Fecal Coliform and Turbidity TMDL Assessment for the Rock River Watershed

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Waterbody ID	Rock River: Elk Creek to MN/IA Border — Fecal Coliform — 10170204-501 Rock River: Elk Creek to MN/IA Border — Turbidity — 10170204-501 Rock River: Champepadan Creek to Elk Creek — Turbidity — 10170204-509 Elk Creek: Headwaters to Rock River — Turbidity — 10170204-519	Page #: 4
Location	The Rock River watershed is located in the southwest corner of Minnesota and is a tributary to the Missouri River Basin. The Rock River originates in Pipestone County and flows south through Rock County into Iowa. The drainage area of the impaired watershed also includes portions of Nobles and Murray counties.	3
Loading Capacity (expressed as daily load)	**FECAL:** Flow regimes were determined for high, moist, mid-range, dry and low flow conditions. The mid-range flow value for each flow regime was then used to calculate the total monthly loading capacity (TMLC). Thus, for the "high flow" regime, the loading capacity is based on the monthly flow value at the 5th percentile. The flow used to determine loading capacity for each flow regime was multiplied by a conversion factor of 146,776,126,400. Fecal coliform TMDLs are expressed in both monthly and maximum daily terms. This is to ensure that both the monthly geometric mean and upper tenth-percentile portions of the water quality standard are addressed. All maximum daily loading capacity and allocation values are set at a third the monthly loading capacity. In conceptual terms, three days of bacteria loads that approach the maximum daily capacities will "use up" most of the monthly capacity. A greater percentage of days would be considered dry; however the majority of bacterial loading to streams occurs during wet conditions. **TURBIDITY:** Flow regimes were determined for high, moist, mid-range, dry and low flow conditions. The mid-range flow value for each flow regime was then used to calculate the total daily loading capacity (TDLC). Thus, for the "high flow" regime, the TDLC is based on the monthly flow value at the 5th percentile. How to convert flow and concentration to load: 1. Determine the median flow value for each flow regime. 2. Calculate the TSS equivalent of 25 NTU. 3. For each flow regime, calculate the total liters per day Flow (cubic feet per second) x 28.31 (cubic feet in one liter) x 86,400 (seconds in one day). 4. For each flow regime, calculate total mg of TSS: TSS surrogate (74 mg/l) x total liters. 5. For each flow regime, calculate total tons TSS per day: Total mg TSS/907,184,740 (the number of mg in one ton). Flow x TSS Surrogate x 28.31 x 86,400 907,184,740=Total Daily Tons TSS Daily flows multiplied by the surrogate TSS value results in a load duration curve. The majority of TSS load does occur during the April through June period, as this is the period when higher flow usually occurred.	36, 37, 45, 47, 48
303(d) Listing Information	The MPCA's projected schedule for TMDL completions, as indicated on Minnesota's 303(d) impaired waters list, implicitly reflects Minnesota's priority ranking of this TMDL. The project was scheduled to begin in 2006 and be completed in 2011. The stream reach impaired for turbidity and fecal coliform stretches from south of the city of Luverne to the Minnesota/Iowa border (listed in 2002, 1994 respectively). This reach watershed encompasses 355,625 acres or 556 square miles. Two upstream reaches are also impaired for turbidity. The first reach is Elk Creek: Headwaters to Rock River, a 41,131 acre watershed located across portions of western Rock County and eastern Nobles County (listed in 2006). The second reach, Rock River: Champepadan Creek to Elk Creek drains 276,845 acres from portions of Murray, Nobles, Pipestone and Rock counties (listed in 2006).	2, 3, 4
Impairment / TMDL Pollutant(s) of Concern	Turbidity and Fecal coliform	3
Impaired Beneficial Use(s)	The applicable water body classifications and water quality standards are specified in Minnesota Rules Chapter 7050. Minnesota Rules Chapter 7050.0407 lists water body classifications and Chapter 7050.2222 subp. 5 list applicable water quality standards for the impaired reaches for Aquatic Recreation and Aquatic Life.	11, 41
Applicable Water Quality Standards/ Numeric Targets	**FECAL:** Minnesota Rules Chapter 7050 provides the water quality standards for Minnesota waters. The rules are as follows for Class 2B surface waters for fecal coliform bacteria: The quality of Class 2B surface waters shall be such as to permit the propagation and maintenance of a healthy community of cool or warm water sport or commercial fish and associated aquatic life, and their habitats. These waters shall be suitable for aquatic recreation of all kinds, including bathing, for which the waters may be usable. Fecal coliform organisms not to exceed 200 organisms per 100 milliliters as a geometric mean of not less than five samples in any calendar month, nor shall more than ten percent of all samples taken during any calendar month individually exceed 2000 organisms per 100 milliliters. The standard applies only between April 1 and October 31.	11, 12, 14, 17, 42, 55
	TURBIDITY: The rules for Class 2B surface waters for turbidity: The numerical and narrative water quality standards in parts 7050.0221 to 7050.0227 prescribe the qualities or properties of the waters of the state that are necessary for the designated public uses and benefits. If the standards in this part are exceeded, it is considered indicative of a polluted condition which is actually or potentially deleterious, harmful, or injurious with respect to designated uses or established classes of the waters of the state. The numeric criteria for turbidity, based on stream classification. There are three impaired reaches that are classified as Class 2B streams and have a turbidity standard of 25 NTU.	

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Wasteload Allocation	Source	Permit #	Individual Daily WLA	Page #
Wasteload Allocation Fecal Coliform Rock River: Elk Creek to MN/IA border	**CAFOs**			34, 39, 40
	Gary Rodrigue-Hoffman Site	105-100160	0	
	Kyle Van Dyke	105-107749	0	
	Donald DeKam Farm	105-50001	0	
	GPFF Inc - Whitetail Run	105-50004	0	
	Verlyn DeKam Farm	105-50008	0	
	Mark Knips Farm	105-92736	0	
	Rick Bullerman Farm	105-92829	0	
	John & Joe Wieneke Farm	105-92976	0	
	Mark Knips Farm	105-93047	0	
	Pig City	117-109160	0	
	Spronk Brothers III	117-50001	0	
	Jeff & Debra Brockberg Farm	117-50005	0	
	New Horizon Farms-Hillview E	117-50013	0	
	East River Farms	117-60142	0	
	Todd Van Essen Farm	117-85163	0	
	Leon Kracht Farm	117-85455	0	
	Ken Winsel Farm	117-85586	0	
	Charla Hunter Farm	117-85608	0	
	G&A Farms Inc	133-105980	0	
	Overgaard Pork	133-109460	0	
	Knutson Feedlots	133-84234	0	
	Kracht Hill Farm	133-84246	0	
	Binford Farms	133-84257	0	
	Craig Stegenga Farm	133-84820	0	
		TOTAL	0	
	Source	**Permit #**	**Individual Daily WLA**	**Page #**
	WWTF			38, 39, 40
	Chandler	MN0039748	0.012	
	Edgerton	MNG580011	0.028	
	Hardwick	MN0039713	0.012	
	Holland	MN0021270	0.007	
	Leota	MN0063941	0.012	
	Luverne	MN0020141	0.114	
	Magnolia	MN0025712	0.019	
	Woodstock	MN0065200	0.007	
		TOTAL	0.211	
	Source	**Permit #**	**Individual Daily WLA**	**Page #**
	Straight-Pipe Septics			38, 39, 40
	Illegal Discharges	NA	0	
		TOTAL	0	
Wasteload Allocation Turbidity Rock River: Elk Creek to MN/IA border	**Source**	**Permit #**	**Individual WLA**	**Page #**
	WWTF and Industrial with discharge limits			49, 50, 52
	Chandler	MN0039748	0.59	
	Edgerton	MNG580011	0.27	
	Hardwick	MN0039713	0.11	
	Holland	MN0021270	0.02	
	Leota	MN0063941	0.12	
	Luverne	MN0020141	0.38	
	Magnolia	MN0025712	0.19	
	Woodstock	MN0065200	0.07	
	Agri-Energy	MN0065033	0.02	
		TOTAL	1.75	

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Wasteload Allocation Turbidity Rock River: Elk Creek to MN/IA border continued	Source		Individual WLA	Page #
	Construction Stormwater			50, 51, 52
	High		1.14	
	Moist		0.37	
	Mid		0.17	
	Dry		0.07	
	Low		0.01	
	Source		**Individual WLA**	**Page #**
	Industrial Stormwater			50, 51, 52
	High		0.57	
	Moist		0.18	
	Mid		0.09	
	Dry		0.03	
	Low		0.01	
Wasteload Allocation Turbidity Rock River: Champedadan Creek to Elk Creek	**Source**	**Permit #**	**Individual WLA**	**Page #**
	WWTF and Industrial with discharge limits			49, 50, 52
	Chandler	MN0039748	0.59	
	Edgerton	MNG580011	0.27	
	Hardwick	MN0039713	0.11	
	Holland	MN0021270	0.02	
	Leota	MN0063941	0.12	
	Luverne	MN0020141	0.38	
	Woodstock	MN0065200	0.07	
		TOTAL	1.55	
	Source		**Individual WLA**	**Page #**
	Construction Stormwater			50, 51, 52
	High		0.88	
	Moist		0.29	
	Mid		0.13	
	Dry		0.05	
	Low		0.009	
	Source		**Individual WLA**	**Page #**
	Industrial Stormwater			50, 51, 52
	High		0.44	
	Moist		0.14	
	Mid		0.07	
	Dry		0.03	
	Low		0.005	
Wasteload Allocation Turbidity Elk Creek: Headwaters to Rock River	**Source**		**Individual WLA**	**Page #**
	WWTF and Industrial with discharge limits			49, 50, 53
	Magnolia	MN0025712	0.18	
		TOTAL	0.18	
	Source		**Individual WLA**	**Page #**
	Construction Stormwater			50, 51, 53
	High		0.13	
	Moist		0.04	
	Mid		0.02	
	Dry		0.008	
	Low		0.002	
	Source		**Individual WLA**	**Page #**
	Industrial Stormwater			50, 51, 53
	High		0.07	
	Moist		0.02	
	Mid		0.01	
	Dry		0.004	
	Low		0.001	

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Load Allocation Fecal Coliform Rock River: Elk Creek to MN/IA border	Source	Individual LA	Page #
	High	30.18	40
	Moist	11.92	
	Mid	6.95	
	Dry	2.19	
	Low	0.90	

Executive Summary

The Clean Water Act, Section 303(d), requires that every two years, States publish a list of streams and lakes that do not meet water quality standards. Waters placed on the list are considered "impaired", leading to the requirement of a Total Maximum Daily Load (TMDL). TMDL assessments determine the maximum amount of pollutant a stream can receive, while maintaining water quality standards. A TMDL is divided into a wasteload allocation (point sources), load allocation (non-point sources and natural background) and a margin of safety.

The state agency responsible for listing waters in Minnesota is the Minnesota Pollution Control Agency (MPCA). In 1994, the MPCA determined the Rock River, Elk Creek to Minnesota/Iowa border (Assessment ID: 10170204-501), was impaired for fecal coliform. In 2002, the MPCA further listed this reach as impaired for turbidity. In 2006, two additional upstream reaches, Rock River, Champepadan Creek to Elk Creek (10170204-509) and Elk Creek, Headwaters to Rock River (10170204-519) were listed as impaired for turbidity. Thus, the following report provides TMDL assessments for one fecal coliform and three turbidity impaired reaches.

The Rock River is located in the southwest corner of Minnesota and is a tributary to the Missouri River Basin. The Rock River originates in Pipestone County and flows south through Rock County into Iowa. The watershed encompasses 365,625 acres, including portions of Nobles and Murray counties. The watershed contains portions of fifteen communities, Luverne the largest, with a population of 4,617. The population of the impaired watershed is 10,942, with 34 percent living in rural areas. Agricultural land use comprises nearly 95 percent of the landscape, with corn and soybeans as the primary crop types. The watershed includes 684 feedlots, with an estimated 151,222 animal units. Swine, beef and dairy are the primary livestock types.

Fecal coliform levels in the Rock River exceeded water quality standards during the months of August and September. To meet water quality standards, fecal coliform levels will need to be decreased up to 60% during these months. The highest levels were found during and after storm runoff. Concentrations of fecal coliform bacteria were an average of ten times higher during storm runoff than during dry periods.

Turbidity was found to be the most excessive in Rock River following storm runoff and high flow periods. During high flow periods, reductions of up to 68 percent will be required to meet turbidity standards. Turbidity levels during mid-range and low flows are at or near the water quality standard.

The TMDL study used a flow duration curve approach to determine pollutant loading capacity for each impaired reach under a variety of flow regimes. The duration curves were used to determine general allocations necessary to meet water quality standards for each of the three impaired stream reaches.

A population source inventory and delivery ratios were used to estimate primary contributing sources of fecal coliform bacteria. This analysis indicated that cattle with access to streams, feedlots without runoff controls, field applied manure and inadequately functioning septic systems are likely the primary contributors of fecal coliform contamination. For turbidity, load duration curves and water quality data indicate the primary sources to be soil erosion in the riparian zone from livestock, streambank erosion/slumping, upland soil loss from row cropland and algae growth.

The report describes the above sources and dynamics in more detail. The report also describes applicable water quality standards for fecal coliform bacteria and turbidity, source inventories, TMDL development and allocations, future monitoring activities and suggested implementation strategies.

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Acronyms

AU – Animal Unit
BWSR Board of Water and Soil Resources
CFU – Colony Forming Units
CWA – Clean Water Act
DNR – Department of Natural Resources
FC – Fecal Coliform
ISTS – Individual Sewage Treatment System
LA – Load Allocation
MG – Milligram
MG/L – Milligrams Per Litter
ML – Milliliter
MN - Minnesota
MOS – Margin of Safety
MPCA – Minnesota Pollution Control Agency
MS4 – Municipal Separate Storm Sewer System Permit
NPDES – National Pollutant Discharge Elimination System
NRCS – Natural Resources Conservation Service
NTU - Nephelometric Turbidity Unit
ORG/100 ML – Organisms Per 100 Milliliters
RC – Reserve Capacity
RRW – Rock River Watershed
SWCD – Soil and Water Conservation District
TDLC – Total Daily Loading Capacity
TMDL – Total Maximum Daily Load
TMLC – Total Monthly Loading Capacity
TSS – Total Suspended Solids
USDA – United States Department of Agriculture
USEPA – United States Environmental Protection Agency
USGS – United States Geological Survey
WLA – Waste Load Allocation
WWTF – Wastewater Treatment Facility

Section 1.0 – Introduction

1.1 Purpose

Section 303(d) of the Clean Water Act (CWA) provides authority for completing Total Maximum Daily Loads (TMDLs) to achieve state water quality standards and/or their designated uses. The TMDL process establishes the allowable loadings of pollutants for a water body based on the relationship between pollution sources and in-stream water quality conditions. TMDLs provide States a basis for determining the pollutant reductions necessary from both point and nonpoint sources to restore and maintain the quality of their water resources.

A TMDL is a calculation of the maximum amount of a pollutant that a water body can receive and still meet water quality standards, and an allocation of that amount to the pollutant's sources. Section 303(d) of the CWA and its implementing regulations (40 C.F.R. § 130.7) require states to identify waters that do not or will not meet applicable water quality standards and to establish TMDLs for pollutants that are causing non-attainment of water quality standards.

Water quality standards are set by States, Territories, and Tribes. They identify the uses for each water body, for example, drinking water supply, contact recreation (swimming), and aquatic life support (fishing), and the scientific criteria to support that use.

A TMDL needs to account for seasonal variation and must include a margin of safety (MOS). The MOS is a safety factor that accounts for any lack of knowledge concerning the relationship between effluent limitations and water quality. Also, a TMDL must specify pollutant load allocations among sources. The total of all allocations, including wasteload allocations (WLA) for point sources, load allocations (LA) for nonpoint sources (including natural background), and the MOS (if explicitly defined) cannot exceed the maximum allowable pollutant load:

$$\mathbf{TMDL} = \text{sum}\mathbf{WLAs} + \text{sum}\mathbf{LAs} + \mathbf{MOS} + \mathbf{RC}^*$$

* The MPCA also requires "Reserve Capacity" (RC) which is an allocation for future growth be addressed in the TMDL.

A TMDL study identifies all sources of the pollutant and determines how much each source must reduce its contribution in order to meet the quality standard. The sum of all contributions must be less than the maximum daily load.

Sources that are part of the waste load allocation, with the exception of "straight-pipe" septic systems, are largely controlled through National Pollutant Discharge Elimination System (NPDES) permits. Load allocation sources are controlled through a variety of regulatory and non-regulatory efforts at the local, state, and federal level.

1.2 Priority Ranking

The Minnesota Pollution Control Agency (MPCA) projected schedule for TMDL completions, as indicated on Minnesota's 303(d) impaired waters list, implicitly reflects Minnesota's priority ranking of this TMDL. The project was scheduled to begin in 2006 and be completed in 2011. Ranking criteria for scheduling TMDL projects include, but are not limited to: impairment impacts on public health and aquatic life; public value of the impaired water resource; likelihood of completing the TMDL in an expedient manner, including a strong base of existing data and restorability of the waterbody; technical capability and willingness locally to assist with the TMDL; and appropriate sequencing of TMDLs within a watershed or basin.

1.3 Criteria Used for Listing

The criteria used for determining stream reach impairments ~~is~~ are outlined in the MPCA document, Guidance Manual for Assessing the Quality of Minnesota Surface Waters for Determination of Impairment – 305(b) Report and 303(d) List), January 2004. The applicable water body classifications and water quality standards are specified in Minnesota Rules Chapter 7050. Minnesota Rules Chapter 7050.0407 lists water body classifications and Chapter 7050.2222 subp. 5 lists applicable water quality standards for the impaired reaches.

Fecal coliform (FC) assessment protocol includes pooling of data by month over a ten-year period. A geometric mean is then calculated for each month, April through October, with a minimum of five samples used for each monthly calculation.

There are two scenarios when a stream reach will qualify to be listed as impaired. If any monthly geometric mean value exceeds 200 organisms per 100 ml the stream qualifies to be listed as impaired. The other scenario involves combining the entire ten-year data set and assessing the percent of samples that exceed 2,000 organisms per 100 ml. If more than ten percent of the samples exceed 2,000 org/100ml, the stream qualifies as listing as impaired.

Turbidity assessment protocol also includes pooling of data over a ten-year period and requires a minimum of twenty samples. The surface water standard for turbidity is 25 nephelometric turbidity units (NTUs). For assessment purposes, a stream is listed as impaired if at least three observations or 10% of observations exceed 25 NTUs. Transparency and total suspended solids samples may also be used as a surrogate for the turbidity standard. A transparency reading of 20 cm or TSS sample of 66 mg/L (Ecoregion based surrogate standard) is considered equivalent to the 25 NTU turbidity standard. If there are two or more parameters observed in a single day, the hierarchy of consideration is turbidity, then transparency, then total suspended solids.

Section 2.0 – Background Information

2.1 **TMDL Study Area Overview**

This report includes the TMDL for one fecal coliform and three turbidity impaired stream reaches in the Rock River Watershed (RRW).

The RRW is located in the southwest corner of Minnesota (see Figure 2.1a) and is a tributary to the Missouri River Basin. The Rock River originates in Pipestone County and flows south through Rock County into Iowa. The drainage area of the impaired watershed also includes portions of Nobles and Murray counties.

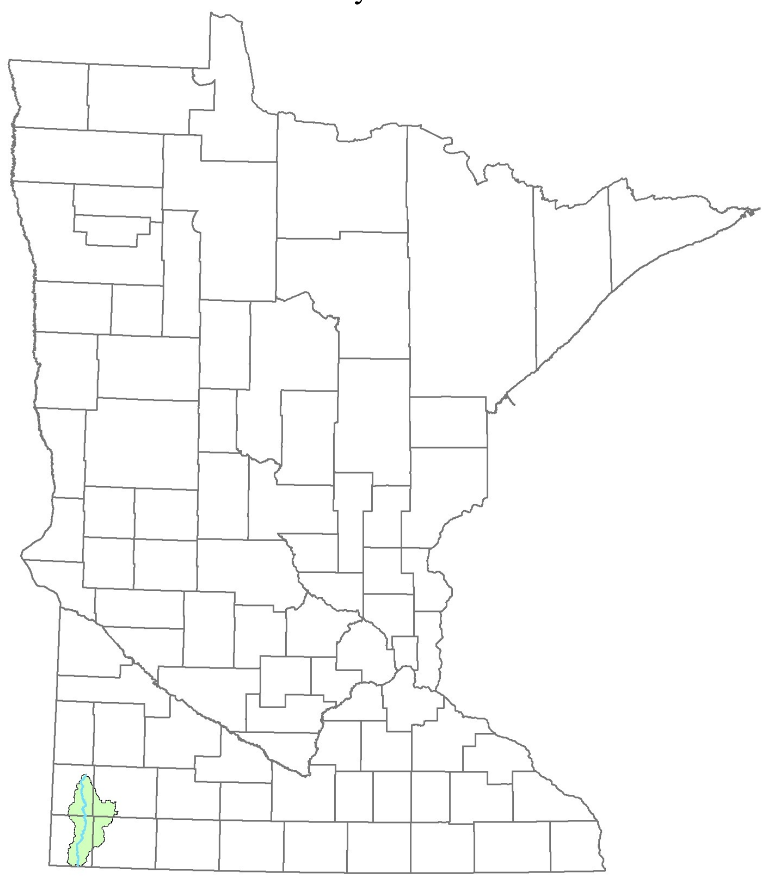


Figure 2.1a – Location of Rock River Watershed

A summary of the impaired reaches is presented in Table 2.1. Locations of the impaired reaches and contributing upstream watersheds are shown in Figure 2.1b. The stream reach impaired for turbidity and fecal coliform stretches from south of the city of Luverne to the Minnesota/Iowa border. This reach watershed encompasses 355,625 acres or 556 square miles. Two upstream reaches are also impaired for turbidity. The first reach is Elk Creek: Headwaters to Rock River, a 41,151 acre watershed located across portions of western Rock County and eastern Nobles County. The second reach, Rock River: Champepadan Creek to Elk Creek drains 276,845 acres from portions of Murray, Nobles, Pipestone and Rock counties.

Table 2.1 - Impaired Stream Reaches

Stream Name	Description	Parameter	Year Listed	MPCA River Assessment ID
Rock River	Elk Creek to Minnesota/Iowa Border	Turbidity	2002	10170204-501
Rock River	Elk Creek to Minnesota/Iowa Border	Fecal Coliform	1994	10170204-501
Rock River	Champepadan Creek to Elk Creek	Turbidity	2006	10170204-509
Elk Creek	Headwaters to Rock River	Turbidity	2006	10170204-519

Overall, the RRW is a gently rolling landscape with occasional rock outcroppings. On average, RRW receives- approximately 28 inches of precipitation annually. Based on 2000 landuse statistics, approximately 95 percent of the landuse is agricultural. As of the 2003 MPCA feedlot inventory, there were 684 feedlots containing 151,222 animal units in the watershed. A majority of livestock includes dairy, beef, swine and poultry.

The population of the impaired portion of RRW is estimated at 10,942 and contains portions of twelve incorporated communities and three unincorporated communities. The urban population is estimated at 7,186 residents. An estimated 3,756 residents live in rural areas and utilize individual septic systems for their waste sewage treatment, equating to roughly 1,450 rural septic systems.

Recreational uses of the Rock River include fishing, swimming and canoeing. In addition, the corridor of the Rock River provides wildlife habitat, and as such is utilized by hunters and bird watchers.

