile
07010206-503 Cont'd	847.7	2005	6	82	3	42	231	42	57	231
			7	554	2	127	2420	127	1274	2420
			8	27	4	9	166	13	19	94
			9	689	3	78	2420	78	1733	2420
			10	133	3	37	390	37	162	390
			12	70	1	70	70	70	70	70
		2006	1	75	3	26	172	26	93	172
			2	16	2	9	28	9	19	28
			3	16	2	13	20	13	17	20
			4	9	4	5	14	6	10	14
			5	40	4	9	106	22	56	92
			6	63	4	19	173	31	79	145
			7	17	5	4	101	7	14	33
			8	56	3	10	276	10	62	276
			9	75	4	16	435	34	71	263
			10	46	5	16	548	17	18	73
			11	550	2	214	1414	214	814	1414
			12	14	1	14	14	14	14	14
		2007	1	25	3	11	59	11	25	59
			2	26	1	26	26	26	26	26
			3	18	4	5	59	8	22	47
			4	19	5	5	90	8	12	57
			5	14	3	9	21	9	14	21
			6	18	4	6	121	8	13	69
			7	19	5	1	2420	6	12	14
			8	111	3	42	387	42	84	387
			9	41	4	16	88	24	49	78
			10	242	5	25	1050	158	326	613
			11	84	2	66	107	66	87	107
			12	83	1	83	83	83	83	83
		2008	1	114	2	81	160	81	121	160
			2	24	2	15	37	15	26	37
			3	14	5	9	28	10	12	15
			4	9	3	3	22	3	11	22
			5	24	4	6	64	13	34	56
			6	54	5	25	96	41	61	74
			7	21	3	14	39	14	17	39
			8	33	4	4	770	5	41	424
			9	101	4	54	307	56	84	208
			10	118	3	14	866	14	137	866
			11	18	2	15	22	15	19	22
			12	28	2	17	46	17	32	46
07010206-505	839.7	2000	8	36	1	36	36	36	36	36
			9	91	1	91	91	91	91	91
		2002	5	16	1	16	16	16	16	16
			6	60	1	60	60	60	60	60
			7	170	1	170	170	170	170	170
			8	1400	1	1400	1400	1400	1400	1400
			9	91	1	91	91	91	91	91
		2004	10	40	1	40	40	40	40	40
		2005	6	128	2	96	170	96	133	170
			7	110	1	110	110	110	110	110
		2006	4	11	2	4	31	4	18	31
			5	10	1	10	10	10	10	10
			6	19	1	19	19	19	19	19
			8	49	1	49	49	49	49	49
			9	20	1	20	20	20	20	20
			10	20	2	11	36	11	24	36
		2007	4	28	1	28	28	28	28	28
			6	11	1	11	11	11	11	11
			9	16	1	16	16	16	16	16

Table A - 2. Continued

AUID	RM	Year	Month	Geometric Mean	N	Minimum	Maximum	25th Percentile	Median (50th Percentile)	75th Percentile
07010206-505 Cont'd	839.1	2005	6	184	3	112	488	112	114	488
			7	41	3	16	148	16	29	148
			8	32	5	13	214	16	19	38
			9	224	3	62	1414	62	129	1414
			10	141	4	24	2420	37	93	1279
			11	71	3	36	111	36	88	111
			12	77	1	77	77	77	77	77
		2006	1	78	2	61	99	61	80	99
			2	104	2	37	291	37	164	291
			3	24	3	15	53	15	18	53
			4	12	4	5	36	8	11	24
			5	37	5	13	219	23	28	38
			6	130	3	53	249	53	167	249
			7	57	5	20	1203	21	31	37
			8	53	3	36	90	36	47	90
			9	26	4	11	41	20	31	37
			10	55	4	13	166	20	94	163
			11	99	3	13	1023	13	74	1023
			12	13	1	13	13	13	13	13
		2007	1	62	1	62	62	62	62	62
			2	228	1	228	228	228	228	228
			3	51	3	36	91	36	41	91
			4	21	4	11	63	13	17	41
			5	18	4	3	161	8	15	89
			6	33	4	22	69	23	28	51
			7	22	4	7	60	11	26	49
			8	83	4	18	448	31	90	292
			9	143	4	42	488	43	253	475
			10	158	5	31	326	148	236	283
			11	72	2	71	73	71	72	73
		2008	1	89	1	89	89	89	89	89
			3	105	2	104	106	104	105	106
			4	269	4	111	816	148	249	565
			5	137	4	102	246	109	118	184
			6	50	4	36	105	37	41	75
			7	36	4	26	51	29	37	46
			8	65	4	10	462	34	63	265
			9	55	5	24	613	26	32	42
			10	96	3	47	366	47	51	366
			11	36	1	36	36	36	36	36
			12	25	1	25	25	25	25	25
	836.8	2007	1	39	1	39	39	39	39	39
			2	80	1	80	80	80	80	80
			3	67	1	67	67	67	67	67
			12	111	2	43	285	43	164	285
		2008	1	147	1	147	147	147	147	147
			2	113	2	65	198	65	132	198
			3	133	2	29	613	29	321	613
			11	86	1	86	86	86	86	86
			12	93	1	93	93	93	93	93

Table A - 2. Continued

AUID	RM	Year	Month	Geometric Mean	N	Minimum	Maximum	25th Percentile	Median (50th Percentile)	75th Percentile
07010206-504	831.0	2005	6	159	3	89	291	89	155	291
			7	29	3	13	46	13	41	46
			8	48	5	13	613	18	20	85
			9	125	3	58	224	58	152	224
			10	219	4	66	2420	67	140	1316
			11	255	3	114	399	114	365	399
			12	291	1	291	291	291	291	291
		2006	1	195	2	131	291	131	211	291
			2	317	2	291	345	291	318	345
			3	80	3	24	157	24	137	157
			4	11	4	5	45	7	8	27
			5	49	4	13	166	27	53	115
			6	102	3	48	172	48	127	172
			7	12	5	8	16	11	12	15
			8	53	3	15	105	15	96	105
			9	46	4	36	73	37	43	61
			10	51	4	38	88	39	45	69
			11	252	3	147	479	147	228	479
			12	153	1	153	153	153	153	153
		2007	1	260	2	248	272	248	260	272
			2	284	2	261	308	261	285	308
			3	110	4	14	818	20	257	653
			4	26	4	13	66	14	26	52
			5	28	4	12	111	16	22	67
			6	30	4	12	88	20	28	59
			7	21	4	12	54	13	19	39
			8	54	4	4	397	23	86	264
			9	89	4	21	613	27	92	382
			10	129	5	38	272	105	144	228
			11	612	2	288	1300	288	794	1300
			12	489	2	276	866	276	571	866
		2008	1	547	2	435	687	435	561	687
			2	314	2	285	345	285	315	345
			3	147	4	50	347	74	187	312
			4	36	4	18	61	25	42	57
			5	31	4	16	62	20	31	50
			6	47	4	27	83	33	47	69
			7	28	4	13	91	15	24	61
			8	25	4	11	57	14	27	48
			9	64	4	31	461	32	34	249
			10	85	4	30	411	43	66	244
			11	241	2	210	276	210	243	276
			12	347	2	261	461	261	361	461

Table A - 2. Continued

AUID	RM	Year	Month	Geometric Mean	N	Minimum	Maximum	25th Percentile	Median (50th Percentile)	75th Percentile
07010206-502 Cont'd	826.7	2005	6	149	3	115	238	115	120	238
			7	16	3	14	20	14	16	20
			8	14	5	5	126	5	7	25
			9	95	3	40	167	40	130	167
			10	217	4	50	2420	55	184	1364
			11	196	3	143	277	143	190	277
			12	308	1	308	308	308	308	308
		2006	1	149	2	140	158	140	149	158
			2	227	2	186	276	186	231	276
			3	72	3	26	128	26	110	128
			4	13	4	4	52	8	12	33
			5	39	5	7	152	22	53	75
			6	84	3	42	147	42	96	147
			7	11	4	7	15	9	11	14
			8	47	4	11	411	12	53	252
			9	28	4	21	36	25	29	33
			10	32	4	22	55	25	30	43
			11	191	3	54	518	54	249	518
			12	58	1	58	58	58	58	58
		2007	1	157	2	108	227	108	168	227
			2	180	2	130	249	130	190	249
			3	74	4	18	270	22	132	254
			4	21	4	11	91	13	15	53
			5	29	4	20	66	22	24	45
			6	20	4	14	38	15	18	29
			7	9	4	4	25	5	9	19
			8	24	4	5	117	8	32	86
			9	27	4	7	104	7	53	102
			10	107	5	25	266	102	130	159
			11	285	2	115	707	115	411	707
			12	330	2	178	613	178	396	613
		2008	1	810	2	649	1010	649	830	1010
			2	246	2	219	276	219	248	276
			3	100	4	45	192	63	111	167
			4	31	4	12	62	22	35	51
			5	24	4	8	62	16	26	45
			6	43	4	27	71	31	44	62
			7	23	4	11	62	15	20	41
			8	8	4	1	32	6	11	22
			9	19	4	6	172	8	12	93
			10	43	4	13	115	21	54	97
			11	164	2	116	233	116	175	233
			12	344	2	325	365	325	345	365
	826.4	2000	8	36	1	36	36	36	36	36
			9	160	1	160	160	160	160	160
		2002	5	16	1	16	16	16	16	16
			6	110	1	110	110	110	110	110
			7	210	1	210	210	210	210	210
			8	760	1	760	760	760	760	760
			9	64	1	64	64	64	64	64
		2004	10	32	1	32	32	32	32	32
		2005	5	8	1	8	8	8	8	8
			7	4	1	4	4	4	4	4
		2006	4	11	2	11	12	11	12	12
			5	15	1	15	15	15	15	15
			6	8	1	8	8	8	8	8
			8	52	1	52	52	52	52	52
			9	23	1	23	23	23	23	23
			10	19	2	15	23	15	19	23
		2007	4	24	1	24	24	24	24	24
			6	8	1	8	8	8	8	8
			9	7	1	7	7	7	7	7

Table A - 2. Continued

AUID	RM	Year	Month	Geometric Mean	N	Minimum	Maximum	25th Percentile	Median (50th Percentile)	75th Percentile
07010206-502 Cont'd	821.8	2007	6	39	2	30	52	30	41	52
			7	7	3	2	30	2	6	30
			8	26	3	7	108	7	23	108
			9	21	2	12	36	12	24	36
		2008	6	29	2	18	47	18	33	47
			7	20	4	15	33	16	18	27
			8	8	3	5	17	5	6	17
			9	20	4	9	66	11	18	45
			10	45	2	40	50	40	45	50
07010206-502	815.6	2005	6	61	3	45	81	45	63	81
			7	18	3	10	28	10	20	28
			8	4	5	1	19	2	2	12
			9	60	3	40	91	40	58	91
			10	274	4	73	1300	156	244	775
			11	146	3	46	488	46	140	488
			12	62	1	62	62	62	62	62
		2006	1	37	2	24	57	24	41	57
			2	43	2	24	78	24	51	78
			3	13	3	6	25	6	16	25
			4	19	4	8	80	10	15	49
			5	25	5	7	72	16	26	50
			6	17	3	8	46	8	14	46
			7	2	4	1	10	1	2	7
			8	11	4	3	48	7	11	30
			9	12	4	5	21	9	15	19
			10	20	4	13	30	16	20	25
			11	13	3	6	42	6	8	42
			12	3	1	3	3	3	3	3
		2007	1	11	2	5	23	5	14	23
			2	43	2	40	46	40	43	46
			3	14	4	7	25	9	16	24
			4	23	4	9	118	10	19	72
			5	8	4	7	11	8	8	10
			6	9	4	7	16	8	9	13
			7	3	4	1	5	2	4	5
			8	7	4	1	38	3	12	29
			9	14	4	6	37	9	13	26
			10	109	5	80	155	91	117	119
			11	117	2	88	155	88	122	155
			12	135	2	63	291	63	177	291
		2008	1	270	2	236	308	236	272	308
			2	108	2	108	108	108	108	108
			3	11	3	2	28	2	27	28
			4	46	4	30	88	30	43	72
			5	20	4	8	54	12	19	38
			6	26	4	20	36	22	26	32
			7	14	4	12	20	12	14	18
			8	3	4	1	6	2	4	6
			9	6	4	2	14	4	6	11
			10	44	4	30	65	32	46	61
			11	37	2	29	46	29	38	46
			12	40	2	17	96	17	57	96

Table A - 2. Continued

AUID	RM	Year	Month	Geometric Mean	N	Minimum	Maximum	25th Percentile	Median (50th Percentile)	75th Percentile
07010206-502	815.2	2000	8	4	1	4	4	4	4	4
			9	36	1	36	36	36	36	36
		2002	4	4	1	4	4	4	4	4
			5	28	1	28	28	28	28	28
			6	84	1	84	84	84	84	84
			7	32	1	32	32	32	32	32
			8	240	1	240	240	240	240	240
			9	120	1	120	120	120	120	120
		2004	10	110	1	110	110	110	110	110
		2005	5	4	1	4	4	4	4	4
			6	120	1	120	120	120	120	120
			7	8	1	8	8	8	8	8
		2006	4	24	2	16	35	16	26	35
			5	12	1	12	12	12	12	12
			6	11	1	11	11	11	11	11
			8	6	1	6	6	6	6	6
			9	29	1	29	29	29	29	29
			10	15	2	10	24	10	17	24
		2007	4	19	1	19	19	19	19	19
			6	3	1	3	3	3	3	3
			9	1	1	1	1	1	1	1

B. Fecal Coliform Data Summary

Table B - 1. Mississippi River fecal coliform data summary by RM by month across all years.

