Upper Mississippi River Bacteria TMDL Implementation Plan

Shingle Creek

Minnesota Pollution Control Agency

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Abbreviations

AgBMP	Agriculture best management practice
AU	Animal unit
AUID	Assessment unit identification
BMP	Best management practice
CD	Collector distributor (road)
Ch	Chapter
Cr	Creek
CSAH	County State-Aid Highway
d	Day
CSO	Combined sewer overflow
DNR	Department of Natural Resources
E. coli	*Escherichia coli,* a common gut bacterium in warm-blooded (and a few other) animals.
EOR	Emmons & Olivier Resources, Inc.
EPA	Environmental Protection Agency
EQIP	Environmental Quality Incentives Program
EQuIS	Environmental Quality Information System
GIS	Geographic information system
HUC	Hydrologic unit code
ID	Insufficient data
IDUL	Impairment due to upstream load
ISTS	Individual sewage treatment system
ITPHS	Imminent threat to public health and safety
LA	Load allocation
lbs	pounds
LGU	Local government Unit
Lk	Lake
MDA	Minnesota Department of Agriculture
MDH	Minnesota Department of Health
Miss	Mississippi
MN	Minnesota
mgd	Million gallons per day
MnDOT	Minnesota Department of Transportation
MOS	Margin of safety
MPCA	Minnesota Pollution Control Agency
MS4	Municipal Separate Storm Sewer System
ml	Milliliters
NLCD	National Land Cover Dataset
MST	Microbial Source Tracking
NA	Not applicable
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
org	Organisms
R	River
RM	River mile

ROW	Right of way
S	South
SDS	State Disposal System
subp	Subpart
SSO	Sanitary sewer overflow
SSTS	Subsurface sewage treatment system
SWCD	Soil and Water Conservation District
SWPPP	Stormwater pollution prevention program
TAC	Technical advisory committee
TMDL	Total Maximum Daily Load
UMRB	Upper Mississippi River Bacteria
US	United States
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
USGS	United States Geological Survey
UV	Ultraviolet
WD	Watershed District
WLA	Wasteload allocation
WHP	Wellhead Protection Area
WMO	Watershed Management Organization
WRAPS	Watershed Restoration and Protection Strategy
WWTF	Wastewater treatment facility
WWTP	Wastewater treatment plant (the term wastewater treatment facility (WWTF) is used in this document with the exception of cases where the official name of the river reach includes reference to a wastewater treatment plant, and in n those cases the acronym WWTP is used)

Executive Summary

The purpose of the Upper Mississippi River Bacteria TMDL Implementation Plan (hereafter, 'Implementation Plan' or 'Plan') is to assist local partners in implementation efforts to reduce bacteria concentrations in streams tributary to the Upper Mississippi River. Streams that exceed State water quality standards for *E. coli* may have increased levels of waterborne pathogens that can be harmful to human health when the streams are used as drinking water sources and for recreational activities. The Mississippi River is the exclusive drinking supply for the St. Cloud Water Treatment facility which serves the cities of St. Cloud and St. Augusta and the Minneapolis Water Treatment and Distribution Services (serves the cities of Golden Valley, Crystal, New Hope, Columbia Heights, Hilltop, Fort Snelling, parts of Bloomington and Edina (Morning Side), and the Minneapolis/St. Paul airport). It is also one of the main sources for the St. Paul Regional Water Services (serves at least part of the cities of Falcon Heights, Lauderdale, Maplewood, Arden Hills, Little Canada, Saint Paul, West Saint Paul, South Saint Paul, Lilydale, Mendota and Mendota Heights, Roseville, and Sunfish Lake). Approximately 940,000 Minnesotans rely on the Mississippi River between Royalton and Hastings for drinking water.

This Plan provides a brief background about the *Upper Mississippi River Bacteria (UMRB) Total Maximum Daily Load (TMDL) Study and Protection Plan* (2014) and its goals. It provides a discussion about general implementation methods, which is then further described for urban and rural subwatersheds. Each impaired subwatershed has its own section that describes in detail how potential bacteria sources were estimated and identifies implementation actions to reduce bacteria concentrations. Finally, this Plan includes guidance on monitoring, as well as a list of potential funding sources for implementation activities.

While this Implementation Plan was specifically developed for twenty-two impaired streams only, the approach for identifying appropriate practices to be used to address bacterial loading are based on types of land uses and potential sources of bacteria. As such, this approach could be applied to the watersheds of non-impaired streams to prevent those waterbodies from becoming impaired.

This project is a joint effort between the Minnesota Pollution Control Agency (MPCA) and the Minnesota Department of Health (MDH), as this TMDL has direct implications for protecting the Upper Mississippi River as a drinking water source for St. Cloud Water Treatment Facility, the Minneapolis Water Treatment and Distribution Services, and the St. Paul Regional Water Services. This project was also done in close coordination with a multitude of project partners.

Numerous organizations play a potential role in implementing the TMDL including all permitted entities as well as those entities that either have land area within the TMDL Subwatershed or have a role in watershed management. Appendix A provides a detailed, cross-referenced listing of the regulated entities (MS4 permit holders, WWTFs) and non-regulated entities that are located within this project area. Hyperlinks are provided that allow easy navigation within this Report to the specific subwatersheds where each entity is involved.

Background on the Upper Mississippi River Bacteria TMDL Study and Protection Plan

The 2014 *Upper Mississippi River Bacteria (UMRB) Total Maximum Daily Load (TMDL) Study and Protection Plan* (https://www.pca.state.mn.us/sites/default/files/wq-iw8-08e.pdf); hereafter referred to as the 'TMDL study', addresses twenty-two aquatic recreation impairments due to high bacteria levels in tributaries to the Mississippi River. These streams are in three Major Watersheds (8-digit HUCs): Mississippi River – Sartell Watershed (07010201), Mississippi River – St. Cloud Watershed (07010203), and Mississippi River – Twin Cities Watershed (07010206). See Figures 1-3 for the locations of the impaired streams and TMDL subwatersheds within each of these major watersheds. This report focuses on the subwatersheds of streams impaired for aquatic recreation due to high bacteria concentrations.

The ultimate goal of the TMDL Study was to describe the reduction in pollutant loading and implementation activities needed so that Upper Mississippi River reaches can meet the water quality standard for aquatic recreation due to *Escherichia coli (E. coli*), a bacteria used to indicate the potential presence of waterborne pathogens that can be harmful to human health. In meeting this goal, the implementation of best management practices (BMPs) in critical areas may also help reduce other contaminants of concern.

Of particular priority for both the TMDL Study and this Implementation Plan is the need to coordinate restoration and protection efforts in the areas identified in the Source Water Protection Plans of the Cities of St. Cloud, Minneapolis, and St. Paul. The Source Water Protection Plans identify Priority A and Priority B areas for management that are at risk for contaminating drinking water supplies (Figure 1). Priority is assigned based on time of travel for a contaminant to reach the intake point with Priority A areas representing acute threats and Priority B representing areas of chronic threat. Priority A areas are the closest river and land area draining near each public water supply intake and pose an acute public health risk. Priority A areas have been identified to reduce potential contaminant threats based on estimated travel times and distance to the intake to protect drinking water, and are a high priority for protection and management. Priority B areas are the remaining lands within the subwatershed that surround Priority A areas. Priority B areas protect water users from chronic health effects related to low levels of chemical contamination or the periodic presence of contaminants at low levels in the source water. Figures 2-4 below delineate each of the three Major Watersheds and show the impaired streams and TMDL subwatersheds, as well as the Priority A Source Water Protection Areas. The implementation of best management practices (BMPs) in these critical source water areas may also help reduce other contaminants of concern for these drinking water suppliers.

It is important to note that the TMDL Study and this Implementation Plan should be a priority in local plans to establish funding for implementation activities.

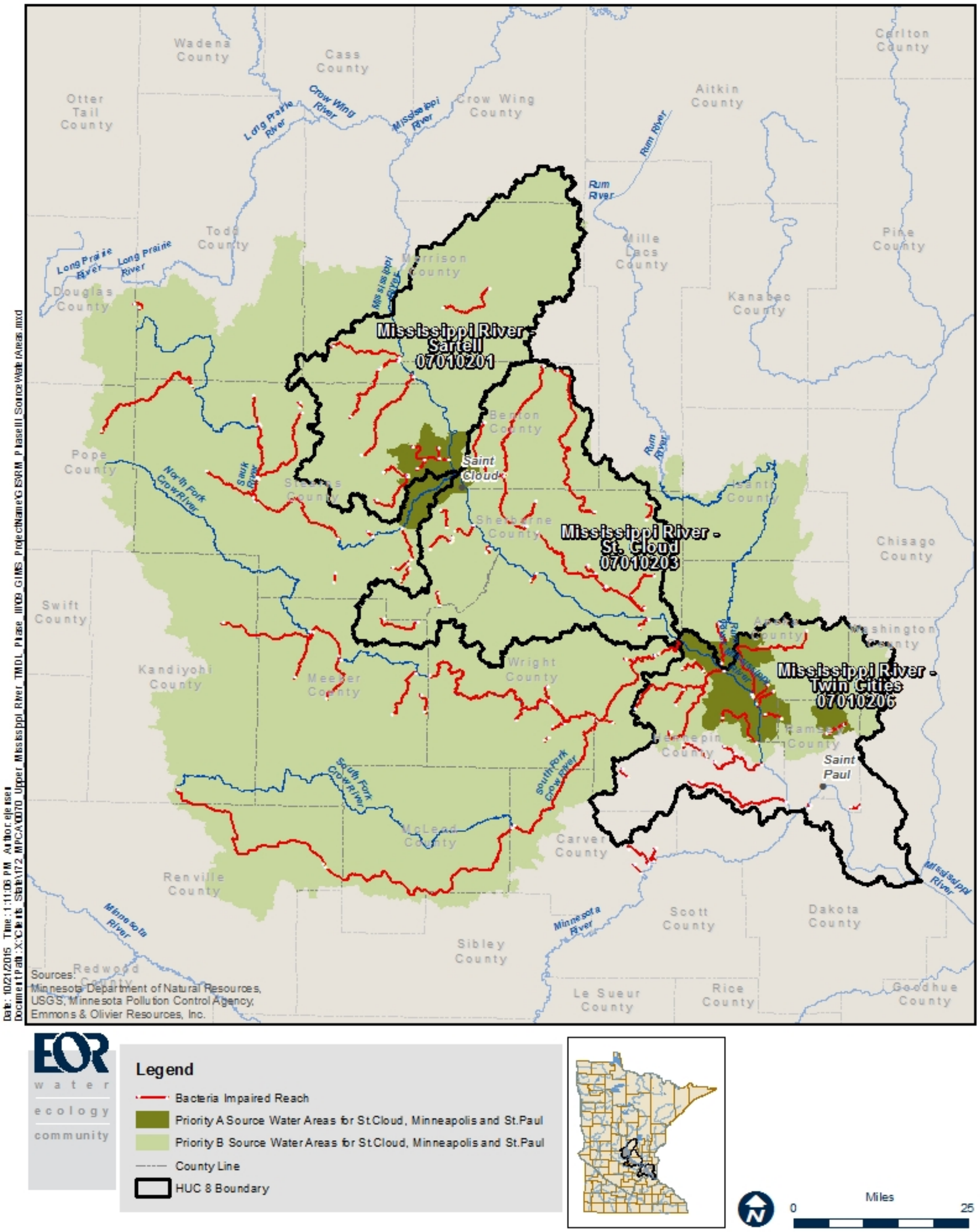

Figure 1. Source Water Protection Areas within the three major HUCs of Implementation Plan project area

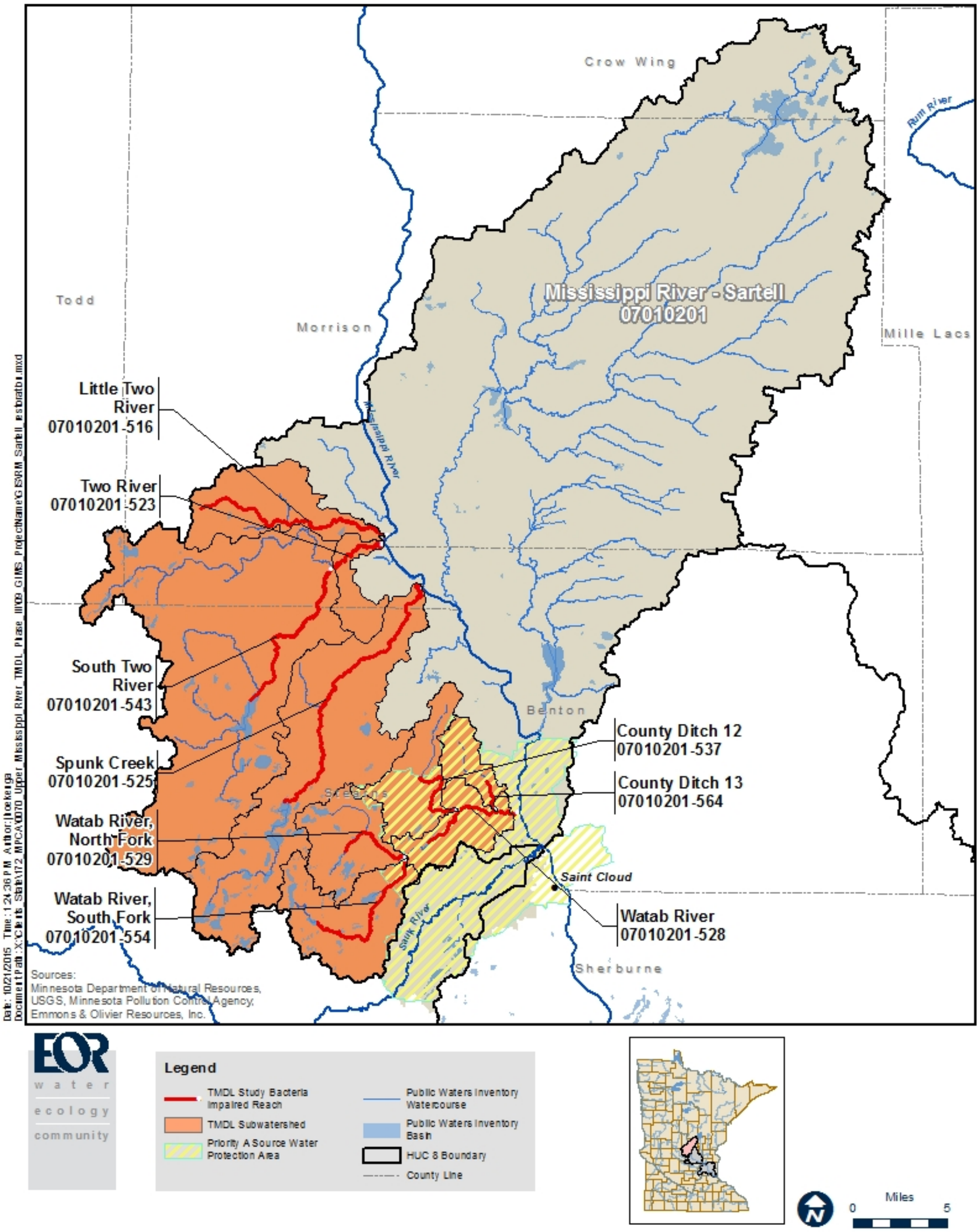

Figure 2. Subwatersheds of Impaired Reaches due to Bacteria Concentrations within the Mississippi River – Sartell (HUC 07010201) Watershed

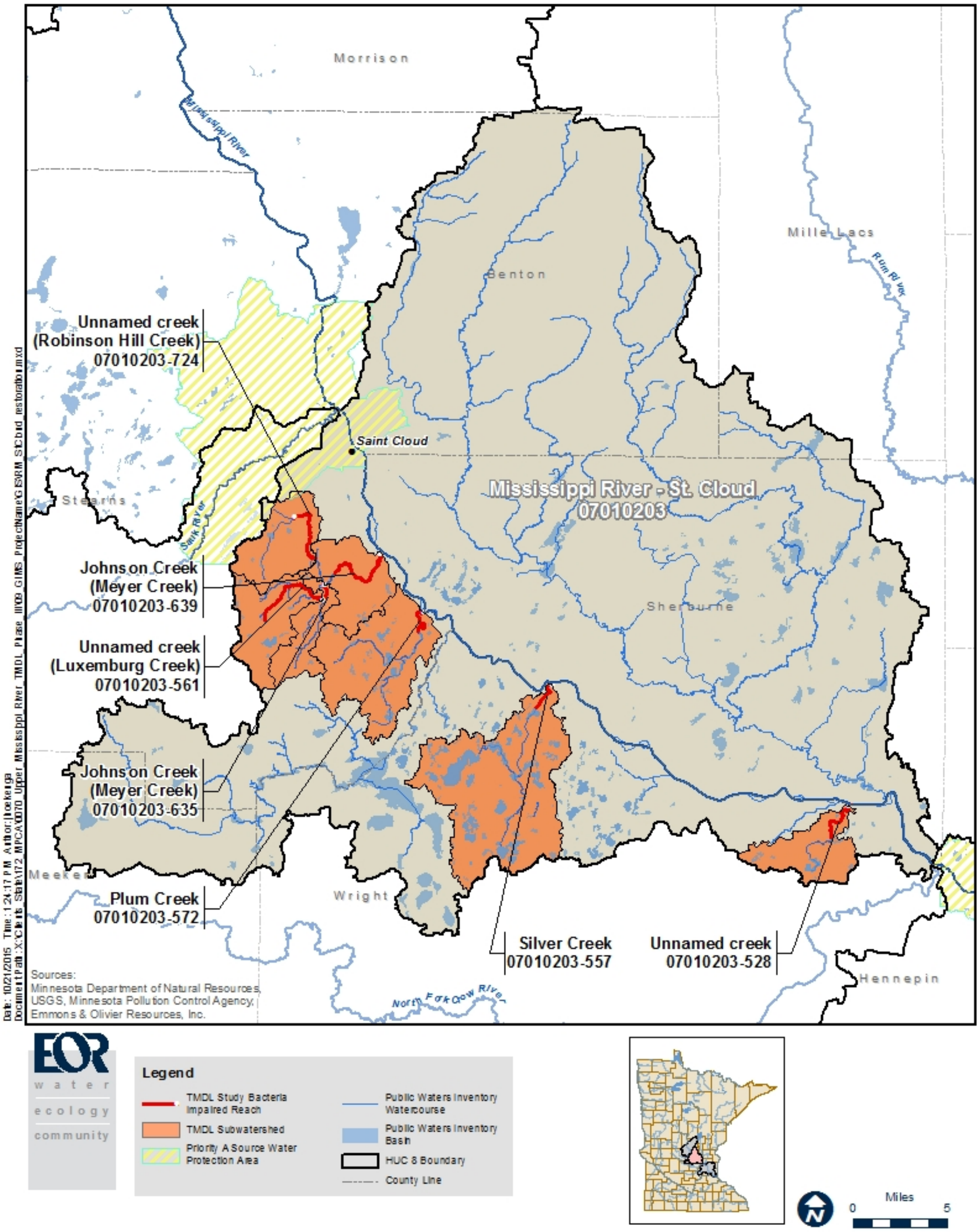

Figure 3. Subwatersheds of impaired reaches due to bacteria concentrations within the Mississippi River – St. Cloud (HUC 07010203) Watershed

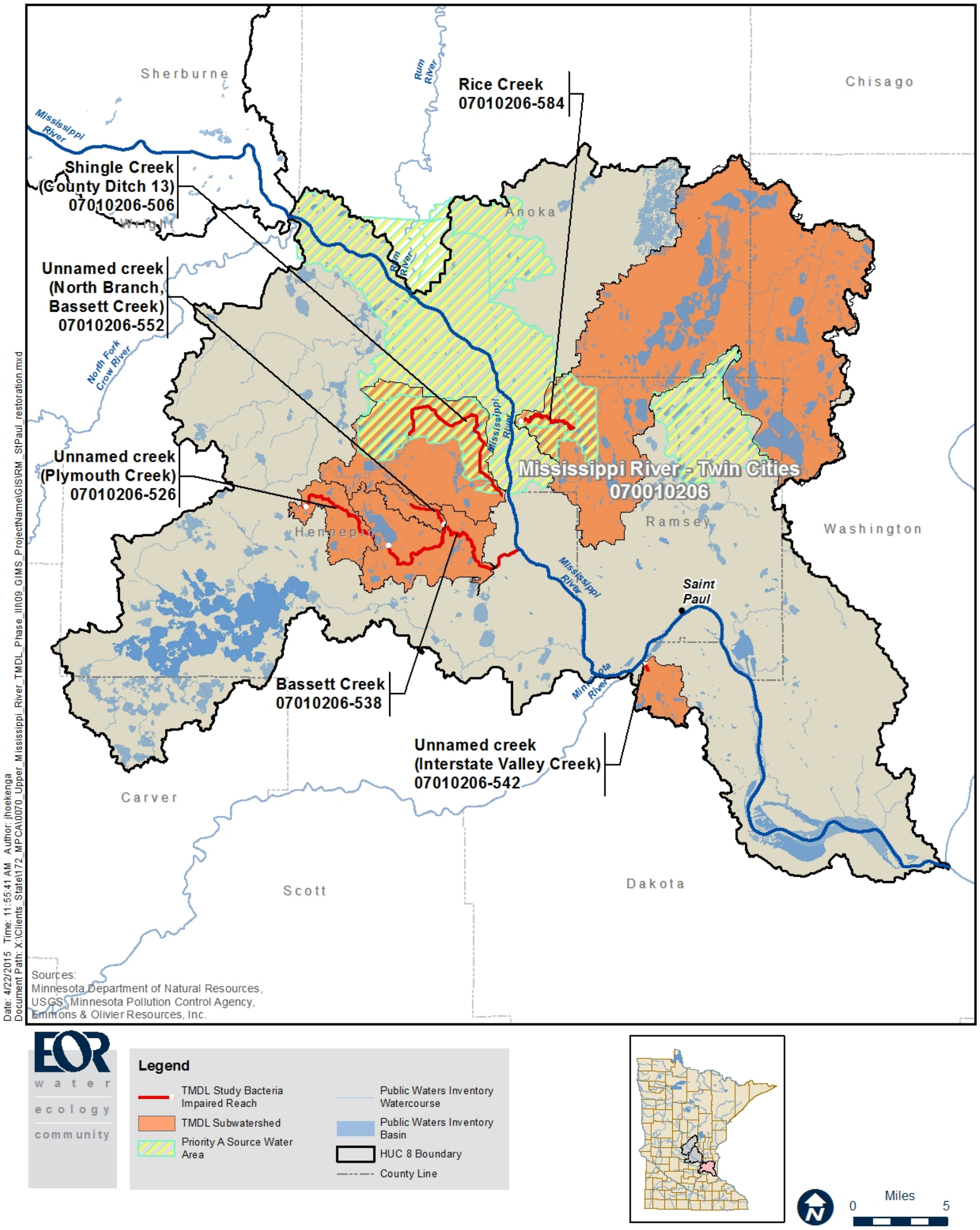

Figure 4. Subwatersheds of impaired reaches due to bacteria concentrations within the Mississippi River – Twin Cities (HUC 07010206) Watershed

Table 1. Reaches known to be impaired for bacteria and for which TMDLs are established as a part of the Upper Mississippi River Bacteria TMDL Study and Protection Plan

TMDL Reach Name	TMDL Reach Description	AUID	Listed Pollutant	Impaired Use	Year Listed	Beneficial Use Class[1]	Source Water Area[2]
Mississippi River – Sartell (HUC 07010201) Watershed							
Little Two River	Headwaters to Mississippi R	07010201-516	*Escherichia coli*	Aquatic recreation	2014	2B, 3C	Priority Area B (St. Cloud)
Two River	North & South Two R to Mississippi R	07010201-523	*Escherichia coli*	Aquatic recreation	2014	2B, 3C	Priority Area B (St. Cloud)
Spunk Creek	Lower Spunk Lk to Mississippi R	07010201-525	Fecal Coliform	Aquatic recreation	2008	2B, 3C	Priority Area B (St. Cloud)
Watab River	Rossier Lk to Mississippi R	07010201-528	*Escherichia coli*	Aquatic recreation	2014	2B, 3C	Priority Area A and B (St. Cloud)
Watab River, North Fork	Headwaters (Stump Lk 73-0091-00) to S Fk Watab R	07010201-529	*Escherichia coli*	Aquatic recreation	2014	2B, 3C	Priority Area A and B (St. Cloud)
County Ditch 12	Unnamed cr to Watab R	07010201-537	*Escherichia coli*	Aquatic recreation	2014	2B, 3C	Priority Area A and B (St. Cloud)
South Two River	Two River Lk to Two R	07010201-543	*Escherichia coli*	Aquatic recreation	2014	2B, 3C	Priority Area B (St. Cloud)
Watab River, South Fork	Little Watab Lk to Watab R	07010201-554	*Escherichia coli*	Aquatic recreation	2014	2B, 3C	Priority Area A and B (St. Cloud)
County Ditch 13	Bakers Lk to Watab R	07010201-564	*Escherichia coli*	Aquatic recreation	2014	2B, 3C	Priority Area A and B (St. Cloud)