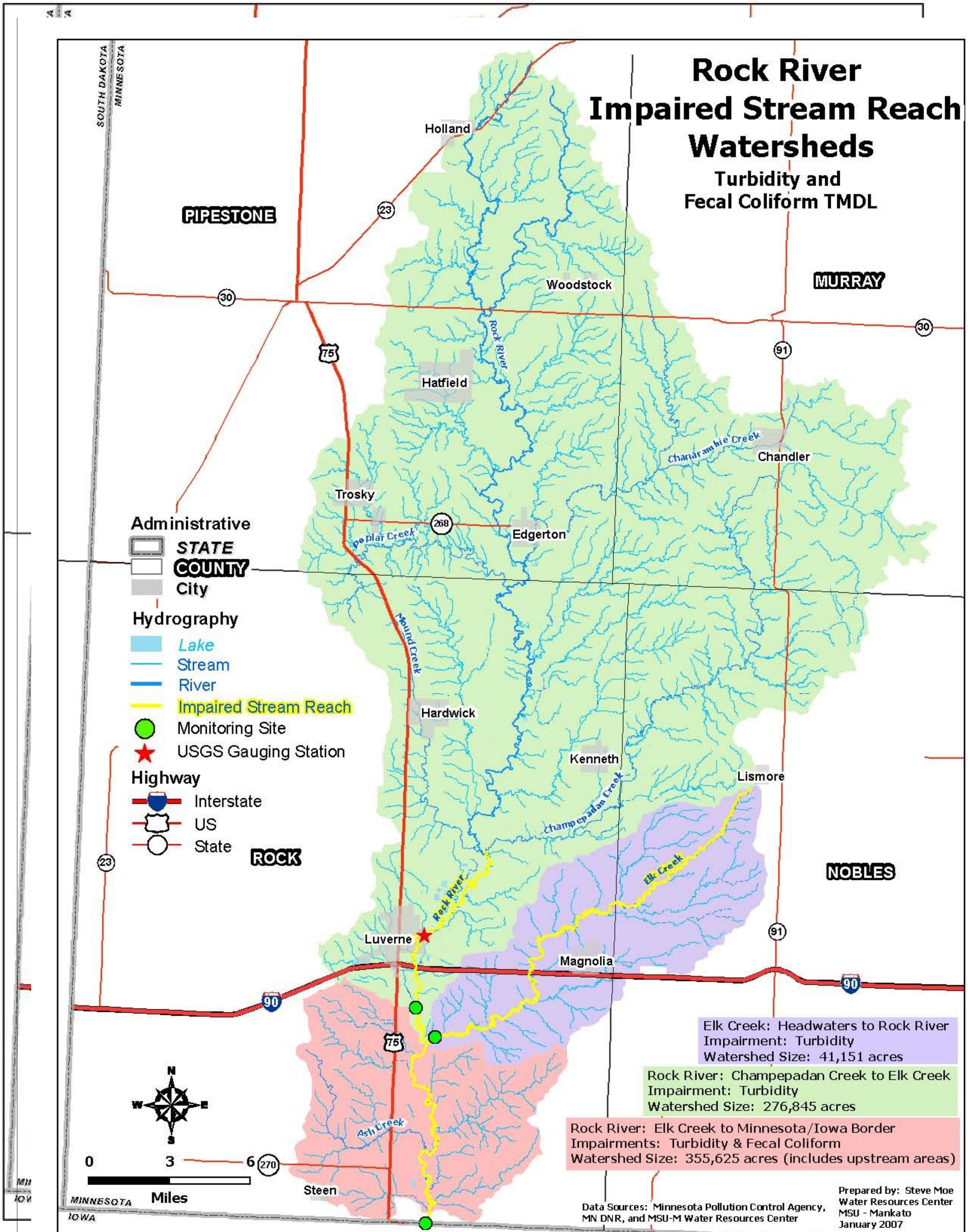


Figure 2.1b – Rock River Watershed – Impaired Reaches

2.2 Land Use and Cover (2000)

The RRW is dominated by cultivated land at nearly 76.7 percent. Pasture and hay lands account for another 18.6 percent. The only other land use and cover categories above one percent are wetlands at 1.7 percent and forest at 1.2 percent. It should be noted that conservation easement lands, such as those enrolled in Wildlife Management Areas and the Conservation Reserve Program, are not included in the landuse inventory. These easement lands cover an estimated 5,400 acres, or 1.5 percent of the watershed landscape. Figure 2.2a present a summary of landuse and cover data for the watershed. Figure 2.2b is a map displaying the landuse data.

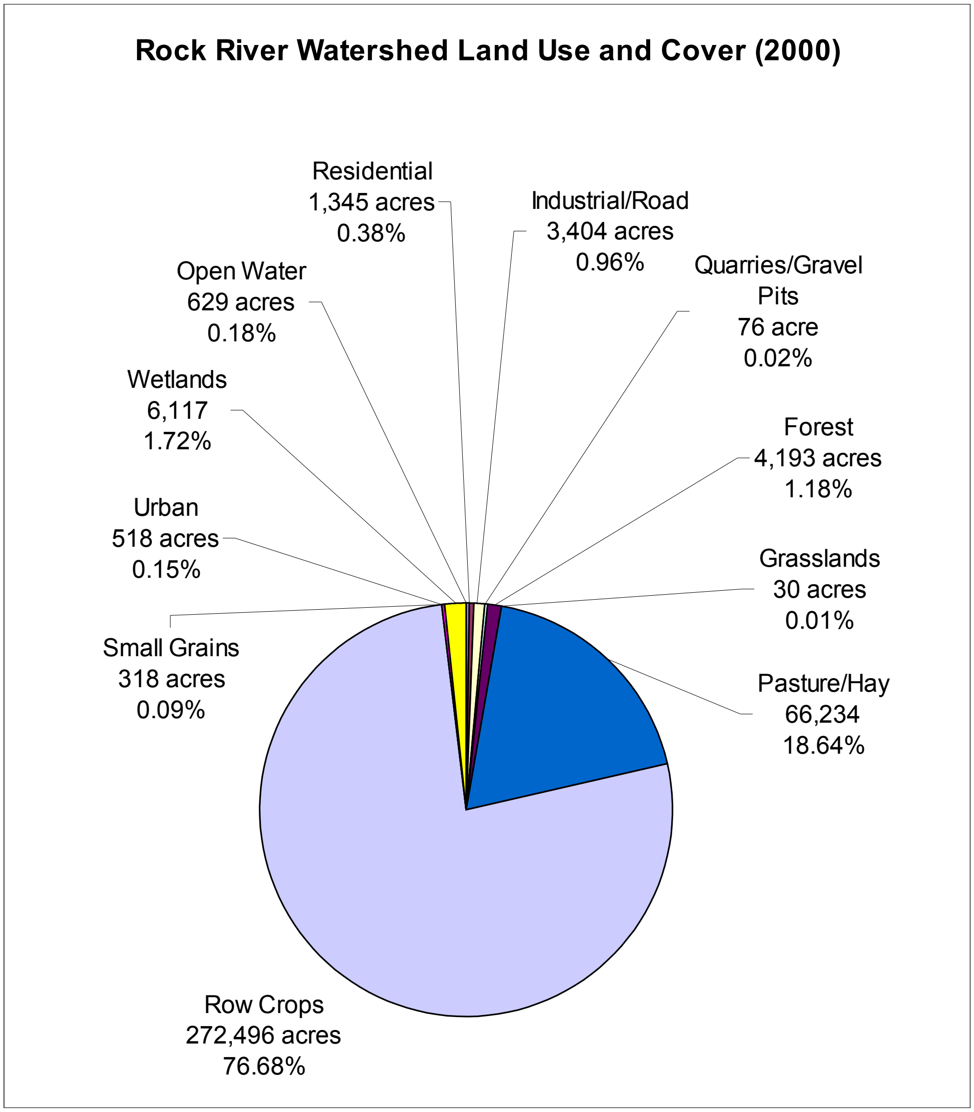


Figure 2.2a – Rock River Watershed Landuse (2000)

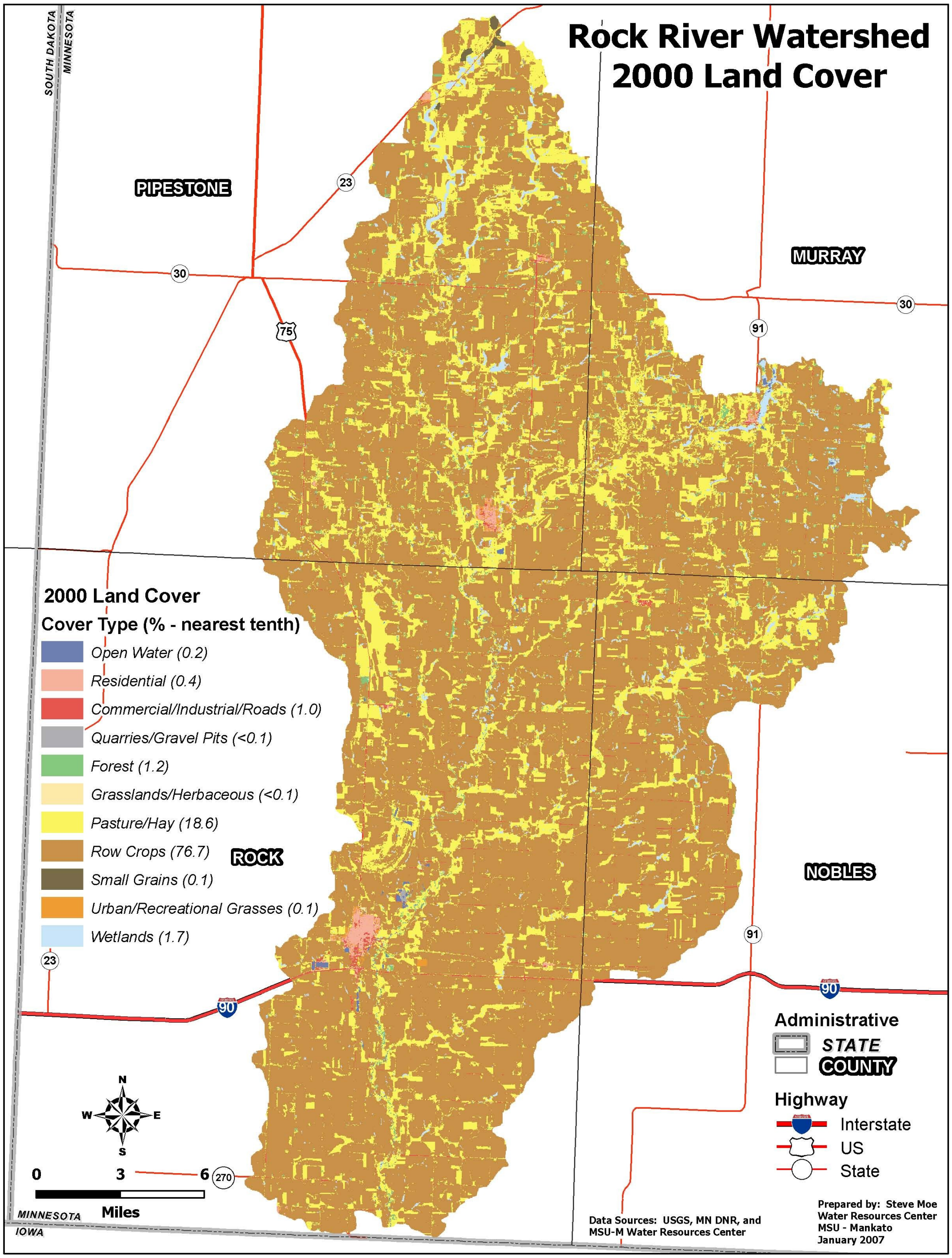


Figure 2.2b – Rock River Watershed Landuse (2000)

2.3 Temperature

Figure 2.3 presents the average monthly high, low and mean temperatures at Luverne, Minnesota. Ice out conditions in the Rock River typically occur between the end of March and early April. Temperatures reach peak levels during July/August and then gradually decline. Monitoring data indicate that temperature has an association with bacterial levels in surface waters, with warmer stream water having higher bacterial levels.

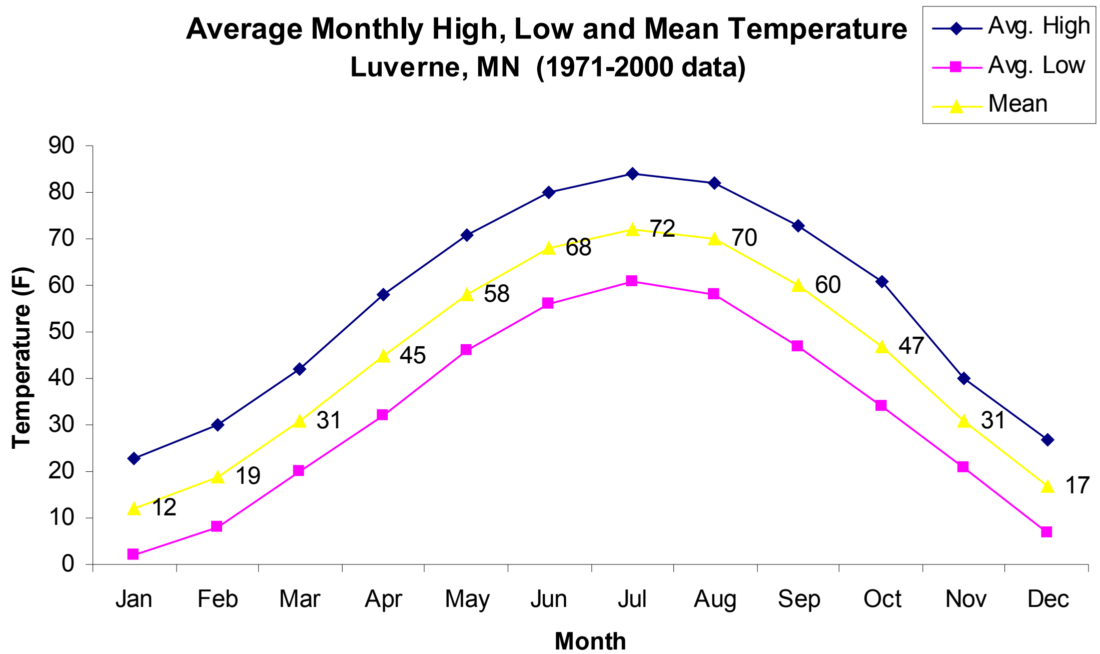


Figure 2.3 – Average Monthly Temperature by Month

2.4 Precipitation

Based on precipitation values used from Luverne, Minnesota, the watershed averages 27.7 inches of precipitation annually. The monitoring season months of April through October represent 79 percent of the annual average precipitation with a total of 21.8 inches. Figure 2.4 presents the average monthly precipitation values for Luverne, MN.

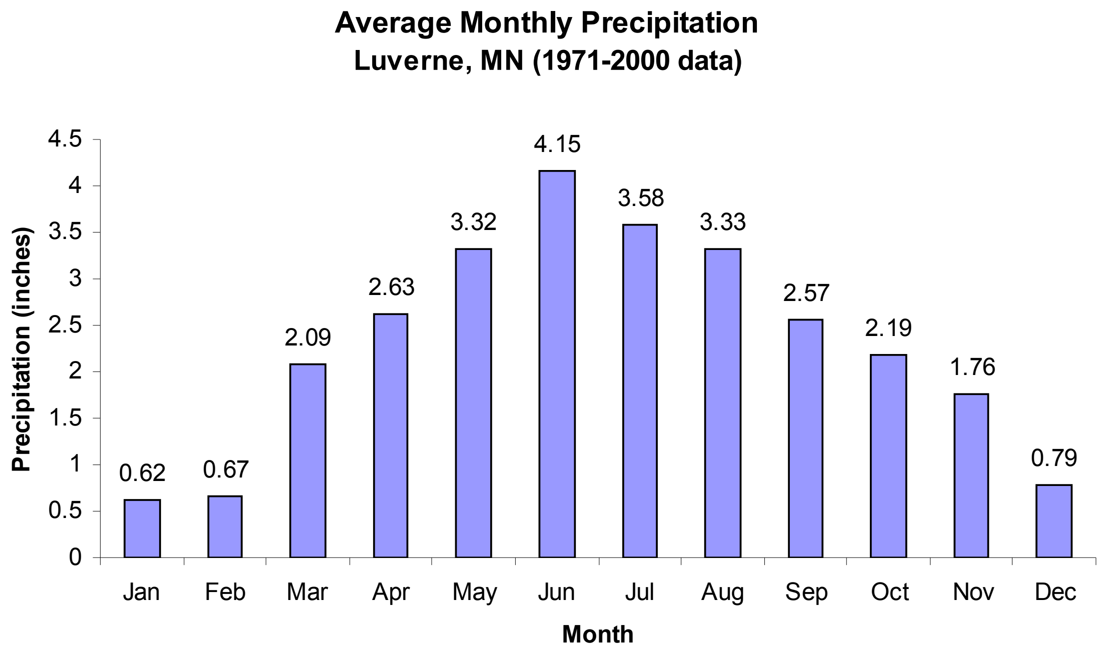


Figure 2.4 - Precipitation Data for Luverne, MN (1971-2000)

Review of monitoring data collected from the Rock River and other streams in southern Minnesota show a strong relationship between pollutant loading and rainfall intensity. The highest bacterial concentrations and turbidity values of any particular year are usually associated with the highest intensity precipitation events. This is especially true during the spring when agricultural fields are not protected by crop canopy. Crop canopy significantly reduces rainfall runoff and associated soil erosion and pollutant movement.

2.5 **Stream Flow Characteristics**

Figure 2.5 displays the mean monthly flow for the Rock River at Luverne (USGS/DNR gage # 06483000) for the months of April through October. These are the months when the majority of flow occurs and thus when most water quality samples are collected. On average, the month with the highest flow volume is April, due to the combination of snowmelt and overland runoff. June, the month with the greatest precipitation totals, has the second highest mean monthly flow.

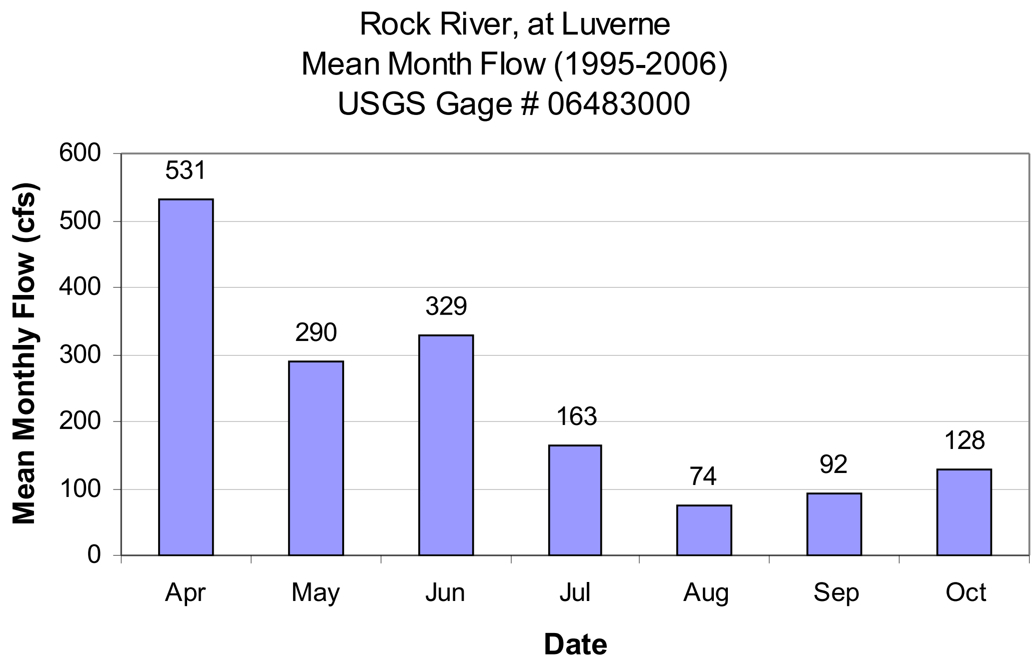


Figure 2.5 – Mean Monthly Flow for Rock River, at Luverne (1995-2006)

2.6 Topeka Shiner: Endangered Fish Species

Topeka shiners are found in the Missouri River drainage – therefore, their presence in Minnesota is limited to the extreme southwestern portions of the state, which includes the Rock River. Topeka shiners prefer prairie stream headwater areas because these smaller streams tend to have cooler temperatures and good water quality. Topeka shiners, however, occupy a variety of habitats, including runs, pools, and backwater areas of various river orders. Larger rivers, although not the primary staging and resting areas for Topeka shiners, serve as critical migration routes that allow the exchange of genetic material and repopulation of areas that periodically run dry. An important characteristic of good quality Topeka shiner habitat is the availability of clean gravel or sand substrates with vegetated banks of grasses and forbs. High turbidity levels in the Rock River are associated with higher turbidity levels in the tributaries. As a result, increased sedimentation has occurred and Topeka shiner habitat has become more limited.

Declines in Topeka shiner numbers have occurred throughout nearly all of its range – thus it is listed as an Endangered Species. The Minnesota population of Topeka shiners is in better condition than those found in other states. An examination of watershed-level activities points to a variety of conclusions about why the species has declined. The TMDLs for turbidity contained in this report, when achieved, will help maintain and improve spawning habitat for the Topeka shiner in the Rock River.

Section 3.0 – Fecal Coliform Standards and Impairment Assessment

3.1 Description of Fecal Coliform Bacteria

Fecal coliform bacteria are a bacteria group that are found in the intestines of warm-blooded mammals. While usually not harmful themselves, fecal coliforms are considered an indicator of the presence of other disease causing bacteria, viruses, and/or protozoans.

Fecal coliform bacteria are passed through the fecal excrement of humans, livestock and wildlife. These bacteria can enter waterways through direct discharge of waste from mammals and birds, from agricultural and urban stormwater runoff and from poorly or untreated human sewage. Agricultural practices, such as spreading manure during wet periods, and allowing livestock uncontrolled access to streams, can contribute high levels of fecal coliform bacteria. Wildlife can also be a contributor of fecal coliform bacteria, especially during low flow conditions.

In addition to bacteria and other pathogens, human and animal waste contain high levels of other pollutants such as phosphorus, nitrogen, and oxygen demanding organic material. Additionally, some of the same soil erosion processes and delivery pathways that lead to sediment pollution of streams and rivers also contribute to human and animal waste entering the water. As such, efforts to contain sewage and animal waste, and to control soil erosion and sedimentation, result in better overall water quality.

3.2 Applicable Minnesota Water Quality Standards – Class 2B Waters

Minnesota Rules Chapter 7050 provides the water quality standards for bacterial concentrations in Minnesota waters. The rules are as follows for Class 2B surface waters. The impaired reaches the Rock River, Elk Creek to Minnesota/Iowa border (Assessment ID: 10170204-501) is a Class 2B waters.

The quality of Class 2B surface waters shall be such as to permit the propagation and maintenance of a healthy community of cool or warm water sport or commercial fish and associated aquatic life, and their habitats. These waters shall be suitable for aquatic recreation of all kinds, including bathing, for which the waters may be usable.

Fecal coliform organisms not to exceed 200 organisms per 100 milliliters as a geometric mean of not less than five samples in any calendar month, nor shall more than ten percent of all samples taken during any calendar month individually exceed 2000 organisms per 100 milliliters. The standard applies only between April 1 and October 31.

Table 3.2 summarizes the fecal coliform bacteria standards for all classes of water in Minnesota.

Table 3.2 – Minnesota Surface Water Standards for Fecal Coliform Bacteria

Use Class	Standard: No. of Organisms Per 100 mL of Water — Monthly Geometric Mean*	Standard: No. of Organisms Per 100 mL of Water — 10% of Samples Maximum**	Applicable Season	Use — Body Contact
2A, trout streams and lakes	200	400	April 1 - October 31	Primary
2Bd, 2B, 2C, non-trout (warm) waters	200	2000	April 1 - October 31	Primary
2D, wetlands	200	2000	April 1 - October 31	Primary, if the use is suitable
7, limited resource value waters	1000	2000	May 1 - October 31	Secondary

* Not to be exceeded as the geometric mean of not less than 5 samples in a calendar month.

** Not to be exceeded by 10% of all samples taken in a calendar month, individually.

Source: Guidance Manual for Assessing the Quality of Minnesota Surface Waters: For the Determination of Impairment. 305(b) Report and 303(d) List

3.3 Change in Standard from Fecal Coliform to *E*. coli

In 2007, the MPCA proposed changing the bacterial water quality standard from fecal coliform to *E*. coli bacteria. As of August 2007, the proposal was in an official comment period. Paired comparison studies of fecal coliform and *E*. coli bacteria conducted by the MPCA have shown on average 63 percent of fecal coliform bacteria to be *E*. coli. The current fecal coliform standard of 200 org/100 ml would be roughly equivalent to 126 *E*. coli bacteria per 100 ml. Therefore, to adapt the fecal coliform TMDL allocations based on future *E*. coli standards would require a simple~~y~~ multiplication factor of 0.63.

More information of the proposed rule change can be found at the MPCA webpage: *http://www.pca.state.mn.us/water/standards/rulechange.html*

3.4 **Impairment Assessment: Fecal Coliform Data**

The majority of bacterial sampling from the Rock River has occurred at a site located on the Minnesota/Iowa border (STORET ID# S000-097) as part of the MPCA Milestone Monitoring Program. This program was designed to collect water quality data at designated rivers over many decades. The data are used to obtain a long-term understanding of river health in Minnesota. The program was initiated in 1953 by the Water Pollution Control Commission. In 1967, the MPCA took over the program, which now includes more than 80 monitoring sites. The Rock River at the Minnesota/Iowa Border became part of this program in 1964. Since 1964, the Rock River as been sampled for fecal coliform and/or *E*. coli bacteria. From 1964 through 2004, a total of 189 fecal coliform samples were collected from the Rock River. Between 1985 through 2006, a total of 32 *E.* coli samples were collected.

In addition to the MPCA samples, the Iowa Department of Natural Resources also collected 22 fecal coliform and *E*. coli samples at the Minnesota/Iowa site in 2002 and 2003 as part of the Big Sioux River fecal coliform TMDL.

3.5 **Utilization of *E*.coli Data**

To strengthen the data set, *E*. coli samples were also included for analytical purposes. From 1985 through 2004, the MPCA collected both fecal coliform and *E*. coli samples from the Rock River. In 2006, the MPCA sampling program replaced fecal coliform with *E*. coli sampling. Using the paired samples from 1985 through 2004, a linear equation was created to convert *E*. coli concentrations into fecal coliform concentrations for the 2006 sample set. As shown in Figure 3.5, there is a strong relationship between fecal coliform and *E*. coli samples (R^2 = .945).