AUID	RM	Month	Geometric Mean	N	Minimum	Maximum	25th Percentile	Median (50th Percentile)	75th Percentile
07010201-501	953.5	3	6	1	6	6	6	6	6
07010203-574	929.4	1	104	1	104	104	104	104	104
		3	36	2	4	333	4	169	333
		4	14	4	4	40	9	15	28
		5	96	6	10	400	30	164	264
		6	211	8	20	3680	90	210	435
		7	70	3	18	270	18	70	270
		8	384	12	28	5720	155	300	1550
		9	261	5	90	1520	140	210	300
		10	175	5	12	816	240	240	290
		12	28	1	28	28	28	28	28
	928.4	1	22	157	1	256	12	21	48
		2	31	140	2	190	20	33	52
		3	14	156	1	172	8	14	28
		4*		146	0	364	2	6	10
		5	10	144	1	118	4	10	20
		6*		156	0	612	16	28	65
		7*		152	0	1745	8	20	44
		8	14	155	1	452	8	12	28
		9	22	145	2	310	10	20	44
		10	13	158	1	2000	5	13	24
		11	15	145	1	356	8	14	28
		12	19	157	1	176	12	21	35
07010203-510	914.0	4	4	1	4	4	4	4	4
		5	32	1	32	32	32	32	32
		6	141	2	52	380	52	216	380
		7	70	2	64	77	64	71	77
		8	38	2	28	52	28	40	52
		9	125	2	120	130	120	125	130
		10	25	3	24	28	24	24	28
	896.9	4	8	1	8	8	8	8	8
		5	8	1	8	8	8	8	8
		6	310	2	120	800	120	460	800
		7	107	2	88	130	88	109	130
		8	71	2	52	96	52	74	96
		9	80	2	28	230	28	129	230
		10	10	3	4	16	4	16	16
07010206-568	871.7	6	765	2	450	1300	450	875	1300
		7	245	2	50	1200	50	625	1200
		8	68	2	27	170	27	99	170
		9	177	2	120	260	120	190	260
	871.6	1	77	20	30	250	53	76	97
		2	57	18	20	190	40	54	82
		3	25	41	3	270	10	28	47
		4	18	38	2	464	7	15	30
		5	45	38	2	710	21	39	100
		6	71	41	10	2520	29	60	130
		7	52	42	8	600	23	46	96
		8	81	39	20	1800	42	55	150
		9	74	41	10	2800	40	60	100
		10	28	38	5	600	10	22	40
		11	43	20	4	300	20	52	84
		12	73	17	20	530	50	80	110

* Zeros in dataset preclude calculation of the geometric mean.

Table B - 1. Continued

AUID	RM	Month	Geometric Mean	N	Minimum	Maximum	25th Percentile	Median (50th Percentile)	75th Percentile
07010206-509	863.0*	1		9	0	178	10	45	76
		2		9	0	312	6	20	32
		3		9	0	260	0	4	16
		4		10	0	100	0	8	46
		5		10	0	100	0	15	24
		6		13	0	50000	40	106	200
		7		10	0	520	36	100	160
		8		9	0	600	13	33	160
		9		9	0	900	52	162	400
		10		7	0	100	0	0	98
		11		8	0	250	17	102	180
		12		9	0	348	38	72	132
	862.8	1	50	6	20	190	33	43	73
		2	25	3	20	36	20	23	36
		3	15	22	2	220	6	20	29
		4	14	29	4	300	7	10	28
		5	40	34	4	1800	20	34	93
		6	86	39	20	4400	30	66	170
		7	60	37	10	756	30	38	82
		8	90	39	21	1670	44	73	140
		9	113	41	27	1160	51	100	190
		10	51	39	6	1700	22	40	91
		11	51	20	9	910	22	53	84
		12	47	10	20	110	30	45	83
	859.1	4	42	8	20	170	20	40	70
		5	65	12	20	800	20	55	140
		6	145	38	20	9000	40	130	300
		7	71	46	20	800	40	70	130
		8	211	47	20	9000	80	130	500
		9	518	44	10	16000	135	460	1950
		10	127	37	20	2400	40	130	300
		11	124	3	80	170	80	140	170
	859.0	7	165	2	72	380	72	226	380
		8	244	3	110	400	110	330	400
		9	96	5	44	180	68	100	150
	858.8	4	8	2	4	16	4	10	16
		5	14	1	14	14	14	14	14
		6	77	2	54	110	54	82	110
		7	192	2	160	230	160	195	230
		8	42	2	24	72	24	48	72
		9	212	2	160	280	160	220	280
		10	16	1	16	16	16	16	16
	858.5	1	136	219	20	2300	78	130	200
		2	113	216	18	1700	78	130	200
		3	61	166	18	2300	20	45	170
		4	46	126	18	1700	20	40	78
		5	67	199	18	3100	20	45	170
		6	116	210	18	4900	45	85	220
		7	100	210	18	13000	45	78	200
		8	125	220	18	7900	45	130	225
		9	178	226	18	11000	78	200	450
		10	84	215	18	3300	45	78	200
		11	83	207	18	2300	40	78	200
		12	118	211	18	1700	68	130	200

* Zeros in dataset preclude calculation of the geometric mean.

Table B - 1. Continued

AUID	RM	Month	Geometric Mean	N	Minimum	Maximum	25th Percentile	Median (50th Percentile)	75th Percentile
07010206-509 Cont'd	857.6	4	123	6	20	700	80	125	230
		5	102	15	20	16000	40	80	170
		6	172	41	20	16000	40	220	500
		7	126	49	20	1300	40	130	300
		8	254	49	20	16000	80	210	700
		9	530	43	70	16000	230	500	1300
		10	202	40	20	3000	110	195	500
		11	334	3	130	1300	130	220	1300
	857.5	7	440	2	88	2200	88	1144	2200
		8	666	3	530	900	530	620	900
		9	181	5	32	380	220	260	280
	855.0	7	299	2	64	1400	64	732	1400
		8	213	3	120	320	120	250	320
		9	93	5	32	310	40	72	250
	854.9	4	39	6	20	130	20	30	80
		5	63	11	20	1100	20	40	230
		6	146	42	20	9000	40	130	300
		7	195	47	20	16000	80	170	300
		8	158	50	20	3730	70	130	500
		9	250	44	20	2400	115	220	750
		10	119	41	20	2300	80	80	220
		11	192	3	80	800	80	110	800
07010206-503	853.1	7	529	2	140	2000	140	1070	2000
		8	354	3	160	580	160	480	580
		9	270	5	94	1000	170	190	470
	852.2	4	43	7	20	130	20	40	80
		5	77	13	20	3000	20	40	230
		6	144	43	20	9000	40	130	270
		7	116	49	20	2400	40	130	230
		8	196	49	20	16000	80	140	500
		9	187	45	20	2400	80	140	500
		10	123	38	20	5000	40	120	260
		11	172	3	20	1100	20	230	1100
	849.9	4	31	10	20	130	20	20	40
		5	57	12	20	1300	20	40	105
		6	146	39	20	9000	40	90	300
		7	132	45	18	2400	40	110	300
		8	197	47	20	9000	40	130	900
		9	214	45	20	16000	80	170	300
		10	134	40	20	5000	55	120	285
		11	164	3	11	800	11	500	800
	848.1	4	40	9	20	170	40	40	40
		5	86	9	20	2400	40	40	130
		6	138	40	20	9000	40	120	300
		7	116	46	20	3000	40	85	300
		8	125	44	20	5000	20	130	400
		9	181	37	20	9000	80	140	500
		10	139	30	20	16000	70	130	230
		11	110	2	40	300	40	170	300
	847.7	1	35	22	8	240	10	40	86
		2	24	20	5	190	15	22	43
		3	12	39	2	380	6	10	22
		4	15	37	2	210	7	10	30
		5	49	37	6	2500	21	40	120
		6	98	42	10	4730	47	79	210
		7	69	41	3	2000	30	82	160
		8	93	39	10	1500	40	100	200
		9	120	39	10	4270	58	96	220
		10	79	38	9	870	27	55	240
		11	59	20	10	620	30	51	115
		12	43	18	10	320	25	44	68

Table B - 1. Continued

AUID	RM	Month	Geometric Mean	N	Minimum	Maximum	25th Percentile	Median (50th Percentile)	75th Percentile
07010206-505	839.7	4	12	1	12	12	12	12	12
		5	40	1	40	40	40	40	40
		6	82	2	48	140	48	94	140
		7	219	2	80	600	80	340	600
		8	263	2	46	1500	46	773	1500
		9	121	2	73	200	73	137	200
		10	34	1	34	34	34	34	34
	839.1	1	76	16	38	360	54	63	85
		2	96	17	22	320	62	98	190
		3	52	37	7	490	30	43	100
		4	35	35	6	570	10	34	96
		5	42	39	4	680	10	30	120
		6	123	39	21	2000	56	100	230
		7	95	41	20	1900	47	80	130
		8	104	41	10	2600	46	90	200
		9	103	40	1	2800	46	77	235
		10	77	40	9	7900	31	57	170
		11	84	21	9	1200	48	67	160
		12	89	15	20	420	50	84	220
	836.8	1	62	4	37	95	43	69	92
		2	75	4	28	160	51	85	129
		3	43	3	9	220	9	41	220
		5	130	1	130	130	130	130	130
		11	97	1	97	97	97	97	97
		12	73	3	32	140	32	87	140
07010206-504	831.0	1	434	20	130	2000	210	460	680
		2	468	21	200	2600	250	410	730
		3	171	39	6	1400	60	240	410
		4	22	36	4	220	10	21	45
		5	37	40	4	380	15	31	99
		6	101	39	20	2000	52	96	170
		7	67	41	9	930	31	56	140
		8	71	41	8	780	30	74	150
		9	94	39	20	680	49	80	200
		10	77	40	10	17800	44	69	115
		11	362	22	68	1750	160	435	600
		12	439	18	120	3100	270	435	688
07010206-502	826.7	1	379	20	90	1400	240	430	560
		2	394	21	96	2100	210	390	560
		3	118	40	5	730	66	125	250
		4	16	35	2	120	9	20	30
		5	34	40	2	1460	10	24	96
		6	86	39	10	4100	44	92	160
		7	55	40	6	1500	23	48	115
		8	43	42	6	400	20	35	100
		9	63	39	10	510	28	58	120
		10	55	41	10	15700	27	44	87
		11	255	22	41	1300	130	245	490
		12	372	17	60	3500	230	380	600
	826.4	4	20	1	20	20	20	20	20
		5	24	1	24	24	24	24	24
		6	85	2	48	150	48	99	150
		7	279	2	130	600	130	365	600
		8	297	2	100	880	100	490	880
		9	121	2	64	230	64	147	230
		10	12	1	12	12	12	12	12

Table B - 1. Continued

AUID	RM	Month	Geometric Mean	N	Minimum	Maximum	25th Percentile	Median (50th Percentile)	75th Percentile
07010206-502 Cont'd	821.8	6	46	6	9	140	20	58	120
		7	49	15	4	1480	21	43	120
		8	41	12	9	220	20	46	79
		9	73	12	7	490	28	80	175
		10	37	6	23	57	30	35	53
	815.6	1	93	20	3	820	42	120	260
		2	68	21	10	1600	31	64	130
		3	15	39	1	180	6	10	29
		4	19	35	2	110	9	21	43
		5	16	39	1	360	8	20	37
		6	34	39	4	220	20	38	60
		7	28	40	1	1200	20	33	71
		8	13	42	1	220	4	10	55
		9	28	39	1	230	10	30	73
		10	74	41	5	1200	45	88	110
		11	87	22	5	1170	41	84	220
		12	90	18	6	4670	40	75	170
	815.2	4	13	2	8	20	8	14	20
		5	8	1	8	8	8	8	8
		6	44	2	32	60	32	46	60
		7	107	2	32	360	32	196	360
		8	22	2	4	120	4	62	120
		9	35	2	9	140	9	75	140
		10	130	1	130	130	130	130	130
07010206-501	813.9	5	8	1	8	8	8	8	8
		7	116	7	20	1200	40	110	190
		8	52	5	20	110	42	58	74
		9	143	3	110	240	110	110	240
		10	57	2	40	82	40	61	82
	812.8	5	8	1	8	8	8	8	8
		7	155	7	40	1180	60	180	290
		8	45	5	10	110	44	58	66
		9	197	3	140	320	140	170	320
		10	44	2	20	98	20	59	98

Table B - 2. Mississippi River fecal coliform data summary by RM by year by month.

AUID	RM	Year	Month	Geometric Mean	N	Minimum	Maximum	25th Percentile	Median (50th Percentile)	75th Percentile
07010201-501	953.5	2007	3	6	1	6	6	6	6	6
07010203-574	929.4	2000	6	230	1	230	230	230	230	230
			7	270	1	270	270	270	270	270
			8	160	1	160	160	160	160	160
			9	140	1	140	140	140	140	140
		2001	10	240	2	240	240	240	240	240
		2002	4	14	1	14	14	14	14	14
			5	30	1	30	30	30	30	30
			6	480	1	480	480	480	480	480
			7	18	1	18	18	18	18	18
			8	28	1	28	28	28	28	28
			9	300	1	300	300	300	300	300
		2004	5	208	1	208	208	208	208	208
			6	97	2	50	190	50	120	190
			8	261	5	150	370	250	250	350
			9	90	1	90	90	90	90	90
			10	59	2	12	290	12	151	290
		2005	4	13	2	4	40	4	22	40
			5	325	2	264	400	264	332	400
			6	51	2	20	130	20	75	130
			7	70	1	70	70	70	70	70
			8	1720	2	1720	1720	1720	1720	1720
			9	1520	1	1520	1520	1520	1520	1520
			10	816	1	816	816	816	816	816
		2006	4	15	1	15	15	15	15	15
			5	35	2	10	120	10	65	120
			6	1198	2	390	3680	390	2035	3680
			8	858	3	80	5720	80	1380	5720
			9	210	1	210	210	210	210	210
			12	28	1	28	28	28	28	28
		2007	1	104	1	104	104	104	104	104
			3	36	2	4	333	4	169	333

Table B - 2. Continued

AUID	RM	Year	Month	Geometric Mean	N	Minimum	Maximum	25th Percentile	Median (50th Percentile)	75th Percentile
07010203-574 Cont'd	928.4	2000	1	37	17	12	72	24	40	60
			2	65	16	36	190	50	64	82
			3	10	18	2	140	5	9	14
			4*		16	0	9	1	1	3
			5	13	17	1	108	8	16	28
			6	46	18	12	108	29	50	72
			7	39	17	4	152	24	44	84
			8	12	19	4	76	8	8	20
			9	25	15	4	96	16	24	44
			10	12	18	4	80	8	12	24
			11	42	18	10	356	10	36	132
			12	15	16	2	32	12	20	26
		2001	1	30	17	12	110	24	28	36
			2	46	16	8	88	40	50	60
			3	23	17	8	68	16	24	32
			4	32	16	4	364	9	36	100
			5	11	16	3	41	4	11	23
			6	54	17	11	468	24	40	78
			7	20	17	4	338	12	16	28
			8	8	17	2	61	4	5	12
			9	16	16	2	264	11	13	20
			10	12	18	4	115	6	12	23
			11	12	16	4	37	7	10	24
			12	21	18	8	48	16	20	35
		2002	1	16	18	5	38	12	18	24
			2	20	14	10	48	14	21	25
			3	12	16	2	56	10	13	16
			4	9	17	2	96	3	6	24
			5	3	10	1	13	1	3	7
			6	43	16	8	340	15	30	151
			7	74	19	10	1745	32	44	120
			8	31	17	10	155	20	26	40
			9	58	16	10	204	40	62	84
			10	27	19	8	416	13	20	55
			11	22	15	11	31	20	22	26
			12	22	19	9	46	14	24	32
		2003	1	16	17	8	75	13	15	17
			2	31	15	10	59	20	32	50
			3	7	17	1	30	5	6	12
			4	4	17	1	74	1	3	8
			5	9	17	1	46	4	13	18
			6	38	17	2	332	22	45	72
			7	40	16	8	180	16	42	114
			8	11	16	5	30	8	10	17
			9	14	18	2	124	8	16	22
			10	7	18	2	19	4	8	13
			11	7	16	2	27	4	7	13
			12	7	20	1	26	5	7	16
		2004	1	5	16	1	25	3	5	10
			2	18	16	10	41	15	18	24
			3	9	20	1	71	4	11	20
			4	4	17	1	9	2	3	6
			5	19	17	5	102	10	15	32
			6	30	18	15	612	20	26	34
			7	26	17	9	76	15	22	47
			8	16	17	3	52	9	20	34
			9	48	17	12	190	32	48	90
			10	30	16	7	240	20	25	34
			11	13	18	5	41	9	12	18
			12	11	17	4	45	7	10	14

* Zeros in dataset preclude calculation of the geometric mean.