TMDL Reach Name	TMDL Reach Description	AUID	Listed Pollutant	Impaired Use	Year Listed	Beneficial Use Class[1]	Source Water Area[2]
Mississippi River – St. Cloud (HUC 07010203) Watershed							
Unnamed creek	T121 R23W S19, south line to Mississippi R	07010203-528	*Escherichia coli*	Aquatic recreation	2014	2B, 3C	Priority Area B (Minneapolis, St. Paul)
Silver Creek	Locke Lk to Mississippi R	07010203-557	*Escherichia coli*	Aquatic recreation	2012	2B, 3C	Priority Area B (Minneapolis, St. Paul)
Unnamed creek (Luxemburg Creek)	T123 R28W S30, south line to Johnson Cr	07010203-561	*Escherichia coli*	Aquatic recreation	2012	1B, 2A, 3B	Priority Area B (Minneapolis, St. Paul)
Plum Creek	Warner Lk to Mississippi R	07010203-572	*Escherichia coli*	Aquatic recreation	2012	2B, 3C	Priority Area B (Minneapolis, St. Paul)
Johnson Creek (Meyer Creek)	Unnamed cr to Unnamed cr	07010203-635	*Escherichia coli*	Aquatic recreation	2012	1B, 2A, 3B	Priority Area B (Minneapolis, St. Paul)
Johnson Creek (Meyer Creek)	T123 R28W S14, west line Mississippi R	07010203-639	*Escherichia coli*	Aquatic recreation	2012	2B, 3C	Priority Area B (Minneapolis, St. Paul)
Unnamed creek (Robinson Hill Creek)	CD 14 to CSAH 136	07010203-724	*Escherichia coli*	Aquatic recreation	2012	1B, 2A, 3B	Priority Area B (Minneapolis, St. Paul)
Mississippi River – Twin Cities (HUC 07010206) Watershed							
Shingle Creek (County Ditch 13)	Headwaters (Eagle Cr/Bass Cr) to Mississippi R	07010206-506	*Escherichia coli*	Aquatic recreation	2014	2B, 3C	Priority Area A and B (Minneapolis, St. Paul)
Unnamed creek (Plymouth Creek)	Headwaters to Medicine Lk	07010206-526	*Escherichia coli*	Aquatic recreation	2014	2B, 3C	Priority Area B (Minneapolis, St. Paul)

TMDL Reach Name	TMDL Reach Description	AUID	Listed Pollutant	Impaired Use	Year Listed	Beneficial Use Class[1]	Source Water Area[2]
Mississippi River – Twin Cities (HUC 07010206) Watershed continued							
Bassett Creek	Medicine Lk to Mississippi R	07010206-538	Fecal Coliform	Aquatic recreation	2008	2B, 3C	Priority Area B (Minneapolis)
Unnamed creek (Interstate Valley Creek)	Unnamed cr to Mississippi R	07010206-542	*Escherichia coli*	Aquatic recreation	2014	2B, 3C	None
Unnamed creek (North Branch, Bassett Creek)	Unnamed Lk to Bassett Cr	07010206-552	*Escherichia coli*	Aquatic recreation	2014	2B, 3C	None
Rice Creek	Long Lk to Locke Lk	07010206-584	*Escherichia coli*	Aquatic recreation	2014	1C, 2Bd, 3C	Priority Area A and B (Minneapolis, St. Paul), Priority Area B (Vadnais)

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

[2] The cities of St. Cloud, St. Paul, and Minneapolis have State endorsed Source Water Protection Plans following the Minnesota Department of Health guidance for surface water intakes from the Mississippi River. In each of these Plans, cities have designated priority areas for drinking water protection, called Source Water Protection Areas.

Implementation Methods

Strategies for Reducing Bacteria

Developing an implementation plan for reducing bacteria concentrations and meeting water quality standards should begin with the most cost effective and efficient methods. This section describes the steps to take to identify sources and reduce loading by source control and the implementation of best management practices (BMPs). For source control, priority will be placed on first reducing human source contributions. The techniques include the topics that were evaluated through the literature reviews (Effectiveness of Best Management Practices for Bacteria Removal and Literature Summary of Bacteria – Environmental Associations) conducted earlier in the project, and are further discussed for urban areas as well as rural areas below.

1. Identify, map, and monitor sources

The most important step is to identify potential and known sources of bacteria. Determining the most likely sources is typically a desktop exercise using mapping to identify where bacteria could be introduced to waterbodies such as pastures/agricultural land where manure is applied, feedlots and residences with Subsurface Sewage Treatment Systems (SSTS) near waterbodies, at dog parks and areas where wildlife congregate near waterbodies such as fields and golf courses. Mapping bacteria conveyance systems (e.g. stormwater and ditches) is also important. Mapping known and potential sources will ensure that these areas are regularly monitored and inspected. Field monitoring will also identify sources, and should be conducted to regularly inspect known sources.

2. Federal, State, and Local Requirements

Ensuring state laws and local ordinances are up-to-date and enforced is also a cost effective and efficient way to reduce bacteria loading into waterbodies. Specifically, local ordinances that address manure management and land use regulations should be coordinated with State level water resource regulations that govern the protection of water resources to minimize potential release of bacteria. For example, an ordinance regulating the siting of a new feedlot further away from a stream is in line with the Minnesota State Administrative Rules 7020 on manure regulation.

3. Outreach/Education

It is very important that residents are aware of and understand the state and local water and land use regulations, as well as steps they can take to reduce bacteria entering water resources. For example, outreach and education can ensure that landowners and residents understand the regulations governing water resources such as collection of pet waste or bans on wildlife feeding in order to comply with them, and are aware of the best management practices and opportunities available to minimize sources of bacteria on their property. See the Outreach and Education section of this report for more information.

4. Best Management Practices that Limit Introduction of Bacteria

The most effective method to reduce loads and meet long-term water quality goals is to address the sources that directly contribute bacteria to waterbodies. Source controls are best management practices that focus on limiting the introduction of bacteria into the landscape where it could be transported to waterbodies. Incorporating source controls into state laws and local ordinances is a very effective method to reduce release of bacteria into the watershed. Source control activities that reduce direct sources for bacteria include excluding livestock from streams, manure management, septic system maintenance, pet waste collection and better site designs that reduce runoff rates, volumes, and associated pollutants.

5. Best Management Practices that reduce Bacteria Loading to Waters

Source control and the methods mentioned above should be the first step of reducing bacterial loading as these methods are the most cost efficient and effective. Source control, however, is not always feasible and there are a number of Best Management Practices BMPs that can be installed or designed to reduce bacteria-laden runoff to waterbodies. Based on available data, some conventional stormwater BMPs have been shown to reduce bacterial loads to receiving waters by (a) reducing bacteria concentrations in discharged water, or (b) reducing total water discharge along with the associated bacterial load. The Minnesota Stormwater Manual (see link in Appendix B) provides a table that reports median pollution reduction values for different Best Management Practices and pollutants. In some cases, multiple BMPs, including pre-treatment, may be necessary to achieve significant reductions in bacteria concentrations. Additionally, many BMPs are designed to reduce the loading of several pollutants at the same time.

Prior to evaluating BMP performance or selecting BMP strategies to target bacteria, it is important to understand basic fate and transport mechanisms as well as treatment processes anticipated to be effective for removing or inactivating bacteria. Inactivating bacteria refers to a natural process in which bacteria die-off or fail to reproduce due to existing environmental factors such as pH. Bacteria therefore can be controlled without being removed, however, bacteria population can also increase without further bacteria loading if environmental conditions are conducive to population growth within the conveyance or receiving waters.

Properly designed BMPs that reduce the total volume of agricultural or urban runoff (e.g., infiltration BMPs) to receiving waters can effectively reduce the bacteria load by an amount equivalent to that contained in the reduced volume. They may also reduce the frequency of bacterial discharges to receiving waters if volume reductions are sufficient to retain runoff from most events.

BMPs that filter and/or reduce the rate or frequency of runoff (e.g., filtration or other BMPs that do not reduce volumes but do provide treatment) may reduce bacteria concentrations in this runoff and thereby reduce loading to receiving waters; however, these should be carefully planned and investigated before implementation as they are sometimes ineffective and may even result in increased bacteria concentrations in discharges.

Examples of BMPs that may be effective in reducing bacteria loads include filter strips, biofiltration, and infiltration/bioinfiltration. Appendix B provides a table with links to sources with more information on each BMP.

Overall, the data on BMP effectiveness are limited both in number and representativeness, and with the exception of properly designed infiltration BMPs, broadly applicable conclusions cannot be drawn based on available data. Additional studies are needed for all BMP types to increase the confidence of performance estimates with regard to bacteria (refer to Additional Research Needs for further discussion).

In assessing potential BMPs priority should be given to those which have the greatest pollution reduction per dollar spent. BWSR has developed a draft Nonpoint Priority Funding Plan (http://www.bwsr.state.mn.us/planning/npfp/index.html) which is designed to rank projects based on a range of factors such as cost effectiveness.

Urban and Rural Subwatersheds

The strategies described above provide a general outline and description for the first steps of reducing bacteria loading through source controls. However, there are inherent differences in how to reduce bacteria loadings from urban and rural subwatersheds. This section provides more detailed explanations of source controls and BMPs that are applicable to each urban and rural subwatershed. The measures and BMPs described below are not the only available methods for reducing bacteria, but are the actions most recommended and applicable to the subwatersheds in this study. Appendix B contains a table listing the BMPs most relevant to reducing bacteria and provides links to sources with more information for each BMP. As mentioned above, efforts to reduce and eliminate bacteria sources should always be conducted first, when possible. Note that all implementation practices should follow local, state, and federal regulations.

Urban Subwatersheds

Based on desktop analyses conducted for the TMDL, the most likely sources of bacteria in urban subwatersheds are from pets, to a lesser extent from wildlife, and in some areas humans may be a source (e.g. failing SSTS).

Source Controls

Identify and map bacteria sources and conditions

- If the stream's watershed is quite large with many stormwater outfalls, consider conducting a two-year *E. coli* monitoring program along the stream to help identify hot spots of higher bacteria concentrations (see the Monitoring Plan for recommended sampling frequency). Monitor tributaries flowing into the stream and also consider monitoring stormwater outfalls (or at least the larger ones).
- Identify subwatersheds for each stormwater outfall or tributary to the stream, making note of potential high-loading features within these such as wildlife congregation areas, parks (especially dog parks), existing monitoring locations, septic systems, sanitary systems that are potentially located above stormwater systems, and recreational access points.
- Walk the stream and visually inspect stormwater outfalls during dry weather for flows, odor, color, condition, etc. (see below for more information on dry weather flows) that would be indicative of an illicit discharge. Take the appropriate actions to eliminate the illicit discharge relying upon information contained in local Stormwater Pollution Prevention Plan (SWPPP) if available or readily available SWPPP guidance documents.

Reduce input from pets

- Pass and enforce pet waste ordinances and educate pet owners about them.
- Add infiltration BMPs downstream of parks/residential areas and upstream of stormwater pipes (i.e., somewhere between the park/residential area and the stormwater outfall so as to intercept and infiltrate some or all of the flow from these areas).
- Reduce transport from parks, residential, and other areas by the use of buffers (e.g., filter strips, un-mowed areas) and other disconnection of flow pathways (e.g., impervious surface disconnection, downspout disconnection).

Reduce input from wildlife

- Consider wildlife feeding bans and control of nuisance populations, including ducks and geese and other wildlife.
- Remove community facilities such as vending machines for feeding ducks and geese.
- Add buffers in riparian areas near waterbodies to deter waterfowl congregation.
- Consider wildlife barriers if wildlife (e.g. raccoons, etc.) are found to be living in storm sewers.
- When possible, use infiltration BMPs instead of detention ponds in residential developments and other areas where wildlife may congregate.

Reduce input from humans

- If a potential human source (e.g. septic systems in area, sewer fungus in stormwater pipes, storm sewer bacteria concentrations above 100,000 total coliform) is detected, consider additional tests (detergents, ammonia, fluoride, video pipe inspection for cracks and leaks, dye testing, fluorometer, or microbial source tracking) to help determine the location and type of source.
- A comprehensive list of potential sources of bacteria in urban areas can be found in Table 3-1 of the 2014 Pathogens in Urban Stormwater Systems Report (http://higherlogicdownload.s3.amazonaws.com/EWRINSTITUTE/c3dac190-e71a-44cc-a432-3ee9a640acfd/UploadedImages/Final%20Pathogens%20Paper%20August%202014%20_MinorRev9-22-14.pdf)
- Information on Source Tracking tools can be found in Table 5-2 of the 2014 Pathogens in Urban Stormwater Systems Report (http://higherlogicdownload.s3.amazonaws.com/EWRINSTITUTE/c3dac190-e71a-44cc-a432-3ee9a640acfd/UploadedImages/Final%20Pathogens%20Paper%20August%202014%20_MinorRev9-22-14.pdf)
- Maintain wastewater treatment systems and sanitary sewers through regular monitoring and perform immediate repairs when necessary.

Reduce conditions that promote bacteria growth and survival

- Reduce dry weather flows, which provide conditions that promote bacteria growth. Dry weather flows could be from nighttime irrigation of lawns/parks or leaky stormsewer pipes. Dry conditions within stormsewer pipes reduce bacteria survival and growth.
- Investigate ways to reduce biofilm in stormsewer pipes to reduce bacteria survival and growth.

Treatment BMPs

Proper design, installation, and maintenance is of paramount importance for any treatment BMP to be effective at protecting water resources. Consult appropriate resources such as the MN Stormwater Manual (http://stormwater.pca.state.mn.us/index.php/Main_Page) (for urban/residential) and others listed in Appendix B early in the planning stage.

Infiltration/Bioinfiltration

Stormwater infiltration practices capture and temporarily store stormwater before allowing it to infiltrate into the soil. As the stormwater penetrates the underlying soil, chemical, biological, and physical processes remove pollutants and reduce or delay peak stormwater flows. Bioinfiltration systems are basically infiltration systems with an additional biological component such as plants or organic amendments that provide additional pollutant removal from water prior to its infiltration to the subsurface. Infiltration is considered to be up to 100% effective in removing the bacteria loads associated with the infiltrated volume of water. However, because infiltrated water is channeled to the subsurface, infiltration is not recommended in areas where shallow groundwater is used as a drinking water source or in vulnerable wellhead protection areas (WHP) where surface water directly influences an aquifer or public water supply. Please consult with a Minnesota Department of Health (MDH) planner or find their geospatial data at http://www.health.state.mn.us/divs/eh/water/swp/maps/index.htm to determine if a proposed infiltration activity is in a vulnerable Wellhead Protection Area. Note that the Minnesota Pollution Control Agency recognizes that the current guidance in the Minnesota Stormwater Manual(http://stormwater.pca.state.mn.us/index.php/Stormwater_and_wellhead_protection#Guidance_for_practices_not_required_to_meet_requirements_of_the_Construction_Stormwater_General_Permit) needs to be updated on infiltration practices in Drinking Water Supply Management Areas (DWSMA) and is working with MDH on this effort. Both agencies agree that specific site conditions (soil conditions, land uses, etc.) and technical expertise are needed to assess these types of infiltration projects on a case-by-case basis.

- Install infiltration practices at sites with naturally permeable soils and with a minimum of 3 feet separation to the seasonally high groundwater table, bedrock, or other impermeable layer.
- If infiltration is not feasible at a site, consider the use of biofiltration, filter strips, and rooftop disconnection, etc.

Filtration/Biofiltration

Biofiltration and bioinfiltration practices filter sediment out of stormwater and watershed runoff through a medium such as sand, compost, soil, or a combination of these materials. "Biofiltration" indicates that, in addition to the physical "filtration" processes, biological or organic matter processes influence pollutant removal. Biofiltration (including rain gardens with underdrains, swales, sand filters) typically occurs on a smaller scale (5 acres or less), such as landscaping islands, cul-de-sacs, parking lot margins, commercial setbacks, open space, rooftop drainage and boulevards where most of the runoff that enters the BMP flows out through an underdrain. Bioinfiltration (infiltration basins, rain gardens without underdrains, or trenches) are more applicable to regional scales and larger storm events. Bioinfiltration BMPs infiltrate the entire stormwater runoff volume for which they were designed. These BMPs are reported to be up to 35% effective in removing bacteria, but more testing is needed.

- Employ finer-grained media (~15 microns) in the filter bed.
- Remove trapped sediments from filter pretreatment chambers on a more frequent basis during the growing season.
- Consider employing pretreatment chambers that are designed to dry out following storm events.
- Consider amending with organic matter, iron filings, or other verified amendment after consulting literature on the design and performance of these amendments for bacterial removal.

Filter strips/buffers

A buffer is an area of vegetation that is planted between development and waterbodies whose aim is to physically protect and separate the resource from future disturbance or encroachment. A vegetative filter is defined as the removal of sediment, nutrients, or pollutants by plant structures. Vegetative filter strips are strips of vegetation that reduce runoff, sediments, and contaminants by settling, infiltration, or filtration, in addition to reducing the volume of runoff. Filter strips also deter congregation of wildlife by reducing direct access from turfgrass areas to open water. Large filter strips (at least half the size of the contributing drainage area) have been reported to remove up to 92% of bacteria in runoff from feedlots, which is largely due to infiltration. Other studies have reported much lower (~35%) removal rates and, depending on the width of the strip and the underlying soils, even zero-to-negative removal rates when the filter strip primarily acts as a settling rather than an infiltration or filtration practice. Refer to Appendix B for further information on BMP effectiveness. Therefore, if bacterial removal is desired, proper sizing relative to the contributing drainage area should be conducted, and estimation of removal rates should account for the size of the practice and whether it will infiltrate water or only settle out solids.

- Consider designing filter strips around ponds, lakes, and streams/rivers where wildlife, such as geese, congregate or within public areas where dog-walking occurs, especially when impervious sidewalks are located near waterbodies.
- Consider using native plant species for filter strips, and avoid mowing the strips.

<u>Stormwater ponds and constructed wetlands</u>

Stormwater ponds are open water ponds constructed to promote the settling of particles in stormwater and watershed runoff and the storage of water to limit flooding. Constructed wetlands are man-made systems that are engineered to provide settling, transformation, and filtration functions that are similar to natural wetlands, and can thereby be used to treat urban/suburban runoff by removing excess nutrients, sediments, and other pollutants. These BMPs are considered to be between 70-75% effective in removing bacteria if designed properly. However, as with other BMPs that may not provide complete infiltration or filtration treatment prior to discharge to receiving waters, some subtypes within this category may provide little to no treatment, and in some cases may provide opportunities for bacterial production (e.g., wet ponds with overflows). Therefore, a review of different options and associated studies of bacterial removal is advised (See Appendix B).

- Note: ponds that dry out between storm events (i.e. dry ponds) function better for bacteria removal than wet ponds.
- Limit overflows. Design inlet and outlet structures to prevent bacteria-laden sediment from being re-suspended and exported during storm events.
- Lengthen the flow path for longer detention times (2-5 days for settling is optimal).
- Add shallow benches to wetlands and ponds to enhance the plankton and microbial community for enhanced predation of bacteria.

Rural Subwatersheds

Based on a desktop analyses developed and conducted specifically for this TMDL, the most likely sources of bacteria in rural subwatersheds come from manure that is spread without incorporation, to a lesser extent from feedlot runoff and manure from pastures, and in some areas humans (e.g. failing SSTS). Wildlife and pets may also be a source. It should be noted that due to the scale of the desktop analysis it does not account for the entire range of potential bacteria sources such as livestock with direct access to streams.

Source Controls

<u>Reduce direct sources of bacteria from livestock</u>

Livestock exclusion from waterbodies and streambanks eliminates a direct source of bacteria and nutrients to waterbodies from animal wastes.

- Identify pastures and grazing lands that have access to streams and waterbodies.
- Work with landowners to exclude animals from or limit access to streams and rivers using fences or other exclusion methods.
- Provide livestock with an alternate water supply source away from the stream and shade to reduce stream access.
- Implement pasture management techniques that promote protection of well-maintained and rotated pastures.
- Evaluate and improve county feedlot site inspections and permit review as needed to reduce run-off as part of new or expanding feedlot operations.
- Evaluate the need for increased technical assistance to feedlot operators located in the impaired watershed.
- Identify feedlots within designated shoreland areas and evaluate them for potential run-off and technical assistance.
- Improve State/local enforcement of State feedlot, manure storage and manure application requirements specified in State Feedlot Rules Chapter 7020 and State Shoreland Rules 6120.

Reduce manure runoff

- Manure can be managed and treated in a number of ways to reduce the risk of bacteria from being transported to waterbodies, such as composting, lime stabilization, and/or anaerobic/aerobic treatments.
- When applying manure to the soil, it should be incorporated or injected into the ground, rather than applied directly to the soil surface, to prevent runoff during rain events or snowmelt.
- Manure application should only be conducted on non-frozen ground.
- Cover crops can also prevent/reduce bacteria-laden runoff from fields.
- Residue management should be used in combination with manure management.
- Reduce runoff from feedlots by installing structures and practices to reduce runoff containing bacteria.
- Filter strips around feedlots can also prevent bacteria from being released from the site. Proper sizing of filter strips relative to the contributing drainage area should be conducted, and estimation of removal rates should account for the size of the practice and whether it will infiltrate water or only settle out solids..
- Evaluate the review process used for manure management plans particularly in areas near tributaries draining to or into the receiving stream.
- Inspect the on-site implementation of manure management plans by producers, particularly in areas near tributaries draining to or into the receiving stream.
- MPCA and County Feedlot delegated programs should evaluate State Feedlot Rules Chapter 7020 feedlot and manure management compliance and needs to reduce run-off.
- Evaluate local land use controls, setbacks and permitting of new and expanding feedlots in areas draining to tributaries or into the receiving stream.
- Hold education/field day or training events for producers on opportunities to improve manure management and reduce run-off.
- Evaluate/target/monitor field tile surface inlets, outlets and drainage ditches for transport of manure from fields to impaired stream.
- Work with growers and promote improved manure utilization through using the right rate, timing, and placement of manure in relation to the crop grown.

Reduce human sources of bacteria

- Update and enforce SSTS ordinances.
- Provide landowners with information about what constitutes a compliant septic system and opportunities to replace failed systems.
- Implement higher standards for setbacks for installing SSTS near waterbodies.
- Develop, implement, and enforce septage land application ordinances.

Treatment BMPs

All of the treatment BMPs described in the previous urban section are also applicable in rural areas. As noted above, reducing the source of the bacteria should be conducted first when possible.

Feedlot runoff control

Feedlot runoff control uses a system of structures and practices to reduce runoff containing bacteria and nutrients, thereby protecting waterbodies from such contaminants. The system collects, stores, and treats manure and feed wastes from feedlots, as well as conserves manure to be used for fertilizers. Feedlot runoff control includes clean runoff water diversion structures and feedlot/wastewater filter strips around the perimeter of the feedlots. When implemented properly, this control method will reduce bacteria in runoff by 100%. The use of proper nutrient management techniques in conjunction with feedlot runoff control is critical.

- Install clean runoff water diversion channels across slopes to prevent rainwater from entering the feedlot area.
- Install filter strips around feedlots to reduce runoff.

Filter strips: Cropland and Pasture Control

Filter strips/ buffers are areas of vegetation that are planted between cropland, and/or pastures to reduce contaminants in runoff. Filter strips reduce up to 92% of bacteria in runoff. Filter strips can be in the form of vegetated buffers or swales. Refer to Appendix B for further information on filter strip effectiveness.