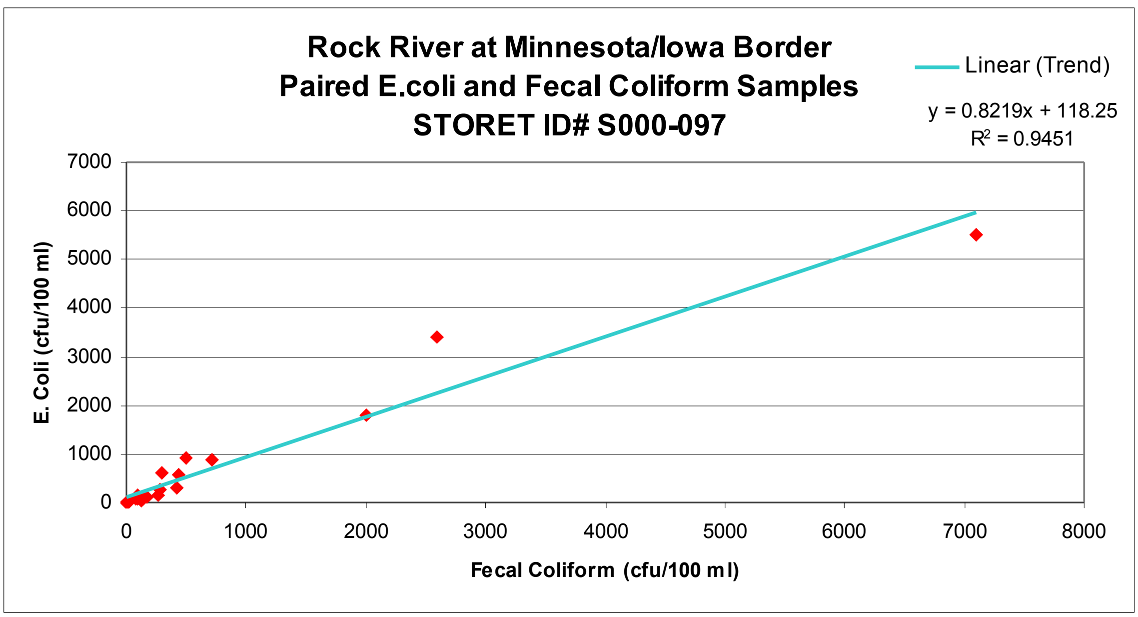


Figure 3.5 – Fecal Coliform and E. coli Paired Samples

3.6 Monthly Fecal Coliform Concentrations in the Rock River

The criteria used for determining fecal coliform impairments ~~is~~ are described in Section 1.3. The procedure involves calculating monthly geometric means for the months of April through October, using the prior ten-year period of water quality data. Forty samples were used to calculate monthly geometric means from 1997 through 2006. Figure 3.6a displays the monthly geometric means from April through October, which shows an exceedance of the standard for August and September. Although the Rock River was first listed as impaired in 1994, the data indicate the Rock River continues to qualify as impaired based on recent monitoring data.

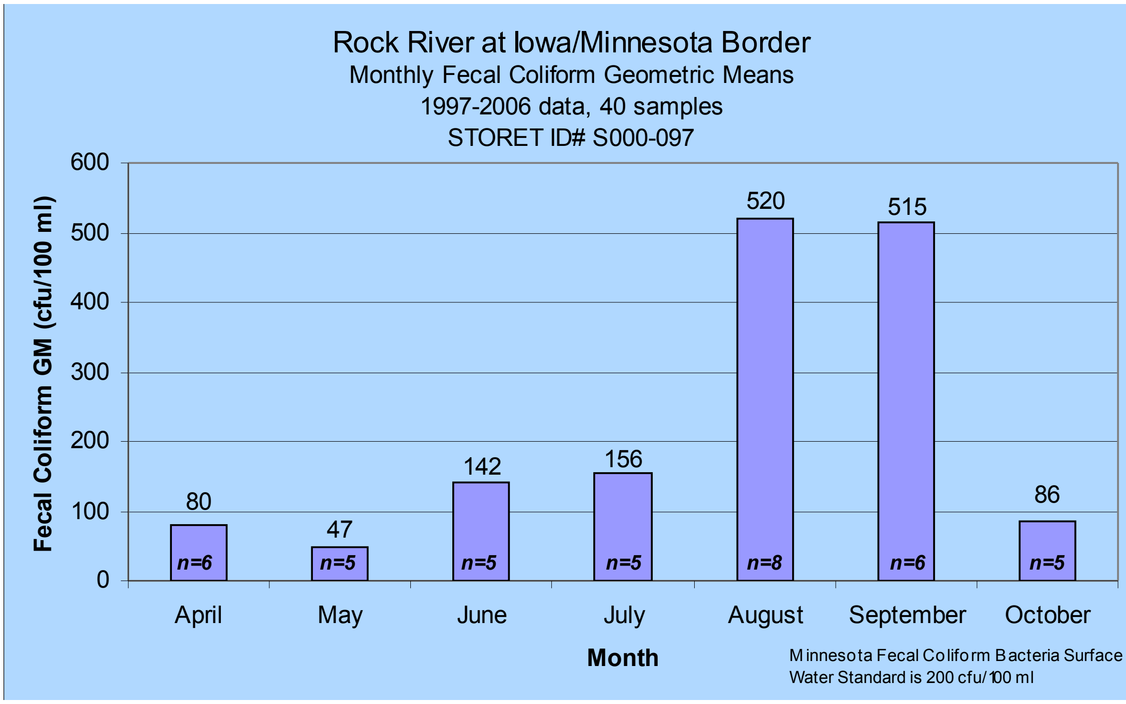


Figure 3.6a – Rock River Monthly Fecal Coliform Geometric Means

In order to determine percent reduction needed to meet the water quality standard, a simple equation is used and shown below.

$$\frac{\text{monthly geomean-water quality standard}}{\text{water quality standard}} = \text{percent reduction}$$

The monthly geomean calculated show that August and September exceeded the water quality standard. August's geomean using eight samples was 520 cfu. Using the equation above, the percent reduction needed to meet the water quality standard is 62 percent. For September, there were six samples collected and the geomean was 515 cfu. a reduction of 63 percent is needed to meet the water quality standard.

Another method of displaying sample data is to plot the water samples based on flow. Figure 3.6b illustrates this concept. This load duration curve was developed by using flow data from the USGS/DNR gaging station #06483000 at Luverne and water quality data from the Minnesota/Iowa monitoring station (STORET ID# S000-097). The figure shows the daily loading capacity over the flow record (1995 through 2006) along with the 40 samples collected in the period. For each sample, the fecal coliform bacteria concentration was multiplied by the daily flow value to compute a daily load. Values that lie above the load duration curve represent samples that exceed 200 cfu. The data shows that using a geomean based on four flow categories revealed greater exceedances of the water quality standard at the highest and higher flow categories.

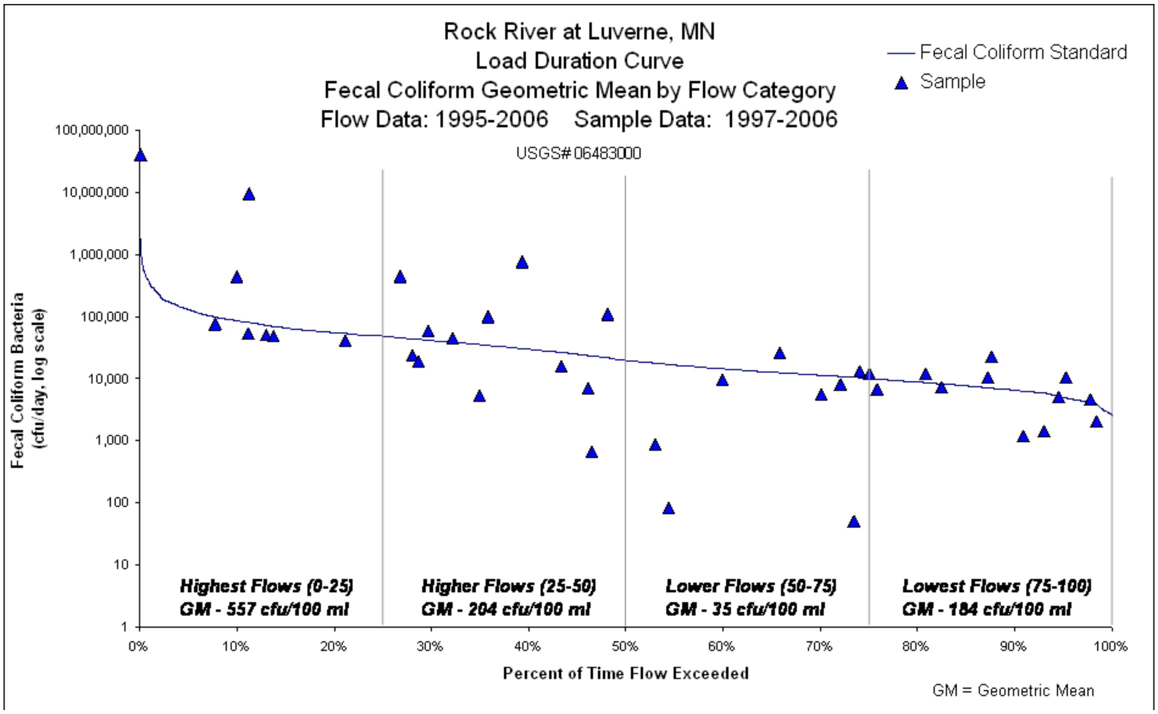


Figure 3.6b – Rock River Fecal Coliform Load Duration Curve

3.7 Fecal Coliform and Precipitation

Fecal coliform bacteria concentrations in the Rock River ~~appear closely associated with precipitation levels~~are highest after precipitation events, regardless of the time of year. Review of precipitation and monitoring data from 1997 through 2006 indicate the highest bacterial concentrations occurred during or within a few days of high precipitation. For example, of the forty samples collected from the Rock River between 1997 and 2006, six samples exceeded 1000 cfu/100 ml. Each of these samples was collected within three days of at least 0.5 inches of precipitation. Samples collected after precipitation events (greater than 0.5 inches within previous three days) had a geometric mean of 898 cfu/100 ml. Samples collected during dry periods had a geometric mean of 97 cfu/100 ml.

3.8 Geographic Scope of Impairment

The geographic scope of fecal coliform impairment upstream of the impaired segment is unknown, as bacterial monitoring has only been conducted at the Iowa/Minnesota border. However, described later in this report, the most likely sources of bacterial contamination are livestock manure and inadequately functioning septic systems. As these sources are distributed fairly evenly across the watershed, and the fact that landuse varies little, it is assumed that bacterial concentrations across the watershed would be similar. It should also be noted that the majority (>90%) of rivers and streams with adequate monitoring data in southern Minnesota qualify as impaired for fecal coliform bacteria.

3.9 Seasonality

Monitoring data show an apparent relationship between season and fecal coliform bacteria concentration. Typically, the highest bacterial concentrations are found in the summer and early fall. In the spring, concentrations are typically lower, despite the fact that significant manure application occurs from October through March and that fields have little crop canopy to protect against water erosion.

The apparent seasonality of fecal coliform bacteria concentrations appears to be associated strongly with stream water temperature. Seasonal changes in landuse, such as timing of manure application, appear to have little correlation with seasonality of bacterial concentrations. Fecal coliform bacteria are the most productive at temperatures similar to their origination environment in animal intestines. Therefore, fecal coliform bacteria are at their highest concentrations during warmer temperatures, possibly due to reproduction in numbers. However, at lower temperatures it is probable the metabolism of organisms slow, therefore prolonging their existence (Chapelle, 2001; Cullimore, 1993). Thus, while bacterial concentrations may be lower during colder periods, survival rates are increased.

Review of fecal coliform concentration and stream water temperature show the apparent relationship. Of non-storm event samples, 33 percent exceeded 200 cfu/100 ml when water temperature was above twenty degrees Celsius, as opposed to 8 percent in colder water samples. Figure 3.9 presents the monthly fecal coliform geometric means for the Rock River when storm samples have been removed from the dataset.

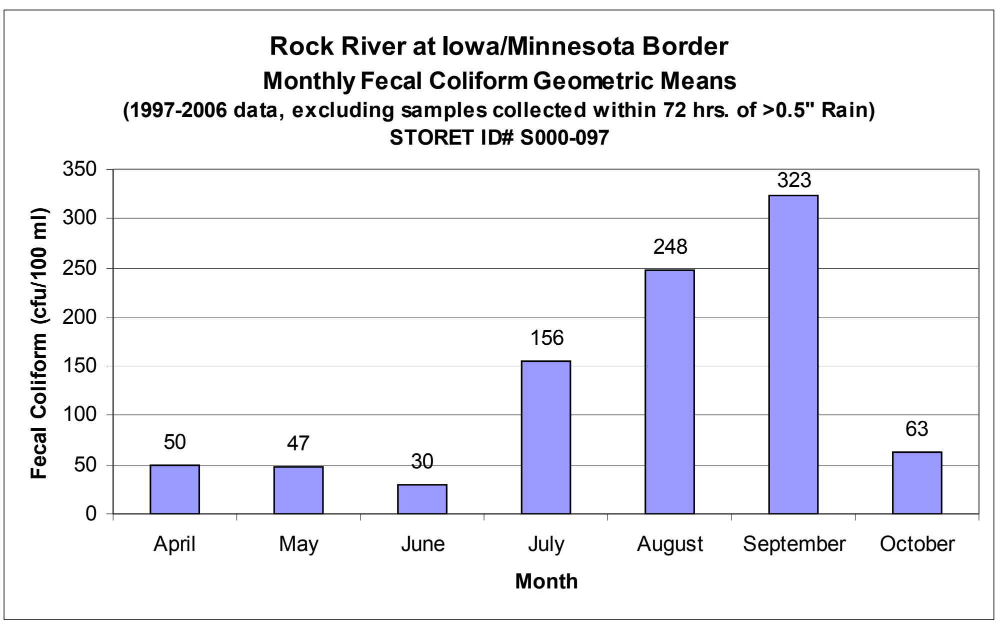
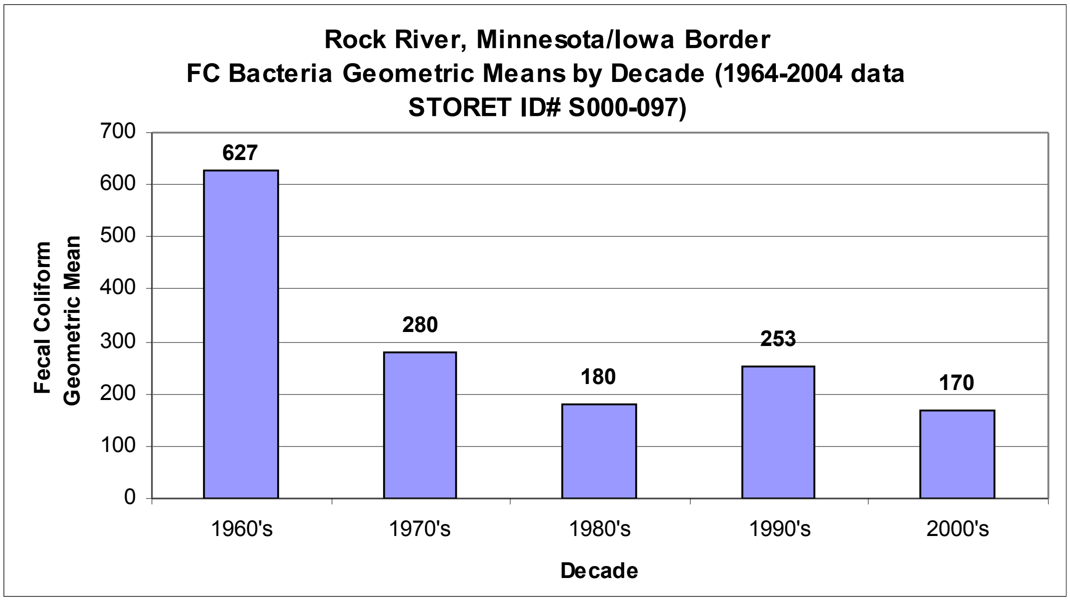


Figure 3.9 – Fecal Coliform GM by Month, Excluding Storm Samples

It should be noted the higher bacterial concentrations during the ~~warm~~ summer/fall months may also be associated with greater nutrient and algae concentrations at that time of year. Nutrients and algae may support bacterial growth and therefore temperature may be a secondary factor. Changes in livestock management, such as greater access of cattle to streams may be another factor in higher bacterial concentrations.

3.10 Trends in Fecal Coliform Surface Water Quality

Figure 3.10 presents the long-term fecal coliform geometric means by decade for the Rock River, based on 189 samples. The data indicate that a significant reduction in bacterial concentration occurred from the 1960's to the 1970's. Since the 1970's, there has been a very gradual decrease in bacterial concentrations.



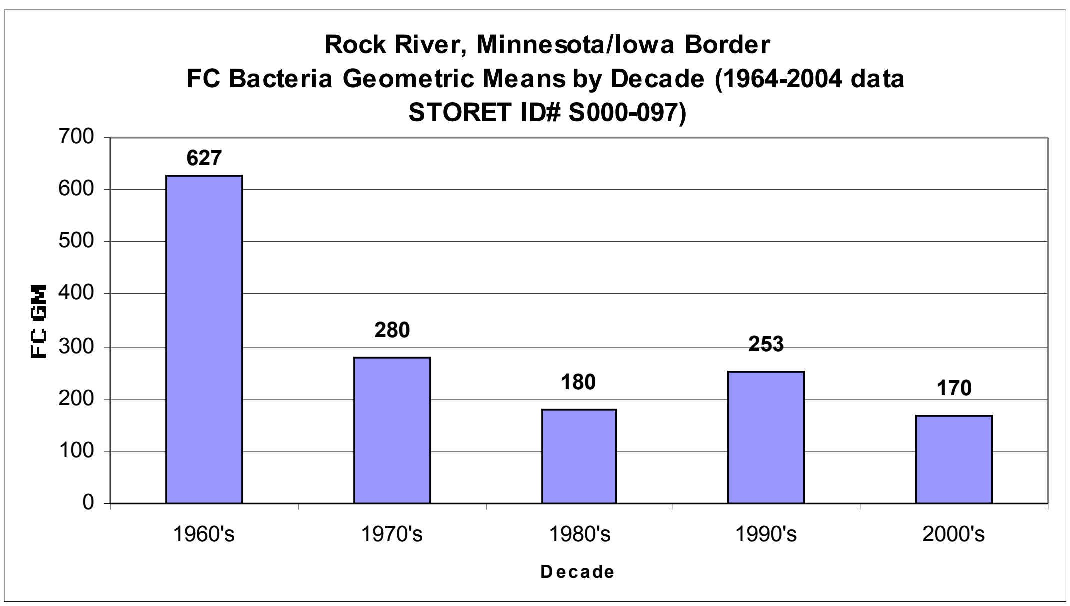


Figure 3.10 – Rock River at Minnesota/Iowa Border -Fecal Coliform GM by Decade

3.11 TMDL Endpoints

TMDL endpoints will meet the 200 cfu/100 ml “chronic” standard and 2000 “acute” standard for fecal coliform bacteria. Section 6.0 outlines the process used to determine monthly and daily TMDL allocations for each of the impaired streams. This process involved using long-term flow data from a USGS flow gaging station and incorporating the two numeric water quality standards for fecal coliform bacteria.

The first numerical standard is that streams will have a monthly geometric mean below 200 cfu/100 ml. This standard was incorporated to calculate the monthly loading capacity and allocations. The second numerical standard is that no more than ten percent of samples may exceed 2,000 cfu/100 ml and was used to calculate the daily loading capacity and allocations. Daily loading capacity and allocations were determined as one third the monthly loading capacity and allocations. This relates to the 2,000 numerical standard being a factor of ten times the 200 numerical standard. Neither the monthly or daily loading capacities (nor individual allocations) may be exceeded.

Section 4.0 – Potential Source Inventory for Fecal Coliform

4.1 Humans

Human waste can be a significant source of fecal coliform contamination during low flow periods. Contamination from individual sewage treatments systems that are not functioning properly can allow untreated or partially treated sewage into waterways. Emergency bypasses from wastewater treatment facilities are an occasional source of bacteria and pollutants. A high priority should be placed on preventing human waste from entering waterways, as human pathogens are often found to be highly communicable.

4.1.1 Human Populations

The 2000 census data indicate the impaired portion of RRW has an estimated population of 10,942. Approximately 66% of the population lives in urban areas, versus 34% rural. The watershed contains all or part of 12 cities and three unincorporated communities. Figure 4.1.1 provides population statistics, city locations, and rural density information for the RRW.

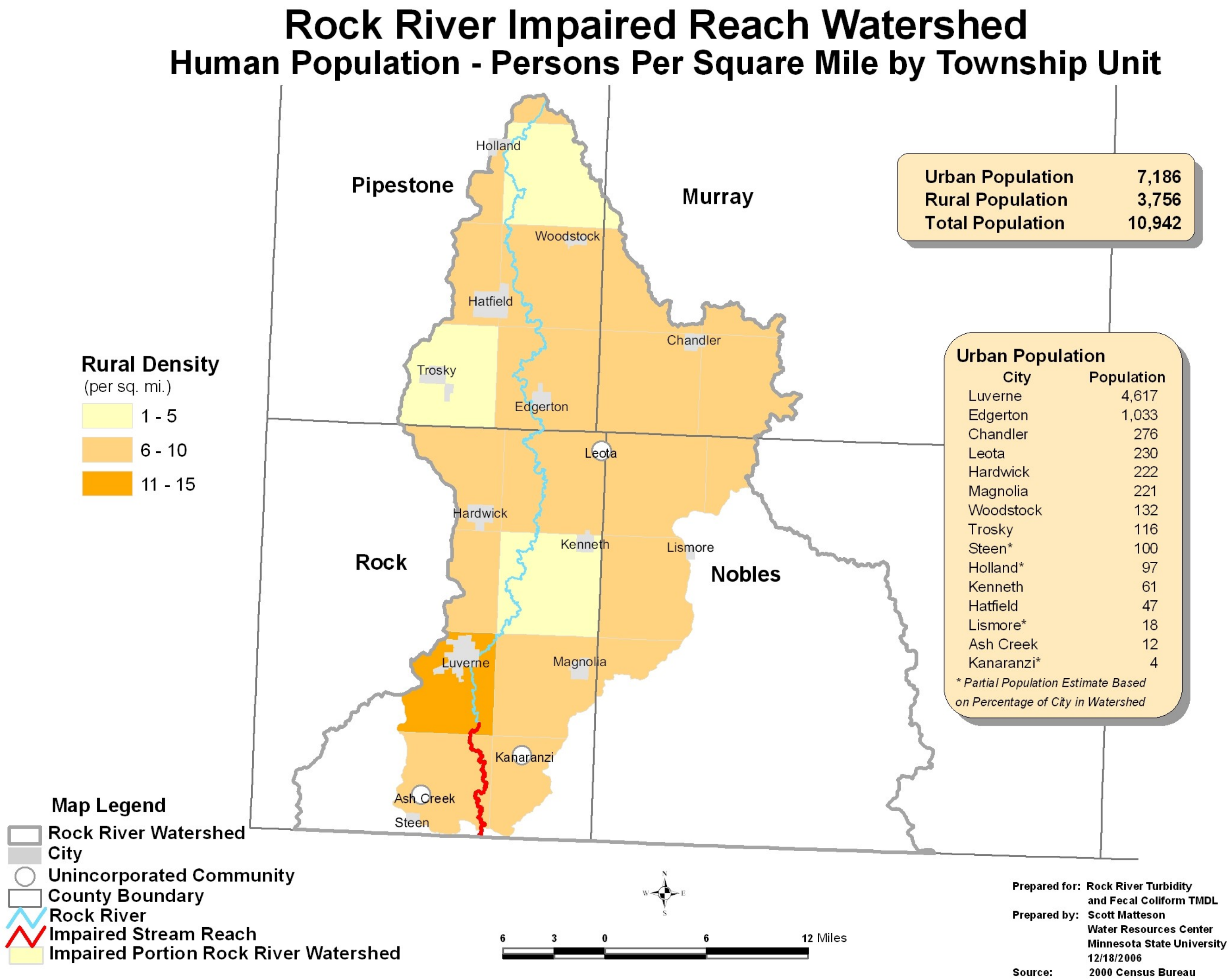


Figure 4.1.1 – Rock River Watershed Human Population – Persons Per Square Mile

4.1.2 Noncompliant Individual Sewage Treatment Systems (ISTS) and Unsewered Communities

Based on county inventories, an estimated 72 percent of Individual Sewage Treatment Systems (ISTS) in the Rock River impaired watershed are allowing inadequately treated wastewater into waterways. These systems are often connected directly into county tile drainage which outlet into the nearest ditch or stream. They systems are often called "straight pipe" systems. These systems are illegal, un-permitted systems pursuant to Minnesota Rules Chapter 7080. Under Minnesota statutes, a straight pipe discharge that has no soil treatment is an "imminent threat to public health or safety" (ITPHS) and when discovered, must be upgraded to acceptable standards within ten months.

In addition, the unincorporated communities of Ash Creek and Kanaranzi and the incorporated community of Trosky are currently unsewered. The representative counties are continually working with the individual residents to consider an ISTS. At least half of the homes in all three communities have an ISTS. Figure 4.1.2 present information on noncompliant systems and unsewered communities in the watershed.