Table B - 2. Continued

AUID	RM	Year	Month	Geometric Mean	N	Minimum	Maximum	25th Percentile	Median (50th Percentile)	75th Percentile
07010203-574 Cont'd	928.4 Cont'd	2005	1	16	17	8	45	12	16	20
			2	27	16	8	110	21	25	40
			3	11	16	2	60	7	10	14
			4	7	16	1	119	4	8	10
			5	10	17	1	118	4	8	24
			6	48	19	8	310	20	50	92
			7	24	16	8	232	16	24	30
			8	11	18	2	98	5	12	19
			9	37	17	6	310	12	36	80
			10	32	17	4	2000	11	24	40
			11	32	17	9	150	20	32	52
			12	28	17	16	84	19	28	34
		2006	1	62	18	28	127	55	62	76
			2	33	16	12	63	31	36	44
			3	14	18	2	56	4	21	32
			4	3	14	1	24	1	2	7
			5	7	18	1	26	4	7	11
			6*		18	0	50	8	17	36
			7*		17	0	127	1	2	5
			8	17	19	2	222	8	12	50
			9	11	15	4	89	8	9	16
			10	3	18	1	12	1	4	8
			11	4	16	1	74	2	4	5
			12	15	14	1	176	6	15	31
		2007	1	10	18	4	40	8	8	14
			2	18	16	2	107	10	17	41
			3	40	17	10	172	20	36	84
			4	10	17	3	52	6	9	13
			5	8	15	1	80	3	7	44
			6	24	16	8	80	12	20	60
			7	5	14	1	210	2	4	8
			8	29	17	3	452	12	28	40
			9	17	14	2	220	8	20	26
			10	32	18	4	320	15	25	76
			11	25	14	12	102	16	24	35
			12	50	17	27	148	44	48	68
		2008	1	67	19	40	256	48	65	84
			2	47	15	20	115	40	48	56
			3	25	17	4	86	12	24	48
			4	5	16	2	8	4	6	8
			5	10	17	4	45	6	12	14
			6	12	17	3	104	8	10	16
			7*		19	0	26	5	11	17
			8	9	15	1	65	4	8	23
			9	10	17	2	36	8	10	11
			10	6	16	1	90	3	5	12
			11	10	15	3	85	7	8	15
			12	29	19	6	110	18	36	42

* Zeros in dataset preclude calculation of the geometric mean.

Table B - 2. Continued

AUID	RM	Year	Month	Geometric Mean	N	Minimum	Maximum	25th Percentile	Median (50th Percentile)	75th Percentile
07010203-510	914	2000	6	52	1	52	52	52	52	52
			7	77	1	77	77	77	77	77
			8	52	1	52	52	52	52	52
			9	130	1	130	130	130	130	130
		2001	10	24	2	24	24	24	24	24
		2002	4	4	1	4	4	4	4	4
			5	32	1	32	32	32	32	32
			6	380	1	380	380	380	380	380
			7	64	1	64	64	64	64	64
			8	28	1	28	28	28	28	28
			9	120	1	120	120	120	120	120
		2004	10	28	1	28	28	28	28	28
	896.9	2000	6	120	1	120	120	120	120	120
			7	88	1	88	88	88	88	88
			8	96	1	96	96	96	96	96
			9	28	1	28	28	28	28	28
		2001	10	16	2	16	16	16	16	16
		2002	4	8	1	8	8	8	8	8
			5	8	1	8	8	8	8	8
			6	800	1	800	800	800	800	800
			7	130	1	130	130	130	130	130
			8	52	1	52	52	52	52	52
			9	230	1	230	230	230	230	230
		2004	10	4	1	4	4	4	4	4
07010206-568	871.7	2002	6	765	2	450	1300	450	875	1300
			7	245	2	50	1200	50	625	1200
			8	68	2	27	170	27	99	170
			9	177	2	120	260	120	190	260
	871.6	1999	1	78	2	76	80	76	78	80
			2	59	2	40	86	40	63	86
			3	8	5	4	20	6	6	10
			4	26	3	10	51	10	36	51
			5	98	4	30	350	35	130	285
			6	78	4	20	270	39	89	195
			7	192	4	89	600	115	160	390
			8	151	5	30	600	120	150	240
			9	56	3	46	78	46	50	78
			10	26	4	10	59	18	28	45
			11	21	2	20	22	20	21	22
			12	57	2	40	80	40	60	80
		2000	1	66	2	43	100	43	72	100
			2	57	1	57	57	57	57	57
			3	45	4	23	130	30	37	84
			4	65	3	20	464	20	30	464
			5	67	4	40	100	53	71	88
			6	370	4	100	2520	145	290	1455
			7	93	5	44	180	60	100	150
			8	133	3	54	270	54	160	270
			9	55	4	30	150	35	46	101
			10	22	4	10	40	15	24	34
			11	139	2	64	300	64	182	300
			12	101	2	92	110	92	101	110

Table B - 2. Continued

AUID	RM	Year	Month	Geometric Mean	N	Minimum	Maximum	25th Percentile	Median (50th Percentile)	75th Percentile
07010206-568 Cont'd	871.6 Cont'd	2001	1	83	2	76	90	76	83	90
			2	39	2	30	50	30	40	50
			3	36	4	23	58	24	39	56
			4	61	5	20	370	20	30	190
			5	78	3	37	280	37	46	280
			6	57	4	10	190	27	87	160
			7	57	5	26	240	34	42	65
			8	30	3	24	43	24	26	43
			9	69	4	50	92	57	70	84
			10	20	3	10	39	10	20	39
			11	11	2	4	30	4	17	30
			12	142	2	96	210	96	153	210
		2002	1	65	2	64	66	64	65	66
			2	57	2	40	80	40	60	80
			3	19	4	8	38	14	20	29
			4	12	5	7	20	8	10	20
			5	45	3	20	150	20	30	150
			6	82	4	20	800	23	68	455
			7	144	4	62	570	75	114	355
			8	350	4	90	1800	105	445	1285
			9	60	5	30	140	38	49	100
			10	65	3	20	380	20	36	380
			11	80	2	79	81	79	80	81
			12	100	2	83	120	83	102	120
		2003	1	160	1	160	160	160	160	160
			2	104	2	57	190	57	124	190
			3	35	5	5	270	6	32	190
			4	23	3	5	240	5	10	240
			5	22	4	2	230	12	23	128
			6	40	5	20	210	25	29	32
			7	51	3	43	64	43	48	64
			8	49	4	29	92	38	47	70
			9	25	5	10	44	20	27	42
			10	13	3	10	20	10	10	20
			11	14	2	10	20	10	15	20
			12	33	2	20	55	20	38	55
		2004	1	41	2	35	48	35	42	48
			2	34	2	28	42	28	35	42
			3	35	5	20	52	31	36	47
			4	9	3	2	36	2	9	36
			5	101	4	23	710	33	97	430
			6	116	4	60	250	74	114	195
			7	66	4	23	350	25	57	219
			8	46	5	34	75	42	43	44
			9	146	3	83	390	83	96	390
			10	17	4	10	22	15	21	22
			11	127	2	90	180	90	135	180
			12	56	2	50	62	50	56	62

Table B - 2. Continued

AUID	RM	Year	Month	Geometric Mean	N	Minimum	Maximum	25th Percentile	Median (50th Percentile)	75th Percentile
07010206-568 Cont'd	871.6 Cont'd	2005	1	230	1	230	230	230	230	230
			2	121	2	82	180	82	131	180
			3	39	3	20	62	20	47	62
			4	15	4	6	37	8	17	31
			5	18	4	4	73	12	20	47
			6	75	4	53	160	55	62	114
			7	40	4	22	73	29	40	59
			8	76	5	41	150	55	57	130
			9	492	4	130	2800	215	418	1668
			10	85	4	30	480	43	60	272
			11	80	2	54	120	54	87	120
			12	241	2	110	530	110	320	530
		2006	1	145	3	93	250	93	130	250
			2	30	2	20	44	20	32	44
			3	60	2	51	70	51	61	70
			4	9	4	5	24	5	7	17
			5	59	5	21	430	38	41	51
			6	74	3	53	130	53	60	130
			7	13	5	10	20	10	10	20
			8	74	3	20	400	20	50	400
			9	141	4	60	750	70	95	430
			10	9	5	5	23	6	8	9
			11	32	2	20	50	20	35	50
			12	20	1	20	20	20	20	20
		2007	1	43	3	30	64	30	41	64
			2	100	1	100	100	100	100	100
			3	24	4	10	110	10	19	69
			4	10	5	4	86	5	7	10
			5	12	3	7	31	7	9	31
			6	27	4	20	56	20	22	40
			7	17	5	8	41	10	20	25
			8	65	3	39	120	39	58	120
			9	36	4	26	68	28	31	50
			10	50	5	10	250	20	40	150
			11	77	2	69	86	69	78	86
			12	80	1	80	80	80	80	80
		2008	1	70	2	58	84	58	71	84
			2	48	2	34	69	34	52	69
			3	13	5	3	42	10	10	31
			4	9	3	6	20	6	7	20
			5	41	4	10	390	17	27	210
			6	47	5	21	69	46	51	69
			7	46	3	20	96	20	51	96
			8	59	4	38	160	40	46	105
			9	66	5	38	180	48	55	68
			10	67	3	20	600	20	25	600
			11	22	2	10	50	10	30	50
			12	21	1	21	21	21	21	21

Table B - 2. Continued

AUID	RM	Year	Month	Geometric Mean	N	Minimum	Maximum	25th Percentile	Median (50th Percentile)	75th Percentile
07010206-509	863.0	1999	6*		2	0	106	0	53	106
			7	34	2	13	87	13	50	87
			8	21	2	13	33	13	23	33
			9	162	1	162	162	162	162	162
			11	50	2	24	103	24	64	103
			12*		2	0	11	0	6	11
		2000	1	15	2	5	45	5	25	45
			2	29	1	29	29	29	29	29
			3	19	2	12	29	12	21	29
			4	7	2	4	11	4	8	11
			5	21	1	21	21	21	21	21
			6	27	1	27	27	27	27	27
			7	66	2	36	120	36	78	120
			8	32	1	32	32	32	32	32
			9	57	2	52	62	52	57	62
			10	98	1	98	98	98	98	98
			11	210	1	210	210	210	210	210
			12	132	1	132	132	132	132	132
		2001	1	76	1	76	76	76	76	76
			2	45	2	32	64	32	48	64
			3	260	1	260	260	260	260	260
			4*		2	0	100	0	50	100
			5	18	1	18	18	18	18	18
			6	358	2	50	2560	50	1305	2560
			7	100	1	100	100	100	100	100
			8*		1	0	0	0	0	0
			9*		2	0	400	0	200	400
			10*		2	0	0	0	0	0
			11		2	0	100	0	50	100
			12	111	1	111	111	111	111	111
		2002	1	40	1	40	40	40	40	40
			2	20	1	20	20	20	20	20
			3*		1	0	0	0	0	0
			5*		1	0	0	0	0	0
			6	1581	2	50	50000	50	25025	50000
			7	160	1	160	160	160	160	160
			8	600	1	600	600	600	600	600
			9		2	0	900	0	450	900
			10		1	0	0	0	0	0
			11	194	2	150	250	150	200	250
			12	72	1	72	72	72	72	72
		2003	1	84	1	84	84	84	84	84
			2	312	1	312	312	312	312	312
			3	4	1	4	4	4	4	4
			4	80	1	80	80	80	80	80
			5	24	1	24	24	24	24	24
			6*		2	0	160	0	80	160
			7*		1	0	0	0	0	0
			8	100	1	100	100	100	100	100
			9	500	1	500	500	500	500	500
			10	40	1	40	40	40	40	40
			12	236	2	160	348	160	254	348

* Zeros in dataset preclude calculation of the geometric mean.

Table B - 2. Continued

AUID	RM	Year	Month	Geometric Mean	N	Minimum	Maximum	25th Percentile	Median (50th Percentile)	75th Percentile
07010206-509 Cont'd	863.0 Cont'd	2004	1*		1	0	0	0	0	0
			2	6	1	6	6	6	6	6
			3*		2	0	16	0	8	16
			4*		1	0	0	0	0	0
			5*		3	0	100	0	40	100
			6	548	2	200	1500	200	850	1500
			7	100	1	100	100	100	100	100
			8*		1	0	0	0	0	0
			12	44	2	38	52	38	45	52
		2005	1	178	1	178	178	178	178	178
			2	8	1	8	8	8	8	8
			3*		2	0	0	0	0	0
			4*		2	0	46	0	23	46
			5*		2	0	12	0	6	12
			6	85	2	40	180	40	110	180
			7	322	2	200	520	200	360	520
			8	305	2	160	580	160	370	580
			9	360	1	360	360	360	360	360
			10*		2	0	100	0	50	100
			11	10	1	10	10	10	10	10
		2006	1	26	2	10	70	10	40	70
			2*		2	0	0	0	0	0
			4	13	2	4	40	4	22	40
			5*		1	0	0	0	0	0
	862.8	1999	2	20	1	20	20	20	20	20
			3	6	5	5	9	5	6	6
			4	14	3	7	38	7	10	38
			5	45	2	10	200	10	105	200
			6	71	4	30	280	30	65	190
			7	101	3	54	240	54	79	240
			8	173	5	40	1430	96	130	220
			9	91	3	40	190	40	100	190
			10	29	4	21	40	22	31	40
			11	46	2	32	66	32	49	66
			12	44	1	44	44	44	44	44
		2000	3	32	3	21	41	21	37	41
			4	8	3	6	10	6	8	10
			5	32	4	24	46	26	31	40
			6	145	4	66	1100	68	79	594
			7	48	5	30	82	37	42	68
			8	118	3	74	160	74	140	160
			9	82	4	40	180	60	80	130
			10	66	4	30	150	30	85	145
			11	276	2	84	910	84	497	910
			12	110	1	110	110	110	110	110
		2001	3	20	1	20	20	20	20	20
			4	28	1	28	28	28	28	28
			5	42	2	20	90	20	55	90
			6	114	4	25	460	46	144	340
			7	94	5	30	756	31	56	190
			8	63	3	44	110	44	52	110
			9	171	4	110	280	115	175	255
			10	63	4	20	190	37	66	134
			11	14	2	9	21	9	15	21
			12	74	2	66	83	66	75	83

* Zeros in dataset preclude calculation of the geometric mean.