- Install filter strips around all ditches and waterways that connect to streams or other waterbodies. Filter strips should be 15-30 feet wide to be most effective at reducing bacteria levels.

Detention and retention ponds

Sedimentation ponds, also called detention, retention, or stormwater ponds, are open water ponds constructed to allow the settling of particles in stormwater and watershed runoff and the storage of water to limit flooding. Sedimentation ponds are constructed with an engineered outlet, and can be used in both agricultural and urban settings on a temporary or permanent basis. When trapping sediment that is contaminated with bacteria, these ponds can reduce bacteria loading into waterbodies by up to 70%. Refer to Appendix B for further information on pond effectiveness.

- Maintain ponds periodically to remove sediments.
- Deter wildlife from congregating on ponds.

Subwatersheds

The following subwatershed sections describe the approach to determining bacteria sources and contributing areas, the TMDL reductions by flow regime, and implementation strategies for reducing bacteria. Maps depicting implementation priority areas are provided for each subwatershed but due to the scale of mapping can be difficult to read. Electronic versions of the maps and the GIS data used to produce them are available upon request from the MPCA. Flow regimes are used in stream TMDLs to differentiate the pollutant loading that occurs across the range of stream flows. The implementation strategies are specific to each subwatershed and address the relative magnitude of practices to meet the TMDL bacteria reduction goals. While the initial estimate for implementing the Upper Mississippi River Bacteria TMDL in the TMDL Subwatersheds is approximately $36 million to $144 million, as specific practices were identified for each subwatershed, it may be that this initial cost estimate overestimated the need. However, we did not include operation and maintenance costs in either estimate. Note, costs for BMPs are provided on a unit basis to provide a general idea of costs for implementing specific BMPs. Total implementation costs have not been calculated for each subwatershed due to local preferences of BMPs and suitability/feasibility of specific BMPs within each subwatershed.

Little Two River (07010201-516) Subwatershed

Reach Description: Headwaters to Mississippi River

Little Two River is a tributary of the Mississippi River which is impaired for aquatic recreation due to *E. coli*. The subwatershed is located within Priority Area B of the St Cloud Source Water Protection Area (Figure 2). Monitoring conducted in 2010 and 2011 indicated elevated levels of *E. coli* throughout the growing season with exceedances of the water quality standard occurring in every month with at least five samples from April through October except April. *E. coli* counts ranged from 4 to 2,420 org/100 ml and monthly geometric means ranged from 30 to 834 org/100 ml (a summary of water quality monitoring data can be found in Appendix D of the TMDL Study). Plotting *E. coli* levels against stream flow, as is shown in the load duration curves in Figure 6.7 on page 117 of the TMDL Study, show that exceedances occur at all flow conditions (e.g. high, moist, mid, dry, low) where there is monitoring data.

Production of *E. coli* in Subwatershed

As described in the TMDL Study and in Table 3 below, the Total Maximum Daily Load for Little Two River is divided into point (permitted) sources and nonpoint (non-permitted) sources. In the Little Two River Subwatershed, the Upsala Wastewater Treatment Facility is the only point source of *E. coli*. For nonpoint sources, the majority of the land in this subwatershed is in agricultural use (Table 2).

Table 2. Little Two River Subwatershed Land uses

Land use	%
Cultivated Crops	48%
Pasture / Hay	38%
Deciduous Forest	5%
Developed Open Space	4%
Woody Wetlands	2%
Evergreen Forest	2%
Emergent Herbaceous Wetland	2%
Table only includes land uses that are > 1% of the land area	

In developing the TMDL Study a desktop analysis was conducted to determine the potential sources of *E. coli* within each subwatershed and estimate the relative contribution of each source. The process, referred to as a bacteria source assessment, is described in Section 4 of the TMDL Study beginning on page 44. In the Little Two River Subwatershed the vast majority of the *E. coli* is likely produced from livestock with slight contributions from humans and from pets and wildlife (Figure 5). Further analysis of livestock numbers suggest that poultry is the type of livestock that produces the most *E. coli* in this subwatershed (Figure 5). The fraction of *E. coli* from various sources of livestock in the pie chart is determined by the total animal units estimated within the subwatershed and takes into account the size discrepancy of the various types of livestock as well as the differences in the amount of bacteria within their waste.

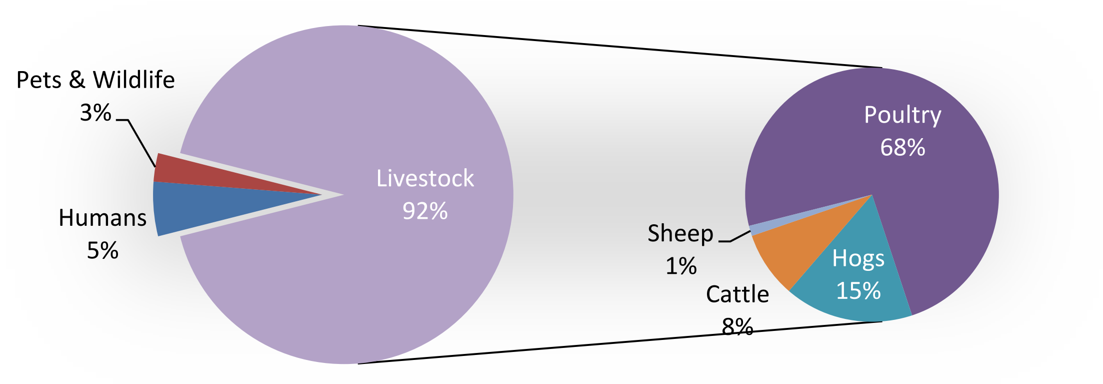

Figure 5. Bacteria production in the Little Two River Subwatershed

As another tool, a Microbial Source Tracking (MST) analysis was conducted as part of this TMDL Study. MST analysis relies on the genetic coding, or markers, found within bacteria samples to determine the source of the bacteria. In the Little Two Rivers Subwatershed the MST analysis found human/pet markers (note this marker is more indicative of a human source) in the storm event sample that was taken in June 2011 but not in the baseflow sample that was taken in September 2011. Both water samples were also tested for swine and cattle markers but these markers were not present in the water samples on those dates. Due to the nature of bacteria caution must be exercised with use of the MST findings. The analysis cannot be used to conclusively dismiss any given source of bacteria. The MST findings can only be applied to the source of bacteria found in that specific sample of water.

Sources Contributing *E. coli* to the Stream Reach

In addition to determining the relative magnitude of *E. coli* sources within the watershed it is important to consider the factors that lead to the *E. coli* being delivered to the stream. The second step in the bacteria source assessment is to evaluate the connection between *E. coli* production, how it is handled on the landscape and how it is ultimately delivered to the stream. In the case of the Little Two River Subwatershed, where poultry is identified as the main potential bacteria source, the primary activity by which the bacteria becomes available to wash into the stream is through manure application to fields where the manure is not immediately incorporated into the soil (Figure 6). Other mechanisms include runoff from feedlots (that do not have adequate controls), failing septic systems (SSTS) and from animals on pasture.

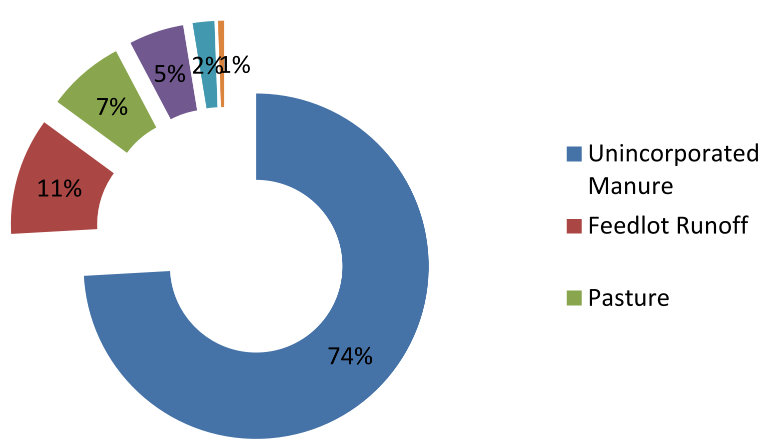

Figure 6. Estimated Percentage of Potential Sources Contributing Bacteria to the Little Two River

Potential *E. coli* Contributing Areas

The final step in the bacteria source assessment methodology developed for the TMDL Study was to determine which areas within the subwatershed have the highest potential to contribute *E. coli* to the stream. In agricultural subwatersheds the areas that have the highest potential to contribute *E. coli* to the stream are areas immediately adjacent to or hydrologically connected to streams where manure is applied or where animals are grazing. Refer to Figure 7 for the map of areas within the Little Two River Subwatershed that have a high potential to contribute bacteria to the stream. These areas should be prioritized for implementation activities. The Priority Implementation Area in Figure 7 was determined by calculating a delivery factor that accounts for fate and transport factors such as proximity to surface waters, slope, imperviousness, and discharge to lakes prior to discharge to stream networks (refer to Section 4.2.6 of the TMDL Study for more specific information on how the delivery factor and Priority Implementation Area was calculated).

TMDL Allocations and Percent Reductions

Wasteload and load allocations for this subwatershed and the calculated percent reductions needed to meet the TMDL are summarized in Table 3. Allocations indicate a sizable decrease needed for bacteria in runoff under moist, mid-range, and dry flow conditions in the Little Two River Subwatershed. There was insufficient data to determine the existing load in low flow conditions. The maximum percent reduction of bacteria load needed is 86%.

Table 3. Little Two River Subwatershed TMDL and Percent Reductions Needed

Flow Regime	Existing Load (billion org/d)	Waste Load Allocations			LA (billion org/d)	MOS (billion org/d)	TMDL (billion org/d)	LA + MS4 WLA (billion org/d)	Estimated Reduction in Watershed Runoff (%)
		WWTFs (Total) (billion org/d)	Straight Pipes (billion org/d)	MS4 (billion org/d)					
High	72.3	3.03	–	–	82.5	9.5	95	82.5	0%
Moist	136	3.03	–	–	36.9	4.44	44.4	36.9	73%
Mid-Range	55	3.03	–	–	22	2.78	27.8	22	60%
Dry	93.5	3.03	–	–	13.2	1.8	18	13.2	86%
Low	ID	3.03	–	–	5.91	0.993	9.93	5.91	ID

Key: WWTF-Waste Water Treatment Facility, MS4-Municipal Separate Storm Sewer System, MOS-Margin of Safety, LA-Load Allocation, org-organisms, d-day, ID–Insufficient Data, IDUL-Impairment due to upstream load, EQN–Based on the equation found on page 104 in the TMDL Study, WLA–Waste Load Allocation

Regulated Entities

The regulated entities within this subwatershed are shown in Table 4

Table 4. Regulated Entities within the Little Two River Subwatershed

Regulated Entity	Permit #
Upsala WWTF	MNG580053

Implementation Plan

The findings of the bacteria source assessment suggest that application of poultry manure that is not appropriately incorporated into the soils is the largest of the likely *E. coli* sources to the Little Two River. Specifically, land immediately surrounding Little Two River has been assessed as a high risk area for surface applied manure. Based on the source assessment and the TMDL the **target goal is up to an 86% reduction** of bacteria for this subwatershed. In other flow regimes the target goal is lower. The following is the magnitude of reductions to the major potential sources of bacteria that would be necessary within the watershed to meet the 86% goal. Given this level of reduction it will likely take 20+ years of active management for the Little Two River to meet water quality standards for *E. coli*.

- Eliminate 90% of the bacteria coming from manure that is not appropriately incorporated into the soil.
- Eliminate 90% of the bacteria coming from feedlots with inadequate controls.
- Eliminate 100% of the SSTS that are an imminent threat to public health by bringing septic systems into compliance with standards.
- Eliminate 70% of the bacteria load from grazing livestock.
- Ensure that the Upsala WWTF (MNG580053) maintains its permitted maximum discharge of 3.03 billion organisms/day.

Priority Actions

As a result of the analyses for bacteria sources and contributing areas, the primary focus of implementation for this subwatershed will be to prevent unincorporated manure from reaching the stream. This can be done by land application with incorporation or by treating manure prior to land application.

There are likely other contributors of bacteria that may not have been captured in the analyses above due to a lack of documentation. Specifically, identifying and reducing direct sources of bacteria is a primary step in this implementation plan. For example, livestock that have access to streams is a direct source of bacteria. Below are the priority actions that are recommended for the subwatershed.

- Identify and map potential and known sources that are directly contributing bacteria to waterbodies (e.g. areas where livestock have access to streams), using local knowledge; windshield surveys, interviews with landowners, etc. Note that mapping sources is a distinct activity from monitoring.
- Continue baseline monitoring of the stream reach and add additional monitoring stations along the stream reach and tributaries to help pinpoint potential sources of bacteria. Refer to the monitoring section for further recommendations.
- Promote the use of manure injection or incorporation of manure on all land where manure is applied. Target land areas near the stream and ditches and tile intakes first.
- Promote good manure application and treatment practices such as:
    - Applying manure to relatively dry fields;
    - Avoiding steep sloping areas;
    - Avoiding areas near water bodies;
    - Avoiding vulnerable locations for spreading manure;
    - Avoiding areas prone to flooding;
    - Avoiding applying on frozen soil.

- Install filter strips around fields, especially where streams are present, to prevent bacteria-laden runoff from reaching streams. Filter strips around fields are recommended to be 15-30 feet wide.
- Implement and enforce feedlot runoff controls, including filter strips around animal confinement areas (65-100 feet wide).
- Ensure that all local feedlot, SSTS, septage and pet-waste ordinances within the subwatershed are stringent enough so that rivers and streams will meet State water quality standards.
- Ensure that ordinances are enforced, through regular inspection and monitoring.
- Conduct education and outreach to ensure that ordinances and BMPs are understood and followed.

Addressing additional sources within the Little Two River Subwatershed that are likely contributing *E. coli* to a lesser degree are also included in the implementation plan since the needed reduction is high in this subwatershed (see Rural Subwatersheds for more information). Table 5 lists the priority actions described above along with a recommended timeframe for implementation and estimated costs. The timeframe that is provided is a timeframe based on priority of implementation, and efforts will likely be ongoing once the action has been implemented. Action items are listed in order of importance. Also included in Table 5 are priority actions that are simply good practices to follow in all subwatersheds regardless of the magnitude of the source/activity they address. Note that some of these practices may have already been initiated within the subwatershed; if that is the case, continue with them and enhance them where necessary. Note that the costs are provided for context and not as an estimate of the total expenditure needed to meet any specified reduction in bacteria.

Refer to Appendix A for the entities responsible for implementing source controls and treatment BMPs in this subwatershed.

Table 5. Priority actions for Little Two River Subwatershed

Priority Timeframe[1]	Action	Estimated Effectiveness of Practice[2] (up to)	Estimated Magnitude in Watershed	Implementation Cost[3]
High	Promote land application of manure with incorporation Land application w/ incorporation	70%	5,000 – 8,500 acres of cultivated cropland	$12/acre
High	Promote good manure application and treatment practices (see text above) Manure Management	Varies by practice	5,000 – 8,500 acres of cultivated cropland	NA
High	Limit livestock from accessing streams/waterbodies by fencing or providing alternative water source Livestock Stream Access Control	100%	Unknown	$0.70-1.50/ linear feet of fencing $3-6/ cu yard to construct a pond as an alternative water source

Priority Timeframe[1]	Action	Estimated Effectiveness of Practice[2] (up to)	Estimated Magnitude in Watershed	Implementation Cost[3]
High	Conduct septic system inspections as warranted and bring all imminent threat to public health septic systems into compliance with standards Septic (SSTS) Maintenance	100%	~ 36 systems	$200-300 (inspection) $7,500 per system (if replacement required)
High	Install vegetated buffers around fields where manure is applied as well as grazed lands Filter Strips	92%	~78 acres (assumed 16 miles of stream; 20 ft buffer)	$600-1000/acre
High	Implement feedlot runoff control and manure management at existing feedlots Feedlot Runoff Control	100%	~2,100 Animal Units (AU)	$8-24/AU
Medium	Ensure that all local feedlot, SSTS, septage and pet-waste ordinances within the subwatershed are enforced through regular inspection and monitoring and are stringent enough so that rivers and streams will meet State water quality standards. Federal, State, and Local Requirements	100%	NA	Staff time
Medium	Conduct education and outreach to ensure that ordinances and BMPs are understood and followed. Outreach/Education	100%	NA	Staff time
Medium	Identify and map any location with potential bacteria sources Monitoring	NA	NA	Staff time
Medium	Conduct outreach to producers to promote manure management practices that prevent the release of and/or treat manure to reduce bacteria concentrations Outreach/Education	NA	NA	Staff time
Medium	Septage application should be incorporated (follow guidelines found in the MPCA guidance document Septage Removal and Disposal) Septage	70%	5,000 – 8,500 acres of cultivated cropland	$12/acre

Priority Timeframe[1]	Action	Estimated Effectiveness of Practice[2] (up to)	Estimated Magnitude in Watershed	Implementation Cost[3]
Medium	Adopt and enforce strict septic ordinances Septic (SSTS) Maintenance	100%	NA	$0
Low	Regularly monitor stream and inspect all significant sources that have the potential to release bacteria Monitoring	NA	NA	Staff time

[1] Priority is based on recommended timeframe to continue or start (not complete) implementation activities: High = 1-2 years, Medium = 2-5 years, Low = 5-10 years.
[2] Estimated effectiveness of practice refers to the reduction of bacteria concentrations in runoff to receiving waterbodies.
[3] Costs based on NRCS EQIP Payment Schedules
http://www.nrcs.usda.gov/wps/portal/nrcs/detail/mn/programs/financial/?cid=stelprdb1245512

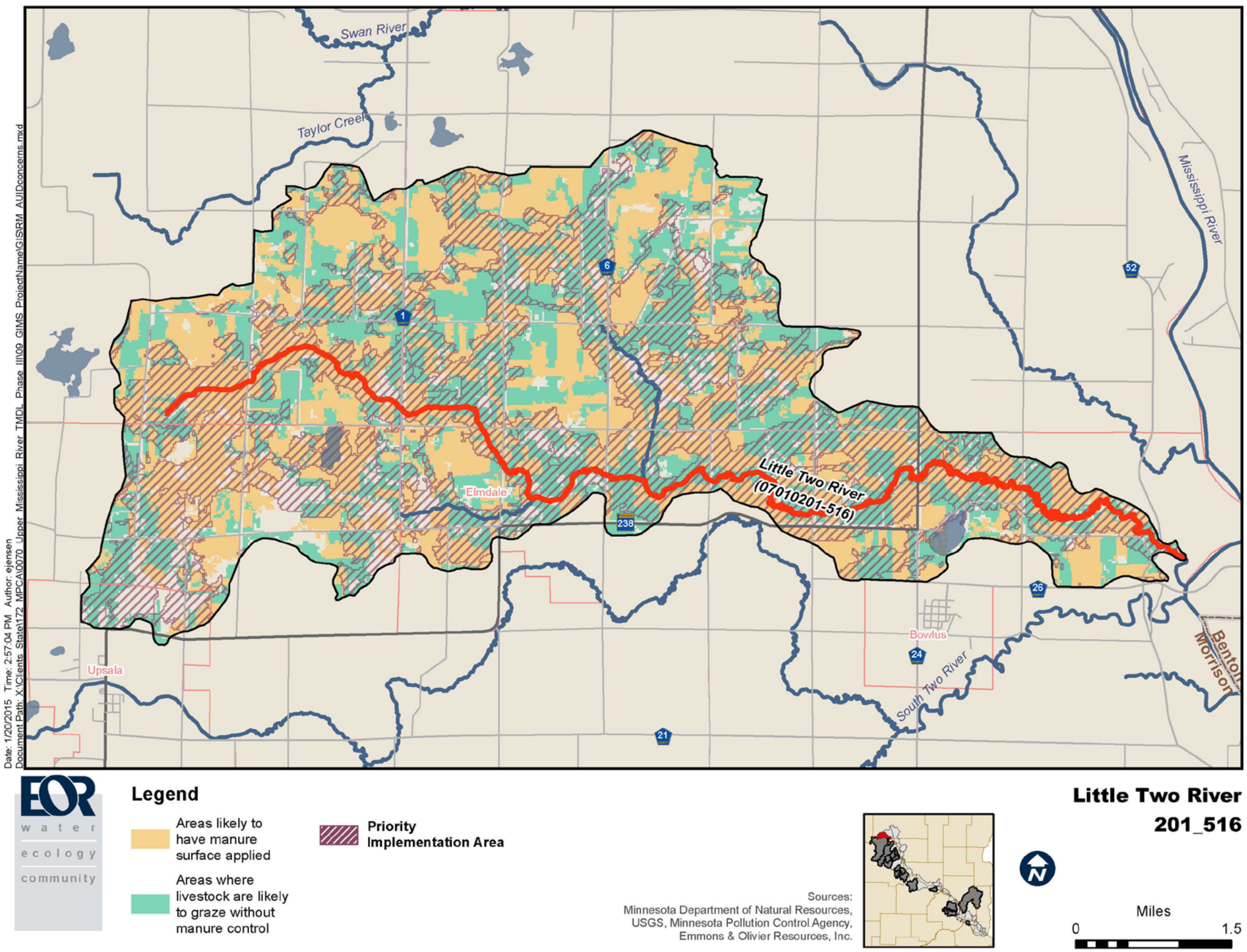

Figure 7. Areas with highest risk for transport of bacteria into streams and rivers to be targeted for initial implementation (hatched areas). Refer to Potential E. coli Contributing Areas for information on how the Priority Implementation Areas were determined.

Two River (07010201-523) Subwatershed

Reach Description: North & South Two River to Mississippi River

Two River, a tributary of the Mississippi River, is impaired for aquatic recreation due to *E. coli*. The subwatershed is located within Priority Area B of the St Cloud Source Water Protection Area (Figure 2). Monitoring conducted in 2010 and 2011 indicated elevated levels of *E. coli* throughout the growing season with exceedances of the water quality standard occurring in every month with at least five samples from April through October except April and July. *E. coli* counts ranged from 4 to 2,400 org/100 ml and monthly geometric means ranged from 13 to 395 org/100 ml (a summary of water quality monitoring data can be found in Appendix D of the TMDL Study). Plotting *E. coli* levels against stream flow, as is shown in the load duration curves in Figure 6.8 on page 118 of the TMDL Study, show that exceedances occur at all flow conditions (e.g. high, moist, mid, dry, low) where there is monitoring data.

Production of *E. coli* in Subwatershed

As described in the TMDL Study and in Table 7 below, the Total Maximum Daily Load for Two River is divided into point (permitted) sources and nonpoint (non-permitted) sources. In the Two River Subwatershed, point sources of *E. coli* are limited to the MS4s (Table 8). For nonpoint sources, the majority of the land in this subwatershed is in agricultural use (Table 6).

Table 6. Two River Subwatershed Land uses

Land use	%
Pasture / Hay	39%
Cultivated Crops	38%
Deciduous Forest	10%
Developed Open Space	5%
Emergent Herbaceous Wetland	4%
Woody Wetlands	2%
Table only includes land uses that are > 1% of the land area	

In developing the TMDL Study a desktop analysis was conducted to determine the potential sources of *E. coli* within each subwatershed and estimate the relative contribution of each source. The process, referred to as a bacteria source assessment, is described in Section 4 of the TMDL Study beginning on page 44. In the Two River Subwatershed the vast majority of the *E. coli* is likely produced from livestock with slight contributions from humans and from pets and wildlife (Figure 8). Further analysis of livestock numbers suggest that poultry is the type of livestock that produces the most *E. coli* in this subwatershed (Figure 8). The fraction of *E. coli* from various sources of livestock in the pie chart is determined by the total animal units estimated within the subwatershed and takes into account the size discrepancy of the various types of livestock as well as the differences in the amount of bacteria within their waste.