Overall, there are an estimated 1,084 “straight pipe” systems in the watershed. These estimates are highly subjective however, as the method of inventorying varies from one county to the next. The estimates were obtained from county Environmental Services offices.

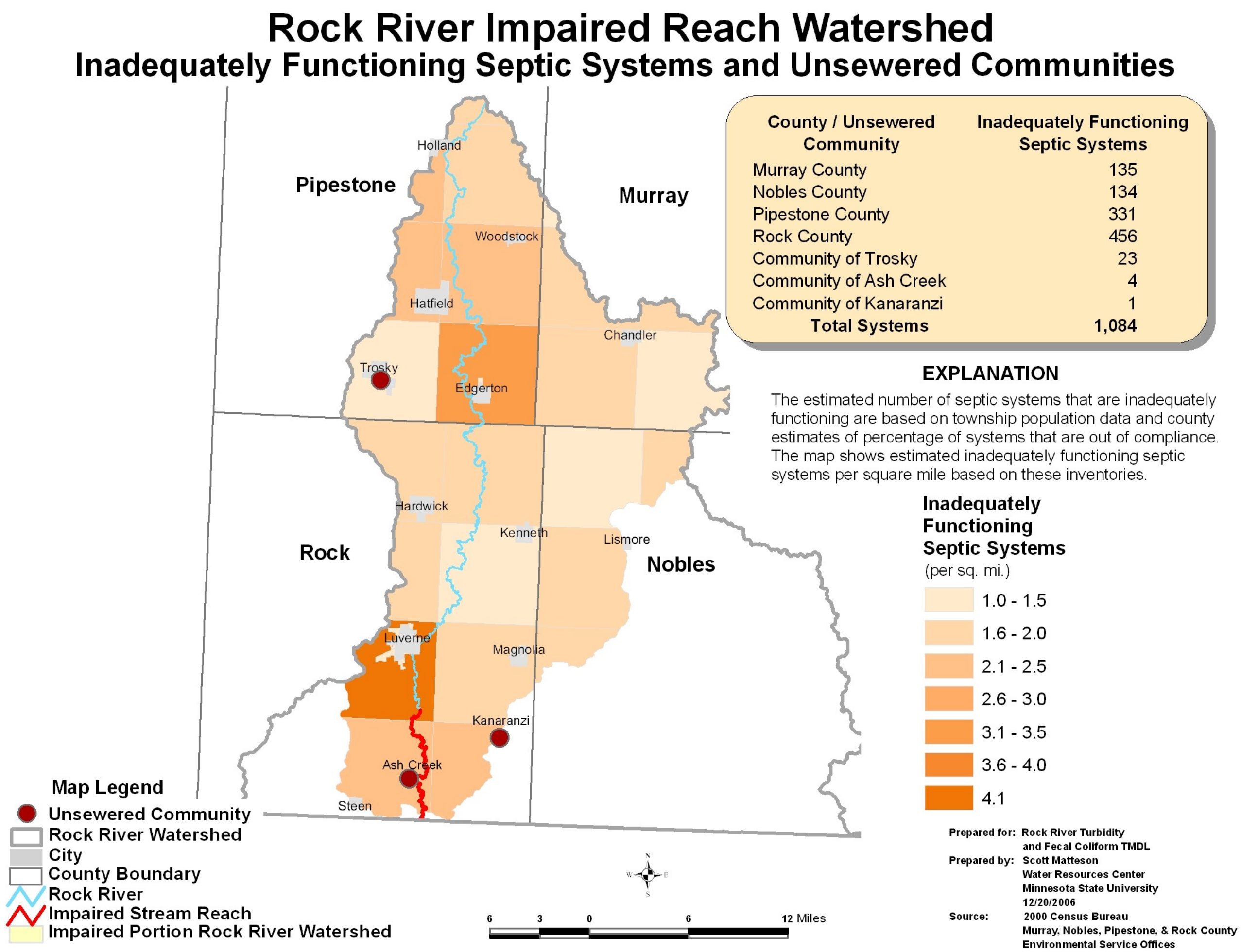


Figure 4.1.2 – Rock River Watershed – ITPHS Systems and Unsewered Communities

4.1.3 MS4 Communities – Stormwater

Pursuant to the TMDL allocation process, cities with populations greater than 5000 are to be provided a wasteload allocation for stormwater discharges. The communities are required to have Municipal Separate Storm Sewer System Permit (MS4) stormwater permits. However, there are no permitted MS4 communities in the Rock River Watershed at time. The City of Luverne is near the 5,000 threshold however, and if ever required to have a MS4 permit, a TMDL revision may be needed for the wasteload allocation.

4.1.4 Municipal Wastewater Treatment Facility Bypasses

Municipal bypasses are legal emergency discharges of partially or untreated human sewage from waste water treatment facilities. Municipal bypasses usually occur during periods of heavy precipitation, when treatment facilities become overloaded. Municipal bypasses typically last from a few hours to a few days. From 2002 through 2006, there was only one reported bypass in the watershed, by the City of Woodstock on March 31, 2006 after 3.5 inches of precipitation.

4.1.5 Municipal Wastewater Treatment Facility Violations

Municipal wastewater treatment facilities (WWTF) are required to test fecal coliform bacteria levels in effluent on a weekly basis. Facilities report a geometric mean fecal coliform level for each month, April through October. The geometric mean for all samples collected in a month must not exceed 200 cfu/100 ml fecal coliform bacteria. Exceedance of the 200 cfu/100 ml limit is considered a WWTF violation.

From 2002 through 2004, the City of Hatfield had 29 violations. Hatfield is in the process of planning a new treatment system for 2007. The only other communities with violations were Edgerton and Holland, each with two over the five-year period.

4.2 Livestock

Runoff from land with manure application, pastures and feedlots has the potential to be a significant source of fecal coliform bacteria and other pollutants. Based on population inventories and the assessment procedures outlined in Section 5.1, nearly 99% of the fecal matter produced (not what is delivered to waterways) in RRW is from livestock manure. Of the fecal matter produced by livestock, the majority is applied to cropland as fertilizer. An estimated 58 percent is incorporated manure and 13 percent is field surface applied manure. Approximately 26 percent of livestock manure (mostly beef), remains on pasture lands. An estimated 2 percent of livestock manure remains in feedlots or on stockpiles without runoff controls.

Based on county feedlot inventories, there are 684 feedlots in the watershed with 151,222 animal units. Swine is the ~~dominate~~ dominant livestock, followed by beef and dairy operations. Figure 4.2 displays the location of inventoried feedlots in the watershed and animal unit density by minor watershed. The majority of these facilities are confined operations with little runoff to surface water. However, there are a number of open feedlots, some of which have pollution problems and pose a risk of fecal contamination. In portions of the watershed, runoff from these feedlots may be a significant source of fecal coliform contamination during periods of heavy precipitation. According to county feedlot officers and MPCA reports, most feedlots store and manage manure adequately to avoid runoff problems.

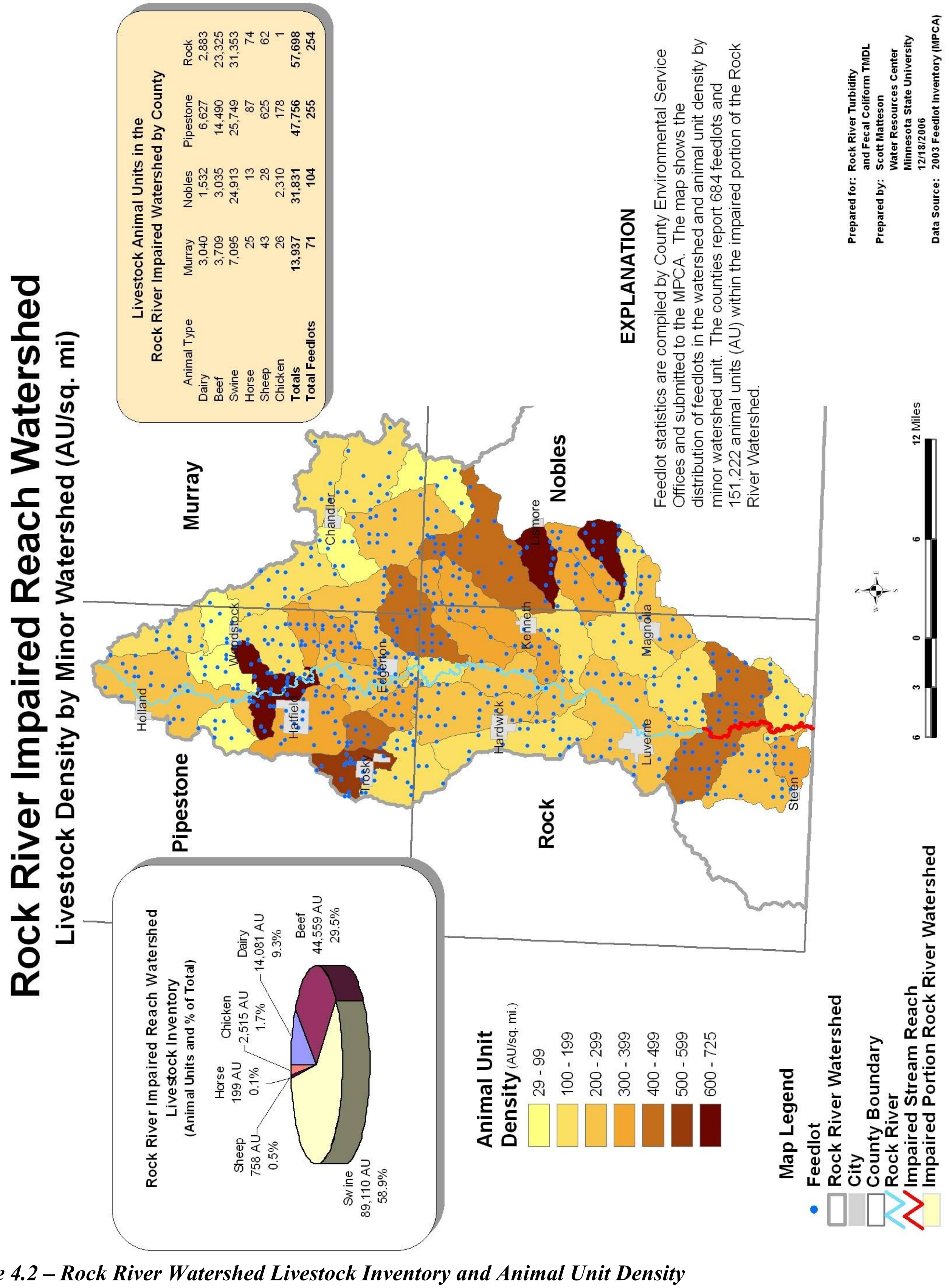


Figure 4.2 – Rock River Watershed Livestock Inventory and Animal Unit Density

Field applied livestock manure accounts ~~from~~ for an estimated 71 percent of the fecal material available in the watershed. As such, it has the potential of being a significant source of contamination to waterways. There are three potential pathways of fecal coliform transport from fields with applied manure to waterways; 1) overland runoff, 2) open tile intakes, and 3) macropores/preferential flow.

4.2.1 Overland Runoff and Open Tile Intakes

During storm events, runoff of fecal coliform bacteria from fields with applied manure can occur by direct surface runoff to waterways or indirectly through field tile open intakes. To help address manure runoff concerns, manure application rules were put into place in Minnesota state rule 7020 (Table 4.2.1). This rule requires a setback of 300 feet for surface applied manure from streams, ditches and open tile intakes. The setback of manure application for incorporated fields is 25 feet from streams and ditches and 0 feet from open intakes. The Minnesota statutes represent the minimum setbacks for manure. Counties may develop ordinances with setback rules that are more restrictive.

The effectiveness of current setbacks for applied manure related to bacterial contamination is largely unknown. Setback distances are primarily based on research involving nutrients (phosphorus), not bacterial transport. It is unclear whether current setbacks for surface applied and incorporated manure are appropriate for preventing bacterial transport to tile drainage systems. According to county and state feedlot officers, it is also difficult to monitor whether setback distances are being observed.

Table 4.2.1 - Manure Application Rules for Minnesota

Manure Application – Minimum setbacks near waters (counties can be more restrictive than state Rule 7020)

	Surface Application	Incorporation within 24 hrs.
Lake, stream	300'*	25'**
Wetlands (10+ ac.)	300'*	25'**
Ditches (w/o 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 buildup within 300'

4.2.2 Macropores/Preferential Flow

Transport of fecal coliform bacteria and associated pathogens may be enhanced by field tile systems. The retardation and retention of bacteria in soils is apparently less effective than previously believed, primarily due to preferential flow processes, which can aid in the rapid transport of bacteria from manure application (Smith et al, 1998; Geohring et al, 1999). Field studies in various locations across the United States have shown significant transport of fecal coliform bacteria to tile drainage through soil macropores. Beven and Germann (1982) outlined the main processes, which contribute to the formation of macropores in natural soils:

- Pores formed by soil fauna such as earthworms, insects, moles and gophers.
- Cracks and fissures formed during the shrinkage of clay soils and freeze/thaw cycles.
- Pores formed by plant roots.
- Natural soil pipes that form due to erosive action of subsurface flows.

In Minnesota, there has been limited research on macropores and bacterial transport. The most significant research in Minnesota related to assessing fecal coliform transport to tile drainage was two separate studies conducted by Gyles Randall at the University of Minnesota Southern Experiment Station in Waseca. The first study (Randall, 2000) conducted from 1995-1997 involved collection of tile water samples from a series of thirteen and a half by fifteen meter plots that had received moldboard incorporation of fall applied dairy manure. The following spring samples were collected within three days of precipitation events that caused significant drainage. The study found 100% of samples to test positive for fecal coliform bacteria, yet *E.* coli was only detected in five of the 30 samples over the three-year period. Fecal coliform concentrations were implied to be low and the authors speculated that significant winter die-off may have occurred.

The second study, (Randall, 2003) involved spring tile monitoring of fall applied (2002/2003) injected swine manure. The study involved comparing field plots with applied manure vs. urea treatments. The authors found the number of fecal coliform bacteria to be similar in both urea-treated and manure treated plots. They suggested organisms did not survive over winter in the added manure and that levels seen during the six-week drainage sampling period were probably background concentrations.

Studies from other parts of the country have shown that the transport of fecal bacteria under conditions of ideal matrix flow is inversely related to particle size. Soil consisting of primarily silt and clay particles are very effective in physically filtering bacterial cells under conditions of matrix flow. However, column and field experiments have indicated that macropore flow is the dominant transport pathway for fecal bacteria. Therefore, soils more susceptible to shrinking or cracking, such as clays, could be less effective than sandy soils in terms of limiting bacterial transport (Jamieson, 2002).

Management strategies to reduce bacterial transport include tillage methods that disrupt preferential flow pathways. Methods of preventing preferential flow may be at odds with other strategies intended to mitigate other environmental impacts. For example, tillage methods that disrupt preferential flow may cause increased soil erosion and nutrient losses when compared to no till and conservation tillage.

4.2.3 Pastureland

Approximately 26 percent of livestock manure in the watershed is potentially deposited to pastureland. Based on review of county livestock inventories, an estimated 60 percent of beef and 25 percent of dairy operations utilize pastureland. Based on GIS analysis, 78 percent of pastureland in the watershed is within 1000 feet of a waterway. Unfenced pastureland, where cattle have direct access to waterways, poses the greatest risk of fecal coliform contamination.

4.3 Pets

The American Veterinary Medical Association estimates there are 0.66 cats and 0.58 dogs per household in the United States. Based on an average household of 2.52 people, this equates to 2,781 cats and 2,444 dogs in the watershed. High densities of pets in isolated areas can lead to bacterial contamination of waterways; however, pets are normally a minor contributor of fecal coliform bacteria contamination at a watershed scale.

4.4 **Wildlife and Natural Background**

Deer, pheasant, Canada goose and wild turkey density estimates were obtained from the Minnesota Department of Natural Resources – Wildlife Section.

Deer density is estimated annually by the DNR for each hunting permit area. The average deer density in the RRW is 4 deer per square mile or 2,223 deer.

Pheasant population estimates were provided for each county in the watershed, based on estimates made in August of each year. There is an average of 50 pheasants per mile. This equates to an estimated 27,783 pheasants in the RRW. The DNR report that April populations are about one-fourth August estimates.

Canada goose populations are estimated by DNR classified Ecoregion. Estimates are based on 2001-2004 data for the Prairie Ecoregion, where the RRW is located. ~~Combine with previous paragraph.~~ The DNR estimates a density of four and a half geese per square mile or 2,476 geese in RRW. The DNR estimate is for the resident geese population, not including migrating geese in the fall. Migrating geese in the fall season can concentrate in lakes and wetlands, contributing large quantities of fecal waste. Geese are one of the largest wildlife sources of fecal contamination, simply because they are found directly on waterways.

The DNR bases wild turkey population estimates on harvest. Similar to deer densities, turkey estimates are based on permitted hunting areas. The mean wild turkey density in the RRW is 1.09 per square mile. However, like other wildlife, they are not equally distributed, instead clumping towards forested areas. The RRW has an estimated wild turkey population of 666.

Population estimates and monitoring data suggest that wildlife normally are not a significant contributor of fecal coliform bacteria contamination in the watershed. Conditions when wildlife can be a significant source include isolated areas of high density and during low flow/drought conditions.

Section 5.0 – Estimates of Primary Sources of Fecal Coliform Contamination in the Rock River Watershed

This section details the process that was used to estimate the primary sources of fecal coliform contamination in the Rock River impaired watershed. This procedure is for implementation planning purposes and has no bearing on the TMDL allocations or regulatory implications.

5.1 Population Inventories

The first step in estimating the likely major sources of fecal coliform bacteria in the Rock River impaired reach watershed was to assemble population inventories for each potential source. Table 5.1 summarizes the population information that is described in greater detail in Section 4.0. The table below provides population statistics for humans, livestock and wildlife.

Table 5.1 – Rock River Watershed Human and Animal Populations

Humans (2000 Census data)	
Urban Population	7,186
Rural Population	3,756
Total Population	10,942

Pets (American Vet. Association)	
Cats	2,781
Dogs	2,444

Livestock (2003 feedlot inventory)	
Dairy	14,081 Animal Units (AU)
Beef	44,559 AU
Swine	89,110 AU
Chicken	2,515 AU
Horse	199 AU
Sheep	758 AU

Wildlife (DNR-Wildlife Division)	
Canada Geese	2,476
Wild Turkeys	666
Pheasants	27,783
Deer	2,223

5.2 Estimated Fecal Coliform Bacteria Available for Potential Runoff

Table 5.2 displays the FC producers, amount of FC per producer and the source of the information. Figure 5.2a presents the percent of total FC produced per day by each animal type. Figure 5.2b shows the same information when animal types are categorized by source group (human, pets, wildlife and livestock). The amount of fecal coliform (FC) produced daily by each animal type was obtained from a variety of sources, which are all recommended in the Environmental Protection Agency's (EPA) guidance document

Protocol for Developing Pathogen TMDLs. Total FC produced by each animal type is calculated by multiplying the population figure by the daily FC produced per individual or animal unit. Note that the below table and graphs represent the total FC available, not the amount delivered to surface waters.

Table 5.2 – Population and Total Estimated Fecal Coliform Produced by Animal Type

Animal Type	Animal Units	Individuals	FC Produced per Individual or AU Per Day	Total FC Available	Source (Daily FC Production)
Dairy	14,081		7.20E+10	1.01E+15	ASAE**, 1998
Beef	44,559		1.30E+11	5.79E+15	ASAE, 1998
Swine	89,110		8.00E+10	7.13E+15	ASAE, 1998
Chicken	2,515		3.40E+10	8.55E+13	ASAE, 1998
Turkey	0		6.20E+09	0.00E+00	ASAE, 1998
Horse	199		4.20E+08	8.36E+10	ASAE, 1998
Sheep	758		2.00E+11	1.52E+14	ASAE, 1998
Humans		10,727	2.00E+09	2.15E+13	Metcalf and Eddy, 1991
Cats		2,781	5.00E+09	1.39E+13	Horsley and Witten, 1996
Dogs		2,444	5.00E+09	1.22E+13	Horsley and Witten, 1996
Deer		2,223	5.00E+08	1.11E+12	Interpolated from Metcalf and Eddy, 1991
Canada Geese		2,476	1.04E+07	2.58E+10	Alderisio and DeLuca, 1999
Wild Turkey		666	9.50E+07	6.33E+10	turkey value used
Pheasants		27,783	5.20E+06	1.44E+11	1/2 geese value used
Other Wildlife*				1.11E+12	

* Unknown, estimated to be roughly the equivalent of the fecal coliform produced by the deer population.

** American Society of Agricultural Engineers

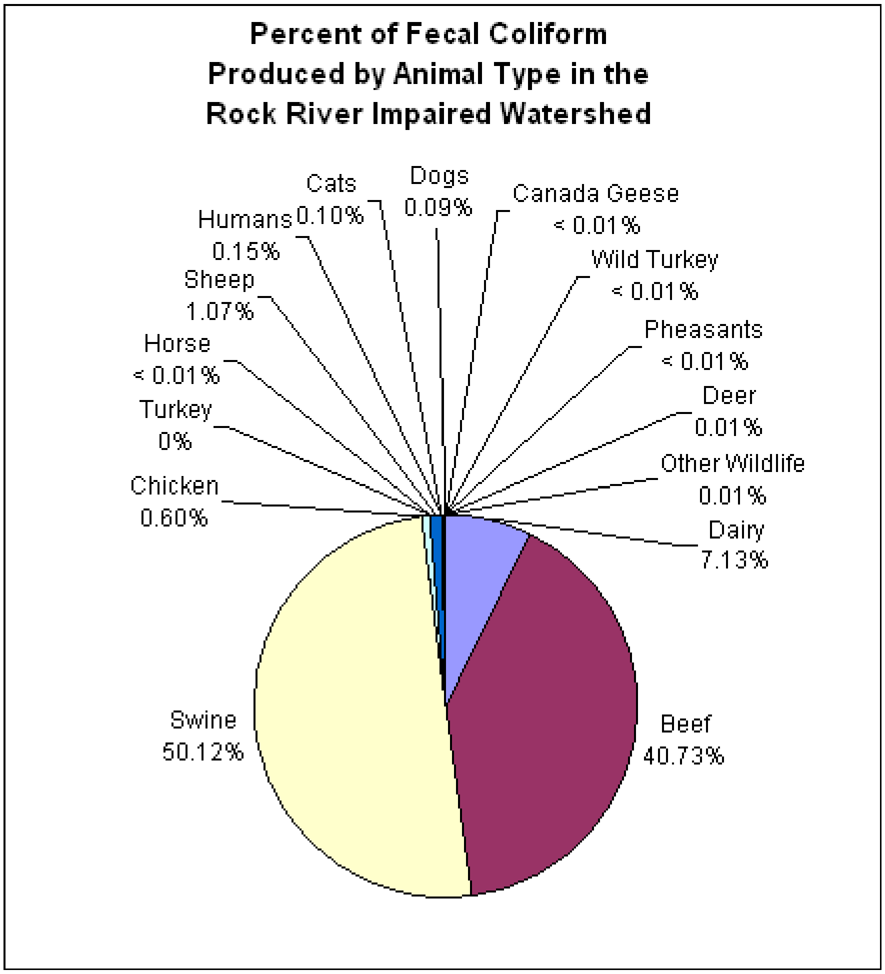


Figure 5.2a – Estimated Fecal Coliform Bacteria Produced by Humans and Animals

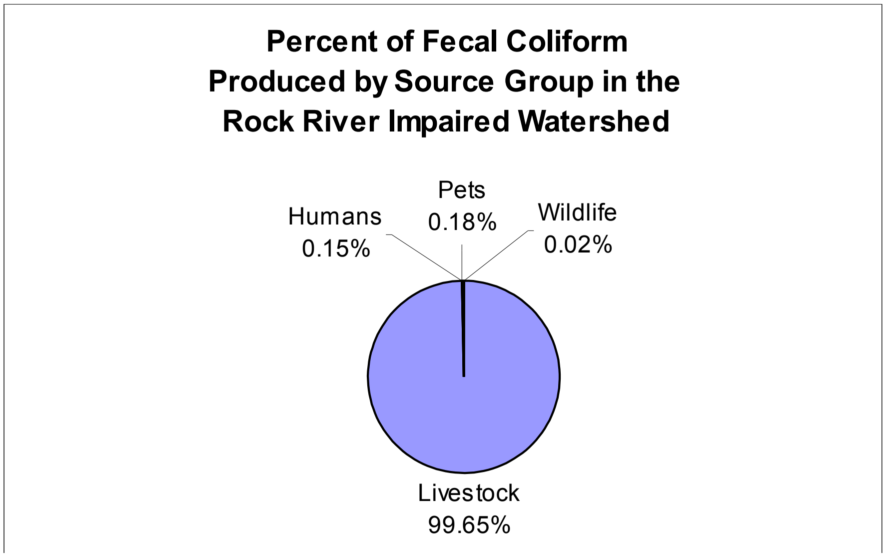


Figure 5.2b – Estimated Fecal Coliform Produced by Source Category

5.3 Potential Fecal Coliform Sources by Application Type / Method

Next, the total fecal coliform produced by each animal type is categorized by application type/method. For humans, this meant calculating the number of people that had adequately treated and inadequately treated wastewater for both rural and urban populations. For livestock, assumptions were derived from the Generic Environmental Impact Statement (GEIS) on Animal Agriculture, prepared by the Minnesota Environmental Quality Board. This document provides general guidelines on how and where livestock manure is applied to farmland in Minnesota. Slight modifications were made for swine assumptions; changing incorporated swine manure from 80 percent to 95 percent and surface applied swine manure from 20 percent to 5 percent. These modifications reflect a continual shift from surface applied to incorporated swine manure based on county feedlot officials. Table 5.3 provides the assumptions used and resulting categories.