Table B - 2. Continued

AUID	RM	Year	Month	Geometric Mean	N	Minimum	Maximum	25th Percentile	Median (50th Percentile)	75th Percentile
07010206-509 Cont'd	862.8 Cont'd	2002	1	34	2	33	36	33	35	36
			2	29	2	23	36	23	30	36
			3	8	4	4	22	5	8	16
			4	18	5	7	42	10	23	25
			5	63	3	40	160	40	40	160
			6	213	4	20	4400	38	242	2414
			7	289	2	220	380	220	300	380
			8	196	4	130	580	130	140	365
			9	194	5	41	1160	70	190	432
			10	72	3	20	390	20	48	390
			11	102	2	52	200	52	126	200
			12	54	2	35	84	35	60	84
		2003	1	73	1	73	73	73	73	73
			3	39	3	2	220	2	130	220
			4	26	3	6	300	6	10	300
			5	45	4	9	110	27	69	102
			6	68	5	30	200	36	48	140
			7	34	2	30	38	30	34	38
			8	40	4	23	52	35	47	50
			9	45	5	27	86	38	46	47
			10	27	3	10	77	10	26	77
			11	28	2	23	35	23	29	35
			12	20	1	20	20	20	20	20
		2004	1	20	1	20	20	20	20	20
			3	27	5	20	46	20	25	29
			4	15	3	7	44	7	10	44
			5	99	4	20	200	70	160	200
			6	77	4	30	170	42	92	150
			7	79	4	26	330	31	83	230
			8	214	5	44	1670	60	130	780
			9	161	3	90	390	90	120	390
			10	24	4	10	41	16	30	39
			11	80	2	53	120	53	87	120
			12	37	2	30	46	30	38	46
		2005	4	7	1	7	7	7	7	7
			5	52	4	4	1800	13	35	924
			6	97	2	27	350	27	189	350
			7	99	3	28	600	28	58	600
			8	49	5	21	120	37	40	73
			9	359	4	120	900	220	400	690
			10	86	4	35	360	48	66	216
			11	33	2	20	53	20	37	53
		2006	1	190	1	190	190	190	190	190
			4	13	3	5	40	5	10	40
			5	38	5	20	180	26	26	34
			6	147	3	50	900	50	70	900
			7	29	5	20	56	20	31	32
			8	92	3	52	270	52	56	270
			9	123	4	42	370	67	126	265
			10	31	5	6	680	10	20	33
			11	119	2	84	170	84	127	170

Table B - 2. Continued

AUID	RM	Year	Month	Geometric Mean	N	Minimum	Maximum	25th Percentile	Median (50th Percentile)	75th Percentile
07010206-509 Cont'd	862.8 Cont'd	2007	1	50	1	50	50	50	50	50
			3	7	1	7	7	7	7	7
			4	14	5	4	46	9	10	29
			5	10	3	10	10	10	10	10
			6	41	4	26	69	29	40	59
			7	35	5	10	220	23	30	34
			8	90	3	55	160	55	84	160
			9	64	4	45	120	49	56	90
			10	122	5	22	1700	81	91	100
			11	51	2	50	53	50	52	53
		2008	4	6	2	4	8	4	6	8
			5	23	3	10	62	10	20	62
			6	46	5	21	150	25	43	60
			7	40	3	31	56	31	36	56
			8	31	4	24	42	28	31	37
			9	84	5	47	200	51	80	110
			10	58	3	28	98	28	72	98
			11	14	2	10	20	10	15	20
			12	23	1	23	23	23	23	23
	859.1	2003	6	204	16	20	9000	40	175	650
			7	78	19	20	800	40	70	130
			8	301	15	40	3000	110	270	1300
			9	1609	16	80	16000	460	2700	7000
			10	155	13	40	2400	110	140	230
		2004	6	144	9	20	3000	80	130	170
			7	130	9	20	800	70	120	170
			8	320	9	80	9000	110	130	500
			9	215	9	40	1700	110	170	800
			10	57	2	40	80	40	60	80
		2005	6	115	5	20	300	110	130	230
			7	66	7	20	170	20	80	130
			8	135	10	40	1300	70	75	500
			9	704	6	300	2200	300	750	1100
			10	107	7	20	360	40	80	300
		2006	4	40	3	20	80	20	40	80
			5	106	5	20	500	70	110	170
			6	67	5	40	130	40	80	80
			7	30	5	20	80	20	20	40
			8	124	8	40	300	80	125	230
			9	175	7	10	800	130	230	300
			10	42	7	20	170	20	40	110
			11	140	1	140	140	140	140	140
		2007	4	44	5	20	170	20	40	60
			5	46	7	20	800	20	20	80
			6	132	3	20	500	20	230	500
			7	49	6	20	110	20	55	110
			8	195	5	20	800	130	170	800
			9	248	6	40	5000	80	135	800
			10	342	8	40	1700	170	400	800
			11	117	2	80	170	80	125	170
		2008	4		0					
	859.0	2002	7	165	2	72	380	72	226	380
			8	244	3	110	400	110	330	400
			9	96	5	44	180	68	100	150

Table B - 2. Continued

AUID	RM	Year	Month	Geometric Mean	N	Minimum	Maximum	25th Percentile	Median (50th Percentile)	75th Percentile
07010206-509 Cont'd	858.8	2000	6	54	1	54	54	54	54	54
			7	160	1	160	160	160	160	160
			8	24	1	24	24	24	24	24
			9	160	1	160	160	160	160	160
		2002	4	4	1	4	4	4	4	4
			5	14	1	14	14	14	14	14
			6	110	1	110	110	110	110	110
			7	230	1	230	230	230	230	230
			8	72	1	72	72	72	72	72
			9	280	1	280	280	280	280	280
		2004	10	16	1	16	16	16	16	16
		2005	4	16	1	16	16	16	16	16
	858.5	1999	1	131	26	45	450	78	120	200
			2	117	20	20	450	73	155	200
			3	38	13	18	130	20	20	78
			4	33	12	20	110	20	20	62
			5	117	23	18	1300	37	130	400
			6	171	23	20	3100	78	200	330
			7	174	23	20	780	78	200	450
			8	135	30	20	5400	78	130	200
			9	104	25	18	1100	45	78	130
			10	34	25	18	230	20	45	45
			11	42	23	18	130	20	45	78
			12	72	22	20	220	45	78	130
		2000	1	140	26	20	490	110	170	200
			2	115	26	20	680	68	130	200
			3	37	15	18	200	20	40	45
			4	31	19	20	78	20	20	45
			5	75	21	18	780	45	78	130
			6	118	26	20	1300	68	94	200
			7	74	26	18	3300	20	73	170
			8	88	27	18	1300	45	45	230
			9	241	25	40	1400	78	230	490
			10	109	28	20	3300	73	110	165
			11	374	25	78	1700	200	450	490
			12	93	23	20	490	45	130	200
		2001	1	151	18	45	400	78	200	200
			2	94	26	18	450	45	110	130
			3	63	24	18	1100	20	45	170
			4	181	10	20	450	170	210	400
			5	81	18	18	400	20	130	200
			6	141	24	20	1300	57	170	200
			7	92	27	20	3100	40	78	130
			8	91	20	20	790	45	78	200
			9	147	26	20	780	78	200	270
			10	77	27	20	330	45	68	130
			11	59	25	18	1300	20	45	78
			12	154	22	20	790	78	190	330
		2002	1	58	19	20	230	20	45	110
			2	86	24	20	460	57	78	150
			3	55	19	20	450	20	45	78
			4	72	14	18	1100	20	43	200
			5	70	16	18	790	30	45	130
			6	157	23	20	4600	45	140	450
			7	323	22	130	3300	200	200	450
			8	193	19	20	1400	130	200	400
			9	152	25	20	2300	78	170	200
			10	89	20	20	1300	20	45	450
			11	78	19	20	200	68	78	110
			12	261	16	45	1700	200	200	450

Table B - 2. Continued

AUID	RM	Year	Month	Geometric Mean	N	Minimum	Maximum	25th Percentile	Median (50th Percentile)	75th Percentile
07010206-509 Cont'd	858.5 Cont'd	2003	1	174	21	68	490	110	200	230
			2	121	21	20	680	45	130	200
			3	63	14	18	450	20	33	200
			4	58	17	18	1700	20	20	200
			5	91	17	20	780	45	45	200
			6	85	19	18	4900	20	45	200
			7	111	20	20	680	45	175	200
			8	105	24	18	2200	57	120	200
			9	163	22	20	1700	78	190	200
			10	72	24	20	490	45	78	120
			11	43	24	20	170	20	45	78
			12	108	28	20	780	57	78	225
		2004	1	116	24	20	780	73	130	195
			2	210	24	78	790	130	200	330
			3	88	13	20	450	40	200	200
			4	28	13	18	78	20	20	45
			5	74	27	20	1100	20	78	170
			6	116	23	20	490	45	130	200
			7	96	25	20	1100	45	78	170
			8	121	25	20	4900	78	110	170
			9	233	26	20	11000	130	200	450
			10	71	20	18	1400	45	57	78
			11	89	24	18	450	45	120	170
			12	105	27	20	1300	45	110	130
		2005	1	168	27	78	450	130	180	200
			2	191	15	45	680	170	200	200
			3	117	20	18	2300	45	110	215
			4	76	7	20	200	20	110	200
			5	55	22	18	330	20	45	110
			6	141	14	20	1400	45	94	450
			7	96	22	18	13000	40	45	200
			8	94	25	20	7900	45	78	170
			9	786	17	180	7900	450	780	1100
			10	384	12	20	3300	200	265	1700
			11	158	18	45	1300	68	135	220
			12	218	8	200	400	200	200	200
		2006	1	179	18	45	2300	110	180	200
			2	106	13	18	450	78	110	200
			3	67	16	18	200	30	57	200
			4	39	15	20	450	20	40	45
			5	61	21	18	780	20	45	200
			6	150	17	20	1400	45	140	400
			7	111	14	20	790	78	94	200
			8	185	24	18	1700	104	200	565
			9	195	17	20	3300	45	200	450
			10	99	15	18	780	45	110	200
			11	74	11	20	2300	20	45	200
			12	89	17	20	1100	20	78	200

Table B - 2. Continued

AUID	RM	Year	Month	Geometric Mean	N	Minimum	Maximum	25th Percentile	Median (50th Percentile)	75th Percentile
07010206-509 Cont'd	858.5 Cont'd	2007	1	201	19	45	1100	130	200	330
			2	103	25	20	1700	78	78	200
			3	76	18	20	780	45	68	170
			4	43	10	18	200	20	43	78
			5	34	21	20	3100	20	20	40
			6	53	20	20	330	20	45	85
			7	35	15	20	130	20	20	68
			8	324	18	45	3300	200	390	450
			9	180	20	20	2300	78	200	450
			10	125	21	18	610	45	170	400
			11	93	19	20	450	45	78	180
			12	188	25	20	1100	110	170	450
		2008	1	106	21	45	450	78	78	130
			2	66	22	20	170	45	78	130
			3	36	14	20	200	20	45	45
			4	24	9	20	45	20	20	20
			5	39	13	18	790	20	20	45
			6	86	21	20	640	45	78	220
			7	39	16	20	490	20	20	45
			8	36	8	18	490	20	20	45
			9	82	23	20	490	20	92	170
			10	67	23	18	700	20	68	170
			11	46	19	20	1300	20	40	45
			12	80	23	18	490	45	78	130
	857.6	2003	6	278	16	20	16000	105	285	600
			7	329	19	20	1300	130	300	1100
			8	179	15	20	16000	80	90	500
			9	429	16	110	2400	250	400	650
			10	180	13	40	800	110	130	300
		2004	6	266	9	40	9000	80	230	300
			7	74	9	20	270	20	110	230
			8	272	9	70	5000	80	170	500
			9	797	8	170	3000	400	1100	1350
			10	278	5	110	800	170	220	500
		2005	5	40	1	40	40	40	40	40
			6	136	5	20	500	40	230	500
			7	104	7	40	500	40	80	300
			8	191	11	40	2000	40	230	500
			9	1533	6	500	16000	500	900	5000
			10	201	7	20	3000	40	300	500
		2006	4	230	1	230	230	230	230	230
			5	157	6	40	700	80	170	230
			6	86	7	20	500	40	70	230
			7	44	7	20	80	20	40	80
			8	300	8	40	1700	150	300	700
			9	256	7	130	800	170	230	300
			10	75	7	20	500	20	90	170
			11	1300	1	1300	1300	1300	1300	1300
		2007	4	166	4	80	700	80	125	435
			5	83	8	20	16000	20	55	80
			6	42	4	20	400	20	20	210
			7	63	7	20	600	20	70	80
			8	729	6	40	9000	80	1050	5000
			9	433	6	70	16000	90	225	1300
			10	478	8	70	2400	200	650	1050
			11	169	2	130	220	130	175	220
		2008	4	20	1	20	20	20	20	20