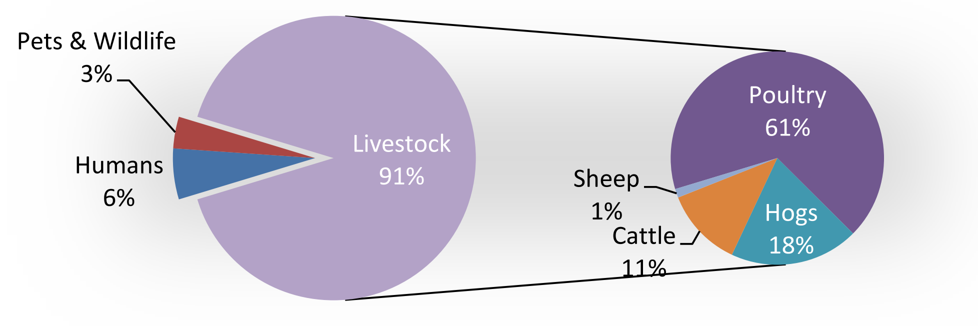

Figure 8. Bacteria production in the Two River Subwatershed

As another tool, a Microbial Source Tracking (MST) analysis was conducted as part of this TMDL Study. MST analysis relies on the genetic coding, or markers, found within bacteria samples to determine the source of the bacteria. In the Two River Subwatershed the MST analysis found cattle markers in the storm event sample that was taken in June 2011 but not in the baseflow sample that was taken in September 2011. Both water samples were also tested for swine and human/pet markers but these markers were not present in the water samples on either of those dates. Due to the nature of bacteria caution must be exercised with use of the MST findings. The analysis can not be used to conclusively dismiss any given source of bacteria. The MST findings can only be applied to the source of bacteria found in that specific sample of water.

Sources Contributing *E. coli* to the Stream Reach

In addition to determining the relative magnitude of *E. coli* sources within the watershed it is important to consider the factors that lead to the *E. coli* being delivered to the stream. The second step in the bacteria source assessment is to evaluate the connection between *E. coli* production, how it is handled on the landscape and how it is ultimately delivered to the stream. In the case of the Two River Subwatershed, where poultry is identified as the main potential bacteria source, the primary activity by which the bacteria becomes available to wash into the stream is through manure application to fields where the manure is not immediately incorporated into the soil (Figure 9). Other mechanisms include runoff from feedlots (that do not have adequate controls) and from animals on pasture.

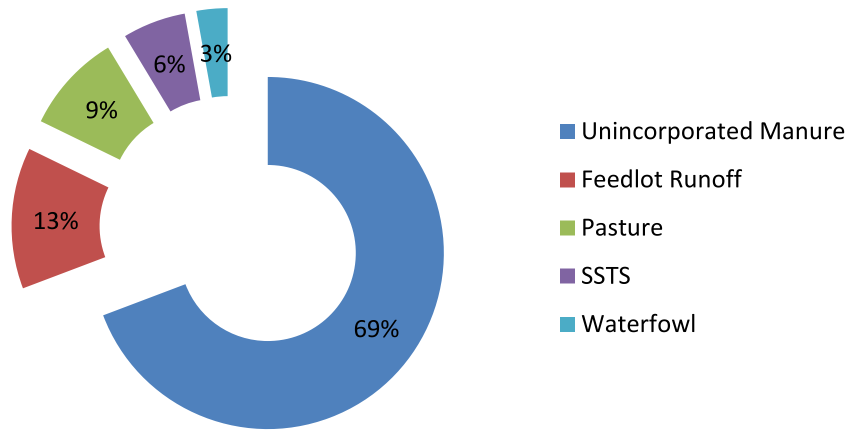

Figure 9. Estimated Percentage of Potential Sources Contributing Bacteria to Two River

Potential *E. coli* Contributing Areas

The final step in the bacteria source assessment methodology developed for the TMDL Study was to determine which areas within the subwatershed have the highest potential to contribute *E. coli* to the stream. In agricultural subwatersheds the areas that have the highest potential to contribute *E. coli* to the stream are areas immediately adjacent to or hydrologically connected to streams where manure is applied or where animals are grazing. Refer to Figure 10 for the map of areas within the Two River Subwatershed that have a high potential to contribute bacteria to the stream. These areas should be prioritized for implementation activities. The Priority Implementation Area in Figure 10 was determined by calculating a delivery factor that accounts for fate and transport factors such as proximity to surface waters, slope, imperviousness, and discharge to lakes prior to discharge to stream networks (refer to Section 4.2.6 of the TMDL Study for more specific information on how the delivery factor and Priority Implementation Area was calculated).

TMDL Allocations and Percent Reductions

Wasteload and load allocations for this subwatershed and the calculated percent reduction needed to meet the TMDL are summarized in Table 7. Load allocations indicate a sizable decrease needed for bacteria in runoff under moist, mid-range and dry flow conditions in the Two River Subwatershed. The maximum percent reduction of bacteria load needed is 94%.

Table 7. Two River Subwatershed TMDL and Percent Reductions Needed

Flow Regime	Existing Load (billion org/d)	Waste Load Allocations: WWTFs (Total) (billion org/d)	Waste Load Allocations: Straight Pipes (billion org/d)	Waste Load Allocations: MS4 (billion org/d)	LA (billion org/d)	MOS (billion org/d)	TMDL (billion org/d)	LA + MS4 WLA (billion org/d)	Estimated Reduction in Watershed Runoff (%)
High	169	–	–	0.274	29.4	3.3	33	29.7	82%
Moist	239	–	–	0.133	14.3	1.6	16	14.4	94%
Mid-Range	IDUL	–	–	0.0832	8.92	1	10	9	0%
Dry	IDUL	–	–	0.0549	5.89	0.66	6.6	5.94	0%
Low	ID	–	–	0.0291	3.12	0.35	3.5	3.15	ID

Key: WWTF-Waste Water Treatment Facility, MS4-Municipal Separate Storm Sewer System, MOS-Margin of Safety, LA-Load Allocation, org-organisms, d-day, ID-Insufficient Data, IDUL-Impairment due to upstream load, EQN-Based on the equation found on page 104 in the TMDL Study, WLA-Waste Load Allocation

Regulated Entities

The regulated entities within this subwatershed are shown in Table 8.

Table 8. Regulated Entities within the Two River Subwatershed

Regulated Entity	Permit #
Brockway Township	MS400068

Implementation Plan

The findings of the bacteria source assessment suggest that application of poultry manure that is not appropriately incorporated into the soils is the largest of the likely *E. coli* sources to the Two River Subwatershed. Specifically, land immediately surrounding Two River has been assessed as a high risk area for surface applied manure. Based on the source assessment and the TMDL the **target goal is up to a 94% reduction** of bacteria for this subwatershed. In other flow regimes the target goal is lower. The following is the magnitude of reductions to the major potential sources of bacteria that would be necessary within the watershed to meet the 94% goal. Given this level of reduction it will likely take 20+ years of active management for the Two River to meet water quality standards for *E. coli*.

- Eliminate 95% of the bacteria coming from manure that is not appropriately incorporated into the soil.
- Eliminate 95% of the bacteria coming from feedlots with inadequate controls.
- Eliminate 100% of the SSTS that are an imminent threat to public health by bringing septic systems into compliance with standards.
- Eliminate 70% of the bacteria load from grazing livestock.
- Eliminate 92% of the bacteria load from waterfowl and wildlife.

Priority Actions

As a result of the analyses for bacteria sources and contributing areas, the primary focus of implementation for this subwatershed will be to prevent unincorporated manure from reaching the stream and to reduce runoff from feedlots. This can be done by land application with incorporation or by treating manure prior to land application and implementing feedlot runoff controls, respectively.

There are likely other contributors of bacteria that may not have been captured in the analyses above due to a lack of documentation. In many cases, local knowledge of bacteria sources may provide superior guidance for determining how to reduce bacteria loading to impaired stream reaches. Addressing additional sources within the Two River Subwatershed that are likely contributing *E. coli* to a lesser degree are also included in the implementation plan since the needed reduction is high in this subwatershed (see Rural Subwatersheds for more information). Below are the priority actions that are recommended for the Two River subwatershed.

- Identify and map potential and known sources that are directly contributing bacteria to waterbodies using local knowledge, windshield surveys, and interviews with landowners, etc. Note that mapping sources is a distinct activity from monitoring.
- Continue baseline monitoring of the stream reach and add additional monitoring stations along the stream reach and tributaries to help pinpoint potential sources of bacteria. Refer to the monitoring section for further recommendations.
- Reduce direct sources of bacteria, such as livestock that have access to streams, installing fences around streams within pastures, or providing water sources within pastures to reduce the frequency of livestock from entering streams.
- Promote the use of manure injection or incorporation of manure on all land where manure is applied. Target land areas near the stream and ditches and tile intakes first. Alternatively, treat manure to reduce bacteria concentrations prior to land application.
- Promote good manure application and treatment practices such as:
    - Applying manure to relatively dry fields;
    - Avoiding steep sloping areas;
    - Avoiding areas near water bodies;
    - Avoiding vulnerable locations for spreading manure;
    - Avoiding areas prone to flooding;
    - Avoiding applying on frozen soil.
- Install filter strips around fields, especially where streams are present, to prevent bacteria-laden runoff from reaching streams. Filter strips around fields are recommended to be 15-30 feet wide.
- Implement and enforce feedlot runoff controls, including filter strips around animal confinement areas (65-100 feet wide).
- Ensure that all local feedlot, SSTS, septage and pet-waste ordinances within the subwatershed are stringent enough so that rivers and streams will meet State water quality standards.
- Ensure that ordinances are enforced, through regular inspection and monitoring.
- Conduct septic inspections and make sure all systems that are imminent threats are brought into compliance.
- Conduct education and outreach to ensure that ordinances and BMPs are understood and followed.
- Ensure septage application is in compliance with state laws and local ordinances.

Table 9 lists the priority actions described above along with a recommended timeframe for implementation and estimated costs. The timeframe that is provided is based on priority of implementation, and efforts will likely be ongoing once the action has been implemented. Action items are listed in order of importance. Also included in Table 9 are priority actions that are simply good practices to follow in all subwatersheds regardless of the magnitude of the source/activity they address. Note that some of these practices may have already been initiated within the subwatershed; if that is the case, continue with them and enhance them where necessary. Note that the costs are provided for context and not as an estimate of the total expenditure needed to meet any specified reduction in bacteria.

Refer to Appendix A for the entities responsible for implementing source controls and treatment BMPs in this subwatershed.

Table 9. Priority actions for Two River Subwatershed

Priority Timeframe[1]	Action	Estimated Effectiveness of Practice[2] (up to)	Estimated Magnitude in Watershed	Implementation Cost[3]
High	Limit livestock from accessing streams/waterbodies by fencing or providing alternative water sources Livestock Stream Access Control	100%	Unknown	$0.70-1.50/ linear feet of fencing $3-6/ cu yard to construct a pond as an alternative water source
High	Promote land application of manure with incorporation Land application w/ incorporation	70%	500 – 2,500 acres of cultivated cropland	$12/acre
High	Promote good manure application and treatment practices (see text above) Manure Management	Varies by practice	500 – 2,500 acres of cultivated cropland	NA
High	Implement feedlot runoff control and manure management at existing feedlots Feedlot Runoff Control	100%	~800 Animal Units (AU)	$8-24/AU
High	Install vegetated buffers around fields where manure is applied as well as grazed lands Filter Strips	92%	~30 acres (assumed 6 miles of stream; 20ft buffer)	$600-1000/acre
Medium	Ensure that all local feedlot, SSTS, septage and pet-waste ordinances within the subwatershed are enforced through regular inspection and monitoring and are stringent enough so that rivers and streams will meet State water quality standards. Federal, State, and Local Requirements	100%	NA	Staff time

Priority Timeframe[1]	Action	Estimated Effectiveness of Practice[2] (up to)	Estimated Magnitude in Watershed	Implementation Cost[3]
Medium	Conduct education and outreach to ensure that ordinances and BMPs are understood and followed.	100%	NA	Staff time
Medium	Identify and map any location with potential bacteria sources Monitoring	NA	NA	Staff time
Medium	Adopt and enforce strict septic ordinances Septic (SSTS) Maintenance	100%	NA	Staff time
Medium	Conduct septic system inspections as warranted and bring septic systems into compliance with standards Septic (SSTS) Maintenance	100%	~ 15 systems	$200-300 (inspection) $7,500 per system (for replacement)
Medium	Conduct outreach to producers to promote manure management practices that prevent the release of and/or treat manure to reduce bacteria concentrations Outreach/Education	NA	NA	Staff time
Medium	Septage application should be incorporated (follow guidelines found in the MPCA guidance document Septage Removal and Disposal) Septage	70%	500 – 2,500 acres of cultivated cropland	$12/acre
Low	Regularly monitor stream and inspect all significant sources that have the potential to release bacteria Monitoring	NA	NA	Staff time

[1] Priority is based on recommended timeframe to continue or start (not complete) implementation activities: High = 1-2 years, Medium = 2-5 years, Low = 5-10 years.
[2] Estimated effectiveness of practice refers to the reduction of bacteria concentrations in runoff to receiving waterbodies.
[3] Costs based on NRCS EQIP Payment Schedules
http://www.nrcs.usda.gov/wps/portal/nrcs/detail/mn/programs/financial/?cid=stelprdb1245512

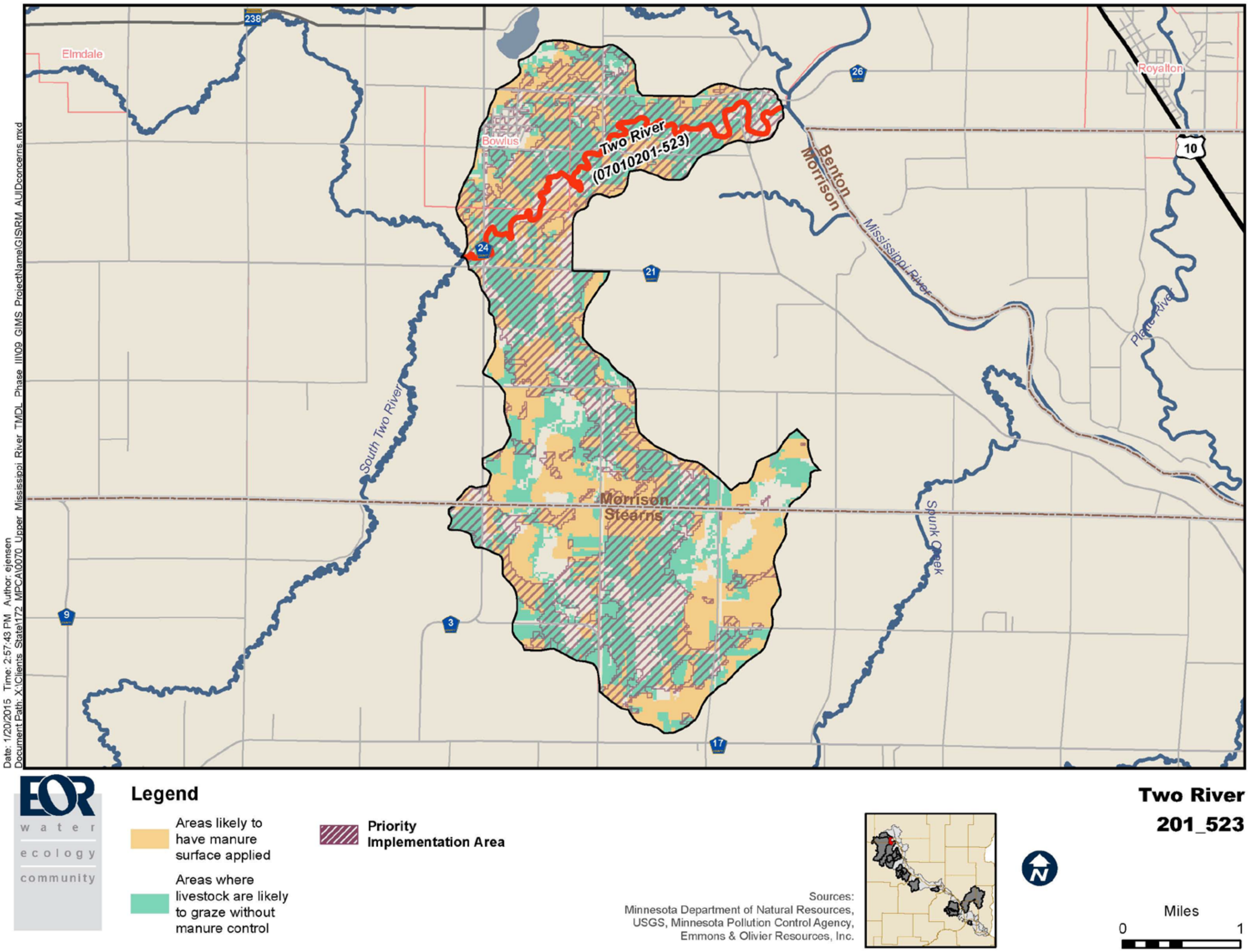

Figure 10. Areas with highest risk for transport of bacteria into streams and rivers to be targeted for initial implementation (hatched areas). Refer to Potential E. coli Contributing Areas to determine how Priority Implementation Areas were determined.

Spunk Creek (07010201-525) Subwatershed

Reach Description: Lower Spunk Lake to Mississippi River

Spunk Creek is a tributary of the Mississippi River and the subwatershed is located within Priority Area B of the St Cloud Source Water Protection Area (Figure 2). Spunk Creek is impaired for aquatic recreation due to fecal coliform data collected in 2008. Monitoring conducted in 2010 and 2011 indicated elevated levels of *E. coli* throughout the growing season with exceedances of the water quality standard occurring in every month with at least five samples from April through October except April and May. *E. coli* counts ranged from 6 to 2,400 org/100 ml and monthly geometric means ranged from 15 to 1,250 org/100 ml (a summary of water quality monitoring data can be found in Appendix D of the TMDL Study). Plotting *E. coli* levels against stream flow, as is shown in the load duration curves in Figure 6.9 on page 119 of the TMDL Study, show that exceedances occur at all flow conditions (e.g. high, moist, mid, dry, low) where there is monitoring data. Note the TMDL does not require reductions under high flow conditions (Table 11).

Production of *E. coli* in Subwatershed

As described in the TMDL Study and in Table 11 below, the Total Maximum Daily Load for Spunk Creek is divided into point (permitted) sources and nonpoint (non-permitted) sources. In the Spunk Creek Subwatershed, the Avon Wastewater Treatment Facility and MS4s (Table 12) are the point sources of *E. coli*. For nonpoint sources, the majority of the land in this subwatershed is in agricultural use (Table 10).

Table 10. Spunk Creek Subwatershed Land uses

Land use	%
Pasture / Hay	36%
Cultivated Crops	28%
Deciduous Forest	17%
Grassland / Herbaceous	5%
Developed Open Space	4%
Open Water	4%
Emergent Herbaceous Wetland	4%
Table only includes land uses that are > 1% of the land area	

In developing the TMDL Study a desktop analysis was conducted to determine the potential sources of *E. coli* within each subwatershed and estimate the relative contribution of each source. The process, referred to as a bacteria source assessment, is described in Section 4 of the TMDL Study beginning on page 44. In the Spunk Creek Subwatershed the vast majority of the *E. coli* is likely produced from livestock with slight contributions from humans and from pets and wildlife (Figure 11). Further analysis of livestock numbers suggest that poultry is the type of livestock that produces the most *E. coli* in this subwatershed (Figure 11). The fraction of *E. coli* from various sources of livestock in the pie chart is determined by the total animal units estimated within the subwatershed and takes into account the size discrepancy of the various types of livestock as well as the differences in the amount of bacteria within their waste.

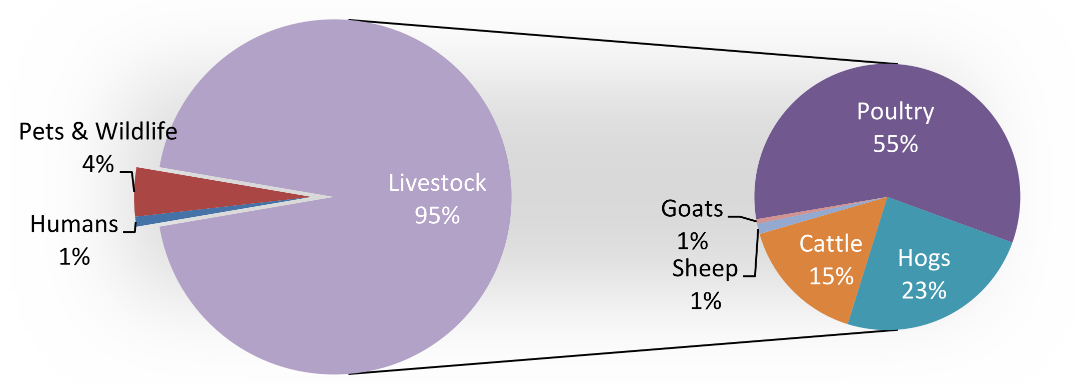

Figure 11. Bacteria production in the Spunk Creek Subwatershed

As another tool, a Microbial Source Tracking (MST) analysis was conducted as part of this TMDL Study. MST analysis relies on the genetic coding, or markers, found within bacteria samples to determine the source of the bacteria. In the Spunk Creek Subwatershed the MST analysis found cattle markers in the storm event samples that were taken in June 2011 and April 2012 but not in the baseflow samples that were taken in June and September 2011. All water samples were also tested for swine and human/pet markers but these markers were not present in the water samples on any of those dates. Due to the nature of bacteria caution must be exercised with use of the MST findings. The analysis can not be used to conclusively dismiss any given source of bacteria. The MST findings can only be applied to the source of bacteria found in that specific sample of water.

Sources Contributing *E. coli* to the Stream Reach

In addition to determining the relative magnitude of *E. coli* sources within the watershed it is important to consider the factors that lead to the *E. coli* being delivered to the stream. The second step in the bacteria source assessment is to evaluate the connection between *E. coli* production, how it is handled on the landscape and how it is ultimately delivered to the stream. In the case of the Spunk Creek Subwatershed, where poultry is identified as the main potential bacteria source, the primary activity by which the bacteria becomes available to wash into the stream is through manure application to fields where the manure is not immediately incorporated into the soil (Figure 12). Other mechanisms include runoff from feedlots (that do not have adequate controls) and from animals on pasture.

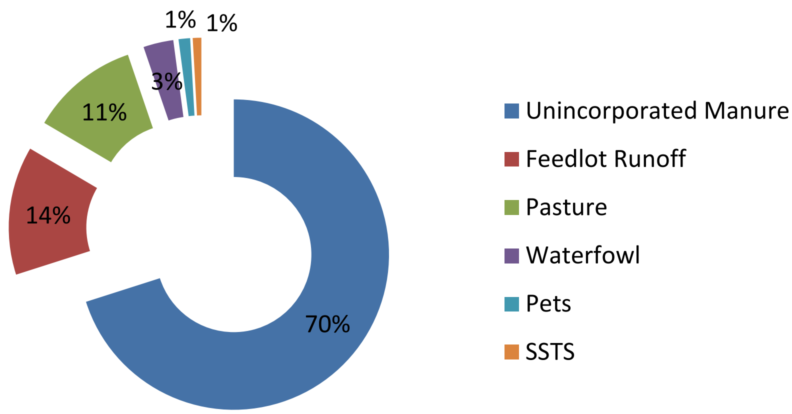

Figure 12. Estimated Percentage of Potential Sources Contributing Bacteria to Spunk Creek

Potential *E. coli* Contributing Areas

The final step in the bacteria source assessment methodology developed for the TMDL Study was to determine which areas within the subwatershed have the highest potential to contribute *E. coli* to the stream. In agricultural subwatersheds the areas that have the highest potential to contribute *E. coli* to the stream are areas immediately adjacent to or hydrologically connected to streams where manure is applied or where animals are grazing. Refer to Figure 13 for the map of areas within the Spunk Creek Subwatershed that have a high potential to contribute bacteria to the stream. These areas should be prioritized for implementation activities. The Priority Implementation Area in Figure 13 was determined by calculating a delivery factor that accounts for fate and transport factors such as proximity to surface waters, slope, imperviousness, and discharge to lakes prior to discharge to stream networks (refer to Section 4.2.6 of the TMDL Study for more specific information on how the delivery factor and Priority Implementation Area was calculated).

TMDL Allocations and Percent Reductions

Wasteload and load allocations for this subwatershed and the calculated percent reduction needed to meet the TMDL are summarized in Table 11. Load allocations indicate a sizable decrease needed for bacteria in runoff under moist, mid-range and dry flow conditions in the Spunk Creek Subwatershed. The maximum percent reduction of bacteria load needed is 84%.