Table 5.3 - Assumptions Used to Calculate the FC Produced by Different Sources

Category	Source	Assumptions*	Animal Units or Individuals
Livestock	Pastures within 1000 ft. of a Waterway (78 percent)	19.5% Dairy Manure 48.6% Beef Manure 1% Horse, Sheep, etc. Manure	2,746 Dairy AU 20,854 Beef AU 10 Horse, Sheep, etc. AU
	Pasture greater than 1000 ft from a Waterway (22 percent)	5.5% Dairy Manure 13.2% Beef Manure	774 Dairy AU 5,882 Beef AU
	Feedlots or Manure Stockpiles without Runoff Controls	1% Dairy Manure 5% Beef Manure 1% Chicken Manure	141 Dairy AU 2,228 Beef AU 25 Chicken AU
	Surface Applied Manure	37% Dairy Manure 17.5% Beef Manure 5% Swine Manure 49.5% Horse, Sheep, etc. Manure 49.5% Chicken Manure	5,210 Dairy AU 7,798 Beef AU 4,456 Swine AU 474 Horse, Sheep, etc. AU 1,245 Chicken AU
	Incorporated Manure	37% Dairy Manure 17.5% Beef Manure 95% Swine Manure 49.5% Horse, Sheep, etc. Manure 49.5% Chicken Manure	5,210 Dairy AU 7,798 Beef AU 84,655 Swine AU 474 Horse, Sheep, etc. AU 1,245 Chicken AU
Human	Inadequately Treated Wastewater	26.20% of Human	2,810 Humans
	Adequately Treated Rural Wastewater Municipal Wastewater Treatment Facilities	9.49% of Humans 64.31% of Humans	1,018 Humans 6,899 Humans
Pets	Cats Dogs	100% of Cats 100% of Dogs	2,781 Cats 2,444 Dogs
Wildlife	Canada Geese (resident population) Deer Wild Turkey Pheasants Other Wildlife	100% of Canada Geese 100% of Deer 100% of Wild Turkey 100% of Pheasant Unknown (est. as deer pop.)	2,476 Canada Geese 2,223 Deer 666 Wild Turkey 27,783 Pheasant Unknown (est. as deer pop.)

* Assumptions used for livestock were derived from information contained in the *Generic Environmental Impact Statement on Animal Agriculture* prepared by the Minnesota Environmental Quality Board and GIS analysis.

Figure 5.3 displays the source/application type for fecal coliform in the RRW. The data indicate most fecal material is applied to agricultural land. Again, note that the figure represents the estimated fecal coliform bacteria produced by source and application type, not the fecal coliform that is actually delivered to surface water.

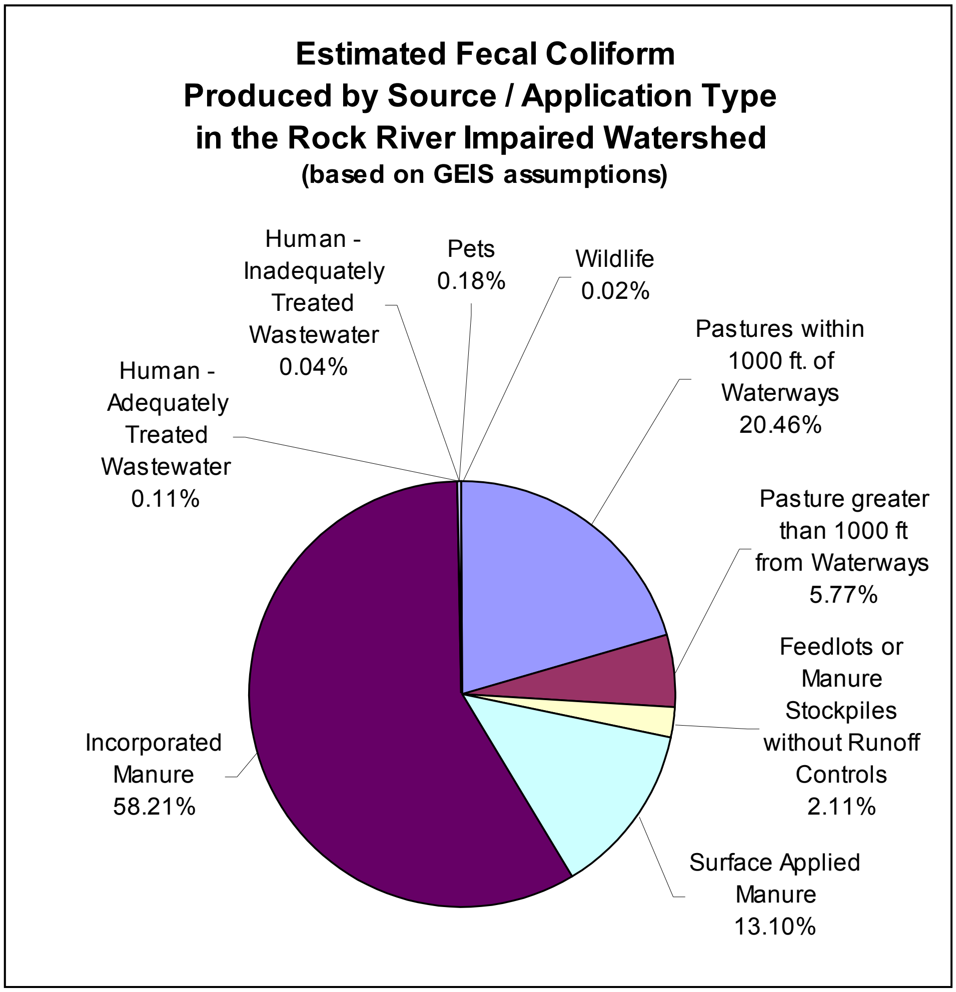


Figure 5.3 – Estimated Fecal Coliform Produced by Source/Application Type

5.4 Delivery Assumptions

To estimate the primary sources of fecal coliform bacteria contamination in the Rock River impaired watershed, the delivery ratios from Table 5.4 were used. The ratios were obtained from Appendix C of the Regional TMDL Evaluation of Fecal Coliform Bacteria Impairments in the Lower Mississippi River Basin in Minnesota, 2002 (revised 2006). The delivery ratios are based on expert opinions and should be considered in relative rather then absolute terms. Thus, while one percent of surface applied manure was assumed to be delivered to waterways during wet conditions, only 0.1 percent of incorporated manure was considered delivered. Straight pipe septic systems were given the highest delivery ratio, at 8 percent.

Table 5.4 – Delivery Assumptions

Category	Source	Wet Conditions	Dry Conditions
Livestock	Pastures within 1000 ft. of Waterways	1.0%	0.1%
	Pasture greater than 1000 ft from Waterways	0.1%	0.0%
	Feedlots or Manure Stockpiles without Runoff Controls	4.0%	0.0%
	Surface Applied Manure	1.0%	0.0%
	Incorporated Manure	0.1%	0.0%
Human	Inadequately Treated Wastewater	8.0%	8.0%
Pets	Cats/Dogs	0.1%	0.0%
Wildlife	Canada Geese (resident population)	4.0%	4.0%
	Other Wildlife	1.0%	1.0%

5.5 **Target Areas for Fecal Coliform Bacteria**

Delivery ratios used in Section 5.4 come with a degree of uncertainty. The amount of fecal material delivered from any one source will vary depending on numerous factors. Because of this uncertainty, it is difficult to accurately determine the percentage contribution of bacterial contamination from each source. Instead, categories were used to list the sources of bacterial contamination in the impaired stream reaches. Table 5.5 presents the likely major sources of bacterial loading RRW during wet and dry conditions. Wet conditions are defined as those during and following precipitation events that cause overland flow. Dry conditions are when overland flow is not occurring. A greater percentage of days would be considered dry; however, the majority of bacterial loading to streams occurs during wet conditions. Categories were defined as less than five percent being a low contributor, five to twenty percent a moderate contributor and greater than twenty percent a high contributor.

Table 5.5 – Target Areas for Fecal Coliform Reduction in Rock River Watershed

Category	Source	Wet Conditions	Dry Conditions
Livestock	Pastures within 1000 ft. of Waterways	High Contributor	High Contributor
	Pasture greater than 1000 ft from Waterways	Low Contributor	Low Contributor
	Feedlots or Manure Stockpiles without Runoff Controls	Moderate Contributor	Low Contributor
	Surface Applied Manure	High Contributor	Low Contributor
	Incorporated Manure	Moderate Contributor	Low Contributor
Human	Inadequately Treated Wastewater	Low Contributor	Moderate Contributor
Pets		Low Contributor	Low Contributor
Wildlife		Low Contributor	Low Contributor

Section 6.0 – Fecal Coliform TMDL Development

for the Rock River Watershed

6.1 Description of Impaired Watershed - Rock River; Elk Creek to Minnesota/Iowa Border

This 11.8 mile reach of Rock River extends from the Minnesota/Iowa border upstream to the confluence with Elk Creek and encompasses 355,625 acres. The stream reach was placed on the impaired waters list in 1994. As mentioned previously, this stream segment was listed based on monitoring conducted as part of the MPCA Milestone Monitoring Program. Figure 2.1b displays the impaired stream reach and its watershed.

Data used for assessing the Rock River was collected from 1985 through 1994. The data showed that fecal coliform concentrations exceeded the water quality standard in May (302 cfu/100ml) and September (830 cfu/100ml). These were the only two months with adequate sample collection for impaired waters listing purposes (geometric mean based on a minimum of five monthly samples over previous ten years).

The impaired stream reach receives wastewater treatment facility discharge from nine communities. Holland and Luverne are continuous discharge facilities. The communities of Chandler, Edgerton, Hardwick, Leota, Magnolia and Woodstock utilize treatment ponds that can discharge from April 1 to June 15 and September 15 to December 15. The community of Kenneth utilizes a community drainfield that is non-discharging. Lismore and Steen, two communities located partially in the watershed, discharge effluent outside the watershed boundary. The community of Hatfield is currently constructing a new treatment system, which should be complete by December 2007. This system will be a non-discharging system. There are three unsewered communities that lie at least partially in the watershed, Ash Creek (unicorporated), Kanaranzi (unincorporated) and Trosky (incorporated). Approximately 3,756 individuals live in rural areas.

Based on county estimates, 75 percent of the rural wastewater septic systems are inadequately functioning. This equates to approximately 1,084 illegally discharging systems in the watershed.

The impaired watershed has approximately 684 feedlots with 151,222 animal units based on 2003 feedlot inventory data. The watershed also includes 24 livestock facilities that have been issued NPDES permits (Table 6.1). Dairy, beef and swine represent 98 percent of the animal units in the watershed.

Table 6.1 – Feedlots with NPDES Permits in the Rock River Watershed

Registration Number	Feedlot Name	County	Animal Number and Type	Animal Units
105-100160	Gary Rodrigue - Hoffman Site	Nobles	3,000 Swine - 55 lbs. or More	900
105-107749	Kyle Van Dyke Section 3	Nobles	950 Mature Dairy Cows	950
105-50001	Donald DeKam Farm - Sec 2	Nobles	4,000 Swine - 55 lbs. or More	1,225
105-50004	GPFF Inc - Whitetail Run	Nobles	3,282 Swine - 55 lbs. or More	1,313
105-50008	Verlyn DeKam Farm	Nobles	8,510 Swine - 55 lbs. or More	2,553
105-92736	Mark Knips Farm Sec 29	Nobles	3,440 Swine - 55 lbs. or More	1,142
105-92829	Rick Bullerman Farm - Sec 25	Nobles	3,200 Swine - 55 lbs. or More	960
105-92976	John & Joe Wieneke Farm - Sec 27	Nobles	1,250 Other Cattle	1,883
105-93047	Mark Knips Farm Sec 31	Nobles	1,491 Other Cattle	1,499
117-109160	Pig City	Pipestone	4,800 Swine - 55 lbs. or More	1,440
117-50001	Spronk Brothers III - Hollyhock	Pipestone	4,800 Swine - 55 lbs. or More	1,440
117-50005	Jeff & Debra Brockberg Farm	Pipestone	6,020 Swine - 55 lbs. or More	1,806
117-50013	New Horizon Farms - Hillview East	Pipestone	3,975 Swine - 55 lbs. or More	1,193
117-60142	East River Farms	Pipestone	6,000 Swine - 55 lbs. or More	1,920
117-85163	Todd Van Essen Farm	Pipestone	1,000 Other Cattle	820
117-85455	Leon Kracht Farm	Pipestone	3,300 Swine - 55 lbs. or More	990
117-85586	Ken Winsel Farm Sec 22	Pipestone	3,900 Swine - 55 lbs. or More	1,170
117-85608	Charla Hunter Farm - Sec 14	Pipestone	3,200 Swine - 55 lbs. or More	960
133-105980	G&A Farms Inc	Rock	3,300 Swine - 55 lbs. or More	990
133-109460	Overgaard Pork - Site 2	Rock	3,000 Swine - 55 lbs. or More	900
133-84234	Knutson Feedlots	Rock	3,500 Other Cattle	3,500
133-84246	Kracht Hill Farm	Rock	3,200 Swine - 55 lbs. or More	960
133-84257	Binford Farms Sec 4	Rock	2,100 Other Cattle	2,125
133-84820	Craig Stegenga Farm	Rock	4,800 Swine - 55 lbs. or More	1,580

6.2 Components of a TMDL

A Total Maximum Daily Load consists of four components: Wasteload Allocation (WLA), Load Allocation (LA), Margin of Safety (MOS) and Reserve Capacity (RC). For fecal coliform TMDLs:

- Wasteload Allocation (Point Sources)
    - Permitted Wastewater Treatment Facilities
    - Livestock Facilities requiring NPDES permits
    - "Straight Pipe" septic systems
    - MS4 Stormwater Communities
- Load Allocation (Non-Point Sources)
    - Manure runoff from farm fields and pastures (NPDES and non-NPDES)
    - Non NPDES Permitted Feedlots
        - Runoff from non-MS4 Communities
    - Wildlife
- Margin of Safety
    - (Accounts for uncertainty that allocations will results in attainment of water quality standards)
- Reserve Capacity
    - Allocation for Future Growth

TMDLs can be developed using any approach approved by the EPA. In Minnesota, the MPCA recommends the use of the "Duration Curve" approach for developing TMDLs. Sections 6.3 through 6.7 describe the steps used in development of the TMDL.

6.3 Compilation of Flow Data

The duration curve approach uses flow monitoring data from the Rock River United States Geological Survey (USGS)/ Minnesota Department of Natural Resources (DNR) gaging site, located near Luverne, Minnesota (10 miles from the Minnesota/Iowa border). This gaging station has the USGS ID# 0648300. The site was selected, as it is the only site with significant flow data over the prior ten-year period. The drainage area for the site represents 75 percent of the impaired watershed drainage area.

The site was originally established in 1911 and daily data is available for a few years. In 1972, the site was established as a flood-warning gage by the USGS. Therefore, only two flow measurements were made per year to assure the upper flow values were being estimated properly. From 1995 through 1997, the USGS conducted more frequent flow measurements and were able to develop adequate rating curves for the estimation of daily flow values. In the fall of 1997, the USGS discontinued the gaging station. In the summer of 1998, the DNR began rigorous flow monitoring of the site, which continues as of 2007. For purposes of this TMDL, mean flow values were obtained for April through October, using available data from 1995 through 2006. The April through October period was selected as this corresponds with the fecal coliform standard. Table 6.3 presents the monthly mean flow values for months with adequate flow data.

Table 6.3 - Rock River at Luverne USGS/DNR# 06483000, Monthly Mean Flows, cfs (95-06)

	Monthly Mean Flow						
Year	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**
1995							444
1996	156	268	468	107	90	135	133
1997	1,186	353	246	264	69	37	
1998				112	63	39	201
1999	672	418	340	326	62	55	32
2000	109	231	323	129	45	17	29
2001	1,547	488	408	252	84	50	41
2002	159	121	84	24	85	28	91
2003	196	199	145	122	39	76	37
2004	121	182	547	210	87	125	25
2005	213	187	425	153	79	353	285
2006	951	449	300	90	110	92	88

6.4 Development of Flow Duration Curve

The resulting 74 monthly flow values were then sorted by flow volume, from highest to lowest to develop a flow duration curve. Figure 6.4 displays the flow duration curve for the Rock River gaging station (#06483000). The chart depicts the percentage of time any particular flow is exceeded. For example, a flow of 468 cfs was exceeded by 10 percent of monthly flow values, thus flows at or above 468 represent "high flow" conditions. A value of 37 cfs was exceeded by 90 percent of monthly flow values, so flows below 37 cfs represent "low flow" conditions.

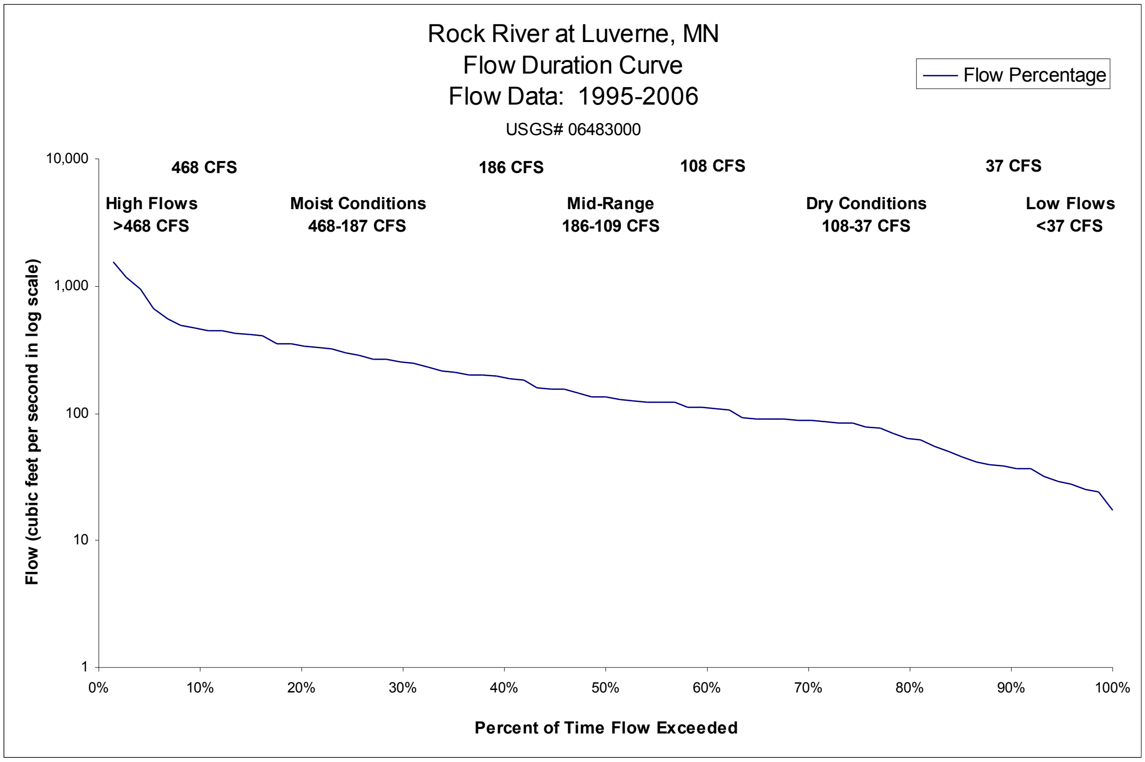


Figure 6.4 - Rock River Flow Duration* Curve *(1995-2006 monthly mean flows)

6.5 Determine Loading Capacity (Maximum amount of Fecal Coliform)

Flow regimes were determined for high, moist, mid-range, dry, and low flow conditions. The mid-range flow value for each flow regime was then used to calculate the total monthly loading capacity (TMLC). Thus, for the "high flow" regime, the loading capacity is based on the monthly flow value at the 5th percentile. Table 6.5 presents the flow regimes that were determined for the Rock River gaging station (#06483000), along with the flow value used to calculate the TMLC.

Table 6.5 - Flow Categories for Rock River (cubic feet per second)

Flow Condition	Percent of Time Flow Exceeded	Flow Range	Flow Used to Calculate Total Monthly Loading Capacity
High	0-10%	>468	672
Moist	10-40%	187-467	285
Mid	40-60%	109-186	133
Dry	60-90%	37-109	79
Low	90-100%	<37	29

The flow used to determine loading capacity for each flow regime was multiplied by a conversion factor of 146,776,126,400. This conversion factor is defined by the following equation:

Load Capacity (org/month) =
Concentration (org/100mL) *X* Flow (cfs) *X* (200 cfu~~org~~/100ml)

Multiply by 3,785.2 to convert mL per gallon to ~~org~~cfu/100 gallons
Divide by 100 to convert to ~~org~~cfu/gallon
Multiply by 7.48 to convert gallon per ft^3 to org/ft^3
Multiply by 86,400 to convert seconds per day to $ft^{3/}$day
Multiply by 30 to convert day per month to $ft^{3/}$month
Multiply by the water quality standard of 200 cfu~~org~~/100 ml

Load Capacity (~~org~~cfu/month) = 733,880,632 *X* Flow

6.6 Determination of Margin of Safety

Next, a margin of safety (MOS) was determined for each flow regime. The purpose of the MOS is to account for uncertainty that the allocations will result in attainment of water quality standards. Because the allocations are a direct function of monthly flow, accounting for potential flow variability is the appropriate way to address the MOS. This is done within each of five flow zones. The MOS was determined as the difference between the median flow and minimum flow in each zone. For example, the MOS for the high flow zone is the 100th percentile flow value subtracted from the 95th percentile flow value. The resulting value was converted to a load and used as the MOS. The values that were used to calculate the TMLC and MOS are presented in Figure 6.6.

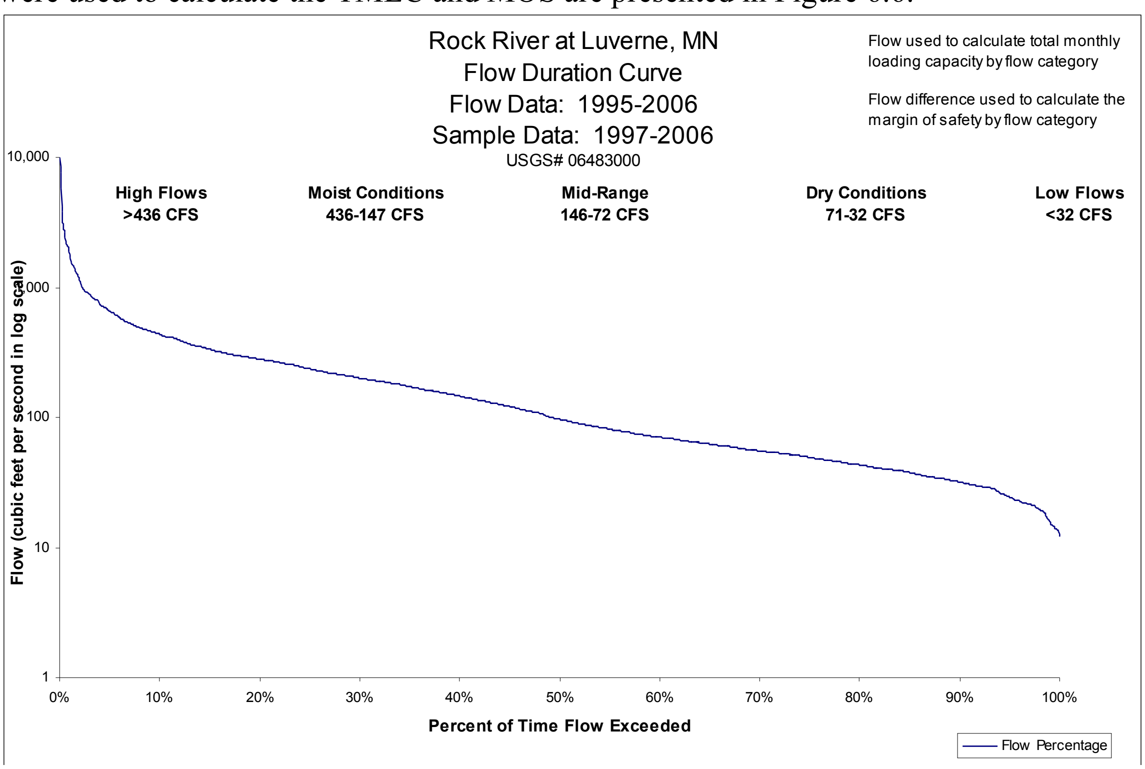


Figure 6.6 - Rock River Flow Duration Curve with TMLC and MOS

Table 6.6 presents the TMLC, MOS and TMDL allocations for the Rock River near Luverne. The TMLC minus the MOS results in the available wasteload and load allocations. The values expressed are in total organisms per month. For each of the five flow regimes, the monthly flow volume was multiplied by the water quality standard of 200 cfu/100 mL. This produces loading capacities in the trillions of organisms per month (T-org/month).