Table B - 2. Continued

AUID	RM	Year	Month	Geometric Mean	N	Minimum	Maximum	25th Percentile	Median (50th Percentile)	75th Percentile
07010206-509 Cont'd	857.5	2002	7	440	2	88	2200	88	1144	2200
			8	666	3	530	900	530	620	900
			9	181	5	32	380	220	260	280
	855.0	2002	7	299	2	64	1400	64	732	1400
			8	213	3	120	320	120	250	320
			9	93	5	32	310	40	72	250
	854.9	2003	6	249	17	20	9000	130	170	300
			7	339	19	20	16000	170	230	500
			8	178	15	20	2400	80	140	500
			9	256	16	40	1300	155	240	400
			10	81	11	20	500	40	80	110
		2004	6	149	9	40	2400	40	90	500
			7	228	9	20	1300	170	230	500
			8	104	9	20	1100	70	80	110
			9	241	9	40	1300	110	130	800
			10	80	8	20	230	80	80	95
		2005	5	40	1	40	40	40	40	40
			6	125	5	40	300	90	130	220
			7	114	5	40	270	70	110	230
			8	204	12	40	3730	40	230	650
			9	654	7	110	2400	220	800	1700
			10	196	7	80	1100	80	170	500
		2006	4	20	2	20	20	20	20	20
			5	64	5	20	300	20	40	230
			6	75	7	20	170	40	80	140
			7	98	7	70	170	80	80	130
			8	115	8	20	500	55	105	352
			9	139	7	80	300	80	130	220
			10	66	7	20	230	40	40	220
			11	800	1	800	800	800	800	800
		2007	4	75	3	40	130	40	80	130
			5	68	5	20	1100	40	40	40
			6	57	4	20	1300	20	20	660
			7	105	7	20	800	20	40	800
			8	201	6	40	800	40	315	800
			9	146	5	20	800	40	130	800
			10	331	8	40	2300	125	360	1050
			11	94	2	80	110	80	95	110
		2008	4	20	1	20	20	20	20	20
07010206-503	853.1	2002	7	529	2	140	2000	140	1070	2000
			8	354	3	160	580	160	480	580
			9	270	5	94	1000	170	190	470

Table B - 2. Continued

AUID	RM	Year	Month	Geometric Mean	N	Minimum	Maximum	25th Percentile	Median (50th Percentile)	75th Percentile
07010206-503 Cont'd	852.2	2003	6	255	17	40	9000	60	130	800
			7	119	19	20	2400	40	130	270
			8	143	15	20	16000	40	80	230
			9	117	16	20	700	40	120	320
			10	87	13	20	1300	40	80	130
		2004	6	152	9	40	800	40	130	500
			7	134	9	40	330	130	130	230
			8	148	10	20	1300	80	170	230
			9	235	9	60	800	80	500	500
			10	80	6	20	230	40	105	140
		2005	5	230	1	230	230	230	230	230
			6	59	5	20	260	20	40	170
			7	116	7	20	1700	40	130	300
			8	224	11	70	4500	80	130	500
			9	819	7	140	2400	230	1300	2200
			10	177	7	40	5000	40	110	300
		2006	4	28	2	20	40	20	30	40
			5	86	6	20	300	40	75	300
			6	98	7	20	300	40	130	170
			7	91	7	20	1700	20	110	130
			8	305	8	80	1100	155	300	650
			9	153	7	20	500	110	140	500
			10	80	5	20	700	20	40	300
			11	1100	1	1100	1100	1100	1100	1100
		2007	4	45	4	20	130	30	40	85
			5	58	6	20	3000	20	30	40
			6	78	5	20	230	40	70	230
			7	112	7	20	300	40	170	300
			8	326	5	20	3000	110	700	800
			9	102	6	40	1700	40	60	130
			10	313	7	130	800	170	300	500
			11	68	2	20	230	20	125	230
		2008	4	80	1	80	80	80	80	80

Table B - 2. Continued

AUID	RM	Year	Month	Geometric Mean	N	Minimum	Maximum	25th Percentile	Median (50th Percentile)	75th Percentile
07010206-503 Cont'd	849.9	2003	6	222	17	20	9000	80	130	800
			7	174	18	20	1700	80	170	300
			8	102	15	20	5000	20	80	130
			9	129	16	20	500	120	135	170
			10	99	13	20	300	80	110	170
		2004	6	138	9	20	1700	70	140	300
			7	171	9	20	2400	70	90	800
			8	177	8	20	2400	55	140	800
			9	257	9	40	1300	130	170	800
			10	123	5	20	500	40	140	500
		2005	5	40	1	40	40	40	40	40
			6	128	5	20	800	80	90	300
			7	187	7	20	2400	20	300	1300
			8	284	11	40	9000	80	230	1100
			9	1604	7	230	16000	300	1100	5000
			10	215	7	40	3000	80	170	700
		2006	4	28	2	20	40	20	30	40
			5	57	5	20	230	40	40	80
			6	93	5	40	500	40	80	110
			7	80	4	20	230	30	130	225
			8	309	7	40	1400	40	500	1300
			9	97	7	40	800	40	70	170
			10	68	7	20	800	20	40	340
			11	800	1	800	800	800	800	800
		2007	4	43	5	20	130	20	40	70
			5	61	6	20	1300	20	30	130
			6	40	3	20	80	20	40	80
			7	45	7	18	110	20	70	80
			8	362	6	20	2400	130	650	900
			9	155	6	40	9000	40	60	300
			10	280	8	40	5000	110	175	800
			11	74	2	11	500	11	256	500
		2008	4	20	3	20	20	20	20	20

Table B - 2. Continued

AUID	RM	Year	Month	Geometric Mean	N	Minimum	Maximum	25th Percentile	Median (50th Percentile)	75th Percentile
07010206-503 Cont'd	848.1	2003	6	219	15	20	9000	40	230	1300
			7	188	19	40	2400	80	140	300
			8	139	12	20	5000	20	135	260
			9	133	16	40	730	75	120	220
			10	90	13	20	1700	40	80	130
		2004	6	185	9	20	3000	80	130	300
			7	82	9	20	2400	40	40	80
			8	61	9	20	1300	20	20	80
			9	125	9	20	800	40	130	300
			10	72	2	40	130	40	85	130
		2005	5	20	1	20	20	20	20	20
			6	173	5	110	300	130	170	210
			7	158	7	20	3000	20	90	1100
			8	182	10	20	2000	110	175	500
			9	784	7	140	9000	220	700	2400
			10	254	7	20	16000	110	140	460
		2006	4	40	2	40	40	40	40	40
			5	81	5	40	210	40	80	130
			6	69	7	20	500	20	80	300
			7	50	6	20	300	20	30	170
			8	92	8	20	800	30	105	200
		2007	4	57	4	40	170	40	40	105
			5	157	3	40	2400	40	40	2400
			6	33	4	20	70	20	30	55
			7	64	5	20	170	40	70	110
			8	279	5	20	1700	110	500	900
			9	121	5	20	800	40	80	500
			10	196	8	40	500	105	265	400
			11	110	2	40	300	40	170	300
		2008	4	25	3	20	40	20	20	40
	847.7	1999	1	71	2	42	120	42	81	120
			2	19	2	9	42	9	26	42
			3	7	5	3	20	5	6	10
			4	18	3	10	30	10	20	30
			5	119	4	37	720	39	115	455
			6	96	4	53	180	59	102	160
			7	167	3	46	600	46	170	600
			8	170	5	60	710	100	140	240
			9	175	3	96	370	96	150	370
			10	30	4	20	70	21	24	48
			11	14	2	10	20	10	15	20
			12	22	2	20	25	20	23	25
		2000	1	10	2	10	10	10	10	10
			2	33	3	20	78	20	24	78
			3	18	3	10	60	10	10	60
			4	8	3	6	9	6	8	9
			5	40	4	10	130	26	45	89
			6	63	4	30	120	38	70	107
			7	81	5	30	160	40	130	140
			8	42	3	30	50	30	48	50
			9	146	4	65	400	88	135	280
			10	53	4	20	240	25	42	147
			11	257	2	110	600	110	355	600
			12	72	2	52	100	52	76	100

Table B - 2. Continued

AUID	RM	Year	Month	Geometric Mean	N	Minimum	Maximum	25th Percentile	Median (50th Percentile)	75th Percentile
07010206-503 Cont'd	847.7 Cont'd	2001	1	98	2	40	240	40	140	240
			2	14	2	5	39	5	22	39
			3	11	3	6	27	6	9	27
			4	44	5	9	210	20	30	150
			5	52	3	24	240	24	25	240
			6	227	4	62	860	126	225	560
			7	73	5	23	240	46	82	97
			8	94	3	40	150	40	140	150
			9	241	4	82	480	136	320	465
			10	66	4	37	190	44	52	122
			11	88	2	35	220	35	128	220
			12	91	2	64	130	64	97	130
		2002	1	45	2	21	96	21	59	96
			2	20	2	20	20	20	20	20
			3	11	4	5	31	5	13	26
			4	15	5	5	32	10	20	25
			5	43	3	21	100	21	38	100
			6	317	4	67	4730	84	210	2525
			7	180	4	110	240	145	200	230
			8	253	4	98	1500	119	170	850
			9	92	5	45	220	55	62	200
			10	154	3	42	360	42	240	360
			11	40	2	35	46	35	41	46
			12	89	2	25	320	25	173	320
		2003	1	43	2	40	46	40	43	46
			2	91	2	44	190	44	117	190
			3	24	5	8	110	10	22	38
			4	20	3	4	190	4	10	190
			5	195	4	24	2500	72	160	1350
			6	91	5	31	320	43	70	210
			7	82	3	64	120	64	73	120
			8	42	4	20	140	24	35	91
			9	47	5	27	110	36	37	60
			10	56	3	9	450	9	43	450
			11	56	2	38	83	38	61	83
			12	38	2	29	50	29	40	50
		2004	1	9	2	8	10	8	9	10
			2	24	2	23	26	23	25	26
			3	25	5	4	380	8	20	41
			4	7	3	2	46	2	3	46
			5	37	4	6	250	8	65	185
			6	95	4	23	300	62	110	210
			7	32	4	3	190	12	57	142
			8	103	5	20	508	55	110	190
			9	65	2	44	96	44	70	96
			10	67	3	28	190	28	56	190
			11	88	2	64	120	64	92	120
			12	24	2	20	30	20	25	30

Table B - 2. Continued

AUID	RM	Year	Month	Geometric Mean	N	Minimum	Maximum	25th Percentile	Median (50th Percentile)	75th Percentile
07010206-503 Cont'd	847.7 Cont'd	2005	1	75	2	30	190	30	110	190
			2	66	2	48	90	48	69	90
			3	13	3	5	20	5	20	20
			4	18	3	7	44	7	20	44
			5	30	4	9	74	18	37	61
			6	69	4	40	230	44	49	141
			7	203	4	41	2000	86	145	1080
			8	67	5	24	320	31	50	110
			9	855	4	140	4270	350	1080	2935
			10	134	4	58	350	79	130	255
			11	37	2	25	54	25	40	54
			12	73	2	44	120	44	82	120
		2006	1	47	3	10	190	10	56	190
			2	13	2	8	20	8	14	20
			3	8	2	7	10	7	9	10
			4	11	4	7	20	8	10	15
			5	57	4	22	120	32	69	109
			6	186	4	53	380	137	245	325
			7	33	5	4	270	10	58	60
			8	104	3	10	380	10	300	380
			9	89	4	30	320	55	81	201
			10	45	5	10	650	20	27	52
			11	284	2	130	620	130	375	620
			12	10	1	10	10	10	10	10
		2007	1	13	3	10	20	10	10	20
			2	20	1	20	20	20	20	20
			3	14	4	5	42	6	18	35
			4	13	5	2	52	7	10	48
			5	20	3	20	21	20	20	21
			6	29	4	10	86	17	29	60
			7	54	5	3	1370	20	62	89
			8	172	3	96	410	96	130	410
			9	42	4	10	110	25	57	92
			10	216	5	26	870	88	350	670
			11	58	2	48	71	48	60	71
			12	68	1	68	68	68	68	68
		2008	1	74	2	64	86	64	75	86
			2	7	2	5	10	5	8	10
			3	5	5	2	10	3	7	9
			4	10	3	6	21	6	9	21
			5	25	4	10	50	16	29	43
			6	63	5	45	110	48	61	71
			7	17	3	10	26	10	20	26
			8	47	4	10	600	10	47	342
			9	123	4	58	492	71	90	294
			10	120	3	20	870	20	100	870
			11	14	2	10	21	10	16	21
			12	21	2	10	44	10	27	44

Table B - 2. Continued

AUID	RM	Year	Month	Geometric Mean	N	Minimum	Maximum	25th Percentile	Median (50th Percentile)	75th Percentile
07010206-505	839.7	2000	6	140	1	140	140	140	140	140
			7	600	1	600	600	600	600	600
			8	46	1	46	46	46	46	46
			9	73	1	73	73	73	73	73
		2002	4		0					
			5	40	1	40	40	40	40	40
			6	48	1	48	48	48	48	48
			7	80	1	80	80	80	80	80
			8	1500	1	1500	1500	1500	1500	1500
			9	200	1	200	200	200	200	200
		2004	10	34	1	34	34	34	34	34
		2005	4	12	1	12	12	12	12	12
	839.1	1999	1	75	2	64	88	64	76	88
			2	136	2	98	190	98	144	190
			3	12	5	8	21	9	10	20
			4	54	3	10	130	10	120	130
			5	102	4	8	680	19	345	670
			6	128	4	56	250	71	153	235
			7	207	4	100	1680	100	105	895
			8	179	5	90	280	140	200	260
			9	195	3	100	310	100	240	310
			10	41	4	30	78	30	35	59
			11	115	2	60	220	60	140	220
			12	289	2	220	380	220	300	380
		2000	1	54	1	54	54	54	54	54
			2	230	3	190	320	190	200	320
			3	39	3	20	97	20	30	97
			4	38	3	25	66	25	34	66
			5	96	4	20	250	57	137	215
			6	92	4	40	220	65	90	155
			7	154	4	50	490	67	177	380
			8	86	4	20	260	51	106	195
			9	96	4	40	310	54	84	205
			10	133	4	42	560	43	172	430
			11	379	2	120	1200	120	660	1200
			12	94	2	88	100	88	94	100
		2001	1	147	2	60	360	60	210	360
			2	66	2	62	70	62	66	70
			3	123	4	30	350	65	160	285
			4	81	2	60	110	60	85	110
			5	42	3	20	120	20	30	120
			6	86	4	21	270	31	140	255
			7	87	4	30	240	35	120	220
			8	189	4	25	2080	47	214	1220
			9	104	4	36	230	58	130	205
			10	122	4	30	419	43	188	370
			11	79	2	35	180	35	108	180
			12	188	2	84	420	84	252	420