Table 11. Spunk Creek Subwatershed TMDL and Percent Reductions Needed

Flow Regime	Existing Load (billion org/d)	Waste Load Allocations: WWTFs (Total) (billion org/d)	Waste Load Allocations: Straight Pipes (billion org/d)	Waste Load Allocations: MS4 (billion org/d)	LA (billion org/d)	MOS (billion org/d)	TMDL (billion org/d)	LA + MS4 WLA (billion org/d)	Estimated Reduction in Watershed Runoff (%)
High	116	2.01	–	2.05	254	28.7	287	256	0%
Moist	756	2.01	–	0.948	118	13.4	134	119	84%
Mid-Range	176	2.01	–	0.588	73	8.4	84	73.6	58%
Dry	189	2.01	–	0.375	46.6	5.44	54.4	47	75%
Low	ID	2.01	–	0.2	24.8	3	30	25	ID

Key: WWTF-Waste Water Treatment Facility, MS4-Municipal Separate Storm Sewer System, MOS-Margin of Safety, LA-Load Allocation, org-organisms, d-day, ID-Insufficient Data, IDUL-Impairment due to upstream load, EQN-Based on the equation found on page 104 in the TMDL Study, WLA-Waste Load Allocation

Regulated Entities

The regulated entities within this subwatershed are shown in Table 12.

Table 12. Regulated Entities within the Spunk Creek Subwatershed

Regulated Entity	Permit #
Avon WWTF	MN0047325
Brockway Township	MS400068

Implementation Plan

The findings of the bacteria source assessment suggest that application of poultry manure that is not appropriately incorporated into the soils is the largest of the likely bacteria sources to the Spunk Creek Subwatershed. Specifically, land immediately surrounding Spunk Creek has been assessed as a high risk area for surface applied manure. Based on the source assessment and the TMDL the **target goal is up to an 84% reduction** of bacteria for this subwatershed. In other flow regimes the target goal is lower. The following is the magnitude of reductions to the major potential sources of bacteria that would be necessary within the watershed to meet the 84% goal. Given this level of reduction it will likely take 20+ years of active management for the Spunk Creek to meet water quality standards for *E. coli*.

- Eliminate 90% of the bacteria coming from manure that is not appropriately incorporated into the soil.
- Eliminate 90% of the bacteria coming from feedlots with inadequate controls.
- Eliminate 100% of the SSTS that are an imminent threat to public health by bringing septic systems into compliance with standards.
- Eliminate 70% of the bacteria load from grazing livestock.
- Ensure appropriate controls are in place to keep the Avon WWTF (MN0047325) to a maximum discharge of 2.01 billion organisms/day.

Priority Actions

As a result of the analyses for bacteria sources and contributing areas, the primary focus of implementation for this subwatershed will be to prevent unincorporated manure from reaching the stream and to reduce runoff from feedlots. This can be done by land application with incorporation or by treating manure prior to land application and implementing feedlot runoff controls, respectively.

There are likely other contributors of bacteria that may not have been captured in the analyses above due to a lack of documentation. In many cases, local knowledge of bacteria sources may provide superior guidance for determining how to reduce bacteria loading to impaired stream reaches. Addressing additional sources within the Spunk Creek Subwatershed that are likely contributing *E. coli* to a lesser degree are also included in the implementation plan since the needed reduction is high in this subwatershed (see Rural Subwatersheds for more information). Below are the priority actions that are recommended for the Spunk Creek Subwatershed.

- Identify and map potential and known sources that are directly contributing bacteria to waterbodies using local knowledge, windshield surveys, and interviews with landowners, etc. Note that mapping sources is a distinct activity from monitoring.
- Continue baseline monitoring of the stream reach and add additional monitoring stations along the stream reach and tributaries to help pinpoint potential sources of bacteria. Refer to the monitoring section for further recommendations.
- Reduce direct sources of bacteria, such as livestock that have access to streams, installing fences around streams within pastures, or providing water sources within pastures to reduce the frequency of livestock from entering streams.
- Promote the use of manure injection or incorporation of manure on all land where manure is applied. Target land areas near the stream and ditches and tile intakes first. Alternatively, treat manure to reduce bacteria concentrations prior to land application.
- Promote good manure application and treatment practices such as:
    - Applying manure to relatively dry fields;
    - Avoiding steep sloping areas;
    - Avoiding areas near water bodies;
    - Avoiding vulnerable locations for spreading manure;
    - Avoiding areas prone to flooding;
    - Avoiding applying on frozen soil.
- Implement and enforce feedlot runoff controls, including filter strips around animal confinement areas (65-100 feet wide).
- Install filter strips around fields, especially where streams are present, to prevent bacteria-laden runoff from reaching streams. Filter strips around fields are recommended to be 15-30 feet wide.
- Ensure that all local feedlot, SSTS, septage and pet-waste ordinances within the subwatershed are stringent enough so that rivers and streams will meet State water quality standards.
- Ensure that ordinances are enforced, through regular inspection and monitoring.
- Conduct septic inspections and make sure all systems that are imminent threats are brought into compliance.
- Conduct education and outreach to ensure that ordinances and BMPs are understood and followed.
- Ensure septage application is in compliance with state laws and local ordinances.

Table 13 lists the priority actions described above along with a recommended timeframe for implementation and estimated costs. The timeframe that is provided is based on priority of implementation, and efforts will likely be ongoing once the action has been implemented. Action items are listed in order of importance. Also included in Table 13 are priority actions that are simply good practices to follow in all subwatersheds regardless of the magnitude of the source/activity they address. Note that some of these practices may have already been initiated within the subwatershed; if that is the case, continue with them and enhance them where necessary. Note that the costs are provided for context and not as an estimate of the total expenditure needed to meet any specified reduction in bacteria.

Refer to Appendix A for the entities responsible for implementing source controls and treatment BMPs in this subwatershed.

Table 13. Priority actions for Spunk Creek Subwatershed

Priority Timeframe[1]	Action	Estimated Effectiveness of Practice[2] (up to)	Estimated Magnitude in Watershed	Implementation Cost[3]
High	Limit livestock from accessing streams/waterbodies by fencing or providing alternative water sources Livestock Stream Access Control	100%	Unknown	$0.70-1.50/ linear feet of fencing $3-6/ cu yard to construct a pond as an alternative water source
High	Promote land application of manure with incorporation Land application w/ incorporation	70%	2,500 – 18,500 acres of cultivated cropland	$12/acre
High	Promote good manure application and treatment practices Manure Management	Varies by practice	2,500 – 18,500 acres of cultivated cropland	NA
High	Implement feedlot runoff control and manure management at existing feedlots Feedlot Runoff Control	100%	~6,900 Animal Units (AU)	$8-24/AU
High	Install vegetated buffers around fields where manure is applied as well as grazed lands Filter Strips	92%	~116 (assume 24 miles of stream; 20ft buffer)	$600-1000/acre
Medium	Identify and map any location with potential bacteria sources Monitoring	NA	NA	Staff time

Priority Timeframe[1]	Action	Estimated Effectiveness of Practice[2] (up to)	Estimated Magnitude in Watershed	Implementation Cost[3]
Medium	Ensure that all local feedlot, SSTS, septage and pet-waste ordinances within the subwatershed are enforced through regular inspection and monitoring and are stringent enough so that rivers and streams will meet State water quality standards. Federal, State, and Local Requirements	100%	NA	Staff time
Medium	Conduct education and outreach to ensure that ordinances and BMPs are understood and followed.	100%	NA	Staff time
Medium	Adopt and enforce strict septic ordinances Septic (SSTS) Maintenance	100%	NA	Staff time
Medium	Conduct septic system inspections as warranted and bring septic systems into compliance with standards Septic (SSTS) Maintenance	100%	~ 20 systems	$200-300 (inspection)
Medium	Conduct outreach to producers to promote manure management practices that prevent the release of and/or treat manure to reduce bacteria concentrations	NA	NA	Staff time
Medium	Septage application should be incorporated (follow guidelines found in the MPCA guidance document Septage Removal and Disposal) Septage	70%	2,500 – 18,500 acres of cultivated cropland	$12/acre
Low	Regularly monitor stream and inspect all significant sources that have the potential to release bacteria Monitoring	NA	NA	Staff time

[1] Priority is based on recommended timeframe to continue or start (not complete) implementation activities: High = 1-2 years, Medium = 2-5 years, Low = 5-10 years.
[2] Estimated effectiveness of practice refers to the reduction of bacteria concentrations in runoff to receiving waterbodies.
[3] Costs based on NRCS EQIP Payment Schedules
http://www.nrcs.usda.gov/wps/portal/nrcs/detail/mn/programs/financial/?cid=stelprdb1245512

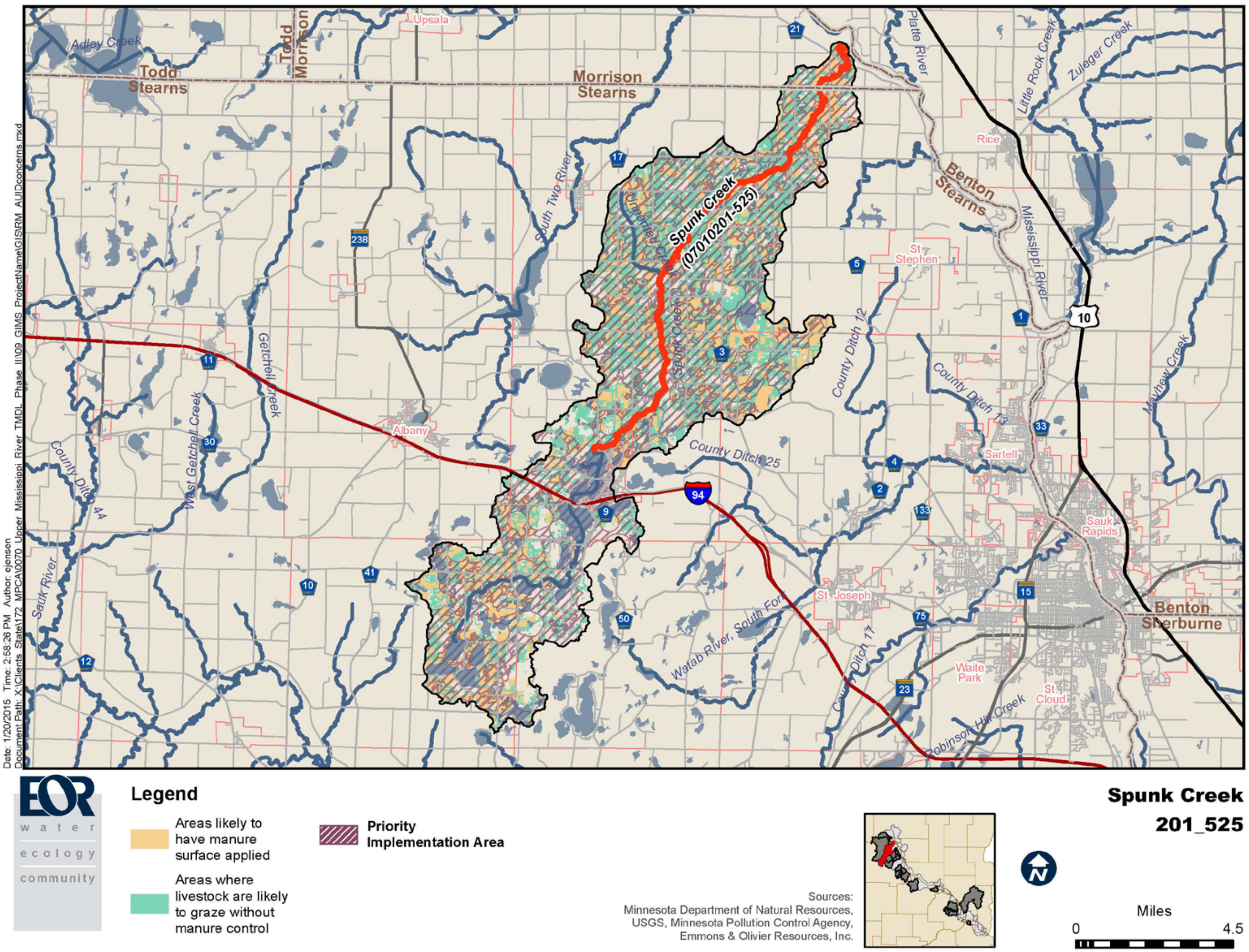

Figure 13. Areas with highest risk for transport of bacteria into streams and rivers to be targeted for initial implementation (hatched areas) (refer to Potential E. coli Contributing Areas for information on how Priority Implementation Areas were determined)

Watab River (07010201-528) Subwatershed

Reach Description: Rosier Lake to Mississippi River

Watab River is a tributary of the Mississippi River and is impaired for aquatic recreation due to *E. coli*. The subwatershed is located within Priority Areas A and B of the St Cloud Source Water Protection Area (Figure 2). Watab River, North Fork (07010201-529) and Watab River, South Fork (07010201-554) are also impaired for *E. coli*. Monitoring conducted in 2010 and 2011 indicated elevated levels of *E. coli* throughout the growing season with exceedances of the water quality standard occurring in every month with at least five samples from April through October except April and May. *E. coli* counts ranged from 2 to 2,420 org/100 ml and monthly geometric means ranged from 15 to 300 org/100 ml (a summary of water quality monitoring data can be found in Appendix D of the TMDL Study). Plotting *E. coli* levels against stream flow, as is shown in the load duration curves in Figure 6.10 on page 120 of the TMDL Study, show that exceedances occur at all flow conditions (e.g. high, moist, mid, dry, low) where there is monitoring data. Note that the TMDL requires reductions for high and moist flow conditions (Table 15).

Production of *E. coli* in Subwatershed

As described in the TMDL Study and in Table 15 below, the Total Maximum Daily Load for Watab River is divided into point (permitted) sources and nonpoint (non-permitted) sources. In the Watab River Subwatershed, the point sources of *E. coli* are limited to MS4s (Table 16). For nonpoint sources, the majority of the land in this subwatershed is in agricultural use (Table 14).

Table 14. Watab River Subwatershed Land uses

Land use	%
Pasture / Hay	34%
Cultivated Crops	30%
Deciduous Forest	10%
Developed Open Space	7%
Emergent Herbaceous Wetland	7%
Developed Low Intensity	5%
Grassland / Herbaceous	3%
Open Water	2%
Table only includes land uses that are > 1% of the land area	

In developing the TMDL Study a desktop analysis was conducted to determine the potential sources of *E. coli* within each subwatershed and estimate the relative contribution of each source. The process, referred to as a bacteria source assessment, is described in Section 4 of the TMDL Study beginning on page 45. In the Watab River Subwatershed the vast majority of the *E. coli* is likely produced from livestock with slight contributions from humans and from pets and wildlife (Figure 14). Further analysis of livestock numbers suggest that poultry is the type of livestock that produces the most *E. coli* in this subwatershed, followed by hogs and cattle (Figure 14). The fraction of *E. coli* from various sources of livestock in the pie chart is determined by the total animal units estimated within the subwatershed and takes into account the size discrepancy of the various types of livestock as well as the differences in the amount of bacteria within their waste.

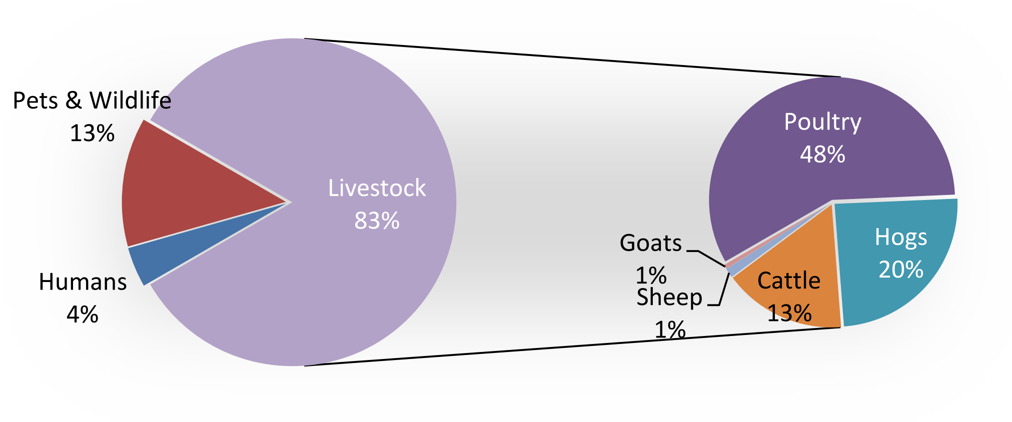

Figure 14. Bacteria production in the Watab River Subwatershed

As another tool, a Microbial Source Tracking (MST) analysis was conducted as part of this TMDL Study. MST analysis relies on the genetic coding, or markers, found within bacteria samples to determine the source of the bacteria. In the Watab River Subwatershed the MST analysis found no markers in either the storm event sample that was taken in June 2011 or the baseflow sample that was taken in September 2011. Due to the nature of bacteria caution must be exercised with use of the MST findings. The analysis can not be used to conclusively dismiss any given source of bacteria. The MST findings can only be applied to the source of bacteria found in that specific sample of water.

Sources Contributing *E. coli* to the Stream Reach

In addition to determining the relative magnitude of *E. coli* sources within the watershed it is important to consider the factors that lead to the *E. coli* being delivered to the stream. The second step in the bacteria source assessment is to evaluate the connection between *E. coli* production, how it is handled on the landscape and how it is ultimately delivered to the stream. In the case of the Watab River Subwatershed, where poultry is identified as the main potential bacteria source, the primary activity by which the bacteria becomes available to wash into the stream is through manure application to fields where the manure is not immediately incorporated into the soil (Figure 15). Other mechanisms include runoff from feedlots (that do not have adequate controls), animals on pasture and pet waste runoff from impervious and pervious surfaces.

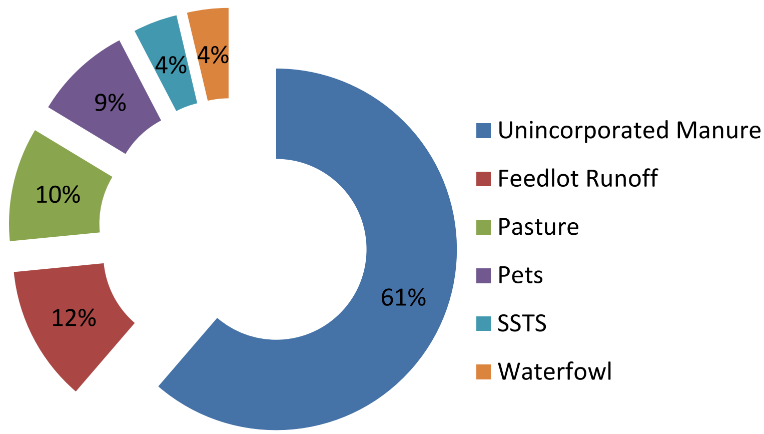

Figure 15. Estimated Percentage of Potential Sources Contributing Bacteria to the Watab River

Potential *E. coli* Contributing Areas

The final step in the bacteria source assessment methodology developed for the TMDL Study was to determine which areas within the subwatershed have the highest potential to contribute *E. coli* to the stream. In agricultural subwatersheds the areas that have the highest potential to contribute *E. coli* to the stream are areas immediately adjacent to or hydrologically connected to streams where manure is applied or where animals are grazing. Refer to Figure 16 for the map of areas within the Watab River Subwatershed that have a high potential to contribute bacteria to the stream. These areas should be prioritized for implementation activities. The Priority Implementation Area Figure 16 in was determined by calculating a delivery factor that accounts for fate and transport factors such as proximity to surface waters, slope, imperviousness, and discharge to lakes prior to discharge to stream networks (refer to Section 4.2.6 of the TMDL Study for more specific information on how the delivery factor and Priority Implementation Area was calculated).

TMDL Allocations and Percent Reductions

Wasteload and load allocations for this subwatershed and the calculated percent reduction needed to meet the TMDL are summarized in Table 15. Load allocations indicate a moderate decrease needed for bacteria in runoff under high and moist flow conditions in the Watab River Subwatershed. The maximum percent reduction of bacteria load needed is 57%.

Table 15. Watab River Subwatershed TMDL and Percent Reductions Needed

Flow Regime	Existing Load (billion org/d)	Waste Load Allocations: WWTFs (Total) (billion org/d)	Straight Pipes (billion org/d)	MS4 (billion org/d)	LA (billion org/d)	MOS (billion org/d)	TMDL (billion org/d)	LA + MS4 WLA (billion org/d)	Estimated Reduction in Watershed Runoff (%)
High	137	–	–	9.46	49.7	6.57	65.7	59.2	57%
Moist	65.4	–	–	4.59	24.1	3.19	31.9	28.7	56%
Mid-Range	IDUL	–	–	2.12	11.1	1.47	14.7	13.2	0%
Dry	IDUL	–	–	1.4	7.32	0.969	9.69	8.72	0%
Low	ID	–	–	0.582	3.05	0.404	4.04	3.63	ID

Key: WWTF-Waste Water Treatment Facility, MS4-Municipal Separate Storm Sewer System, MOS-Margin of Safety, LA-Load Allocation, org-organisms, d-day, ID-Insufficient Data, IDUL-Impairment due to upstream load, EQN-Based on the equation found on page 104 in the TMDL Study, WLA-Waste Load Allocation

Regulated Entities

The regulated entities within this subwatershed are shown in Table 16.

Table 16. Regulated Entities within the Watab River Subwatershed

Regulated Entity	Permit #
Le Sauk Township	MS400143
Sartell City	MS400048
St Cloud City	MS400052
St Joseph City	MS400125
St Joseph Township	MS400157
Stearns County	MS400159

Implementation Plan

The findings of the bacteria source assessment suggest that application of poultry manure that is not appropriately incorporated into the soils is the largest of the likely *E. coli* sources to the Watab River Subwatershed. Specifically, land immediately surrounding Watab River has been assessed as a high risk area for surface applied manure. Based on the source assessment and the TMDL the **target goal is up to a 57% reduction** of bacteria for this subwatershed. In other flow regimes the target goal is lower. The following is the magnitude of reductions to the major potential sources of bacteria that would be necessary within the watershed to meet the 57% goal. Given this level of reduction it will likely take 20+ years of active management for the Watab River Subwatershed to meet water quality standards for *E. coli*.

- Eliminate 95% of the bacteria coming from manure that is not appropriately incorporated into the soil.
- Eliminate 95% of the bacteria coming from feedlots with inadequate controls.

- Eliminate 100% of the SSTS that are an imminent threat to public health by bringing septic systems into compliance with standards.
- Eliminate 70% of the bacteria load from grazing livestock.
- Eliminate 92% of the bacteria load from waterfowl and wildlife.

Priority Actions

As a result of the analyses for bacteria sources and contributing areas, the primary focus of implementation for this subwatershed will be to prevent unincorporated manure from reaching the stream and to reduce runoff from feedlots. This can be done by land application with incorporation or by treating manure prior to land application and implementing feedlot runoff controls, respectively.

There are likely other contributors of bacteria that may not have been captured in the analyses above due to a lack of documentation. In many cases, local knowledge of bacteria sources may provide superior guidance for determining how to reduce bacteria loading to impaired stream reaches. Addressing additional sources within the Watab River Subwatershed that are likely contributing *E. coli* to a lesser degree are also included in the implementation plan since the needed reduction is high in this subwatershed (see Rural Subwatersheds for more information). Below are the priority actions that are recommended for the Watab River Subwatershed.

- Identify and map potential and known sources that are directly contributing bacteria to waterbodies using local knowledge, windshield surveys, and interviews with landowners, etc. Note that mapping sources is a distinct activity from monitoring.
- Continue baseline monitoring of the stream reach and add additional monitoring stations along the stream reach and tributaries to help pinpoint potential sources of bacteria. Refer to the monitoring section for further recommendations.
- Reduce direct sources of bacteria, such as livestock that have access to streams, installing fences around streams within pastures, or providing water sources within pastures to reduce the frequency of livestock from entering streams.
- Promote the use of manure injection or incorporation of manure on all land where manure is applied. Target land areas near the stream and ditches and tile intakes first. Alternatively, treat manure to reduce bacteria concentrations prior to land application.
- Promote good manure application and treatment practices such as:
    - Applying manure to relatively dry fields;
    - Avoiding steep sloping areas;
    - Avoiding areas near water bodies;
    - Avoiding vulnerable locations for spreading manure;
    - Avoiding areas prone to flooding;
    - Avoiding applying on frozen soil.
- Implement and enforce feedlot runoff controls
- Install filter strips around fields, especially where streams are present, to prevent bacteria-laden runoff from reaching streams; buffer strips should also be installed along ditches within fields that flow directly to streams. Priority should be given to BMPs that provide multiple benefits.
- Ensure that all local feedlot, SSTS, septage and pet-waste ordinances within the subwatershed are stringent enough so that rivers and streams will meet State water quality standards.
- Ensure that ordinances are enforced, through regular inspection and monitoring.
- Conduct septic inspections and make sure all systems that are imminent threats are brought into compliance.