Table 6.6 - TMDL and MOS for Rock River, Luverne, MN

Flow Zone	TMLC*	MOS*	Allocation*
High	98.6	29.9	68.8
Moist	41.8	14.4	27.5
Mid	19.5	3.3	16.2
Dry	11.6	6.2	5.4
Low	4.3	1.8	2.5

* Values expressed as trillion organisms per month

At this point in the process, we have determined a TMLC and MOS for the five different flow regimes. However, this computation is for the USGS site at Luverne, which represents only 75 percent of the drainage area of the impaired reach. To determine the loading capacity of the impaired reach a conversion factor of 1.33 was applied to the TMLC, TMDL and MOS from Table 6.6. This conversion factor is used to calculate the expected flow values at the impaired stream reach based on the additional drainage area.

The next step was to split the TMDL into a wasteload allocation and load allocation.

6.7 Split the TMDL into a Wasteload Allocation and Load Allocation

WASTELOAD ALLOCATION

Luverne and Holland – Direct Discharge Facilities

Wastewater treatment facility (WWTF) allocations were calculated by multiplying wet-weather design flows for all facilities in an impaired reach watershed by the permitted discharge limit (200 cfu per 100 ml) that applies to all WWTFs. As long as WWTFs discharge at or below this permit limit, they will not cause violations of the fecal coliform water quality standard regardless of their fecal coliform load.

Hardwick, Edgerton, Chandler, Woodstock, Magnolia and Leota – Pond Systems

There are six NPDES-permitted WWTF's that are stabilization pond systems. Unlike the larger (and some smaller) mechanical treatment systems which have continuous discharges, pond systems typically discharge over a 1-2 week period in the spring and fall. Because the discharge volumes from these pond systems are small, and to provide an extra margin of safety in the event they need to discharge outside of the spring or fall window, the WWTF wasteload allocation assumed that these facilities could discharge for an entire month under any flow condition.

Hatfield
This community was first issued an NPDES permit in 1977. More recently, this facility's permit expired in 2004. At the time, city officials were working towards designing and incorporating a new system. Hatfield acquired USDA funds to assist with the project. The new system is in its final construction stages, with an expected completion date of October 30th, 2007. Once the facility is operational, the NPDES permit will be terminated because it will be a non-discharging system. As such, Hatfield was not allocated a wasteload allocation.

Since wet-weather design flows represent a "maximum" flow for a facility, the WWTF allocations are conservative in that they are substantially greater than what is actually required. Table 6.7 presents the wasteload allocation for all wastewater facilities in the Rock River impaired watershed.

Design Flow for WWTF X 200 cfu/100 ml = WWTF Wasteload Allocation

Table 6.7 - Wasteload Allocation for Rock River WWTFs

Name/Location	Permit Number	Design Flow (mgd)	WLA (t-orgs./mo.)
Chandler	MN0039748	0.16	0.037
Edgerton	MNG580011	0.37	0.083
Hardwick	MN0039713	0.15	0.035
Holland	MN0021270	0.10	0.022
Leota	MN0063941	0.16	0.037
Luverne	MN0020141	1.50	0.341
Magnolia	MN0025712	0.26	0.058
Woodstock	MN0065200	0.09	0.021
Totals		**2.79**	**0.63**

Straight Pipe Systems
- Straight-pipe septic systems are illegal and un-permitted, and as such are assigned a zero wasteload allocation.

NPDES Livestock Facilities

- Livestock facilities that have been issued NPDES permits are assigned a zero wasteload allocation. This is consistent with the conditions of the permits, which allow no pollutant discharge from the livestock housing facilities and associated site. Discharge of fecal coliform from fields where manure has been land applied may occur at times. Such discharges are covered under the load allocation portion of the TMDLs, provided the manure is applied in accordance with the permit requirements.

LOAD ALLOCATION

- Once the WLA and MOS were determined for a given reach and flow zone, the remaining loading capacity was considered the load allocation. The load allocation includes nonpoint pollution sources that are not subject to NPDES permit requirements, as well as "natural background" sources such as wildlife. The nonpoint pollution sources are largely related to livestock production, inadequate human wastewater treatment, and municipal non-permitted stormwater systems.

6.8 Calculate Daily Maximum Loads

Table 6.8 presents the monthly and daily FC loading capacities and allocations for the Rock River. Fecal coliform TMDLs are expressed in both monthly and maximum daily terms. This is to ensure that both the monthly geometric mean and upper tenth percentile portions of the water quality standard are addressed. All maximum daily loading capacity and allocation values are set at a third the monthly loading capacity and allocation values based on the following rationale:

The upper tenth percentile criterion is ten times the geometric mean criterion (2000 cfu per 100ml = upper 10 tenth percentile; 200 cfu per 100ml = geometric mean). Thus, assuming average daily loading capacities and allocations are 1/30th of the monthly values, ten times the average daily values could be allocated as maximum daily loading capacities and allocations under the upper tenth percentile standard. In mathematical terms the maximum daily value = ten x 1/30th of the monthly value = 10/30th or a third of the monthly value.

It is important to note that neither the daily or monthly loading capacities should be violated. In conceptual terms, three days of bacteria loads that approach the maximum daily capacities will "use up" most of the monthly capacity.

~~Table 6.8 presents the monthly and daily FC loading capacities and allocations for the Rock River.~~

Table 6.8 - Monthly/Daily FC Loading Capacities and Allocations for the Rock River

Drainage Area (square miles): 556										
Total WWTF Design Flow (mgd): 2.82	Flow Zone									
	High		Moist		Mid		Dry		Low	
	Monthly	Daily	Monthly	Daily	Monthly	Daily	Monthly	Daily	Monthly	Daily
	values expressed as trillion organisms per month/day									
TOTAL MONTHLY/DAILY LOADING CAPACITY	130.80	43.60	55.48	18.49	25.89	8.63	15.38	5.13	5.64	1.88
Wasteload Allocation										
Permitted Wastewater Treatment Facilities	0.63	0.21	0.63	0.21	0.63	0.21	0.63	0.21	0.63	0.21
Livestock Facilities Requiring NPDES Permits	0	0	0	0	0	0	0	0	0	0
"Straight Pipe" Septic Systems	0	0	0	0	0	0	0	0	0	0
Load Allocation	90.54	30.18	35.77	11.92	20.84	6.95	6.57	2.19	2.69	0.90
Margin of Safety	39.63	13.21	19.08	6.36	4.42	1.47	8.18	2.73	2.32	0.77
	values expressed as percent of total monthly/daily loading capacity									
TOTAL MONTHLY/DAILY LOADING CAPACITY	100%		100%		100%		100%		100%	
Wasteload Allocation										
Permitted Wastewater Treatment Facilities	0.5%		1.1%		2.4%		4.1%		11.2%	
Livestock Facilities Requiring NPDES Permits	0.0%		0.0%		0.0%		0.0%		0.0%	
"Straight Pipe" Septic Systems	0.0%		0.0%		0.0%		0.0%		0.0%	
Load Allocation	69.2%		64.5%		80.5%		42.7%		47.7%	
Margin of Safety	30.3%		34.4%		17.1%		53.2%		41.1%	

6.9 Impacts of Growth on Allocations and Need for Reserve Capacity

As a result of population growth and movement, changes in the agricultural sector, and other land use changes in the Rock River impaired watershed, sources and pathways of bacteria to surface waters will not remain constant over time. The potential impact of these changes on specific bacteria sources are discussed below.

Straight-Pipe Septic Systems

As a result of state and local rules, ordinances, and programs, the number of straight pipe septic systems will decrease over time. Because these systems constitute illegal discharges, they are not provided a load allocation for any of the impaired reaches covered in this report. As such, other elements of the TMDL allocation will not change as these systems are eliminated.

Wastewater Treatment Facilities

Flows at some wastewater treatment facilities are likely to increase over time with increases in the populations they serve. As long as current fecal coliform discharge limits are met at these facilities, however, such increases will not impact the allocation provided to other sources. This is because increased flows from wastewater treatment facilities add to the overall loading capacity by increasing river flows.

Livestock

Along with humans, the other major source of fecal coliform in the watershed is livestock. While there have been changes in the sizes and types of facilities, there do not appear to be clear trends in overall livestock numbers. With changes in facility size and type, a continuing shift in focus from the facilities themselves to land application practices may be warranted in the future. If growth in livestock numbers does occur, newer regulations for facility location and construction, manure storage design, and land application practices should help mitigate potential increases in fecal coliform loading to the Rock River and its tributaries.

For the reasons discussed above, no explicit adjustments were made to the waste load or load allocations, and no reserve capacity was added, to account for human or livestock population growth. The MPCA will monitor population growth, urban expansion, and changes in agriculture, and reopen the TMDLs covered in this report if and when adjustments to allocations may be required.

Section 7.0 – Turbidity Standards and Impairment Assessment

7.1 Description of Turbidity

Turbidity is the measurement of water clarity. Turbidity is caused by soil particles, algae, dissolved salts and other organic materials that scatter light in the water column making the water appear cloudy. Turbidity is detrimental as excessive levels can harm aquatic life. Aquatic organisms can have trouble finding food, gill function can be affected and spawning beds may become covered.

7.2 Applicable Minnesota Water Quality Standards – Class 2B Waters

The turbidity water quality standard in Minnesota is addressed in Minn. Rules Chapter 7050.0220. The chapter states:

"The numerical and narrative water quality standards in parts 7050.0221 to 7050.0227 prescribe the qualities or properties of the waters of the state that are necessary for the designated public uses and benefits. If the standards in this part are exceeded, it is considered indicative of a polluted condition which is actually or potentially deleterious, harmful, or injurious with respect to designated uses or established classes of the waters of the state."

The numeric criteria for turbidity, based on stream classification, is provided in Table 7.2. There are three impaired reaches that are classified as Class 2B streams and have a turbidity standard of 25 NTU. The impaired reaches are:

- Rock River, Elk Creek to Minnesota/Iowa border (10170204-501)
- Rock River, Champepadan Creek to Elk Creek (10170204-509)
- Elk Creek, Headwaters to Rock River (10170204-519)

Table 7.2 – Minnesota Turbidity Standards by Stream Classification

Class	Description	Turbidity (NTUs)
1B	drinking water	10
2A	cold water fishery, all recreation	10
2B	cool & warm water fishery, all recreation	25
2C	indigenous fish, most recreation	25

7.3 Impairment Assessment: Turbidity

To assess a stream, there must be a minimum of twenty samples over the prior ten-year period; in this TMDL, data was used from 1997-2006. For a water body to be listed as impaired for turbidity, at least three observations and ten percent of observations must be in violation of the turbidity standard. The assessment process also allows for use of transparency and total suspended solids data if adequate turbidity data is not available. According to the MPCA, Total Suspended Solids (TSS) values selected as surrogate thresholds are 58 and 66 mg/L in the Western Corn Belt Plains Ecoregion and Northern Glaciated Plains Ecoregion, respectively. Most of the Rock River watershed is located in the Northern Glaciated Plains Ecoregion. The use of transparency tube data is also an acceptable surrogate, with the threshold of 20 cm.

There were a total of 53 turbidity, 37 transparency and 51 total suspended solids samples collected from 1997-2006. In 2006, the MPCA revised the listing criteria to accept volunteer transparency monitoring data for the assessment of streams and lakes. In 2006, with the use of transparency data, two additional stream segments became classified as impaired for turbidity; Rock River; Champepadan Creek to Elk Creek (10170204-509) and Elk Creek; Headwaters to Rock River (10170204-519). Volunteers collected 69 transparency tube readings from both sites in 1999, 2000, 2002, 2003 and 2005. Table 7.3 provides of summary of water quality data collected from the three impaired stream reaches. The data indicate each reach to be well above the assessment criteria.

Table 7.3 – Summary of Turbidity, Transparency and TSS Samples for Impaired Reaches

	Stream Name	Rock River	Rock River	Elk Creek
	Description	Elk Creek to Minnesota/Iowa Border	Champepadan Creek to Elk Creek	Headwaters to Rock River
	Assessment Unit ID	10170204-501	10170204-509	10170204-519
Turbidity	Number Turbidity Observations	53		
	Percent Observations >25 NTU	***51%***		
	Range, NTU	6 - 190	No Data	No Data
	Mean, NTU	40		
	Median, NTU	26		
Transparency	Number T-tube Observations	37	69	69
	Percent Observations <20 cm	***19%***	***90%***	***96%***
	Range, cm	7 - 98	4 - 26	4 - 22
	Mean, cm	34	13	12
	Median, cm	26	13	12
Total Suspended Solids	Number TSS Observations	51		
	Percent Observations >66 mg/l	***28%***		
	Range, mg/l	5 - 490	No Data	No Data
	Mean, mg/l	64		
	Median, mg/l	33		

Section 8.0 – Turbidity TMDL Development for the Rock River Watershed

The following section describes the development process for three turbidity TMDLs in the Rock River Watershed.

8.1 Description of Impaired Reaches

The Rock River; Elk Creek to Minnesota/Iowa border was placed onf the 303(d) impaired waters list in 2002 based on monitoring data collected by the MPCA. This reach is also listed as impaired for fecal coliform bacteria. Figure 2.1b displays the location of this impairment and its contributing 355,626 acre drainage area.

In 2006, two additional reaches were added to the 303(d) list of impaired waters. These sites were listed based on the results of transparency tube volunteer monitoring data. Elk

Creek, Headwaters to Rock River is a 41,151 acre watershed located across portions of eastern Rock County and western Nobles County. Rock River, Champepadan Creek to Elk Creek drains 276,845 acres from portions of Murray, Nobles, Pipestone and Rock counties. Figure 2.1b present these impaired reaches along with the contributing drainage areas.

8.2 Components of Turbidity TMDLs

Turbidity TMDLs consists of four components: Wasteload Allocation (WLA), Load Allocation (LA), Margin of Safety (MOS) and Reserve Capacity (RC).

WLA = Waste Load Allocation, which is the sum of all point sources, including:
Permitted Wastewater Treatment Facilities (NPDES)
Construction Stormwater (NPDES)
Industrial Stormwater (NPDES)

LA = Load Allocation, which is the sum of all nonpoint sources, including;
Runoff from Row Cropland
Feedlots with Pollution Hazards
Livestock in Riparian Zone
Impervious Surfaces
In-stream Sources

MOS = Margin of Safety (may be implicit and factored into conservative WLA or LA, or explicit.)

RC = Reserve Capacity (Allocation for Future Growth)

As with the fecal coliform TMDL, the "Duration Curve" approach was utilized to address the turbidity TMDLs. This process involved the following steps: compiling the flow data, producing a flow duration curve, calculating the TSS surrogate for the Rock River and determine loading capacity and allocations.

There is a need to identify, evaluate, and select the type/method of analysis to be used in quantifying the source loads and allocations for TMDLs. The duration curve model was chosen for this project because of available data, watershed characteristics, minor urban influence, consultant experience and guidance and ease of application. Also, duration curves are well-tested, widely used, and acceptable to the EPA. The MPCA recommends using the simplest model that includes all the important processes affecting water quality as along as integrity is not comprised.

8.3 Compilation of Flow Data

As with the fecal coliform TMDL, the duration curve approach for turbidity involved using flow monitoring data from the Rock River USGS/DNR gaging site (*#06483000)*, located at Luverne, Minnesota. This USGS/DNR site is located in within ten miles of the impaired reaches. (See Figure 2.1b) Unlike the fecal coliform duration curve, which used monthly mean flow values, turbidity TMDL duration curves require daily mean flow values. A total of 2,825 daily flow values were compiled for the flow record, which spanned from 1995 through 2006.

8.4 Development of Flow Duration Curve

The daily flow values were then sorted by flow volume, from highest to lowest to develop a flow duration curve. Figure 8.4 displays the flow duration curve for the Rock River USGS gage #06483000. As expected, this duration curve is very similar to the fecal coliform monthly duration curve, with the ends of the curve becoming more pronounced due to the use of daily values rather than monthly averages (Figure 6.4).

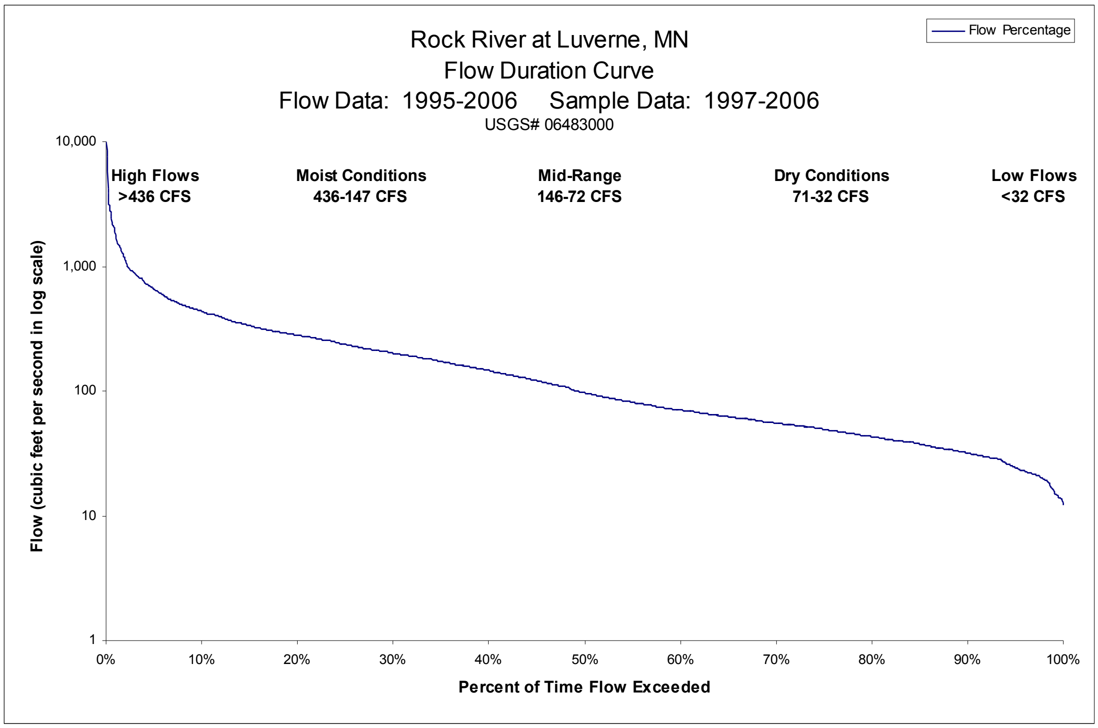


Figure 8.4 - ~~Rock River~~ Flow Duration Curve for Rock River, at Luverne (USGS/DNR gage # - 06483000)

8.5 Calculation of TSS Equivalent for Turbidity Standard

As turbidity is a dimensionless unit, loading allocations, capacities and reductions are commonly based on a surrogate parameter, total suspended solids (TSS). TSS is the measurement of sediment and organic matter in a sample and is often used to calculate loading allocations and capacities.

As described in Section 7.3, protocol used for listed streams allows for use of TSS data when adequate turbidity data is not available. The protocol suggests TSS values of 58 mg/L in the Western Corn Belt Plains Ecoregion and 66 mg/L in the Northern Glaciated Plains Ecoregion, is assumed to be equivalent to 25 NTU. Most of the Rock River watershed is located in the Northern Glaciated Plains Ecoregion.

In reality, the relationship between turbidity and total suspended solids varies in streams across Minnesota. Even different segments of the same stream can have varying relationships of TSS to turbidity. The relationship of turbidity and TSS will depend on contributing water sources and landscape features. Sediment particle size and type will also often change from one portion of a stream to other, which can impact the relationship of turbidity and TSS. To account for this issue, the MPCA recommends that stream specific relationships of turbidity and TSS be made for each stream undergoing a TMDL (when adequate data exists). In the Rock River watershed, the MPCA monitoring site, located at the Minnesota /Iowa border had ample data to use the stream specific relationship. The watershed does remain fairly uniform from headwaters to the monitoring station so this relationship should be fairly constant throughout the watershed.

To determine the TSS equivalent to the turbidity standard of 25 NTU, paired turbidity and TSS samples collected from the Minnesota/Iowa monitoring station (STORET ID S000-097) were compiled using data from 1962 through 2006. Based on criteria recommended by the MPCA, only sample sets with a turbidity value of 40 NTU or below and TSS values of 10 mg/L or above were used for the analysis. Review of turbidity data revealed varying methods of laboratory and field turbidity analysis. Following MPCA criteria, only accepted turbidity methods and types were used for the analysis. A total of 68 paired turbidity/TSS samples met these criteria. A regression analysis was completed as shown in Figure 8.5. Using the regression line equation, a TSS concentration of 74 mg/l was determined to be the surrogate value to the 25 NTU turbidity standard.

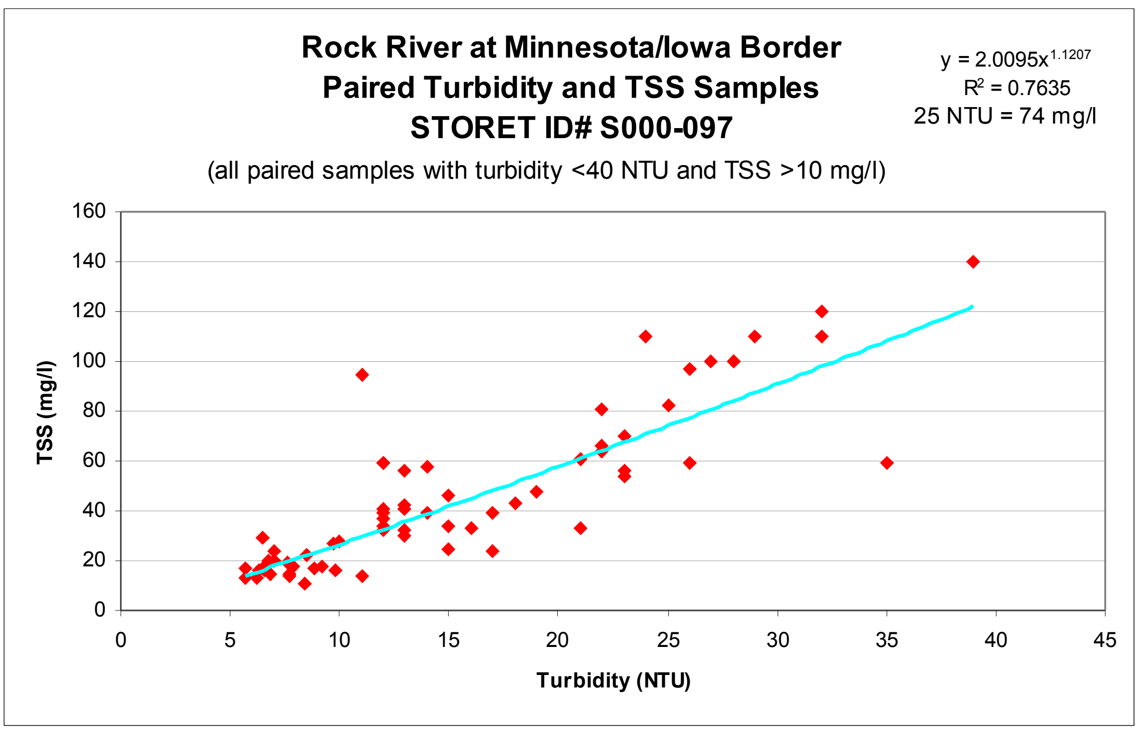


Figure 8.5 – Paired Turbidity/TSS Samples at the Rock River, Minnesota/Iowa Border Site

8.6 Determining Loading Capacity (Maximum amount of Pollutant)

Flow regimes were determined for high, moist, mid-range, dry, and low flow conditions. The mid-range flow value for each flow regime was then used to calculate the total daily loading capacity (TDLC). Thus, for the "high flow" regime, the TDLC is based on the monthly flow value at the 5th percentile. Table 8.6 presents the flow regimes and the flow value used to calculate the TDLC.

Table 8.6 - Flow Categories for Rock River

Flow Condition	Percent of Time Flow Exceeded	Flow Range (cfs)	Flow Used to Calculate Total Daily Loading Capacity (cfs)
High	0-10%	>436	654
Moist	10-40%	147-436	237
Mid	40-60%	72-146	97
Dry	60-90%	32-71	49
Low	90-100%	<32	24

Next, the TDLC for each flow regime was multiplied by the Rock River TSS surrogate standard of 74 mg/L, which is converted in tons of TSS per day using the following equation:

How to convert flow and concentration to load

1. Determine the median flow value for each flow regime.
2. Calculate the TSS equivalent of 25 NTU.
3. For each flow regime, calculate the total liters per day:
   Flow (cubic feet per second) x 28.31 (cubic feet in one liter) x 86,400 (seconds in one day).
4. For each flow regime, calculate total mg of TSS:
   TSS surrogate (74 mg/l) x total liters.
5. For each flow regime, calculate total tons TSS per day:
   Total mg TSS/907,184,740 (the number of mg in one ton).

$$\frac{\text{Flow} \times \text{TSS Surrogate} \times 28.31 \times 86{,}400}{907{,}184{,}740} = \text{Total Daily Tons TSS}$$

Daily flows multiplied by the surrogate TSS value results in a load duration curve. Figure 8.6 presents the load duration curve for the Rock River near Luverne. The chart shows the TDLC for each of the five flow regimes. The loading capacity varies from ~~3.6~~4.8 tons per day during low flow conditions, up to 130.5 tons per day during high flow conditions.