Table B - 2. Continued

AUID	RM	Year	Month	Geometric Mean	N	Minimum	Maximum	25th Percentile	Median (50th Percentile)	75th Percentile
07010206-505 Cont'd	839.1 Cont'd	2002	1	67	2	54	82	54	68	82
			2	53	2	23	120	23	72	120
			3	55	4	42	76	43	56	72
			4	26	4	9	46	22	35	41
			5	20	4	8	97	9	15	59
			6	379	4	120	970	205	450	790
			7	132	4	52	900	62	81	495
			8	230	4	80	2600	85	120	1375
			9	136	4	36	410	73	160	310
			10	50	4	20	250	21	41	156
			11	44	2	40	48	40	44	48
			12	123	2	54	280	54	167	280
		2003	1	48	1	48	48	48	48	48
			2	56	1	56	56	56	56	56
			3	68	4	35	180	38	62	132
			4	57	4	20	250	22	58	172
			5	27	3	10	190	10	10	190
			6	251	4	100	2000	100	150	1100
			7	66	4	20	130	44	89	120
			8	49	4	10	600	10	54	349
			9	14	4	1	61	11	27	47
			10	37	4	21	80	25	34	60
			11	107	2	67	170	67	119	170
			12	92	2	50	170	50	110	170
		2004	1	51	2	45	58	45	52	58
			2	66	2	22	200	22	111	200
			3	66	5	20	170	47	72	110
			4	17	3	6	96	6	8	96
			5	26	4	4	200	13	25	114
			6	116	4	66	230	67	124	205
			7	116	4	32	630	38	127	420
			8	33	4	20	53	27	34	44
			9	333	4	58	2800	119	300	1610
			10	37	4	21	83	26	33	59
			11	85	2	73	100	73	87	100
			12	50	2	39	63	39	51	63
		2005	1	172	2	90	330	90	210	330
			2	88	2	83	93	83	88	93
			3	127	4	41	490	67	117	315
			4	19	4	10	43	10	20	37
			5	41	4	9	230	15	43	148
			6	155	4	43	680	87	140	415
			7	68	4	24	160	36	84	140
			8	66	5	29	190	33	77	90
			9	228	4	73	730	147	225	480
			10	219	4	32	7900	58	97	4005
			11	83	3	44	160	44	80	160
			12	50	1	50	50	50	50	50

Table B - 2. Continued

AUID	RM	Year	Month	Geometric Mean	N	Minimum	Maximum	25th Percentile	Median (50th Percentile)	75th Percentile
07010206-505 Cont'd	839.1 Cont'd	2006	1	55	2	38	80	38	59	80
			2	77	2	30	200	30	115	200
			3	17	3	7	38	7	20	38
			4	14	4	6	81	7	9	46
			5	34	5	10	110	29	35	43
			6	232	3	170	350	170	210	350
			7	137	5	52	1900	66	80	93
			8	115	3	90	180	90	94	180
			9	57	4	45	73	51	58	66
			10	52	4	9	160	24	84	145
			11	61	3	9	520	9	48	520
			12	20	1	20	20	20	20	20
		2007	1	62	1	62	62	62	62	62
			2	170	1	170	170	170	170	170
			3	42	3	32	58	32	40	58
			4	19	4	10	53	10	17	38
			5	19	4	6	210	8	10	110
			6	45	4	30	58	37	48	55
			7	39	4	20	120	25	31	77
			8	140	4	46	410	67	159	320
			9	130	4	45	400	46	193	370
			10	149	5	56	230	160	180	200
			11	58	2	51	66	51	59	66
		2008	1	64	1	64	64	64	64	64
			3	160	2	160	160	160	160	160
			4	201	4	100	570	130	170	375
			5	104	4	88	160	89	91	126
			6	51	4	30	100	32	51	84
			7	55	4	35	79	46	58	69
			8	131	4	40	370	75	145	275
			9	79	5	31	564	41	60	72
			10	89	3	50	240	50	58	240
			11	35	1	35	35	35	35	35
			12	20	1	20	20	20	20	20
	836.8	2000	1	48	1	48	48	48	48	48
		2003	1	95	1	95	95	95	95	95
			2	160	1	160	160	160	160	160
			5	130	1	130	130	130	130	130
		2007	1	37	1	37	37	37	37	37
			2	73	1	73	73	73	73	73
			3	41	1	41	41	41	41	41
			12	67	2	32	140	32	86	140
		2008	1	89	1	89	89	89	89	89
			2	52	2	28	97	28	63	97
			3	44	2	9	220	9	115	220
			11	97	1	97	97	97	97	97
			12	87	1	87	87	87	87	87

Table B - 2. Continued

AUID	RM	Year	Month	Geometric Mean	N	Minimum	Maximum	25th Percentile	Median (50th Percentile)	75th Percentile
07010206-504	831.0	1999	1	707	2	500	1000	500	750	1000
			2	662	2	600	730	600	665	730
			3	15	5	6	26	10	20	22
			4	44	3	10	160	10	54	160
			5	65	4	8	380	28	84	250
			6	89	4	64	130	74	87	110
			7	216	4	70	670	125	220	465
			8	151	5	48	340	80	200	300
			9	172	3	88	410	88	140	410
			10	58	3	30	92	30	71	92
			11	744	2	490	1130	490	810	1130
			12	583	2	340	1000	340	670	1000
		2000	1	914	2	760	1100	760	930	1100
			2	856	3	500	2200	500	570	2200
			3	486	3	200	1400	200	410	1400
			4	9	3	8	10	8	9	10
			5	110	4	33	220	65	154	215
			6	92	4	60	200	65	77	142
			7	156	4	50	530	55	215	450
			8	81	4	30	220	37	97	185
			9	119	4	40	630	62	90	363
			10	53	4	20	140	35	53	98
			11	1025	2	600	1750	600	1175	1750
			12	1504	2	730	3100	730	1915	3100
		2001	1	341	2	200	580	200	390	580
			2	995	2	900	1100	900	1000	1100
			3	504	4	380	930	385	430	700
			4	85	3	40	220	40	70	220
			5	42	4	20	100	24	44	80
			6	87	4	26	230	47	104	185
			7	74	4	10	532	20	110	361
			8	67	4	28	110	55	82	96
			9	73	4	30	150	43	83	130
			10	102	4	40	150	85	135	145
			11	490	2	400	600	400	500	600
			12	797	2	530	1200	530	865	1200
		2002	1	883	2	390	2000	390	1195	2000
			2	1032	2	410	2600	410	1505	2600
			3	765	4	240	1300	620	1050	1200
			4	22	4	6	44	14	31	42
			5	20	4	10	58	10	20	44
			6	235	4	96	620	98	305	565
			7	143	4	55	930	68	91	515
			8	162	4	67	780	71	127	480
			9	79	4	44	200	50	68	140
			10	63	4	24	230	34	55	149
			11	448	2	340	590	340	465	590
			12	454	2	430	480	430	455	480
		2003	1	949	2	600	1500	600	1050	1500
			2	784	2	430	1430	430	930	1430
			3	392	3	320	570	320	330	570
			4	21	4	8	60	9	24	49
			5	66	4	20	200	23	103	190
			6	281	4	83	2000	97	225	1170
			7	55	4	20	140	31	60	109
			8	32	4	10	210	15	23	118
			9	51	4	35	84	40	48	67
			10	35	4	10	83	21	44	70
			11	302	2	190	480	190	335	480
			12	439	2	280	688	280	484	688

Table B - 2. Continued

AUID	RM	Year	Month	Geometric Mean	N	Minimum	Maximum	25th Percentile	Median (50th Percentile)	75th Percentile
07010206-504 Cont'd	831.0 Cont'd	2004	1	342	2	260	450	260	355	450
			2	245	2	240	250	240	245	250
			3	307	5	190	930	190	280	290
			4	28	3	20	46	20	25	46
			5	23	4	4	120	14	24	72
			6	114	4	48	200	79	135	180
			7	89	4	35	540	39	61	310
			8	42	4	28	60	31	44	57
			9	182	4	59	680	70	210	510
			10	47	4	20	83	30	57	78
			11	574	2	330	1000	330	665	1000
			12	329	2	270	400	270	335	400
		2005	1	332	2	220	500	220	360	500
			2	245	2	200	300	200	250	300
			3	165	4	60	320	95	215	310
			4	17	4	8	46	9	17	35
			5	34	4	8	140	19	36	91
			6	95	4	23	200	72	135	175
			7	49	4	10	150	29	64	115
			8	58	5	20	440	21	41	83
			9	172	4	80	250	140	210	235
			10	368	4	67	17800	72	139	9000
			11	276	3	160	470	160	280	470
			12	190	1	190	190	190	190	190
		2006	1	161	2	130	200	130	165	200
			2	255	2	250	260	250	255	260
			3	58	3	10	200	10	100	200
			4	12	4	4	54	7	10	32
			5	41	4	10	120	21	53	97
			6	178	3	150	220	150	170	220
			7	22	5	9	56	20	20	25
			8	73	3	48	96	48	83	96
			9	81	4	44	290	50	58	175
			10	56	4	38	89	42	55	77
			11	143	3	68	510	68	84	510
			12	120	1	120	120	120	120	120
		2007	1	153	2	130	180	130	155	180
			2	250	2	240	260	240	250	260
			3	84	4	20	420	20	155	355
			4	18	4	6	93	8	15	57
			5	20	4	10	81	10	15	51
			6	42	4	21	63	33	48	57
			7	35	4	10	98	18	42	78
			8	93	4	8	420	59	155	310
			9	50	4	20	160	29	46	107
			10	106	5	46	210	92	100	150
			11	458	2	160	1310	160	735	1310
			12	273	2	170	440	170	305	440
		2008	1	455	2	440	470	440	455	470
			2	214	2	200	230	200	215	230
			3	151	4	60	230	120	195	220
			4	19	4	8	43	9	26	42
			5	19	4	10	66	10	16	44
			6	35	4	20	52	25	39	50
			7	37	4	31	52	32	35	45
			8	41	4	20	130	23	34	86
			9	80	4	37	340	43	59	204
			10	89	4	46	300	47	72	198
			11	135	2	130	140	130	135	140
			12	322	2	200	520	200	360	520

Table B - 2. Continued

AUID	RM	Year	Month	Geometric Mean	N	Minimum	Maximum	25th Percentile	Median (50th Percentile)	75th Percentile
07010206-502	826.7	1999	1	460	2	450	470	450	460	470
			2	1075	2	550	2100	550	1325	2100
			3	18	5	5	40	9	28	36
			4	39	3	9	120	9	56	120
			5	90	4	2	1460	21	300	1010
			6	70	4	40	120	41	81	120
			7	245	4	85	1500	91	194	895
			8	112	5	60	240	72	85	200
			9	156	3	92	410	92	100	410
			10	40	4	20	80	25	41	66
			11	392	2	240	640	240	440	640
			12	748	2	400	1400	400	900	1400
		2000	1	707	2	500	1000	500	750	1000
			2	691	3	440	1500	440	500	1500
			3	282	3	100	640	100	350	640
			4	5	3	2	10	2	5	10
			5	92	4	20	240	51	131	210
			6	102	4	70	170	81	96	135
			7	110	4	44	230	60	133	210
			8	22	4	6	100	13	20	60
			9	107	4	48	310	53	104	230
			10	34	4	10	140	20	30	85
			11	778	2	600	1010	600	805	1010
			12	600	1	600	600	600	600	600
		2001	1	346	2	240	500	240	370	500
			2	518	2	480	560	480	520	560
			3	201	4	60	570	130	220	405
			4	46	2	30	70	30	50	70
			5	53	3	30	150	30	33	150
			6	89	4	36	160	58	110	150
			7	70	4	20	240	33	78	175
			8	59	4	30	100	37	67	96
			9	56	4	41	80	45	56	72
			10	65	4	20	200	39	67	139
			11	323	2	290	360	290	325	360
			12	1497	2	640	3500	640	2070	3500
		2002	1	603	2	280	1300	280	790	1300
			2	681	2	290	1600	290	945	1600
			3	301	4	180	730	210	250	495
			4	17	4	10	40	10	16	31
			5	18	4	10	41	10	17	32
			6	134	4	48	230	94	175	220
			7	123	4	48	680	53	89	400
			8	164	4	83	400	97	155	300
			9	58	4	22	190	32	54	129
			10	67	4	27	290	36	52	175
			11	614	2	290	1300	290	795	1300
			12	498	2	310	800	310	555	800
		2003	1	828	2	490	1400	490	945	1400
			2	847	2	390	1840	390	1115	1840
			3	354	4	140	580	285	440	515
			4	16	4	9	41	10	15	31
			5	49	4	10	180	16	81	160
			6	141	4	31	4100	43	56	2079
			7	66	4	31	120	39	79	115
			8	17	4	9	21	15	20	21
			9	31	4	20	52	21	33	48
			10	30	4	10	58	22	37	50
			11	169	2	130	220	130	175	220
			12	460	2	400	530	400	465	530

Table B - 2. Continued

AUID	RM	Year	Month	Geometric Mean	N	Minimum	Maximum	25th Percentile	Median (50th Percentile)	75th Percentile
07010206-502 Cont'd	826.7 Cont'd	2004	1	431	2	300	620	300	460	620
			2	426	2	240	756	240	498	756
			3	136	5	72	300	97	110	200
			4	15	3	8	20	8	20	20
			5	19	4	6	110	8	16	66
			6	148	4	90	240	100	155	220
			7	75	4	36	220	36	73	165
			8	24	4	10	59	16	24	43
			9	125	4	46	510	67	104	315
			10	33	4	21	60	24	31	48
			11	397	2	250	630	250	440	630
			12	270	2	270	270	270	270	270
		2005	1	314	2	240	410	240	325	410
			2	173	2	150	200	150	175	200
			3	145	4	90	290	95	135	230
			4	19	4	10	40	10	20	35
			5	25	4	10	150	10	18	88
			6	103	4	26	180	88	155	170
			7	53	4	23	190	30	43	120
			8	32	5	10	150	20	24	47
			9	148	4	95	210	108	160	205
			10	379	4	60	15700	80	160	7960
			11	176	3	110	260	110	190	260
			12	130	1	130	130	130	130	130
		2006	1	124	2	110	140	110	125	140
			2	183	2	160	210	160	185	210
			3	49	3	10	120	10	100	120
			4	10	4	6	29	7	8	19
			5	36	5	10	190	10	45	70
			6	148	3	99	220	99	150	220
			7	16	4	8	22	14	21	22
			8	75	4	20	240	28	113	215
			9	30	4	24	39	26	29	34
			10	20	4	10	44	15	20	32
			11	128	3	41	230	41	220	230
			12	60	1	60	60	60	60	60
		2007	1	127	2	90	180	90	135	180
			2	142	2	96	210	96	153	210
			3	74	4	30	210	35	80	165
			4	15	4	5	62	7	15	41
			5	15	4	8	66	9	10	38
			6	23	4	10	65	10	28	56
			7	12	4	6	34	8	10	22
			8	50	4	7	220	16	93	190
			9	47	4	20	100	24	60	96
			10	104	5	40	260	87	90	150
			11	252	2	130	490	130	310	490
			12	239	2	150	380	150	265	380
		2008	1	502	2	260	970	260	615	970
			2	159	2	120	210	120	165	210
			3	101	4	44	180	72	115	155
			4	20	4	8	38	15	23	32
			5	21	4	10	49	15	21	35
			6	38	4	20	62	29	41	53
			7	24	4	10	64	15	22	44
			8	17	4	9	34	10	20	32
			9	30	4	10	160	15	23	93
			10	49	4	20	110	30	54	89
			11	88	2	70	110	70	90	110
			12	198	2	170	230	170	200	230