- Conduct education and outreach to ensure that ordinances and BMPs are understood and followed.
- Ensure septage application is in compliance with state laws and local ordinances.

Table 17 lists the priority actions described above along with a recommended timeframe for implementation and estimated costs. The timeframe that is provided is based on priority of implementation, and efforts will likely be ongoing once the action has been implemented. Action items are listed in order of importance. Also included in Table 17 are priority actions that are simply good practices to follow in all subwatersheds regardless of the magnitude of the source/activity they address. Note that some of these practices may have already been initiated within the subwatershed; if that is the case, continue with them and enhance them where necessary. Note that the costs are provided for context and not as an estimate of the total expenditure needed to meet any specified reduction in bacteria.

Refer to Appendix A for the entities responsible for implementing source controls and treatment BMPs in this subwatershed.

Table 17. Priority actions for Watab River Subwatershed

Priority Timeframe[1]	Action	Estimated Effectiveness of Practice[2] (up to)	Estimated Magnitude in Watershed	Implementation Cost[3]
High	Promote land application of manure with incorporation Land application w/ incorporation	70%	500 – 3,500 acres of cultivated cropland	$12/acre
High	Promote good manure application and treatment practices (see text above) Manure Management	Varies by practice	500 – 3,500 acres of cultivated cropland	NA
High	Implement feedlot runoff control and manure management at existing feedlots Feedlot Runoff Control	100%	~2,100 Animal Units (AU)	$8-24/AU
High	Install vegetated buffers around fields where manure is applied as well as grazed lands Filter Strips	92%	~39 acres (assume 8 miles of stream; 20ft buffer)	$600-1000/acre
Medium	Identify and map any location with potential bacteria sources Monitoring	NA	NA	Staff time

Priority Timeframe[1]	Action	Estimated Effectiveness of Practice[2] (up to)	Estimated Magnitude in Watershed	Implementation Cost[3]
Medium	Ensure that all local feedlot, SSTS, septage and pet-waste ordinances within the subwatershed are enforced through regular inspection and monitoring and are stringent enough so that rivers and streams will meet State water quality standards. Federal, State, and Local Requirements	100%	NA	Staff time
Medium	Conduct education and outreach to ensure that ordinances and BMPs are understood and followed.	100%	NA	Staff time
Medium	Adopt and enforce strict septic ordinances Septic (SSTS) Maintenance	100%	NA	Staff time
Medium	Conduct septic system inspections as warranted and bring septic systems into compliance with standards Septic (SSTS) Maintenance	100%	~ 15 systems	$200-300 (inspection) $7,500 per system (if replacement required)
Medium	Conduct outreach to producers to promote manure management practices that prevent the release of and/or treat manure to reduce bacteria concentrations Outreach/Education	NA	NA	Staff time
Medium	Septage application should be incorporated (follow guidelines found in the MPCA guidance document Septage Removal and Disposal) Septage	70%	500 – 3,500 acres of cultivated cropland	$12/acre
Low	Regularly monitor stream and inspect all significant sources that have the potential to release bacteria Monitoring	NA	NA	Staff time

[1] Priority is based on recommended timeframe to continue or start (not complete) implementation activities: High = 1-2 years, Medium = 2-5 years, Low = 5-10 years.
[2] Estimated effectiveness of practice refers to the reduction of bacteria concentrations in runoff to receiving waterbodies.
[3] Costs based on NRCS EQIP Payment Schedules
http://www.nrcs.usda.gov/wps/portal/nrcs/detail/mn/programs/financial/?cid=stelprdb1245512

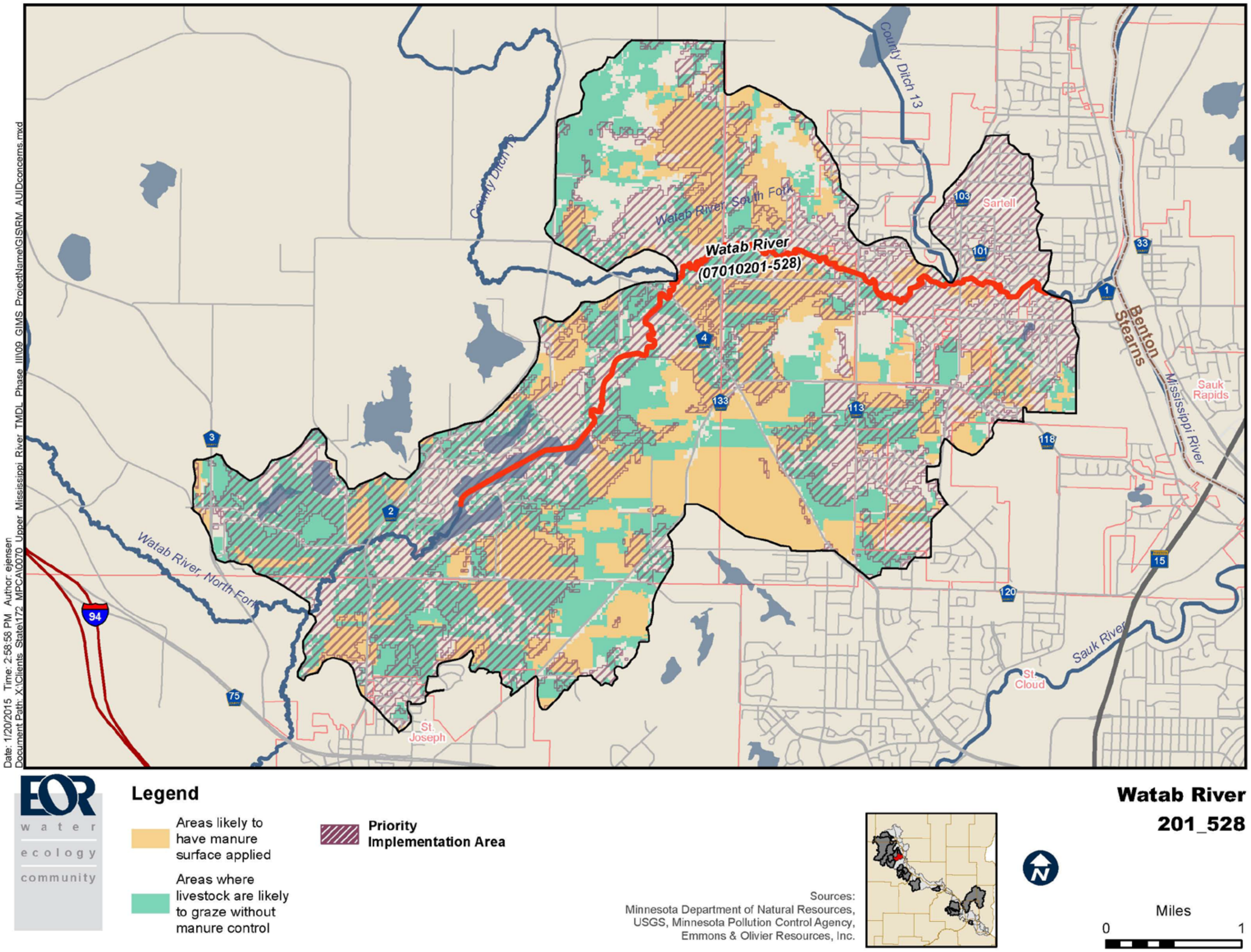

Figure 16. Areas with highest risk for transport of bacteria into streams and rivers to be targeted for initial implementation (hatched areas). Refer to Potential E. coli Contributing Areas to determine how Priority Implementation Areas were determined.

Watab River, North Fork (07010201-529) Subwatershed

Reach Description: Headwaters (Stump Lake 73-0091-00) to South Fork Watab River

The North Fork Watab River, a tributary of Watab River, is impaired for aquatic recreation due to *E. coli*. The subwatershed is located within Priority Areas A and B of the St Cloud Source Water Protection Area (Figure 2). Watab River (07010201-528) and Watab River, South Fork (07010201-554) Subwatershed reaches are also impaired for *E. coli*. Monitoring conducted in 2010 and 2011 indicated elevated levels of *E. coli* throughout the growing season with exceedances of the water quality standard occurring in every month with at least five samples from June through September. *E. coli* counts ranged from 82 to 1,414 org/100 ml and monthly geometric means ranged from 177 to 1,410 org/100 ml (a summary of water quality monitoring data can be found in Appendix D of the TMDL Study). Plotting *E. coli* levels against stream flow, as is shown in the load duration curves in Figure 6.11 on page 121 of the TMDL Study, show that exceedances occur at all flow conditions (e.g. high, moist, mid, dry, low) where there is monitoring data.

Production of *E. coli* in Subwatershed

As described in the TMDL Study and in Table 19 below, the Total Maximum Daily Load for North Fork Watab River is divided into point (permitted) sources and nonpoint (non-permitted) sources. In the North Fork Watab River Subwatershed, the St. Benedict Wastewater Treatment Facility and MS4s (Table 20) are the point sources of *E. coli*. For nonpoint sources, the land in this subwatershed includes agricultural uses (Table 18).

Table 18. Watab River, North Fork Subwatershed Land uses

Land use	%
Deciduous Forest	32%
Pasture / Hay	26%
Cultivated Crops	10%
Grassland / Herbaceous	8%
Emergent Herbaceous Wetland	8%
Developed Open Space	5%
Open Water	5%
Table only includes land uses that are > 1% of the land area	

In developing the TMDL Study a desktop analysis was conducted to determine the potential sources of *E. coli* within each subwatershed and estimate the relative contribution of each source. The process, referred to as a bacteria source assessment, is described in Section 4 of the TMDL Study beginning on page 45. In the North Fork Watab River Subwatershed the vast majority of the *E. coli* is likely produced from livestock with slight contributions from humans and from pets and wildlife (Figure 17). Further analysis of livestock numbers suggest that poultry is the type of livestock that produces the most *E. coli* in this subwatershed followed by hogs and cattle (Figure 17). The fraction of *E. coli* from various sources of livestock in the pie chart is determined by the total animal units estimated within the subwatershed and takes into account the size discrepancy of the various types of livestock as well as the differences in the amount of bacteria within their waste.

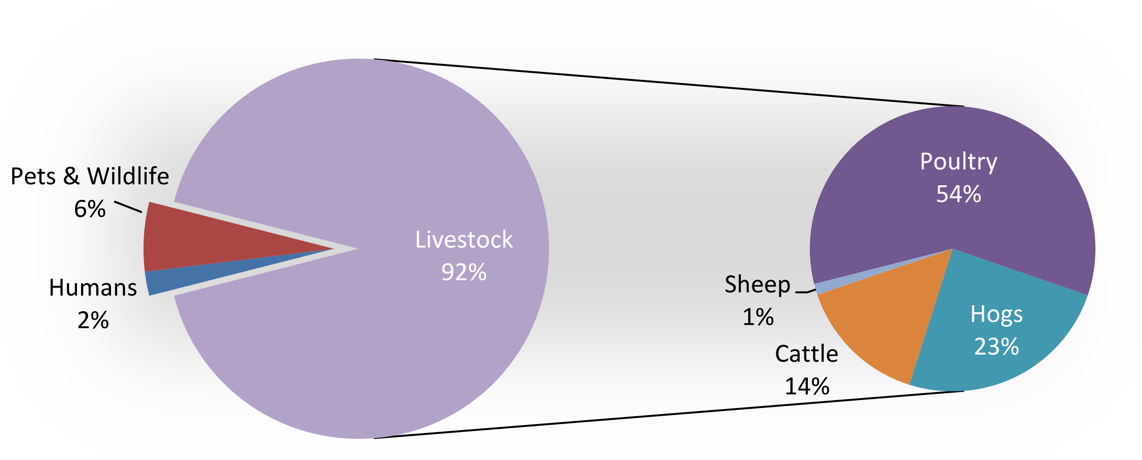

Figure 17. Bacteria production in the Watab River, North Fork Subwatershed

Sources Contributing *E. coli* to the Stream Reach

In addition to determining the relative magnitude of *E. coli* sources within the watershed it is important to consider the factors that lead to the *E. coli* being delivered to the stream. The second step in the bacteria source assessment is to evaluate the connection between *E. coli* production, how it is handled on the landscape and how it is ultimately delivered to the stream. In the case of the North Fork Watab River Subwatershed, where poultry is identified as the main potential bacteria source, the primary activity by which the bacteria becomes available to wash into the stream is through manure application to fields where the manure is not immediately incorporated into the soil (Figure 18). Other mechanisms include runoff from feedlots (that do not have adequate controls) and from animals on pasture.

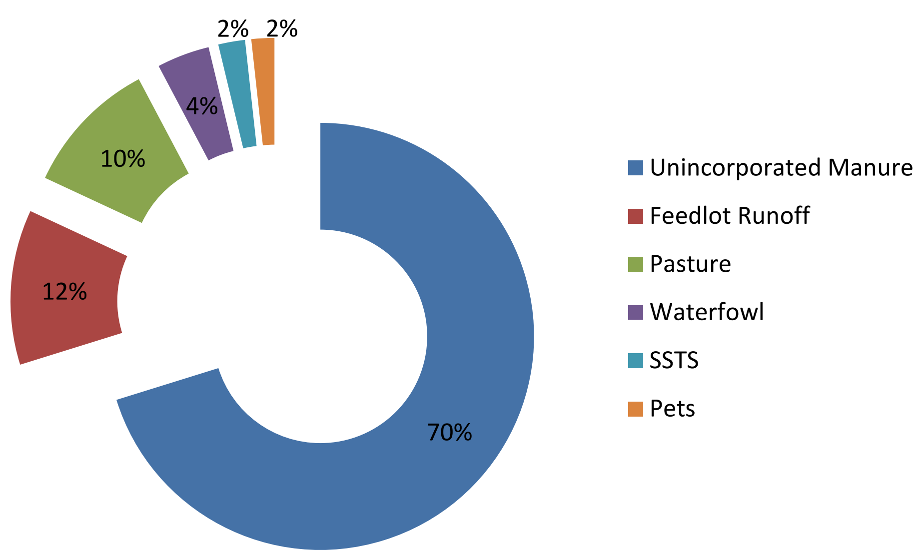

Figure 18 Estimated Percentage of Potential Sources Contributing Bacteria to the Watab River, North Fork

Potential *E. coli* Contributing Areas

The final step in the bacteria source assessment methodology developed for the TMDL Study was to determine which areas within the subwatershed have the highest potential to contribute *E. coli* to the stream. In agricultural subwatersheds the areas that have the highest potential to contribute *E. coli* to the stream are areas immediately adjacent to or hydrologically connected to streams where manure is applied or where animals are grazing. Refer to Figure 19 for the map of areas within the North Fork Watab River Subwatershed that have a high potential to contribute bacteria to the stream. These areas should be prioritized for implementation activities. The Priority Implementation Area in Figure 19 was determined by calculating a delivery factor that accounts for fate and transport factors such as proximity to surface waters, slope, imperviousness, and discharge to lakes prior to discharge to stream networks (refer to Section 4.2.6 of the TMDL Study for more specific information on how the delivery factor and Priority Implementation Area was calculated).

TMDL Allocations and Percent Reductions

Wasteload and load allocations for this subwatershed and the calculated percent reduction needed to meet the TMDL are summarized in Table 19. Load allocations indicate a sizable decrease needed for bacteria in runoff under moist, mid-range and dry flow conditions in the Watab River North Fork Subwatershed. The maximum percent reduction of bacteria load needed is 74%.

Table 19. Watab River, North Fork Subwatershed TMDL and Percent Reductions Needed

Flow Regime	Existing Load (billion org/d)	Waste Load Allocations			LA (billion org/d)	MOS (billion org/d)	TMDL (billion org/d)	LA + MS4 WLA (billion org/d)	Estimated Reduction in Watershed Runoff (%)
		WWTFs (Total) (billion org/d)	Straight Pipes (billion org/d)	MS4 (billion org/d)					
High	ID	1.15	–	0.655	73	8.31	83.1	73.7	ID
Moist	45.7	1.15	–	0.269	29.9	3.48	34.8	30.2	34%
Mid-Range	60.2	1.15	–	0.139	15.5	1.86	18.6	15.6	74%
Dry	18.5	1.15	–	0.067	7.46	0.964	9.64	7.53	59%
Low	ID	1.15	–	0.0305	3.4	0.509	5.09	3.43	ID

Key: WWTF-Waste Water Treatment Facility, MS4-Municipal Separate Storm Sewer System, MOS-Margin of Safety, LA-Load Allocation, org-organisms, d-day, ID-Insufficient Data, IDUL-Impairment due to upstream load, EQN-Based on the equation found on page 104 in the TMDL Study, WLA-Waste Load Allocation

Regulated Entities

The regulated entities within this subwatershed are shown in Table 20.

Table 20. Regulated Entities within the Watab River, North Fork Subwatershed

Regulated Entity	Permit #
Order of St. Benedict WWTF	MN0022411
St Joseph Township	MS400157

Implementation Plan

The findings of the bacteria source assessment suggest that application of poultry manure that is not appropriately incorporated into the soils is the largest of the likely bacteria sources to the Watab River North Fork Subwatershed. Specifically, land immediately surrounding Watab River has been assessed as a high risk area for surface applied manure. Based on the source assessment and the TMDL the **target goal is up to a 74% reduction** of bacteria for this subwatershed. In other flow regimes the target goal is lower. The following is the magnitude of reductions to the major potential sources of bacteria that would be necessary within the watershed to meet the 74% goal. Given this level of reduction it will likely take 20+ years of active management for the Watab River North Fork to meet water quality standards for *E. coli*.

- Eliminate 70% of the bacteria coming from manure that is not appropriately incorporated into the soil.
- Eliminate 70% of the bacteria coming from feedlots with inadequate controls.
- Eliminate 100% of the SSTS that are an imminent threat to public health by bringing septic systems into compliance with standards.
- Eliminate 25% of the bacteria load from grazing livestock.

Priority Actions

As a result of the analyses for bacteria sources and contributing areas, the primary focus of implementation for this subwatershed will be to prevent unincorporated manure from reaching the stream and to reduce runoff from feedlots. This can be done by land application with incorporation or by treating manure prior to land application and implementing feedlot runoff controls, respectively.

There are likely other contributors of bacteria that may not have been captured in the analyses above due to a lack of documentation. In many cases, local knowledge of bacteria sources may provide superior guidance for determining how to reduce bacteria loading to impaired stream reaches. Addressing additional sources within the Watab River North Fork Subwatershed that are likely contributing E. coli to a lesser degree are also included in the implementation plan since the needed reduction is high in this subwatershed (see Rural Subwatersheds for more information). Below are the priority actions that are recommended for the Watab River North Fork Subwatershed.

- Identify and map potential and known sources that are directly contributing bacteria to waterbodies using local knowledge, windshield surveys, and interviews with landowners, etc. Note that mapping sources is a distinct activity from monitoring.
- Continue baseline monitoring of the stream reach and add additional monitoring stations along the stream reach and tributaries to help pinpoint potential sources of bacteria. Refer to the monitoring section for further recommendations.
- Reduce direct sources of bacteria, such as livestock that have access to streams, installing fences around streams within pastures, or providing water sources within pastures to reduce the frequency of livestock from entering streams.
- Promote the use of manure injection or incorporation of manure on all land where manure is applied. Target land areas near the stream and ditches and tile intakes first. Alternatively, treat manure to reduce bacteria concentrations prior to land application.
- Promote good manure application and treatment practices such as:
    - Applying manure to relatively dry fields;

- Avoiding steep sloping areas;
  - Avoiding areas near water bodies;
  - Avoiding vulnerable locations for spreading manure;
  - Avoiding areas prone to flooding;
  - Avoiding applying on frozen soil.
- Implement and enforce feedlot runoff controls.
- Install filter strips around fields, especially where streams are present, to prevent bacteria-laden runoff from reaching streams; buffer strips should also be installed along ditches within fields that flow directly to streams. Priority should be given to BMPs that provide multiple benefits.
- Ensure that all local feedlot, SSTS, septage and pet-waste ordinances within the subwatershed are stringent enough so that rivers and streams will meet State water quality standards.
- Ensure that ordinances are enforced, through regular inspection and monitoring.
- Conduct septic inspections and make sure all systems that are imminent threats are brought into compliance.
- Conduct education and outreach to ensure that ordinances and BMPs are understood and followed.
- Ensure septage application is in compliance with state laws and local ordinances.

Table 21 lists the priority actions described above along with a recommended timeframe for implementation and estimated costs. The timeframe that is provided is based on priority of implementation, and efforts will likely be ongoing once the action has been implemented. Action items are listed in order of importance. Also included in Table 21 are priority actions that are simply good practices to follow in all subwatersheds regardless of the magnitude of the source/activity they address. Note that some of these practices may have already been initiated within the subwatershed; if that is the case, continue with them and enhance them where necessary. Note that the costs are provided for context and not as an estimate of the total expenditure needed to meet any specified reduction in bacteria.

Refer to Appendix A for the entities responsible for implementing source controls and treatment BMPs in this subwatershed.