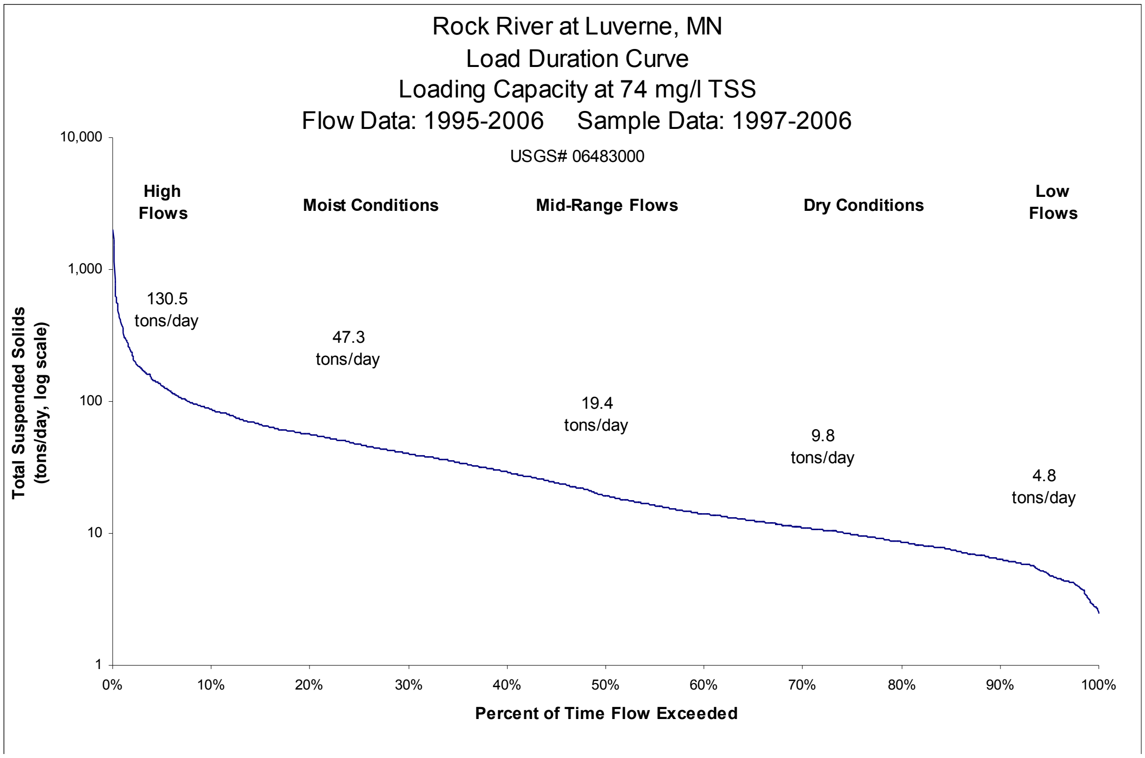


Figure 8.6 – TDLC by Flow Regime for Rock River, at Luverne (USGS/DNR gage # - 06483000)

8.7 Determining Margin of Safety

Next, a Margin of Safety (MOS) was determined for each flow regime. The purpose of the MOS is to account for uncertainty that the allocations will result in attainment of water quality standards. The MOS was determined as the difference between the median flow and minimum flow in each zone. For example, the MOS for the high flow zone is the 95^{th} percentile flow value subtracted from the 100^{th} percentile flow value. The resulting value was converted to a load and used as the MOS.

8.8 TDLC, MOS and TMDL Allocations for Rock River near Luverne

Table 8.8 presents the TDLC, MOS and TMDL allocations for the Rock River near Luverne. The TDLC minus the MOS results in the available wasteload and load allocations. The values expressed are in tons of TSS per day.

Table 8.8 – TMDL, MOS and TDLC for the Rock River, near Luverne

Flow Zone	TDLC (tons TSS/day)	MOS (tons TSS/day)	Allocation (tons TSS/day)
High	130.5	43.5	87.0
Moist	47.3	18.2	29.1
Mid	19.4	5.2	14.2
Dry	9.8	3.4	6.4
Low	4.8	2.4	2.4

8.9 Calculating the TDLC, MOS and TMDL Allocations for the Impaired Reaches

Sections 8.3 through 8.8 describe the creation of a turbidity TMDL for the Rock River DNR/USGS gaging station (#06483000) at Luverne. A watershed conversation factor was applied to account for the impaired reaches located downstream and upstream of the USGS/DNR gage #6583000. For example, the Rock River impaired reach watershed at Minnesota/Iowa border encompasses 355,625 acres, while the upstream DNR/USGS station encompasses only 268,160 acres. To estimate flow for the downstream-impaired reach, a conversion factor of 1.3262 (132.62 percent) was multiplied by the flow values at the DNR/USGS site. Table 8.9 provides the total size of each turbidity impaired watershed, and the conversion factor that was used.

Table 8.9 – Conversion Factors Used to Calculate TDLC for Impaired Reaches

Impaired Reach Name	Assessment Unit ID	Acreage	Sq. Mi.	Watershed Conv. Factor
Rock River, nr. Luverne USGS Station (#06483000)		268,160	419	100.00%
Rock River: Elk Creek to Minnesota/Iowa Border	10170204-501	355,625	556	132.62%
Rock River: Champepadan Creek to Elk Creek	10170204-509	276,845	433	103.24%
Elk Creek: Headwaters to Rock River	10170204-519	41,151	64	15.35%

8.10 Split the TMDL into a Wasteload Allocation and Load Allocation

WASTELOAD ALLOCATION

NPDES Municipal Wastewater Treatment Facilities (WWTF)

- Through permit requirements, WWTP may be allocated a concentration and or load based TSS effluent discharge limit. This TSS limit was then converted into tons per day TSS Table 8.10 provides the tons per day TSS discharge permitted to each of the facilities in the Rock River Watershed for each of the three turbidity impaired watersheds. To account for potential growth/expansion impacts, a reserve capacity of an additional 50 percent was added to each NPDES wasteload allocation.

Table 8.10 – Wastewater Treatment Facilities and Industrial Facilities with Numeric Discharge Limits for TSS

Name	Permit Number	Wasteload Allocation (Tons Per Day TSS)	Wasteload Allocation, with Reserve Capacity (Tons Per Day TSS)
Chandler	MN0039748	0.3939	0.5908
Edgerton	MNG580011	0.1773	0.2659
Hardwick	MN0039713	0.0748	0.1122
Holland	MN0021270	0.0157	0.0236
Leota	MN0063941	0.0787	0.1181
Luverne	MN0020141	0.2510	0.3765
Magnolia	MN0025712	0.1233	0.1850
Woodstock	MN0065200	0.0433	0.0650
Agri-Energy	MN0065033	0.0101	0.0151
Totals		**1.1681**	**1.7521**

NPDES Industrial and Construction Discharges and Stormwater

- Agri-Energy, located near Luverne, was the only industrial facility with an TSS effluent limit (see Table 8.10). The facility has a TSS concentration limit of 30 mg/L and maximum design flow of .09 million gallons per day. This equates to a limit of .01 tons per day. This industrial wasteload allocation was utilized with the municipal WWTF allocations in Tables 8.11a and 8.11b, which presents the TDLC. This facility lies outside the Elk Creek impaired watershed therefore is not included in the Table 8.11c.

- There are fourteen operations with construction stormwater permits in the impaired watershed. The wasteload allocation was determined based on estimated percentage of land in the impaired reach watersheds. The estimates are based on the number of disturbed acres divided by the total acreage of the watershed. Estimates as of 2007 are that 0.14 percent has disturbed land from construction practices. This current loading is representative of the typical loading in the watershed. To account for future growth (reserve capacity), allocations in the TMDL were rounded to one percent, which is considered a de minimus allocation. De minimus is defined as a load that is less than 1 percent of the TMDL and a load that is difficult to quantify. Construction storm water activities are considered in compliance with provisions of the TMDL if they obtain a Construction General Permit under the NPDES program and properly select, install and maintain all BMPs required under the permit, or meet local construction stormwater requirements if they are more restrictive than requirements of the State General Permit.

- There are five (including Agri-Energy) industrial stormwater permits in the impaired watershed. The wasteload allocation was determined based on estimated percentage of land in the impaired reach watersheds affected by industrial activities. The estimates are based on the number of disturbed acres divided by the total acreage of the watershed. In 2007, 0.03 percent of the watershed had disturbed land. To account for future growth (reserve capacity), allocations in the

TMDL were rounded to a half percent. Under all flow regimes, industrial stormwater is allocated less than one percent of the total loading capacity, otherwise known as a de minimus wasteload allocation. De minimus is defined as a load that is less than 1 percent of the TMDL and a load that is difficult to quantify. Industrial storm water activities are considered in compliance with provisions of the TMDL if they obtain an industrial stormwater general permit or General Sand and Gravel general permit (MNG49) under the NPDES program and properly select, install and maintain all BMPs required under the permit.

- When applicable, permitted MS4 communities are also allocated a portion of the loading capacity based on percentage of land coverage in the impaired watershed. As of 2007, the Rock River Watershed had no MS4 permitted communities, although Luverne is near the threshold of being classified as such. As of the 2000 census, Luverne had a population of 4,617, just below the criteria of 5,000 to be classified as a MS4 community. According to Census Bureau estimates, the population of Luverne has declined every year since 2005. The most recent estimate, for July 1, 2005, places the population at 4,459. In communication with the city of Luverne administrator, the projected population estimate is to continue slowly declining. As such, no wasteload allocation is provided to Luverne at this time.

LOAD ALLOCATION

- Once the WLA and MOS were determined for a given reach and flow zone, the remaining loading capacity was considered the load allocation. The load allocation includes nonpoint pollution sources that are not subject to NPDES permit requirements, as well as “background” sources, such as natural soil erosion from stream channel and upland areas. The load allocation also includes runoff from agricultural lands and non-NPDES stormwater runoff.

8.11 Turbidity TMDLs for Rock River Watershed

Tables 8.11a, 8.11b and 8.11c present the wasteload and load allocations for the three turbidity-impaired reaches. The tables provide allocations in tons per day and also in percent of total loading capacity.

Table 8.11a – TSS Total Daily Loading Capacities and Allocations – Rock River: Elk Creek to Minnesota/Iowa Border

Rock River: Elk Creek to Minnesota/Iowa Border AU ID: 10170204-501 Watershed Area: 355,625 acres / 556 sq. mi.	Flow Zone				
	High Flows	**Moist Conditions**	**Mid-Range Flows**	**Dry Conditions**	**Low Flows**
	values expressed as tons TSS/day				
Total Daily Loading Capacity	173.05	62.71	25.67	12.97	6.35
Wasteload Allocation					
Wastewater Treatment Facilities and Industrial Facilities with Numeric Discharge Limits for TSS (NPDES)	1.76	1.76	1.76	1.76	1.76
Construction Stormwater (NPDES)	1.14	0.37	0.17	0.07	0.01
Industrial Stormwater (NPDES)	0.57	0.18	0.09	0.03	0.01
Wasteload Allocation Total	3.46	2.31	2.02	1.86	1.78
Load Allocation	111.91	36.32	16.77	6.61	1.39
MOS	57.68	24.08	6.88	4.50	3.18
	value expressed as percentage of total daily loading capacity				
Total Daily Loading Capacity	100%	100%	100%	100%	100%
Wasteload Allocation					
Wastewater Treatment Facilities and Industrial Facilities with Numeric Discharge Limits for TSS (NPDES)	1.02%	2.81%	6.86%	13.57%	27.72%
Construction Stormwater (NPDES)	0.66%	0.59%	0.66%	0.52%	0.22%
Industrial Stormwater (NPDES)	0.33%	0.29%	0.33%	0.26%	0.11%
Wasteload Allocation Total	2.00%	3.69%	7.85%	14.35%	28.05%
Load Allocation	64.67%	57.91%	65.35%	50.96%	21.87%
MOS	33.33%	38.40%	26.80%	34.70%	50.08%

Table 8.11b – TSS Total Daily Loading Capacities and Allocations – Rock River: Champepadan Creek to Elk Creek

Rock River: Champepadan Creek to Elk Creek AU ID: 10170204-509 Watershed Area: 276,845 acres / 433 sq. mi.	Flow Zone				
	High Flows	**Moist Conditions**	**Mid-Range Flows**	**Dry Conditions**	**Low Flows**
	values expressed as tons TSS/day				
Total Daily Loading Capacity	134.710	48.820	19.980	10.090	4.940
Wasteload Allocation					
Wastewater Treatment Facilities and Industrial Facilities with Numeric Discharge Limits for TSS (NPDES)	1.560	1.560	1.560	1.560	1.560
Construction Stormwater (NPDES)	0.883	0.285	0.131	0.050	0.009
Industrial Stormwater (NPDES)	0.441	0.143	0.065	0.025	0.005
Wasteload Allocation Total	2.884	1.988	1.756	1.635	1.574
Load Allocation	86.926	28.092	12.864	4.955	0.896
MOS	44.900	18.740	5.360	3.500	2.470
	value expressed as percentage of total daily loading capacity				
Total Daily Loading Capacity	100%	100%	100%	100%	100%
Wasteload Allocation					
Wastewater Treatment Facilities and Industrial Facilities with Numeric Discharge Limits for TSS (NPDES)	1.16%	3.20%	7.81%	15.46%	31.58%
Construction Stormwater (NPDES)	0.66%	0.58%	0.65%	0.50%	0.18%
Industrial Stormwater (NPDES)	0.33%	0.29%	0.33%	0.25%	0.09%
Wasteload Allocation Total	2.14%	4.07%	8.79%	16.21%	31.86%
Load Allocation	64.53%	57.54%	64.38%	49.10%	18.14%
MOS	33.33%	38.39%	26.83%	34.69%	50.00%

Table 8.11c – TSS Total Daily Loading Capacities and Allocations – Elk Creek: Headwaters to Rock River

Elk Creek: Headwaters to Rock River	Flow Zone				
AU ID: 10170204-519	**High Flows**	**Moist Conditions**	**Mid-Range Flows**	**Dry Conditions**	**Low Flows**
Watershed Area: 41,151 acres / 64 sq. mi.	values expressed as tons TSS/day				
Total Daily Loading Capacity	20.020	7.260	2.970	1.500	0.730
Wasteload Allocation					
Wastewater Treatment Facilities and Industrial Facilities with Numeric Discharge Limits for TSS (NPDES)	0.180	0.180	0.180	0.180	0.180
Construction Stormwater (NPDES)	0.132	0.043	0.020	0.008	0.002
Industrial Stormwater (NPDES)	0.066	0.021	0.010	0.004	0.001
Wasteload Allocation Total	0.378	0.244	0.210	0.192	0.183
Load Allocation	12.972	4.226	1.960	0.788	0.177
MOS	6.670	2.790	0.800	0.520	0.370
	value expressed as percentage of total daily loading capacity				
Total Daily Loading Capacity	100%	100%	100%	100%	100%
Wasteload Allocation					
Wastewater Treatment Facilities and Industrial Facilities with Numeric Discharge Limits for TSS (NPDES)	0.90%	2.48%	6.06%	12.00%	24.66%
Construction Stormwater (NPDES)	0.66%	0.59%	0.67%	0.53%	0.25%
Industrial Stormwater (NPDES)	0.33%	0.30%	0.34%	0.27%	0.12%
Wasteload Allocation Total	1.89%	3.37%	7.07%	12.80%	25.03%
Load Allocation	64.80%	58.20%	66.00%	52.53%	24.29%
MOS	33.32%	38.43%	26.94%	34.67%	50.68%

8.12 Impacts of Growth on Allocations

Potential changes in population and landuse over time in the Rock River watershed could result in changing sources of excess turbidity. Discussion on how these changes may impact TMDL allocations are discussed below.

Wasteload Allocations

Monthly TSS discharge limits for facilities with NPDES permits typically are from 30 to 45 mg/l. Weekly TSS discharge limits for NPDES facilities are typically from 45 to 65 mg/l. As discussed previously, the TSS equivalent to 25 NTU in the Rock River is approximately 74 mg/l. While new facilities may add increased sediment loading to the system, they would also add additional water. As long as facilities continue to meet existing and new effluent limits, point sources would continue to have minimal impact on the turbidity of receiving waters.

Load Allocations

The amount of land in agricultural land use in the Rock River Watershed is likely to remain fairly consistent over the next two decades. The watershed is comprised primarily of row crops (corn and soybeans) and pasture and hay land. While the majority of the landscape is likely to remain in an agricultural landuse, it is possible a shift from pasture/ hay land to row crop could occur. While this could occur, this shift would likely not affect loading capacity of the stream. This is due to the loading capacity being based on long-term flow values, and slight shifts in landuse would likely not substantially increase or decrease annual flows.

Section 9 – Turbidity Assessment for the Rock River Watershed

The following section details the most recent ten-year period of TSS loading and necessary reductions by varying flow conditions. The presentation of data also attempts to provide a general sense of the magnitude, timing and sources of TSS.

9.1 TSS Loading

Figure 9.1 presents TSS samples plotted on a load duration curve using flow data from the USGS/DNR gaging station #06483000 at Luverne and water quality data from the Minnesota/Iowa monitoring station (STORET ID# S000-097). The figure shows the daily loading capacity over the flow record (1995 through 2006) along with the 42 samples collected in the period. For each sample, the TSS concentration was multiplied by the daily flow value to compute a daily load in tons of TSS. Values that lie above the load duration curve represent samples that exceed 74 mg/L. The data show that exceedances of the TSS surrogate of 74 mg/L is more likely to occur at higher flow rates. Less than ten percent of the samples (2 of 21) exceeded 74 mg/L when flows were less than the 50th percentile flow value (97cfs). Nearly 29 percent of samples exceeded the criteria when flows exceeded 97 cfs.

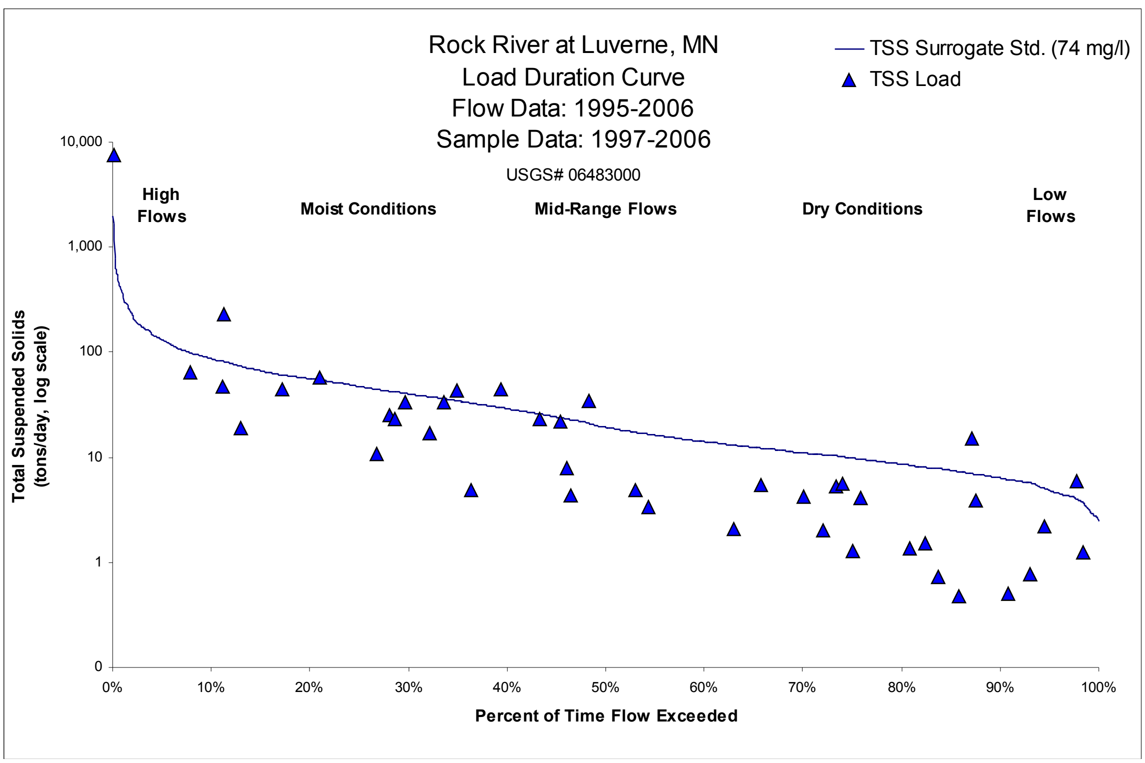


Figure 9.1 – Loading Duration Curve for Rock River

9.2 Necessary Load Reductions

Figure 9.2 compares the 90th percentile TSS load for four flow regimes compared to a loading capacity at the mid-point of the flow regime to obtain reductions. The number of flow regimes was reduced to four, to allow for more samples per category and more accurate calculations of reductions required. The difference between the loading capacity and 90th percentile of sampled loads produced an estimated percent reduction in TSS that will be needed for the Rock River to be removed from the impaired waters list (i.e. fewer than ten percent of samples may exceed 25 NTU). The data indicate that the greatest reductions in TSS load will need to occur during higher flow periods. These would be the periods when stream water velocity would be greatest, and likely the amount of overland runoff and in-channel erosion is greatest. Even though there were limited samples collected, this analysis does correspond with local observations. It should be noted, however, the reductions are merely an estimate.

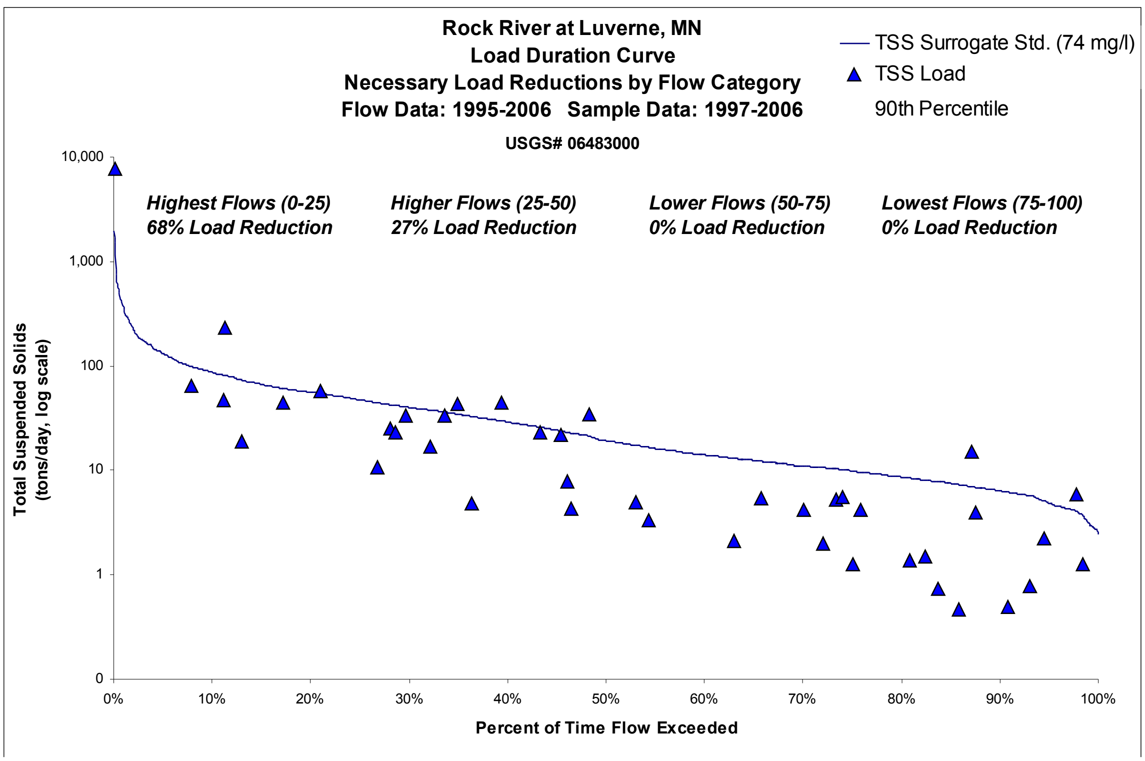


Figure 9.2 – Necessary Load Reductions by Flow Category

9.3 Potential Sources of TSS

Sources of TSS and turbidity in stream settings are often categorized as external and internal sources. External sources include point and non-point contributors. External point contributors would include municipal and industrial wastewater facility discharges. Examples of external non-point sources would include runoff from agricultural lands and stormwater from nonpermitted communities. Internal sources would include streambed

load movement and bank slumping. Internal processes can also include growth and decay of algae and other plant material in the channel or water column.
To help assess the sources of TSS loading, flow data from the USGS/DNR gaging station (#06483000) was run through a hydrograph separation program called HYSEP. This program takes the entire flow record and for each day calculates the amount of flow that is base flow and storm flow. Storm flow is runoff that occurs from the landscape rapidly, from either precipitation or snowmelt periods. For each of the 42 samples, the percentage of storm flow was calculated. Figure 9.3a shows that based on HYSEP output, four of the 42 samples collected since 1995 occurred when storm flow exceeded fifty percent. Each of these samples exceeded the daily load limit. The data indicate that when storm samples are removed from the dataset, the remaining samples that exceed standards are closer to meeting the loading capacity.