Table B - 2. Continued

AUID	RM	Year	Month	Geometric Mean	N	Minimum	Maximum	25th Percentile	Median (50th Percentile)	75th Percentile
07010206-502 Cont'd	826.4	2000	6	150	1	150	150	150	150	150
			7	600	1	600	600	600	600	600
			8	100	1	100	100	100	100	100
			9	64	1	64	64	64	64	64
		2002	4	20	1	20	20	20	20	20
			5	24	1	24	24	24	24	24
			6	48	1	48	48	48	48	48
			7	130	1	130	130	130	130	130
			8	880	1	880	880	880	880	880
			9	230	1	230	230	230	230	230
		2004	10	12	1	12	12	12	12	12
		2005	4		0					
	821.8	1999	7	359	3	120	1480	120	260	1480
			8	85	4	50	180	55	79	139
			9	297	2	180	490	180	335	490
			10	40	1	40	40	40	40	40
		2000	7	72	3	52	140	52	52	140
			8	32	2	20	52	20	36	52
			9	133	3	64	370	64	100	370
			10	27	3	23	30	23	30	30
		2001	6	140	1	140	140	140	140	140
		2002	6	120	1	120	120	120	120	120
			7	61	2	42	90	42	66	90
			9	170	1	170	170	170	170	170
		2007	6	21	2	9	51	9	30	51
			7	11	3	4	43	4	7	43
			8	57	3	20	220	20	41	220
			9	39	2	21	72	21	47	72
		2008	6	36	2	20	64	20	42	64
			7	22	4	20	28	21	21	25
			8	13	3	9	24	9	10	24
			9	26	4	7	88	14	28	62
			10	55	2	53	57	53	55	57
	815.6	1999	1	444	2	420	470	420	445	470
			2	169	2	130	220	130	175	220
			3	5	5	2	24	3	5	5
			4	23	3	3	99	3	40	99
			5	44	4	3	360	17	75	240
			6	34	4	20	50	25	37	47
			7	199	4	58	1200	99	150	680
			8	78	5	60	140	64	70	78
			9	145	3	70	230	70	190	230
			10	89	4	60	120	76	94	108
			11	675	2	390	1170	390	780	1170
			12	53	2	40	70	40	55	70
		2000	1	314	2	120	820	120	470	820
			2	419	3	100	1600	100	460	1600
			3	52	3	20	110	20	64	110
			4	5	3	2	20	2	4	20
			5	15	3	3	62	3	20	62
			6	49	4	40	60	44	49	55
			7	45	4	30	110	30	36	76
			8	11	4	8	20	9	10	15
			9	44	4	20	95	30	44	72
			10	49	4	22	88	36	55	74
			11	381	2	220	660	220	440	660
			12	1164	2	290	4670	290	2480	4670

Table B - 2. Continued

AUID	RM	Year	Month	Geometric Mean	N	Minimum	Maximum	25th Percentile	Median (50th Percentile)	75th Percentile
07010206-502 Cont'd	815.6 Cont'd	2001	1	283	2	200	400	200	300	400
			2	169	2	70	410	70	240	410
			3	26	4	6	140	6	47	114
			4	98	2	88	110	88	99	110
			5	34	3	20	68	20	30	68
			6	74	4	20	220	44	84	160
			7	33	4	8	120	19	35	80
			8	10	4	5	25	7	10	18
			9	30	4	7	73	16	44	68
			10	48	4	20	120	33	48	85
			11	152	2	80	290	80	185	290
			12	189	2	170	210	170	190	210
		2002	1	104	2	52	210	52	131	210
			2	25	2	20	32	20	26	32
			3	32	4	10	110	15	35	80
			4	26	4	10	48	16	32	46
			5	10	4	6	20	8	10	15
			6	54	4	22	190	23	56	139
			7	92	4	36	410	48	70	245
			8	91	4	57	220	62	75	152
			9	85	4	62	170	65	70	122
			10	135	4	100	280	100	110	200
			11	126	2	83	190	83	137	190
			12	161	2	130	200	130	165	200
		2003	1	59	2	36	97	36	67	97
			2	118	2	70	200	70	135	200
			3	31	4	6	180	8	55	140
			4	16	4	7	42	9	18	34
			5	22	4	8	62	9	29	55
			6	14	4	5	30	7	19	30
			7	54	4	25	140	30	52	105
			8	5	4	3	20	3	4	12
			9	8	4	1	43	3	17	37
			10	35	4	5	100	27	56	82
			11	32	2	10	100	10	55	100
			12	45	2	25	80	25	53	80
		2004	1	31	2	20	47	20	34	47
			2	45	2	28	72	28	50	72
			3	14	5	10	29	10	10	20
			4	7	3	5	10	5	6	10
			5	7	4	1	40	3	8	25
			6	50	4	32	93	35	47	74
			7	48	4	20	130	28	46	94
			8	9	4	3	25	5	9	18
			9	32	4	5	150	17	39	100
			10	90	4	45	180	59	92	145
			11	81	2	59	110	59	85	110
			12	45	2	36	57	36	47	57
		2005	1	201	2	130	310	130	220	310
			2	44	2	31	63	31	47	63
			3	10	4	5	25	7	10	18
			4	31	4	20	51	22	32	46
			5	13	4	2	73	6	15	47
			6	46	4	20	100	30	49	79
			7	35	4	21	73	22	34	59
			8	8	5	2	23	4	10	20
			9	72	4	20	170	54	90	132
			10	298	4	110	1200	170	245	730
			11	150	3	51	510	51	130	510
			12	60	1	60	60	60	60	60

Table B - 2. Continued

AUID	RM	Year	Month	Geometric Mean	N	Minimum	Maximum	25th Percentile	Median (50th Percentile)	75th Percentile
07010206-502 Cont'd	815.6 Cont'd	2006	1	40	2	28	57	28	43	57
			2	23	2	10	53	10	32	53
			3	12	3	9	20	9	10	20
			4	11	4	4	40	4	14	32
			5	25	5	10	57	20	21	37
			6	37	3	10	120	10	41	120
			7	2	4	1	10	1	2	6
			8	16	4	4	80	7	15	50
			9	16	4	10	30	10	15	25
			10	28	4	10	42	23	38	41
			11	12	3	5	41	5	8	41
			12	6	1	6	6	6	6	6
		2007	1	5	2	3	10	3	7	10
			2	10	2	10	10	10	10	10
			3	12	4	4	30	7	15	25
			4	21	4	9	78	10	20	54
			5	7	4	5	10	6	7	9
			6	10	4	4	21	7	10	16
			7	4	4	1	20	2	3	12
			8	9	4	2	55	3	14	40
			9	12	4	3	40	7	15	30
			10	108	5	93	140	96	100	120
			11	83	2	82	85	82	84	85
			12	92	2	53	160	53	107	160
		2008	1	147	2	120	180	120	150	180
			2	54	2	46	64	46	55	64
			3	6	3	1	24	1	9	24
			4	38	4	10	110	15	56	101
			5	16	4	8	36	9	17	30
			6	30	4	10	63	22	35	50
			7	15	4	6	23	13	20	22
			8	3	4	1	10	2	3	7
			9	7	4	3	22	4	6	15
			10	53	4	38	86	42	50	70
			11	28	2	20	38	20	29	38
			12	59	2	38	92	38	65	92
	815.2	2000	6	32	1	32	8	32	32	32
			7	360	1	360	60	360	360	360
			8	4	1	4	8	4	4	4
			9	9	1	9	20	9	9	9
		2002	4	8	1	8	360	8	8	8
			5	8	1	8	120	8	8	8
			6	60	1	60	9	60	60	60
			7	32	1	32	130	32	32	32
			8	120	1	120	140	120	120	120
			9	140	1	140	32	140	140	140
		2004	10	130	1	130	32	130	130	130
		2005	4	20	1	20		20	20	20
07010206-501	813.9	1999	7	239	4	110	1200	120	160	695
			8	67	4	42	110	50	66	92
			9	110	2	110	110	110	110	110
			10	82	1	82	82	82	82	82
		2000	7	44	3	20	110	20	40	110
			8	20	1	20	20	20	20	20
			9	240	1	240	240	240	240	240
			10	40	1	40	40	40	40	40
		2003	5	8	1	8	8	8	8	8
	812.8	1999	7	265	4	76	1180	133	240	735
			8	66	4	44	110	51	62	88
			9	154	2	140	170	140	155	170
			10	98	1	98	98	98	98	98
		2000	7	76	3	40	180	40	60	180
			8	10	1	10	10	10	10	10
			9	320	1	320	320	320	320	320
			10	20	1	20	20	20	20	20
		2003	5	8	1	8	8	8	8	8

C. Pairing of *E. coli*, Flow and Precipitation Monitoring Sites Used throughout Analysis

Table C - 1. Pairing of E. coli, flow and precipitation monitoring sites used throughout analysis.

E. coli			Flow				Precipitation
Waterbody	**AUID**	**RM**	**Flow Monitoring Sites and Calculation [Subtracted (-) or Added (+)]**	**Waterbody**	**Tributary RM**	**Mississippi RM of Mississippi River Site or of Tributary Inflow Location**	**NWS Precipitation Monitoring Station**
Mississippi River	07010201-501	953.5	5267000	Mississippi River	N/A	953.5	217157
	07010201-502	930.2	5270700	Mississippi River	N/A	926.4	217294
			- 5270500	Sauk River	5.3	N/A	
	07010203-574	929.4	5270700	Mississippi River	N/A	926.4	217294
		928.4	5270700	Mississippi River	N/A	926.4	217294
	07010203-510	914.0	None	Mississippi River	N/A	N/A	210570
		896.9	None	Mississippi River	N/A	N/A	211107
	07010206-568	871.7	None	Mississippi River	N/A	N/A	211390
		871.6	None	Mississippi River	N/A	N/A	211390
	07010206-509	863.0	5288500	Mississippi River	N/A	864.9	215838
		862.8	5288500	Mississippi River	N/A	864.9	215838
		859.1	None	Mississippi River	N/A	N/A	215838
		859.0	None	Mississippi River	N/A	N/A	215838
		858.8	None	Mississippi River	N/A	N/A	215838
		858.5	None	Mississippi River	N/A	N/A	214884
		857.6	None	Mississippi River	N/A	N/A	214884
		857.5	None	Mississippi River	N/A	N/A	214884
		855.0	None	Mississippi River	N/A	N/A	214884
		854.9	5331000	Mississippi River	N/A	840.5	214884
			- East Kittsondale	East Kittsondale storm sewer	1.1	841.6	
			- 5330920	Minnesota River	3.0	843.9	
			- MH0017	Minnehaha Creek	1.7	847.1	
			- St. Anthony Park	St. Anthony Park storm sewer	0.0	850.3	
			- BS0019	Bassett Creek	1.9	854.8	
	07010206-503	853.1	None	Mississippi River	N/A	N/A	214884
		852.2	5331000	Mississippi River	N/A	840.5	214884
			- East Kittsondale	East Kittsondale storm sewer	1.1	841.6	
			- 5330920	Minnesota River	3.0	843.9	
			- MH0017	Minnehaha Creek	1.7	847.1	
			- St. Anthony Park	St. Anthony Park storm sewer	0.0	850.3	
		849.9	5331000	Mississippi River	N/A	840.5	218450
			- East Kittsondale	East Kittsondale storm sewer	1.1	841.6	
			- 5330920	Minnesota River	3.0	843.9	
			- MH0017	Minnehaha Creek	1.7	847.1	
		848.1	5331000	Mississippi River	N/A	840.5	215435
			- East Kittsondale	East Kittsondale storm sewer	1.1	841.6	
			- 5330920	Minnesota River	3.0	843.9	
			- MH0017	Minnehaha Creek	1.7	847.1	
		847.7	5331000	Mississippi River	N/A	840.5	215435
			- East Kittsondale	East Kittsondale storm sewer	1.1	841.6	
			- 5330920	Minnesota River	3.0	843.9	
			- MH0017	Minnehaha Creek	1.7	847.1	
	07010206-505	839.7	5331000	Mississippi River	N/A	840.5	217377
		839.1	5331000	Mississippi River	N/A	840.5	217377
		836.8	None	Mississippi River	N/A	N/A	217377
	07010206-504	831.0	5331000	Mississippi River	N/A	840.5	217377
			+ Trout Brook Outlet	Trout Brook storm sewer	0.2	838.3	
			+ Phalen Creek	Phalen Creek storm sewer	0.2	838.3	
			+ BA0022	Battle Creek	2.2	833.3	
			+ FC0002	Fish Creek	0.2	833.3	
	07010206-502	826.7	None	Mississippi River	N/A	N/A	217107
		826.4	None	Mississippi River	N/A	N/A	217107
		821.8	None	Mississippi River	N/A	N/A	213567
		815.6	5331580	Mississippi River	N/A	813.7	213567
		815.2	5331580	Mississippi River	N/A	813.7	213567
	07010206-501	813.9	None	Mississippi River	N/A	N/A	213567
		812.8	None	Mississippi River	N/A	N/A	213567
Sauk River	07010202-501	0.1	5270500	Sauk River	5.3	930.1	217294
Elk River	07010203-548	9	5275000	Elk River	9	884.6	212500
Crow River	07010204-502	0.1	5280000	Crow River	12.3	879.5	212500
Rum River	07010207-555	0.6	RUM0007	Rum River	0.7	871.3	211390
Elm Creek	07010206-508	13	5287890	Elm Creek	4.7	871.1	211390
Bassett Creek	07010206-538	1.9	BS0019	Bassett Creek	1.9	854.8	214884
St. Anthony Park storm sewer	N/A	0.0	St. Anthony Park	St. Anthony Park storm sewer	0.0	850.3	N/A
Minnehaha Creek	07010206-539	0.9	MH0017	Minnehaha Creek	1.7	847.1	215435
Minnesota River	07020012-505	3.0	5330920	Minnesota River	3.0	843.9	215435
East Kittsondale storm sewer	N/A	1.1	East Kittsondale	East Kittsondale storm sewer	1.1	841.6	N/A
Phalen Creek storm sewer	N/A	0.2	Phalen Creek	Phalen Creek storm sewer	0.2	838.3	N/A
Trout Brook storm sewer	N/A	0.2	Trout Brook Outlet	Trout Brook storm sewer	0.2	838.3	N/A

D. BACTERIA DATA SUMMARY FOR SELECT TRIBUTARIES

Table D - 1. Tributary data for sites with *E. coli* but no flow data or having only fecal coliform data.