Table 21. Priority actions for Watab River North Fork Subwatershed

Priority Timeframe[1]	Action	Estimated Effectiveness of Practice[2] (up to)	Estimated Magnitude in Watershed	Implementation Cost[3]
High	Limit livestock from accessing streams/waterbodies by fencing or providing alternative water sources Livestock Stream Access Control	100%	Unknown	$0.70-1.50/ linear feet of fencing $3-6/ cu yard to construct a pond as an alternative water source
High	Promote land application of manure with incorporation Land application w/ incorporation	70%	500 – 3,500 acres of cultivated cropland	$12/acre

Priority Timeframe[1]	Action	Estimated Effectiveness of Practice[2] (up to)	Estimated Magnitude in Watershed	Implementation Cost[3]
High	Promote good manure application and treatment practices (see text above) Manure Management	Varies by practice	500 – 3,500 acres of cultivated cropland	NA
High	Implement feedlot runoff control and manure management at existing feedlots Feedlot Runoff Control	100%	~1,500 Animal Units (AU)	$8-24/AU
High	Install vegetated buffers around fields where manure is applied as well as grazed lands Filter Strips	92%	~29 acres (assume 6 miles of stream; 20ft buffer)	$600-1000/acre
Medium	Identify and map any location with potential bacteria sources Monitoring	NA	NA	Staff time
Medium	Ensure that all local feedlot, SSTS, septage and pet-waste ordinances within the subwatershed are enforced through regular inspection and monitoring and are stringent enough so that rivers and streams will meet State water quality standards. Federal, State, and Local Requirements	100%	NA	Staff time
Medium	Conduct education and outreach to ensure that ordinances and BMPs are understood and followed. Outreach/Education	100%	NA	Staff time
Medium	Adopt and enforce strict septic ordinances Septic (SSTS) Maintenance	100%	NA	Staff time
Medium	Conduct septic system inspections as warranted and bring septic systems into compliance with standards Septic (SSTS) Maintenance	100%	~ 10 systems	$200-300 (inspection) $7,500 per system (if replacement required)
Medium	Conduct outreach to producers to promote manure management practices that prevent the release of and/or treat manure to reduce bacteria concentrations Outreach/Education	NA	NA	Staff time

Priority Timeframe[1]	Action	Estimated Effectiveness of Practice[2] (up to)	Estimated Magnitude in Watershed	Implementation Cost[3]
Medium	Septage application should be incorporated (follow guidelines found in the MPCA guidance document Septage Removal and Disposal) Septage	70%	500 – 3,500 acres of cultivated cropland	$12/acre
Low	Regularly monitor stream and inspect all significant sources that have the potential to release bacteria Monitoring	NA	NA	Staff time

[1] Priority is based on recommended timeframe to continue or start (not complete) implementation activities: High = 1-2 years, Medium = 2-5 years, Low = 5-10 years.
[2] Estimated effectiveness of practice refers to the reduction of bacteria concentrations in runoff to receiving waterbodies.
[3] Costs based on NRCS EQIP Payment Schedules
http://www.nrcs.usda.gov/wps/portal/nrcs/detail/mn/programs/financial/?cid=stelprdb1245512

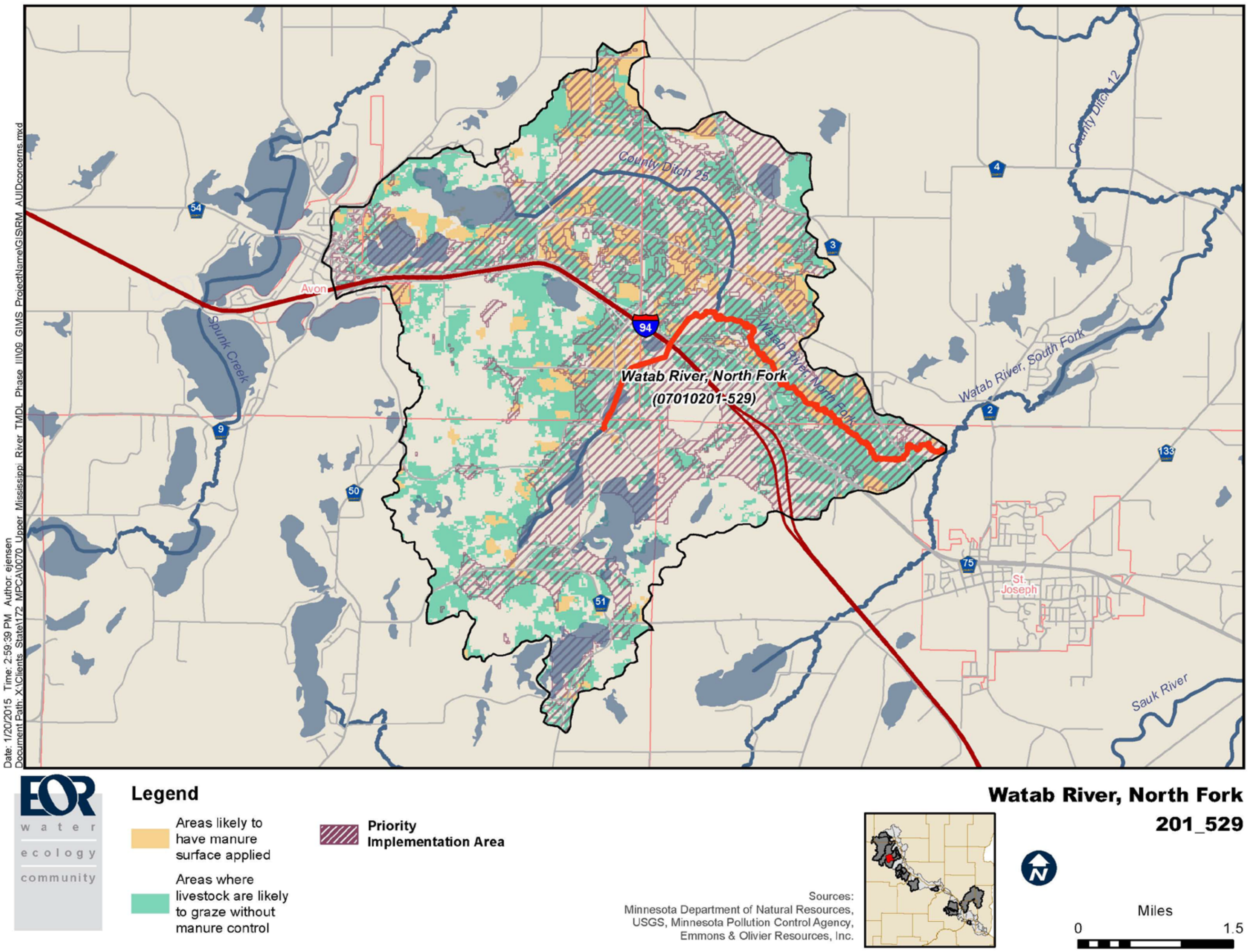

Figure 19. Areas with highest risk for transport of bacteria into streams and rivers to be targeted for initial implementation (hatched areas) (refer to Potential E. coli Contributing Areas to determine how Priority Implementation Areas were determined)

County Ditch 12 (07010201-537) Subwatershed

Reach Description: Unnamed Creek to Watab River

County Ditch 12, a tributary of the Watab River (Watab River (07010201-528) Subwatershed), is impaired for aquatic recreation due to *E. coli*. The subwatershed is located within Priority Areas A and B of the St. Cloud Source Water Protection Area (Figure 2). Monitoring conducted in 2010 and 2011 indicated elevated levels of *E. coli* throughout the growing season with an exceedance of the water quality standard occurring only in July. *E. coli* counts ranged from 19 to 921 org/100 ml and monthly geometric means ranged from 50 to 220 org/100 ml (a summary of water quality monitoring data can be found in Appendix D of the TMDL Study). Plotting *E. coli* levels against stream flow, as is shown in the load duration curves in Figure 6.12 on page 122 of the TMDL Study show that exceedances occur at all flow conditions (high, moist, mid, dry, low), except low, where there is monitoring data. However, the TMDL requires a reduction for the mid-range flow condition (Table 23).

Production of *E. coli* in Subwatershed

As described in the TMDL Study and in Table 23 below, the Total Maximum Daily Load for County Ditch 12 is divided into point (permitted) sources and nonpoint (non-permitted) sources. In the County Ditch 12 Subwatershed, the point sources of *E. coli* are limited to MS4s (Table 24). For nonpoint sources, a main land use in this watershed is in agricultural use (Table 22).

Table 22. County Ditch 12 Subwatershed Land uses

Land use	%
Pasture / Hay	36%
Deciduous Forest	20%
Cultivated Crops	18%
Emergent Herbaceous Wetland	10%
Woody Wetlands	8%
Grassland / Herbaceous	4%
Developed Open Space	3%
Table only includes land uses that are > 1% of the land area	

In developing the TMDL Study a desktop analysis was conducted to determine the potential sources of *E. coli* within each subwatershed and estimate the relative contribution of each source. The process, referred to as a bacteria source assessment, is described in Section 4 of the TMDL Study beginning on page 45. In the County Ditch 12 Subwatershed the vast majority of the *E. coli* is likely produced from livestock with slight contributions from humans and from pets and wildlife (Figure 20). Further analysis of livestock numbers suggest that poultry is the type of livestock that produces the most *E. coli* in this subwatershed followed by hogs and cattle (Figure 20). The fraction of *E. coli* from various sources of livestock in the pie chart is determined by the total animal units estimated within the subwatershed and takes into account the size discrepancy of the various types of livestock as well as the differences in the amount of bacteria within their waste.

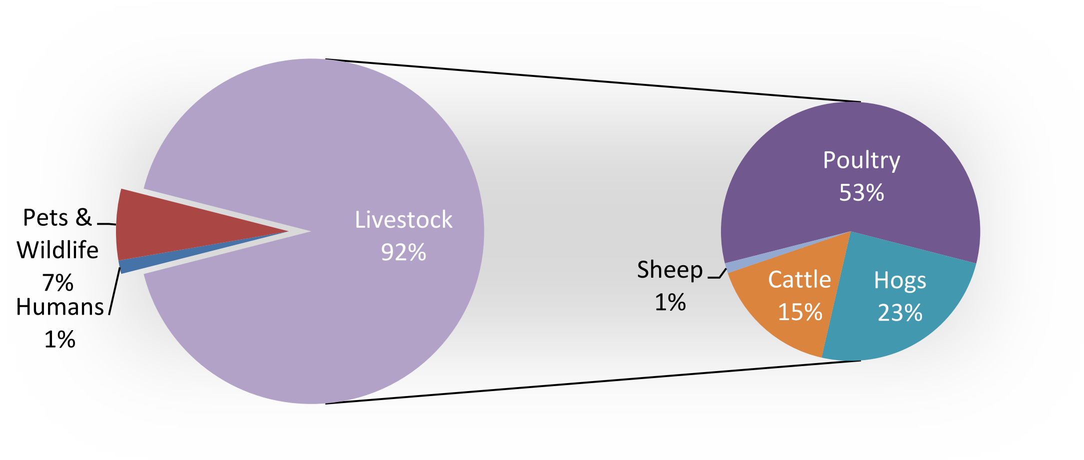

Figure 20. Bacteria production in the County Ditch 12 Subwatershed

Sources Contributing *E. coli* to the Stream Reach

In addition to determining the relative magnitude of *E. coli* sources within the watershed it is important to consider the factors that lead to the *E. coli* being delivered to the stream. The second step in the bacteria source assessment is to evaluate the connection between *E. coli* production, how it is handled on the landscape and how it is ultimately delivered to the stream. In the case of the County Ditch 12 Subwatershed, where poultry is identified as the main potential bacteria source, the primary activity by which the bacteria becomes available to wash into the stream is through manure application to fields where the manure is not immediately incorporated into the soil (Figure 21). Other mechanisms include runoff from feedlots (that do not have adequate controls) and from animals on pasture.

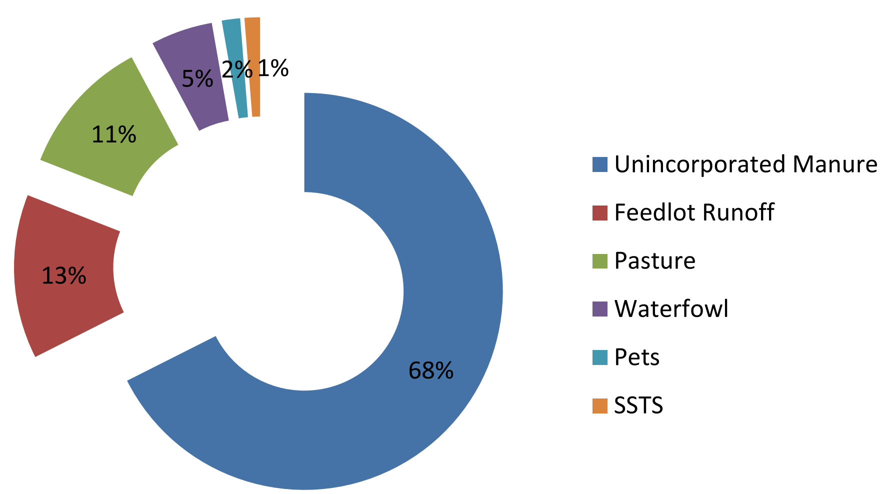

Figure 21. Estimated Percentage of Potential Sources Contributing Bacteria to County Ditch 12

Potential *E. coli* Contributing Areas

The final step in the bacteria source assessment methodology developed for the TMDL Study was to determine which areas within the subwatershed have the highest potential to contribute *E. coli* to the stream. In agricultural subwatersheds the areas that have the highest potential to contribute *E. coli* to the stream are areas immediately adjacent to or hydrologically connected to streams where manure is applied or where animals are grazing. Refer to Figure 22 for the map of areas within the County Ditch 12 Subwatershed that have a high potential to contribute bacteria to the stream. These areas should be prioritized for implementation activities. The Priority Implementation Area in Figure 22 was determined by calculating a delivery factor that accounts for fate and transport factors such as proximity to surface waters, slope, imperviousness, and discharge to lakes prior to discharge to stream networks (refer to Section 4.2.6 of the TMDL Study for more specific information on how the delivery factor and Priority Implementation Area was calculated).

TMDL Allocations and Percent Reductions

Wasteload and load allocations for this subwatershed and the calculated percent reduction needed to meet the TMDL are summarized in Table 23. Load allocations indicate a moderate decrease needed for bacteria in runoff under mid-range flow conditions in the County Ditch 12 Subwatershed. The maximum percent reduction of bacteria load needed is 29%.

Table 23. County Ditch 12 Subwatershed TMDL and Percent Reductions Needed

Flow Regime	Existing Load (billion org/d)	Waste Load Allocations			LA (billion org/d)	MOS (billion org/d)	TMDL (billion org/d)	LA + MS4 WLA (billion org/d)	Estimated Reduction in Watershed Runoff (%)
		WWTFs (Total) (billion org/d)	Straight Pipes (billion org/d)	MS4 (billion org/d)					
High	ID	–	–	0.268	73.2	8.16	81.6	73.5	ID
Moist	29.9	–	–	0.112	30.7	3.42	34.2	30.8	0%
Mid-Range	23.1	–	–	0.0601	16.4	1.83	18.3	16.5	29%
Dry	7.47	–	–	0.0311	8.49	0.947	9.47	8.52	0%
Low	ID	–	–	0.0164	4.48	0.5	5	4.5	ID

Key: WWTF-Waste Water Treatment Facility, MS4-Municipal Separate Storm Sewer System, MOS-Margin of Safety, LA-Load Allocation, org-organisms, d-day, ID-Insufficient Data, IDUL-Impairment due to upstream load, EQN-Based on the equation found on page 104 in the TMDL Study, WLA-Waste Load Allocation

Regulated Entities

The regulated entities within this subwatershed are shown in Table 24.

Table 24. Regulated Entities within the County Ditch 12 Subwatershed

Regulated Entity	Permit #
Brockway Township	MS400068

Implementation Plan

The findings of the bacteria source assessment suggest that application of poultry manure that is not appropriately incorporated into the soils is the largest of the likely bacteria sources to the County Ditch 12 Subwatershed. Specifically, land immediately surrounding County Ditch 12 has been assessed as a high risk area for surface applied manure. Based on the source assessment and the TMDL the **target goal is up to a 29% reduction** of bacteria for this subwatershed. In other flow regimes the target goal is lower. The following is the magnitude of reductions to the major potential sources of bacteria that would be necessary within the watershed to meet the 29% goal. Given this level of reduction it will likely take 20+ years of active management for the County Ditch 12 Creek to meet water quality standards for *E. coli*.

- Eliminate 35% of the bacteria coming from manure that is not appropriately incorporated into the soil.
- Eliminate 25% of the bacteria coming from feedlots with inadequate runoff controls.
- Eliminate 100% of the SSTS that are an imminent threat to public health by bringing septic systems into compliance with standards.
- Eliminate 25% of the bacteria load from grazing livestock.

Priority Actions

As a result of the analyses for bacteria sources and contributing areas, the primary focus of implementation for this subwatershed will be to prevent unincorporated manure from reaching the stream and to reduce runoff from feedlots. This can be done by land application with incorporation or by treating manure prior to land application and implementing feedlot runoff controls, respectively.

There are likely other contributors of bacteria that may not have been captured in the analyses above due to a lack of documentation. In many cases, local knowledge of bacteria sources may provide superior guidance for determining how to reduce bacteria loading to impaired stream reaches. Addressing additional sources within the County Ditch 12 Subwatershed that are likely contributing *E. coli* to a lesser degree are also included in the implementation plan since the needed reduction is high in this subwatershed (see Rural Subwatersheds for more information). Below are the priority actions that are recommended for the County Ditch 12 Subwatershed.

- Identify and map potential and known sources that are directly contributing bacteria to waterbodies using local knowledge, windshield surveys, and interviews with landowners, etc. Note that mapping sources is a distinct activity from monitoring.
- Continue baseline monitoring of the stream reach and add additional monitoring stations along the stream reach and tributaries to help pinpoint potential sources of bacteria. Refer to the monitoring section for further recommendations.
- Reduce direct sources of bacteria, such as livestock that have access to streams, installing fences around streams within pastures, or providing water sources within pastures to reduce the frequency of livestock from entering streams.
- Promote the use of manure injection or incorporation of manure on all land where manure is applied. Target land areas near the stream and ditches and tile intakes first. Alternatively, treat manure to reduce bacteria concentrations prior to land application.
- Promote good manure application and treatment practices such as:
    - Applying manure to relatively dry fields;

    - Avoiding steep sloping areas;
    - Avoiding areas near water bodies;
    - Avoiding vulnerable locations for spreading manure;
    - Avoiding areas prone to flooding;
    - Avoiding applying on frozen soil.
- Implement and enforce feedlot runoff controls.
- Install filter strips around fields, especially where streams are present, to prevent bacteria-laden runoff from reaching streams; buffer strips should also be installed along ditches within fields that flow directly to streams. Priority should be given to BMPs that provide multiple benefits.
- Ensure that all local feedlot, SSTS, septage and pet-waste ordinances within the subwatershed are stringent enough so that rivers and streams will meet State water quality standards.
- Ensure that ordinances are enforced, through regular inspection and monitoring.
- Conduct septic inspections and make sure all systems that are imminent threats are brought into compliance.
- Conduct education and outreach to ensure that ordinances and BMPs are understood and followed.
- Ensure septage application is in compliance with state laws and local ordinances.

Table 25 lists the priority actions described above along with a recommended timeframe for implementation and estimated costs. The timeframe that is provided is based on priority of implementation, and efforts will likely be ongoing once the action has been implemented. Action items are listed in order of importance. Also included in Table 25 are priority actions that are simply good practices to follow in all subwatersheds regardless of the magnitude of the source/activity they address. Note that some of these practices may have already been initiated within the subwatershed; if that is the case, continue with them and enhance them where necessary. Note that the costs are provided for context and not as an estimate of the total expenditure needed to meet any specified reduction in bacteria.

Refer to Appendix A for the entities responsible for implementing source controls and treatment BMPs in this subwatershed.

Table 25. Priority actions for County Ditch 12 Subwatershed

Priority Timeframe[1]	Action	Estimated Effectiveness of Practice[2] (up to)	Estimated Magnitude in Watershed	Implementation Cost[3]
High	Limit livestock from accessing streams/waterbodies by fencing or providing alternative water sources Livestock Stream Access Control	100%	Unknown	$0.70-1.50/ linear feet of fencing $3-6/ cu yard to construct a pond as an alternative water source
High	Promote land application of manure with incorporation Land application w/ incorporation	70%	2,000 – 5,000 acres of cultivated cropland	$12/acre

Priority Timeframe[1]	Action	Estimated Effectiveness of Practice[2] (up to)	Estimated Magnitude in Watershed	Implementation Cost[3]
High	Promote good manure application and treatment practices (see text above) Manure Management	Varies by practice	2,000 – 5,000 acres of cultivated cropland	NA
High	Implement feedlot runoff control and manure management at existing feedlots Feedlot Runoff Control	100%	~1,700 Animal Units (AU)	$8-24/AU
High	Install vegetated buffers around fields where manure is applied as well as grazed lands Filter Strips	92%	~29 acres (assume 6 miles of stream; 20ft buffer)	$600-1000/acre
Medium	Identify and map any location with potential bacteria sources Monitoring	NA	NA	Staff time
Medium	Ensure that all local feedlot, SSTS, septage and pet-waste ordinances within the subwatershed are enforced through regular inspection and monitoring and are stringent enough so that rivers and streams will meet State water quality standards. Federal, State, and Local Requirements	100%	NA	Staff time
Medium	Conduct education and outreach to ensure that ordinances and BMPs are understood and followed. Outreach/Education	100%	NA	Staff time
Medium	Adopt and enforce strict septic ordinances. Septic (SSTS) Maintenance	100%	NA	Staff time
Medium	Conduct septic system inspections as warranted and bring septic systems into compliance with standards Septic (SSTS) Maintenance	100%	~5 systems	$200-300 (inspection) $7,500 per system (if replacement required)
Medium	Conduct outreach to producers to promote manure management practices that prevent the release of and/or treat manure to reduce bacteria concentrations Outreach/Education	NA	NA	Staff time

Priority Timeframe[1]	Action	Estimated Effectiveness of Practice[2] (up to)	Estimated Magnitude in Watershed	Implementation Cost[3]
Medium	Septage application should be incorporated (follow guidelines found in the MPCA guidance document Septage Removal and Disposal) Septage	70%	2,000 – 5,000 acres of cultivated cropland	$12/acre
Low	Regularly monitor stream and inspect all significant sources that have the potential to release bacteria Monitoring	NA	NA	Staff time

[1] Priority is based on recommended timeframe to continue or start (not complete) implementation activities: High = 1-2 years, Medium = 2-5 years, Low = 5-10 years.
[2] Estimated effectiveness of practice refers to the reduction of bacteria concentrations in runoff to receiving waterbodies.
[3] Costs based on NRCS EQIP Payment Schedules
http://www.nrcs.usda.gov/wps/portal/nrcs/detail/mn/programs/financial/?cid=stelprdb1245512

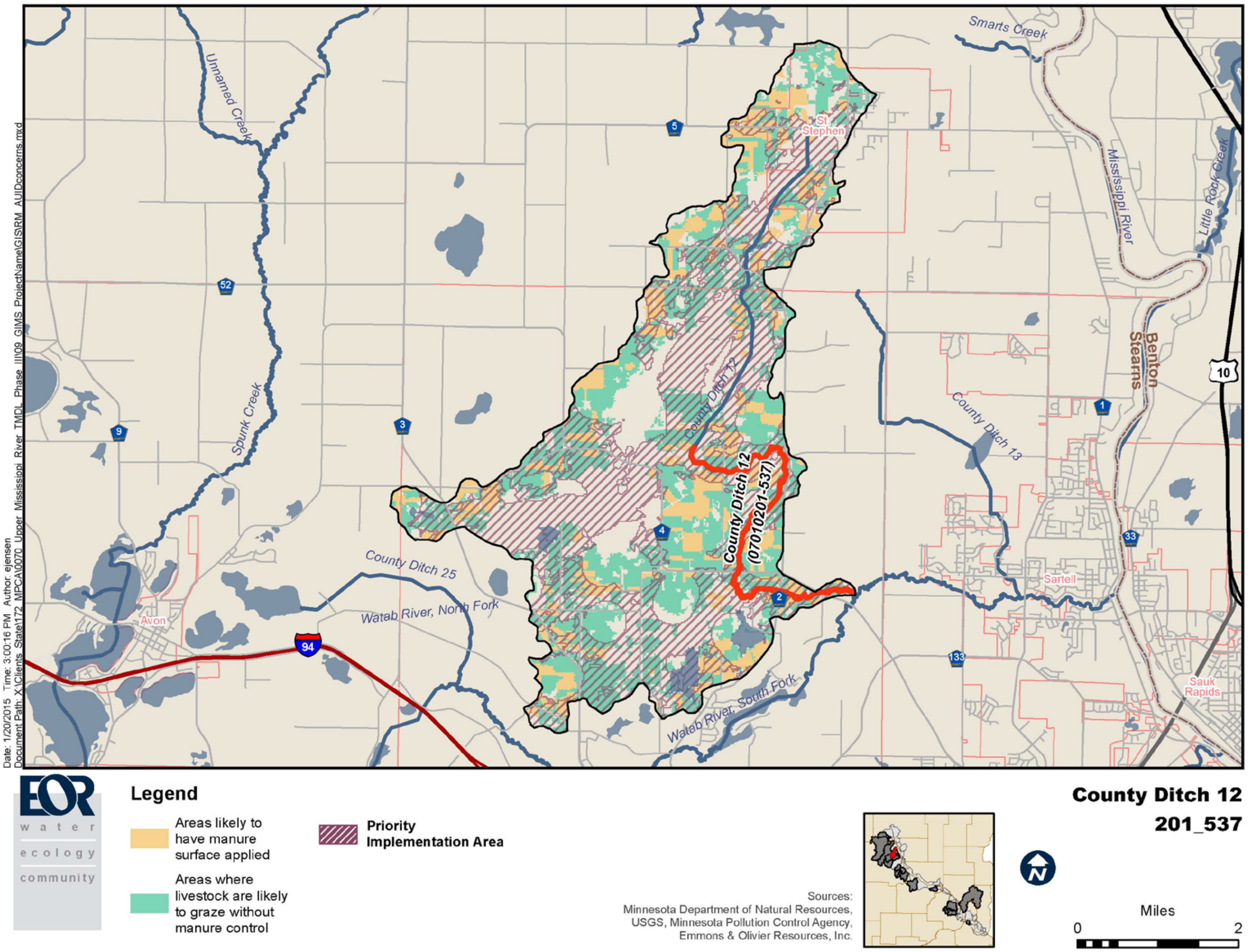

Figure 22. Areas with highest risk for transport of bacteria into streams and rivers to be targeted for initial implementation (hatched areas) (refer to Potential E. coli Contributing Areas to determine how Priority Implementation Areas were determined)

South Two River (07010201-543) Subwatershed

Reach Description: Two River Lake to Two River

South Two River, a tributary of Two River (Two River (07010201-523) Subwatershed), is impaired for aquatic recreation due to *E. coli*. The subwatershed is located within Priority Area B of the St Cloud Source Water Protection Area (Figure 2). Monitoring conducted in 2010 and 2011 indicated elevated levels of *E. coli* throughout the growing season with exceedances of the water quality standard occurring in July and August. *E. coli* counts ranged from 24 to 921 org/100 ml and monthly geometric means ranged from 108 to 548 org/100 ml (a summary of water quality monitoring data can be found in Appendix D of the TMDL Study). Plotting *E. coli* levels against stream flow, as is shown in the load duration curves in Figure 6.13 on page 123 of the TMDL Study, show that exceedances occur at all flow conditions (e.g. high, moist, mid, dry, low) where there is monitoring data. A very high reduction is required by the TMDL for low flow conditions (Table 27).