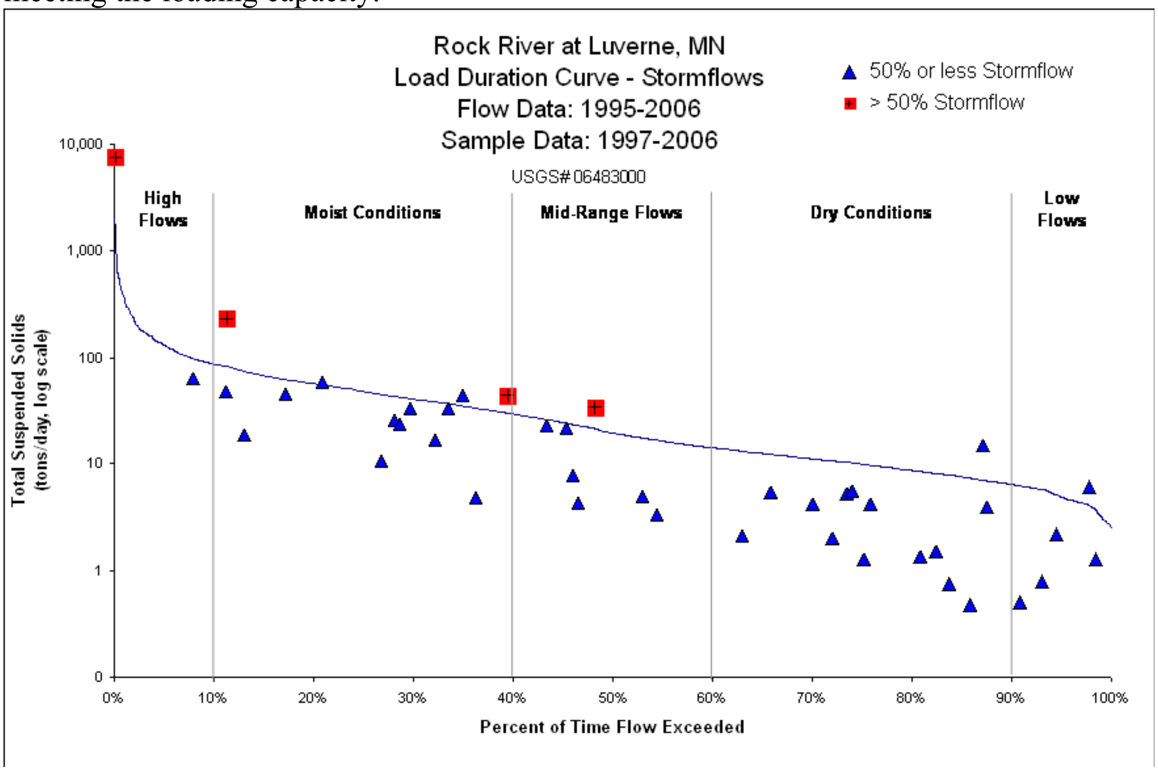


Figure 9.3a – Load Duration Curve with Stormflow Samples for the Rock River

Figure 9.3b shows the TSS samples plotted on a load duration curve for the Rock River, categorized by two separate seasons, April through June and July through March. In many streams in southern Minnesota, the highest TSS concentrations and loads are observed in the April through June period. This period often receives the majority of yearly runoff from a combination of snowmelt runoff and higher rainfall totals. The lack of crop canopy during this period leads to higher runoff rates from the agricultural lands. Figure 9.3b does show that the majority of TSS load does occur during the April through June period, as this is the period when higher flow usually occurred. In both seasonal categories, nearly an identical nineteen percent of samples exceeded the daily loading capacity. It should be noted that when stormflow samples are removed from the dataset only seven percent of samples from the July through March period exceeded the loading capacity. Based on this analysis, it can be assumed that higher flows are causing turbid conditions from overland runoff.

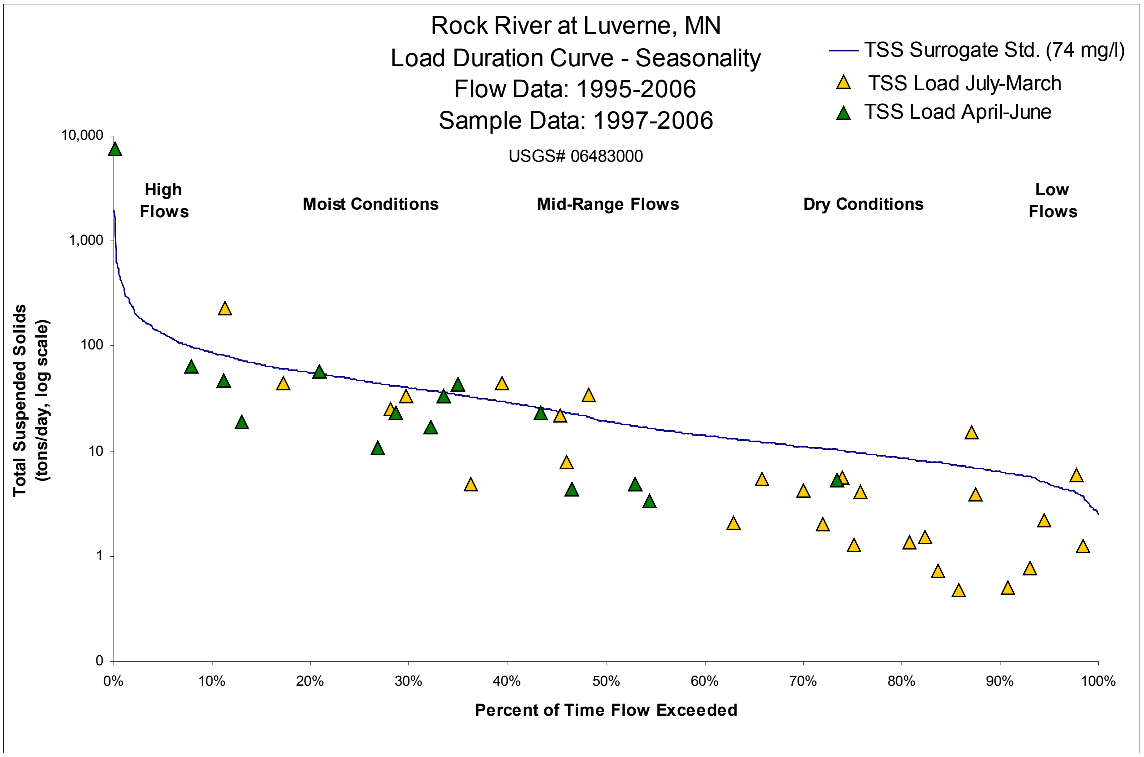


Figure 9.3b – Load Duration Curve with Stormflow Samples by Season for Rock River

Overall, the major sources of excessive turbidity in the Rock River during snowmelt/storm runoff and higher flows is streambank erosion and upland soil loss. High turbidity during ~~dryer~~ drier conditions and low flow is likely related to algae growth and livestock with access to the riparian zone.

9.4 Geographic Scope of Impairment

Determining the geographic scope of impairment is best accomplished through comparing monitoring data from several locations across a watershed. At this time monitoring data exists only for three locations in the watershed and assessment of geographic scope of impairment is limited. However, since similar land use and cover exists across the watershed, it is expected that upper portions of these impaired watersheds would also exceed listing criteria.

The watershed characteristic that usually has a strong influence on sediment loading is slope. Monitoring data from watershed diagnostic studies indicate that steeply sloped lands are associated with higher sediment loading. Steeply sloped areas where erosion is most susceptible include row crop agricultural lands, ravines and streambanks. Figure 9.4 presents the slope characteristics for the Rock River watershed. Much of the steepest sloped land is located in the northern portions of the watershed. County officials report that much of the agricultural land in these portions of the watershed are in pasture, which has significantly less erosion potential than row crops.

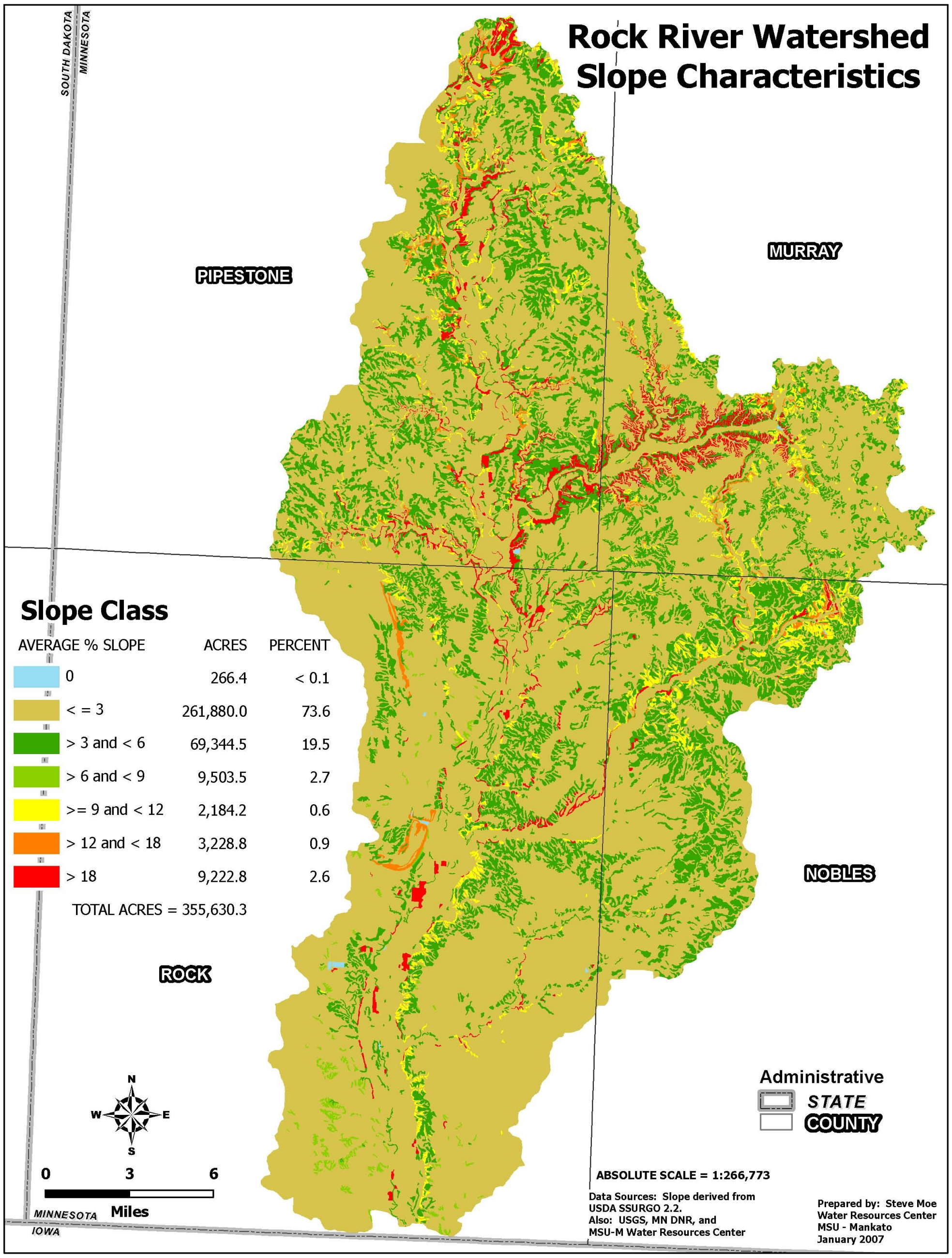


Figure 9.4 – Slope Characteristics of the Rock River Watershed

Section 10.0 – Monitoring Plan

Water quality monitoring of the Rock River will be needed to assess if reductions in fecal coliform bacteria and turbidity are being achieved. This monitoring will rely on monitoring conducted by the MPCA and the four counties.

Long term monitoring as part of the MPCA Milestone Monitoring Program occurs at the Rock River station at the Minnesota and Iowa border (STORET ID# S000-097). The Milestone Program consists of monitoring trends in water quality from over 80 streams in Minnesota. The Milestone Program tests each of Minnesota's ten basins twice in a five-year period. Stream water is tested for a variety of parameters, including turbidity, total suspended solids and *E.* coli. Samples are collected monthly for one year, beginning in October and running through September. This monitoring is next scheduled for the Rock River in 2009.

In 2007, a partnership between the City of Luverne, Rock County and Rock county Rural Water System began monitoring at five locations along the Rock River in Rock County. Four of these sites are sampled once monthly, April through September. Samples are analyzed for several parameters, including total suspended solids, transparency tube and *E.* coli bacteria. This monitoring will continue annually, and should assist county staff in targeting implementation activities to specific portions of the watershed. Rock County also collected samples at the DNR/USGS gaging site #06483000. Twenty-five samples were collected from March to September. Water quality data from this site will be combined with DNR/USGS flow values to compute annual parameter loading and yields for the watershed. Analytical costs for this monitoring are paid through Clean Water Legacy funding (MPCA). Monitoring after 2007 will be dependant on available funding.

Section 11.0 – Implementation Activities

This section provides general implementation strategies targeted towards reduction of fecal coliform bacteria and turbidity. Following approval of the Rock River TMDL study a more detailed implementation plan will be developed. As fecal coliform and turbidity have several sources and pathways, several of the suggestions have the common goal of addressing both pollutants.

11.1 Feedlot Runoff Reduction

State rules for feedlot runoff control will reduce, but not eliminate, bacteria transport to waters from open lots by October 2010. At that time, the bacteria contributions from open lot runoff will need to be reassessed. The Environmental Quality Incentive Program (EQIP) assists feedlots that have a high risk for runoff problems. This cost share funding typically goes for high cost fixes, such as manure storage basins. Financial assistance for low cost fixes such as gutters, diversions, filter strips is usually provided through State Cost Share funding from the Board of Soil and Water Resources (BWSR). Soil and Water Conservation Districts receive between $10,000 to $20,000 from BWSR each year for cost share practices (terraces, diversions, sediment control basin, feedlot runoff structures, etc). When this funding is spread between these various cost share practices, funding is expended quickly. Implementation strategies that target runoff reduction from feedlots will continue to rely on EQIP and the State Cost-Share program.

11.2 Manure Management Planning

Feedlot rules require manure management plans be developed for any feedlots that are required a permit. Manure management plans are an important step in minimizing pathogen transport from manure applied lands. Principles of manure management plans include: (from Developing a Manure Management Plan, Busch, Busman, and Nesse, 2002)

- Know your crop nutrient needs. Before applying manure or fertilizer determine what amounts of nutrients are needed based on realistic yield goals, previous crop, and soil testing.
- Know your manure. Based on laboratory analysis, method of application, and estimates of availability, determine how much nutrients will provide the crop.
- Determine proper rate of manure application. Based on crop needs and nutrients available from the manure, determine optimum rate of application.
- Apply manure uniformly on fields at planned rates. Calibrate spreader to insure correct application rates.
- Keep records of manure application. Record application rates, nutrient content of manure, and fields where manure was applied.

- Rotate manure applications among available fields. Applying manure to the same fields year after year may lead to high soil phosphorus levels that do not improve yields and pose a threat to water quality.

11.3 Non-Conforming Septic Systems

According to county estimates, 72 percent of ISTS in the watershed are non-conforming systems that can contribute fecal coliform bacteria to the Rock River. County staff estimate the number of non-complaint systems based on the number of permitted systems. There is a need for a more thorough inventorying of septic system status for the majority of the watershed. Current administrative funding does not adequately allow for proper inventorying or educational activities related to septic systems. It is recommended that funding be increased or that additional funding be obtained through available grant opportunities.

While most homeowners may be willing to upgrade non-conforming systems, a major deterrent can be cost. As a means to help homeowners pay for new systems, many counties offer a Revolving Load Fund. SWCD offices also provide low interest loans through the Ag BMP program. These programs typically offer loans over a five-year period at three percent interest.

11.4 Pasture Management

Pasture management includes exclusion of livestock from streams and use of rotational grazing.

Livestock with access to streams pose a major risk of contaminating waters through direct deposit of fecal material in the stream or along the banks. Livestock can also cause instability of streambanks, which leads to greater turbidity during higher flows. Exclusion of livestock through fencing will be an important step in reducing fecal coliform bacteria and turbidity in the Rock River.

Rotational grazing involves using only one portion of a pasture at a time. Pastures are divided into paddocks, and livestock are moved from one paddock to another before forage is overgrazed. This type of grazing decreases soil erosion potential, requires minimal fertilizers and pesticides, and decreases the amount of fecal coliform and nutrient runoff. As livestock are moved frequently, forage is able to survive. This vegetation, as opposed to bare soil, allows for higher water infiltration, thus reducing runoff losses.

The MDA has recently released a document on managing grazing in stream corridors that provides additional information on pasture management.
http://www.mda.state.mn.us/news/publications/animals/livestockproduction/grazing.pdf

11.5 **Vegetative Practices**

Vegetative practices include wetland restorations, filter strips, riparian buffers and grassed waterways. These practices minimize bacteria and sediment runoff from agricultural lands through increased infiltration and decreased pollutant transport.

Wetland Restorations

Wetlands are natural swamps, bogs, sloughs, potholes or marshes that have saturated soils and water loving plants. Wetlands are important as they provide wildlife habitat and serve as natural filter for agricultural and urban runoff. They also remove nutrients, pesticides and bacteria from surface waters and can act as efficient, low cost sewage and animal waste treatment practices. Wetlands slow overland flow and store runoff water, which reduces both soil erosion and flooding downstream.

Filter Strips

Filter strips are strips of grass and trees and/or shrubs that slow water flow and cause contaminants like sediment, chemicals and nutrients to collect in vegetation. The nutrients and chemicals are then used by the vegetated filter strips, rather then entering water supplies and water bodies. Filter strips are often constructed along ditches, thus moving row crop operations farther from the stream.

Riparian Buffers

Riparian buffers are also strips of grass, trees and or shrubs that slow water flow and prevent contaminants like sediment, chemical and nutrients from reaches streams and lakes. Riparian buffers are created in and along the cultivated floodplain and along the mainstem of streams.

Grassed Waterways

A grassed waterway is where a natural drainage way is graded and shaped to form a smooth, bowl shaped channel. This area is seeded to sod-forming grasses. Runoff water that flows down the drainage way flows across the grass rather than tearing away soil and forming a larger gully. An outlet is often installed to stabilize the waterway and prevent a new gully from forming. The grass cover protects the drainage way from gully erosion and can act as a filter to absorb some of the chemicals and nutrients in the runoff water.

11.6 **Structural Practices**

Water and sediment control basins, terraces, diversions and grade control structures are all structural practices that help reduce runoff and thus reduce soil erosion.

Terraces

Terraces break long slopes into shorter ones. As water makes its way down a hill, terraces serve as small dams to intercept water and guide it to an outlet. There are two types of terraces – storage terraces and gradient terraces. Storage terraces collect water and store it until it can infiltrate into the ground or be released through a stable outlet. Gradient terraces are designed as a channel to slow runoff water and carry it to a stable outlet like a grassed waterway. Terraces can be effective at reducing overland runoff that carry sediment and nutrients.

Water and Sediment Control Basins

A water and sediment control basin is an embankment that is built across a depressional area of concentrated water runoff to act similar to a terrace. These basins trap sediment and water running off farmland above the structure. These structures help reduce gully erosion by controlling water flow within a drainage area. Spacing for water and sediment control basins depends on the land slope, tillage and management system.

Diversions

A diversion is much like a terrace, but its purpose is to direct or divert runoff from an area. A diversion is often built at the base of a slope to divert runoff away from bottom lands. A diversion may also be used to divert runoff flows away from a feedlot, or to collect and direct water to a pond. Diversions help reduce soil erosion on lowlands by catching runoff water and preventing it from reaching farmland below.

Grade Control Structures

A grade control structure is a dam, embankment or other structure built across a grassed waterway or existing gully control. The structure drops water from one stabilized grade to another and prevents overfall gullies (i.e. sediment) from advancing up a slope. Grassed, non-eroding waterways made possible with grade control structure give better water quality, can be crossed with equipment, and look better than non-stabilized gullies. Grade control structures can also be used to store water, which provides a water source and habitat for wildlife.

Section 12.0 – Reasonable Assurance

As a requirement of TMDL studies, reasonable assurance must be provided demonstrating the ability to reach and maintain water quality endpoints. The source reduction strategies detailed in Section 11.0 have been shown to be effective in reducing pathogen transport/survival and reducing turbidity. These strategies are capable of widespread adoption by landowners and local resource managers.

Many of the goals outlined in this TMDL study run parallel to objectives outlined in the Murray, Nobles, Pipestone and Rock County Water Plans. These county plans have the same goal of removing streams from the 303(d) Impaired Waters List. These plans provide watershed specific strategies for addressing water quality issues. In addition, the commitment and support from the local governmental units will ensure that this TMDL project is carried successfully through implementation.

Various program and funding sources will be used to implement measures that will be detailed in an implementation plan to be completed in the year following approval of this TMDL. Funding sources include a mixture of state and federal programs, such as the Environmental Quality Incentive Program, Conservation Reserve Program and Clean Water Legacy funding. Local officials agree there is a need for additional BMPs and through implementation; water quality improvement can be realized.

Through existing permit programs, turbidity and fecal coliform impairments are being addressed and monitored. In the future, it can be assumed that this will continue.

Section 13.0 – Public Participation

Public participation opportunities were provided during the project in the form of a public open house, new releases and a project newsletter. At the onset of the project, the Rock River Technical Committee was formed that served an advisory and review role for the project. This group was comprised of staff from the following groups:

- City of Luverne
- Minnesota Department of Natural Resources
- Minnesota Pollution Control Agency
- Murray County Planning and Zoning
- Nobles County Environmental Services and SWCD
- Natural Resources Conservation Service
- Pipestone County Planning and Zoning and SWCD
- Rock County Land Management Office and SWCD
- Rock County Rural Water System
- Water Resources Center, MN State University, Mankato
- US Fish and Wildlife Service

The Technical Committee met every two months beginning in November 2006. The committee assisted with reviewing the project workplan, outreach materials and the draft TMDL report. Key findings were discussed and input was gathered from the group.

Public outreach for this project also included the following activities:

Dec. 2006 Rock County LMO sent newsletters to approximately 1,000 landowners in the county. TMDL information and project updates were included.

Jan. 2007 Rock County LMO sent newsletters to approximately 1,000 landowners in the county. TMDL information and project updates were included.

Feb. 2007 Two news releases were developed and submitted to all the newspapers in and near the watershed. The first news release described the TMDL process and impaired waters. The second news release explained the Rock River TMDL and the impairments for fecal coliform and turbidity. The Daily Globe newspaper, with a distribution of 9,327, printed an article on the project. Rock County Star Herald, a distribution of 2,570, also printed an article on the project.

Feb. 2007 Rock County LMO sent newsletters to approximately 1,000 landowners in the county. TMDL information and project updates were included.

Mar. 2007 Rock County Rural Water published article in newsletter, distributed to approximately 750 residents.

Mar. 2007 Rock River TMDL presentation given at the annual Rock County Rural Water meeting in Luverne, attended by about 50 watershed residents.

Mar. 2007 Rock River TMDL PowerPoint presentation given at the annual Rock County Township meeting by Rock County Land Management office.

Mar. 2007 Rock County LMO sent newsletters to approximately 1,000 landowners in the county. TMDL information and project updates were included.

Jun. 2007 Tour of Rock River Watershed by Technical Committee members given to EPA project managers.

Jun. 2007 Rock County LMO sent newsletters to approximately 1,000 landowners in the county. TMDL information and project updates were included.

Aug. 2007 Rock County LMO provided information at the Rock County Fair.

Oct. 2007 Rock County LMO sent newsletters to approximately 1,000 landowners in the county. TMDL information and project updates were included.

~~Nov~~Jan. 2008 A four-page newsletter detailing the project was sent to landowners and homeowners in the watershed (estimated 4,000 newsletters)

Jan. 2008 Public comment period (December 31, 2007-January 31, 2008) Public notice was sent to 108 individuals. A press release was sent to local and state media outlets.

Jan. 2008 Two public meetings: Thursday, January 24, 2008 in Edgerton and Luverne. Three newspapers reported on the meeting: The Daily Globe newspaper, with a distribution of 9,327; Rock County Star Herald, a distribution of 2,570; and the Edgerton Enterprise with a distribution of 1,780. MPCA feedlot update and a TMDL publication highlighted the project.

Jan. 2008 Personalized letters were sent to agricultural groups, targeted individuals, and environmental groups requesting attendance at the public meetings and participation on the Advisory Committee.

There have been several publications about the project. A copy of newsletter articles, news releases, meeting announcements, newspaper articles and meeting materials is included in Appendix C.

Appendix