Waterbody	RM	AUID	RM of Entry into Down-stream Tributary	Mississippi RM of Entry into Mississippi River	Para-meter	Year	Month	Geometric Mean	N	25th Percentile	Median (50th Percentile)	75th Percentile	Mini-mum	Max-imum
Two River	0.8	07010201-523		953.5	Fecal Coliform	2004	5	76.0	1	76.000	76.000	76.00	76.0	76.0
							6	214.5	2	184.000	217.000	250.00	184.0	250.0
							8	137.5	2	105.000	142.500	180.00	105.0	180.0
							9	300.0	1	300.000	300.000	300.00	300.0	300.0
							10	140.0	1	140.000	140.000	140.00	140.0	140.0
						2005	4	24.5	2	20.000	25.000	30.00	20.0	30.0
							5	62.3	2	51.000	63.500	76.00	51.0	76.0
							6	120.0	1	120.000	120.000	120.00	120.0	120.0
							7	70.0	1	70.000	70.000	70.00	70.0	70.0
							8	460.0	2	460.000	460.000	460.00	460.0	460.0
							9	2717.3	2	2520.000	2725.000	2930.00	2520.0	2930.0
							10	154.0	1	154.000	154.000	154.00	154.0	154.0
						2006	4	30.0	1	30.000	30.000	30.00	30.0	30.0
							5	289.8	2	60.000	730.000	1400.00	60.0	1400.0
							6	124.9	2	60.000	160.000	260.00	60.0	260.0
							8	139.6	2	130.000	140.000	150.00	130.0	150.0
							9	260.0	1	260.000	260.000	260.00	260.0	260.0
Platte River	2.1	07010201-545		947.5	*E. coli*	2007	4	20.9	2	6.000	39.500	73.00	6.0	73.0
							5	18.7	2	12.000	20.500	29.00	12.0	29.0
							6	27.8	3	13.000	33.000	50.00	13.0	50.0
							7	10.0	1	10.000	10.000	10.00	10.0	10.0
							8	19.0	2	12.000	21.000	30.00	12.0	30.0
							9	189.8	2	138.000	199.500	261.00	138.0	261.0
							10	77.0	1	77.000	77.000	77.00	77.0	77.0
							11	21.0	1	21.000	21.000	21.00	21.0	21.0
						2008	3	3.0	1	3.000	3.000	3.00	3.0	3.0
							4	7.4	2	5.000	8.000	11.00	5.0	11.0
							5	31.0	1	31.000	31.000	31.00	31.0	31.0
							6	53.0	1	53.000	53.000	53.00	53.0	53.0
							7	45.0	1	45.000	45.000	45.00	45.0	45.0
							8	20.0	1	20.000	20.000	20.00	20.0	20.0
					Fecal Coliform	2002	4	51.4	2	22.000	71.000	120.00	22.0	120.0
							5	18.0	1	18.000	18.000	18.00	18.0	18.0
							6	33.8	2	26.000	35.000	44.00	26.0	44.0
							7	63.5	2	48.000	66.000	84.00	48.0	84.0
							8	54.5	2	28.000	67.000	106.00	28.0	106.0
							9	459.6	2	220.000	590.000	960.00	220.0	960.0
							10	142.2	2	16.000	640.000	1264.00	16.0	1264.0
							11	14.0	1	14.000	14.000	14.00	14.0	14.0
						2003	5	116.0	1	116.000	116.000	116.00	116.0	116.0
							6	29.9	5	14.000	36.000	42.00	12.0	94.0
							7	34.0	2	34.000	34.000	34.00	34.0	34.0
							8	62.0	1	62.000	62.000	62.00	62.0	62.0
							9	74.3	2	60.000	76.000	92.00	60.0	92.0
						2004	5	20.0	1	20.000	20.000	20.00	20.0	20.0
							6	14.8	2	10.000	16.000	22.00	10.0	22.0
							8	17.9	2	8.000	24.000	40.00	8.0	40.0
							9	20.0	1	20.000	20.000	20.00	20.0	20.0
							10	20.0	1	20.000	20.000	20.00	20.0	20.0
						2005	4	8.9	2	8.000	9.000	10.00	8.0	10.0
							5	13.0	2	6.000	17.000	28.00	6.0	28.0
							6	20.0	2	20.000	20.000	20.00	20.0	20.0
							7	30.0	1	30.000	30.000	30.00	30.0	30.0
							8	20.0	2	20.000	20.000	20.00	20.0	20.0
							9	236.6	2	140.000	270.000	400.00	140.0	400.0
							10	98.0	1	98.000	98.000	98.00	98.0	98.0
						2006	4	20.0	1	20.000	20.000	20.00	20.0	20.0
							5	66.3	2	40.000	75.000	110.00	40.0	110.0
							6	47.2	3	30.000	50.000	70.00	30.0	70.0
							8	38.7	2	30.000	40.000	50.00	30.0	50.0
							9	120.0	1	120.000	120.000	120.00	120.0	120.0
							12	2.0	1	2.000	2.000	2.00	2.0	2.0
						2007	1	2.0	2	2.000	2.000	2.00	2.0	2.0
							3	14.0	2	4.000	26.500	49.00	4.0	49.0
Zuleger Creek	0.5	07010201-541	5.5 into Little Rock Creek	937.3	*E. coli*	2008	6	350.0	1	350.000	350.000	350.00	350.0	350.0
					Fecal Coliform	2004	11	44.0	1	44.000	44.000	44.00	44.0	44.0
						2006	6	230.0	1	230.000	230.000	230.00	230.0	230.0
							9	560.0	1	560.000	560.000	560.00	560.0	560.0
						2007	3	214.3	3	48.000	82.000	2500.00	48.0	2500.0
							4	12.0	2	12.000	12.000	12.00	12.0	12.0
							5	174.9	2	170.000	175.000	180.00	170.0	180.0
							6	150.0	1	150.000	150.000	150.00	150.0	150.0
							7	200.0	1	200.000	200.000	200.00	200.0	200.0
							8	150.0	1	150.000	150.000	150.00	150.0	150.0
							9	82.0	1	82.000	82.000	82.00	82.0	82.0
							10	32.0	1	32.000	32.000	32.00	32.0	32.0

Table D - 1. Continued

Waterbody	RM	AUID	RM of Entry into Down-stream Tributary	Mississippi RM of Entry into Mississippi River	Para-meter	Year	Month	Geometric Mean	N	25th Percentile	Median (50th Percentile)	75th Percentile	Mini-mum	Max-imum
Little Rock Creek	7.9	07010201-548		937.3	*E. coli*	2008	6		1	88.000	88.000	88.00		
					Fecal Coliform	2004	11		1	20.000	20.000	20.00		
						2006	6		1	130.000	130.000	130.00		
							9		1	210.000	210.000	210.00		
						2007	3		3	13.000	420.000	4600.00		
							4		2	8.000	10.000	12.00		
							5		2	20.000	34.000	48.00		
							6		1	44.000	44.000	44.00		
							7		2	56.000	78.000	100.00		
							8		1	340.000	340.000	340.00		
							9		1	48.000	48.000	48.00		
							10		1	88.000	88.000	88.00		
Bunker Hill Creek	0.8	07010201-511	11.3 into Little Rock Creek	937.3	*E. coli*	2008	6		1	220.000	220.000	220.00		
					Fecal Coliform	2006	6		1	480.000	480.000	480.00		
							7		1	230.000	230.000	230.00		
							9		1	140.000	140.000	140.00		
							10		1	120.000	120.000	120.00		
						2007	3		3	50.000	1400.000	4600.00		
							4		2	4.000	9.500	15.00		
							5		2	24.000	56.000	88.00		
							6		1	48.000	48.000	48.00		
							9		1	640.000	640.000	640.00		
							10		1	9500.000	9500.000	9500.00		
Sucker Creek	0.5	07010201-550	3.1 into Little Rock Creek	937.3	*E. coli*	2008	6		1	69.000	69.000	69.00		
					Fecal Coliform	2004	11		1	18.000	18.000	18.00		
						2007	3		3	6.000	66.000	1300.00		
							4		1	8.000	8.000	8.00		
							5		1	110.000	110.000	110.00		
							10		1	90.000	90.000	90.00		
Watab River	0.2	07010201-528		932.5	Fecal Coliform	2004	5	68.0	1	68.000	68.000	68.00	68.0	68.0
							6	348.5	2	165.000	450.500	736.00	165.0	736.0
							8	166.2	5	100.000	180.000	265.00	70.0	380.0
							9	310.0	1	310.000	310.000	310.00	310.0	310.0
							10	60.0	1	60.000	60.000	60.00	60.0	60.0
						2005	4	13.4	2	10.000	14.000	18.00	10.0	18.0
							5	136.0	1	136.000	136.000	136.00	136.0	136.0
							6	207.6	3	80.000	260.000	430.00	80.0	430.0
							7	55.0	1	55.000	55.000	55.00	55.0	55.0
							8	290.0	2	290.000	290.000	290.00	290.0	290.0
							9	1277.5	2	150.000	5515.000	10880.00	150.0	10880.0
							10	254.0	1	254.000	254.000	254.00	254.0	254.0
						2006	4	10.0	1	10.000	10.000	10.00	10.0	10.0
							5	156.8	2	60.000	235.000	410.00	60.0	410.0
							6	397.4	2	390.000	397.500	405.00	390.0	405.0
							8	48.5	2	10.000	122.500	235.00	10.0	235.0
							9	160.0	1	160.000	160.000	160.00	160.0	160.0
Clearwater River	0.3	07010203-511		914.4	Fecal Coliform	2007	4		0					
							5		3	40.000	120.000	150.00		
							6		2	73.000	86.500	100.00		
							7		1	36.000	36.000	36.00		
							8		2	910.000	1655.000	2400.00		
Tibbets Brook	0.1	07010203-522	8.5 into Elk River	884.5	Fecal Coliform	2005	5	24.3	5	32.000	40.000	41.00	1.0	162.0
							6	188.9	5	50.000	98.000	872.00	41.0	1373.0
							7	120.5	5	86.000	115.000	153.00	70.0	240.0
							8	136.3	5	150.000	160.000	161.00	68.0	179.0
							9	268.9	5	95.000	95.000	645.00	50.0	4830.0
						2006	6	93.8	2	59.000	104.000	149.00	59.0	149.0
							7	111.1	2	71.000	122.500	174.00	71.0	174.0
							8	185.9	3	120.000	141.000	380.00	120.0	380.0
							9	67.0	2	65.000	67.000	69.00	65.0	69.0
						2007	5	36.0	1	36.000	36.000	36.00	36.0	36.0
							6	76.5	2	76.000	76.500	77.00	76.0	77.0
							7	88.3	3	78.000	92.000	96.00	78.0	96.0
							8	2390.0	2	1680.000	2540.000	3400.00	1680.0	3400.0
							9	85.9	2	62.000	90.500	119.00	62.0	119.0
						2008	4	18.7	5	16.000	20.000	28.00	8.0	32.0
							5	34.4	4	24.000	35.000	59.00	14.0	82.0
							6	58.8	4	48.000	66.000	77.00	32.0	86.0
							7	206.6	5	90.000	148.000	250.00	78.0	1448.0
							8	70.6	3	58.000	76.000	80.00	58.0	80.0
							9	43.0	2	26.000	48.500	71.00	26.0	71.0

Table D - 1. Continued

Waterbody	RM	AUID	RM of Entry into Down-stream Tributary	Mississippi RM of Entry into Mississippi River	Para-meter	Year	Month	Geometric Mean	N	25th Percentile	Median (50th Percentile)	75th Percentile	Mini-mum	Max-imum
Diamond Creek	0.7	07010206-525	3.7 into Elm Creek	871.1	*E. coli*	2007	7		2	199.000	204.500	210.00		
							8		2	299.000	1359.000	2419.00		
							9		2	155.000	727.500	1300.00		
							10		3	26.000	195.000	387.00		
							11		1	13.000	13.000	13.00		
						2008	4		1	105.000	105.000	105.00		
							5		5	9.000	20.000	41.00		
							6		4	45.000	50.000	58.50		
							7		4	102.500	204.500	297.50		
							8		4	181.000	261.000	421.50		
							9		5	84.000	96.000	152.00		
							10		4	26.000	60.500	95.00		
							11		3	12.000	18.000	75.00		
Rush Creek	3.6	07010206-528	5.9 into Elm Creek	871.1	*E. coli*	2007	7		2	72.000	96.000	120.00		
							8		2	55.000	734.500	1414.00		
							9		2	43.000	204.000	365.00		
							10		3	61.000	187.000	770.00		
							11		1	35.000	35.000	35.00		
						2008	4		1	28.000	28.000	28.00		
							5		5	9.000	12.000	15.00		
							6		4	47.000	76.500	104.00		
							7		4	136.500	147.000	218.50		
							8		4	5.000	15.000	31.00		
							9		5	21.000	50.000	115.00		
							10		4	11.000	32.500	62.00		
							11		3	2.000	11.000	12.00		
Unnamed Ditch (Pleasant Creek)	0.2	07010206-594		864.9	*E. coli*	2006	5	211.4	8	205.000	221.500	300.00	67.0	322.0
							6	209.7	12	92.500	215.000	500.00	44.0	800.0
							7	161.8	4	113.500	160.000	280.00	67.0	400.0
							8		0					
						2007	3		1	3.000	3.000	3.00		
							4		1	8.000	8.000	8.00		
							5		4	1123.800	2203.150	2420.00		
							6		1	235.900	235.900	235.90		
							9		1	579.400	579.400	579.40		
Shingle Creek	0.6	07010206-506		857.7	Fecal Coliform	2004	4	1296.1	2	600.000	1700.000	2800.00	600.0	2800.0
							5	916.5	2	560.000	1030.000	1500.00	560.0	1500.0
							7	2061.6	2	1700.000	2100.000	2500.00	1700.0	2500.0
							8	480.0	1	480.000	480.000	480.00	480.0	480.0
							9	110.0	1	110.000	110.000	110.00	110.0	110.0
							10	120.0	1	120.000	120.000	120.00	120.0	120.0
Unnamed Creek (Beltline Interceptor)	0.5	07010206-616		837.2	*E. coli*	2008	8	326.0	1	326.000	326.000	326.00	326.0	326.0
							9	249.0	1	249.000	249.000	249.00	249.0	249.0
							10	26.0	1	26.000	26.000	26.00	26.0	26.0
							11	35.0	1	35.000	35.000	35.00	35.0	35.0
							12	135.0	1	135.000	135.000	135.00	135.0	135.0