Production of *E. coli* in Subwatershed

As described in the TMDL Study and in Table 27 below, the Total Maximum Daily Load for South Two River is divided into point (permitted) sources and nonpoint (non-permitted) sources. In the South Two River Subwatershed, the Albany, Bowlus and Holdingford Wastewater Treatment Facilities are the point sources of *E. coli* (Table 28). For nonpoint sources, the majority of the land in this subwatershed is in agricultural use (Table 26).

Table 26. South Two River Subwatershed Land uses

Land use	%
Pasture / Hay	41%
Cultivated Crops	35%
Deciduous Forest	10%
Developed Open Space	5%
Open Water	3%
Emergent Herbaceous Wetland	2%
Woody Wetlands	2%
Grassland / Herbaceous	2%
Table only includes land uses that are > 1% of the land area	

In developing the TMDL Study a desktop analysis was conducted to determine the potential sources of *E. coli* within each subwatershed and estimate the relative contribution of each source. The process, referred to as a bacteria source assessment, is described in Section 4 of the TMDL Study beginning on page 45. In the South Two River Subwatershed the vast majority of the *E. coli* is likely produced from livestock with slight contributions from humans and from pets and wildlife (Figure 23). Further analysis of livestock numbers suggest that poultry is the type of livestock that produces the most *E. coli* in this subwatershed followed by hogs and cattle (Figure 23). The fraction of *E. coli* from various sources of livestock in the pie chart is determined by the total animal units estimated within the subwatershed and takes into account the size discrepancy of the various types of livestock as well as the differences in the amount of bacteria within their waste.

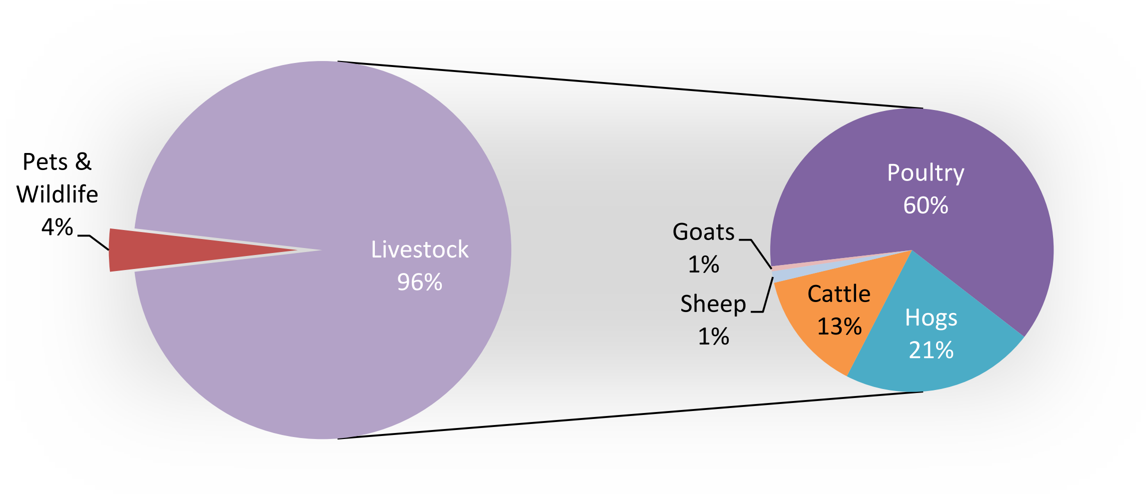

Figure 23. Bacteria production in the South Two River Subwatershed

Sources Contributing *E. coli* to the Stream Reach

In addition to determining the relative magnitude of *E. coli* sources within the watershed it is important to consider the factors that lead to the *E. coli* being delivered to the stream. The second step in the bacteria source assessment is to evaluate the connection between *E. coli* production, how it is handled on the landscape and how it is ultimately delivered to the stream. In the case of the South Two Subwatershed, where poultry is identified as the main potential bacteria source followed by hogs and cattle, the primary activity by which the bacteria becomes available to wash into the stream is through manure application to fields where the manure is not immediately incorporated into the soil (Figure 24). Other mechanisms include runoff from feedlots (that do not have adequate controls) and from animals on pasture.

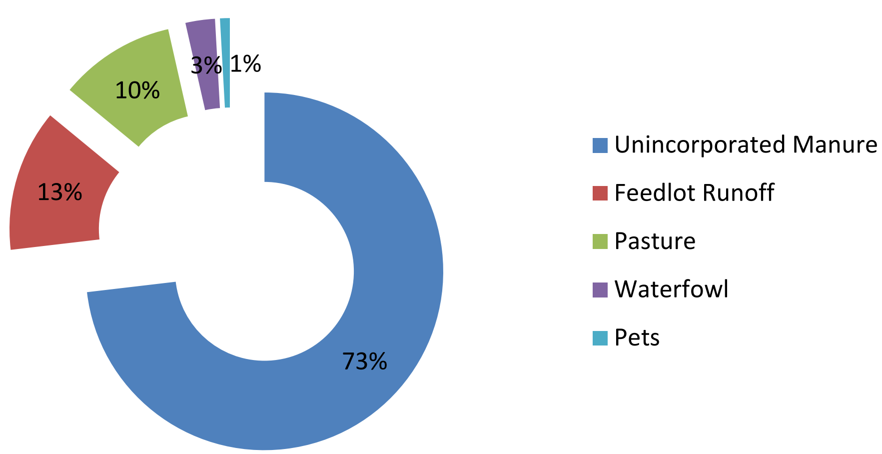

Figure 24. Estimated Percentage of Potential Sources Contributing Bacteria to the South Two River

Potential *E. coli* Contributing Areas

The final step in the bacteria source assessment methodology developed for the TMDL Study was to determine which areas within the subwatershed have the highest potential to contribute *E. coli* to the stream. In agricultural subwatersheds the areas that have the highest potential to contribute *E. coli* to the stream are areas immediately adjacent to or hydrologically connected to streams where manure is applied or where animals are grazing. Refer to Figure 25 the map of areas within the South Two River Subwatershed that have a high potential to contribute bacteria to the stream. These areas should be prioritized for implementation activities. The Priority Implementation Area in Figure 25 was determined by calculating a delivery factor that accounts for fate and transport factors such as proximity to surface waters, slope, imperviousness, and discharge to lakes prior to discharge to stream networks (refer to Section 4.2.6 of the TMDL Study for more specific information on how the delivery factor and Priority Implementation Area was calculated).

TMDL Allocations and Percent Reductions

Wasteload and load allocations for this subwatershed and the calculated percent reduction needed to meet the TMDL are summarized in Table 27. Load allocations indicate a sizable decrease needed for bacteria in runoff under mid-range, dry and low flow conditions in the South Two River Subwatershed. The maximum percent reduction of bacteria load needed is 90%.

Table 27. South Two River Subwatershed TMDL and Percent Reductions Needed

Flow Regime	Existing Load (billion org/d)	Waste Load Allocations			LA (billion org/d)	MOS (billion org/d)	TMDL (billion org/d)	LA + MS4 WLA (billion org/d)	Estimated Reduction in Watershed Runoff (%)
		WWTFs (Total) (billion org/d)	Straight Pipes (billion org/d)	MS4 (billion org/d)					
High	ID	27.3	–	–	435	51.4	514	435	ID
Moist	230	27.3	–	–	189	24	240	189	18%
Mid-Range	245	27.3	–	–	108	15	150	108	56%
Dry	291	27.3	–	–	60.4	9.74	97.4	60.4	79%
Low	206	27.3	–	–	21	5.37	53.7	21	90%

Key: WWTF-Waste Water Treatment Facility, MS4-Municipal Separate Storm Sewer System, MOS-Margin of Safety, LA-Load Allocation, org-organisms, d-day, ID-Insufficient Data, IDUL-Impairment due to upstream load, EQN-Based on the equation found on page 104 in the TMDL Study, WLA-Waste Load Allocation

Regulated Entities

The regulated entities within this subwatershed are shown in Table 28.

Table 28. Regulated Entities within the South Two River Subwatershed

Regulated Entity	Permit #
Albany WWTF	MN0020575
Bowlus WWTF	MN0020923
Holdingford WWTF	MN0023710

Implementation Plan

The findings of the bacteria source assessment suggest that application of poultry manure that is not appropriately incorporated into the soils is the largest of the likely bacteria sources to the South Two River Subwatershed. Specifically, land immediately surrounding South Two River has been assessed as a high risk area for surface applied manure. Based on the source assessment and the TMDL the **target goal is up to a 90% reduction** of bacteria for this subwatershed. In other flow regimes the target goal is lower. The following is the magnitude of reductions to the major potential sources of bacteria that would be necessary within the watershed to meet the 90% goal. Given this level of reduction it will likely take 20+ years of active management for the South Two River to meet water quality standards for *E. coli*.

- Eliminate 95% of the bacteria coming from manure that is not appropriately incorporated into the soil.
- Eliminate 95% of the bacteria coming from feedlots with inadequate runoff controls.
- Eliminate 95% of the bacteria load from grazing livestock.
- Ensure appropriate controls are in place to keep the Albany WWTF (MN0020575) to a maximum discharge of 23.8 billion organisms/day**.**
- Ensure appropriate controls are in place to keep the Bowlus WWTF (MN0020923) to a maximum discharge of 2.38 billion organisms/day.
- Eliminate 100% of the SSTS that are an imminent threat to public health by bringing septic systems into compliance with standards.

Priority Actions

As a result of the analyses for bacteria sources and contributing areas, the primary focus of implementation for this subwatershed will be to prevent unincorporated manure from reaching the stream and to reduce runoff from feedlots. This can be done by land application with incorporation or by treating manure prior to land application and implementing feedlot runoff controls, respectively.

There are likely other contributors of bacteria that may not have been captured in the analyses above due to a lack of documentation. In many cases, local knowledge of bacteria sources may provide superior guidance for determining how to reduce bacteria loading to impaired stream reaches. Addressing additional sources within the South Two River Subwatershed that are likely contributing *E. coli* to a lesser degree are also included in the implementation plan since the needed reduction is high in this subwatershed (see Rural Subwatersheds for more information). Below are the priority actions that are recommended for the South Two River Subwatershed.

- Identify and map potential and known sources that are directly contributing bacteria to waterbodies using local knowledge, windshield surveys, and interviews with landowners, etc. Note that mapping sources is a distinct activity from monitoring.
- Continue baseline monitoring of the stream reach and add additional monitoring stations along the stream reach and tributaries to help pinpoint potential sources of bacteria. Refer to the monitoring section for further recommendations.
- Reduce direct sources of bacteria, such as livestock that have access to streams, installing fences around streams within pastures, or providing water sources within pastures to reduce the frequency of livestock from entering streams.
- Promote the use of manure injection or incorporation of manure on all land where manure is applied. Target land areas near the stream and ditches and tile intakes first. Alternatively, treat manure to reduce bacteria concentrations prior to land application.
- Promote good manure application and treatment practices such as:
    - Applying manure to relatively dry fields;
    - Avoiding steep sloping areas;
    - Avoiding areas near water bodies;
    - Avoiding vulnerable locations for spreading manure;
    - Avoiding areas prone to flooding;
    - Avoiding applying on frozen soil;
- Implement and enforce feedlot runoff controls.
- Install filter strips around fields, especially where streams are present, to prevent bacteria-laden runoff from reaching streams; buffer strips should also be installed along ditches within fields that flow directly to streams. Priority should be given to BMPs that provide multiple benefits.
- Ensure that all local feedlot, SSTS, septage and pet-waste ordinances within the subwatershed are stringent enough so that rivers and streams will meet State water quality standards.
- Ensure that ordinances are enforced, through regular inspection and monitoring.
- Conduct education and outreach to ensure that ordinances and BMPs are understood and followed.
- Ensure septage application is in compliance with state laws and local ordinances.

Table 29 lists the priority actions described above along with a recommended timeframe for implementation and estimated costs. The timeframe that is provided is based on priority of implementation, and efforts will likely be ongoing once the action has been implemented. Action items are listed in order of importance. Also included in Table 29 are priority actions that are simply good practices to follow in all subwatersheds regardless of the magnitude of the source/activity they address. Note that some of these practices may have already been initiated within the subwatershed; if that is the case, continue with them and enhance them where necessary. Note that the costs are provided for context and not as an estimate of the total expenditure needed to meet any specified reduction in bacteria.

Refer to Appendix A for the entities responsible for implementing source controls and treatment BMPs in this subwatershed.

Table 29. Priority actions for South Two River Subwatershed

Priority Timeframe[1]	Action	Estimated Effectiveness of Practice[2] (up to)	Estimated Magnitude in Watershed	Implementation Cost[3]
High	Limit livestock from accessing streams/waterbodies by fencing or providing alternative water sources Livestock Stream Access Control	100%	Unknown	$0.70-1.50/ linear feet of fencing $3-6/ cu yard to construct a pond as an alternative water source
High	Promote land application of manure with incorporation Land application w/ incorporation	70%	30,000 – 40,000 acres of cultivated cropland	$12/acre
High	Promote good manure application and treatment practices (see text above) Manure Management	Varies by practice	30,000 – 40,000 acres of cultivated cropland	NA
High	Implement feedlot runoff control and manure management at existing feedlots Feedlot Runoff Control	100%	~13,000 Animal Units (AU)	$8-24/AU
High	Install vegetated buffers around fields where manure is applied as well as grazed lands Filter Strips	92%	~77 acres (assume 16 miles of stream; 20ft buffer)	$600-1000/acre
High	Adopt, enforce, and ensure that all local feedlot, SSTS, septage and pet-waste ordinances within the subwatershed are enforced through regular inspection and monitoring and are stringent enough so that rivers and streams will meet State water quality standards. Federal, State, and Local Requirements	100%	NA	Staff time
Medium	Conduct education and outreach to ensure that ordinances and BMPs are understood and followed.	100%	NA	Staff time
Medium	Identify and map any location with potential bacteria sources Monitoring	NA	NA	Staff time
Medium	Conduct outreach and education to ensure ordinances and BMPs are followed and understood Outreach/Education	NA	NA	Staff time
Low	Septage application should be incorporated (follow guidelines found in the MPCA guidance document Septage Removal and Disposal) Septage	NA	NA	Staff time

Priority Timeframe[1]	Action	Estimated Effectiveness of Practice[2] (up to)	Estimated Magnitude in Watershed	Implementation Cost[3]
Low	Regularly monitor stream and inspect all significant sources that have the potential to release bacteria Monitoring	NA	NA	Staff time

[1] Priority is based on recommended timeframe to continue or start (not complete) implementation activities: High = 1-2 years, Medium = 2-5 years, Low = 5-10 years.
[2] Estimated effectiveness of practice refers to the reduction of bacteria concentrations in runoff to receiving waterbodies.
[3] Costs based on NRCS EQIP Payment Schedules
http://www.nrcs.usda.gov/wps/portal/nrcs/detail/mn/programs/financial/?cid=stelprdb1245512

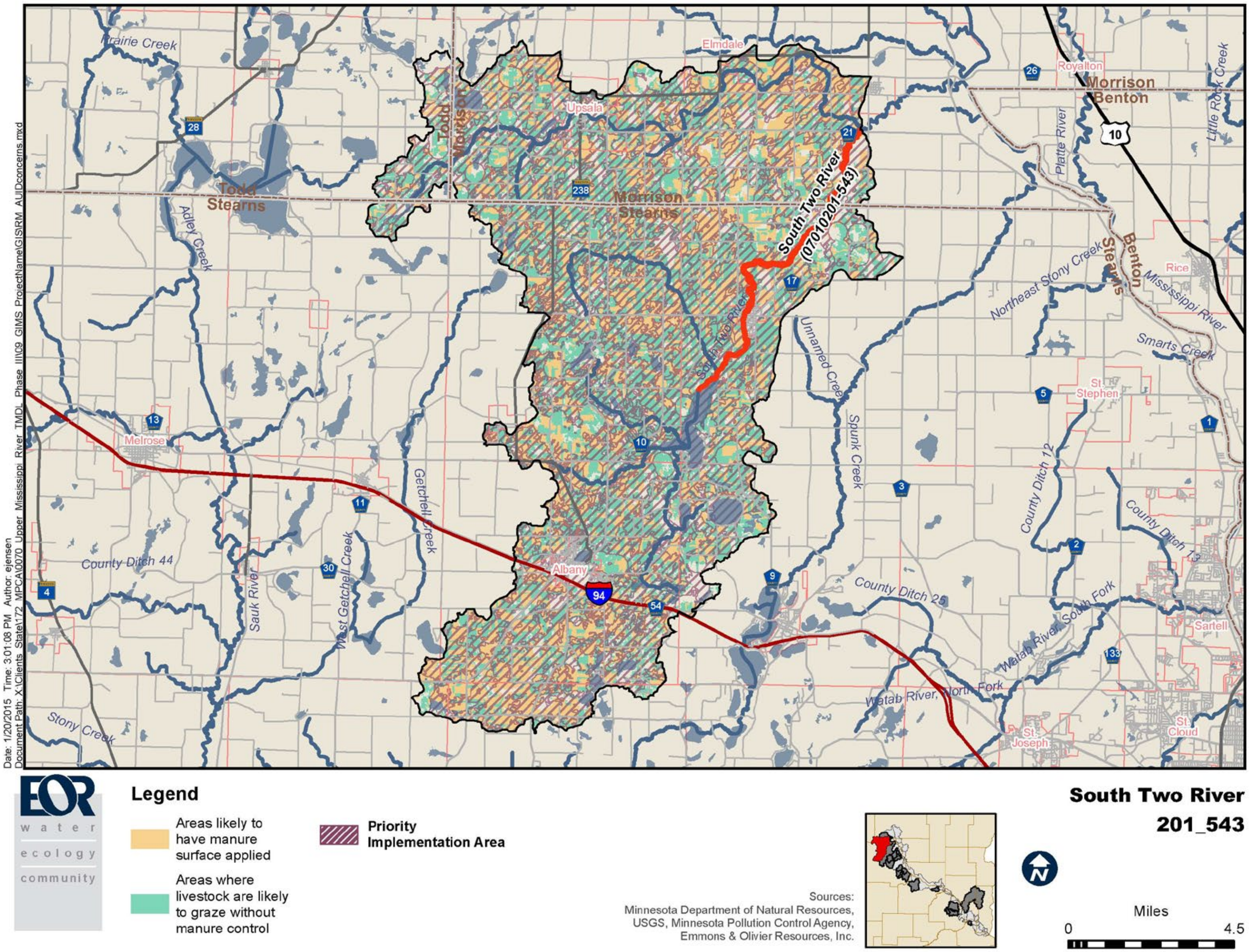

Figure 25. Areas with highest risk for transport of bacteria into streams and rivers to be targeted for initial implementation (hatched areas). Refer to [Potential E. coli Contributing Areas] to determine how Priority Implementation Areas were determined.

Watab River, South Fork (07010201-554) Subwatershed

Reach Description: Little Watab Lake to Watab River

South Fork Watab River, a tributary of the Watab River, is impaired for aquatic recreation due to *E. coli*. The subwatershed is located within Priority Areas A and B of the St. Cloud Source Water Protection Area (Figure 2). Watab River (07010201-528) and Watab River, North Fork (07010201-529) are also impaired for *E. coli*. Monitoring conducted in 2010 and 2011 indicated elevated levels of *E. coli* throughout the growing season with exceedances of the water quality standard occurring in every month with at least five samples from April through October. *E. coli* counts ranged from 54 to 921 org/100 ml and monthly geometric means ranged from 189 to 407 org/100 ml (a summary of water quality monitoring data can be found in Appendix D of the TMDL Study). Plotting *E. coli* levels against stream flow, as is shown in the load duration curves in Figure 6.15 on page 125 of the TMDL Study, show that exceedances occur at all flow conditions (e.g. high, moist, mid, dry, low) where there is monitoring data.

Production of *E. coli* in Subwatershed

As described in the TMDL Study and in Table 31 below, the Total Maximum Daily Load for South Fork Watab River is divided into point (permitted) sources and nonpoint (non-permitted) sources. In the South Fork Watab River Subwatershed, point sources of *E. coli* are limited to MS4s (Table 32). For nonpoint sources, the majority of the land use in this watershed is in agricultural use (Table 30).

Table 30. South Fork Watab River Subwatershed Land uses

Land use	%
Pasture / Hay	28%
Deciduous Forest	26%
Cultivated Crops	22%
Grassland / Herbaceous	9%
Open Water	5%
Developed Open Space	5%
Emergent Herbaceous Wetland	3%
Table only includes land uses that are > 1% of the land area	

In developing the TMDL Study a desktop analysis was conducted to determine the potential sources of *E. coli* within each subwatershed and estimate the relative contribution of each source. The process, referred to as a bacteria source assessment, is described in Section 4 of the TMDL Study beginning on page 45. In the Watab River South Fork Subwatershed the vast majority of the *E. coli* is likely produced from livestock with slight contributions from humans and from pets and wildlife (Figure 26). Further analysis of livestock numbers suggest that poultry is the type of livestock that produces the most *E. coli* in this subwatershed followed by hogs and cattle (Figure 26). The fraction of *E. coli* from various sources of livestock in the pie chart is determined by the total animal units estimated within the subwatershed and takes into account the size discrepancy of the various types of livestock as well as the differences in the amount of bacteria within their waste.

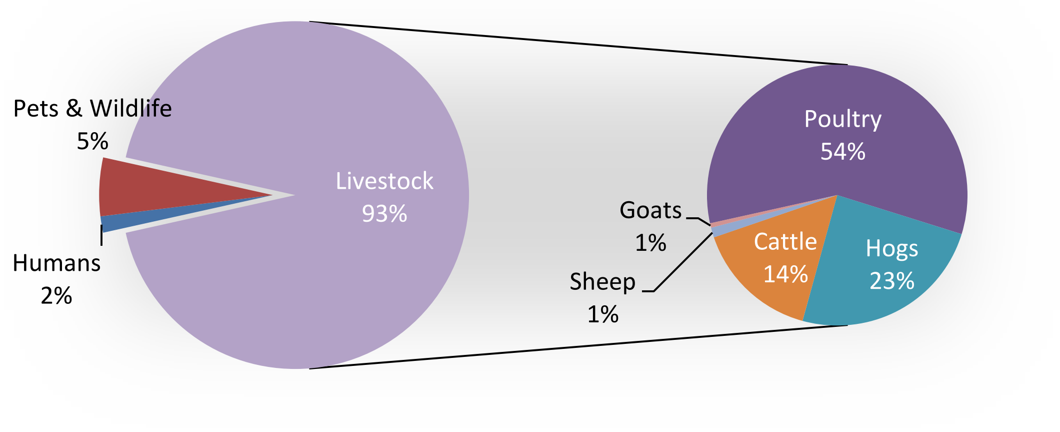

Figure 26. Bacteria production in the Watab River, South Fork Subwatershed

Sources Contributing *E. coli* to the Stream Reach

In addition to determining the relative magnitude of *E. coli* sources within the watershed it is important to consider the factors that lead to the *E. coli* being delivered to the stream. The second step in the bacteria source assessment is to evaluate the connection between *E. coli* production, how it is handled on the landscape and how it is ultimately delivered to the stream. In the case of the Watab River South Fork Subwatershed, where poultry is identified as the main potential bacteria source, the primary activity by which bacteria becomes available to wash into the stream is through manure application to fields where the manure is not immediately incorporated into the soil Figure 27). Other mechanisms include runoff from feedlots (that do not have adequate controls) and from animals on pasture.

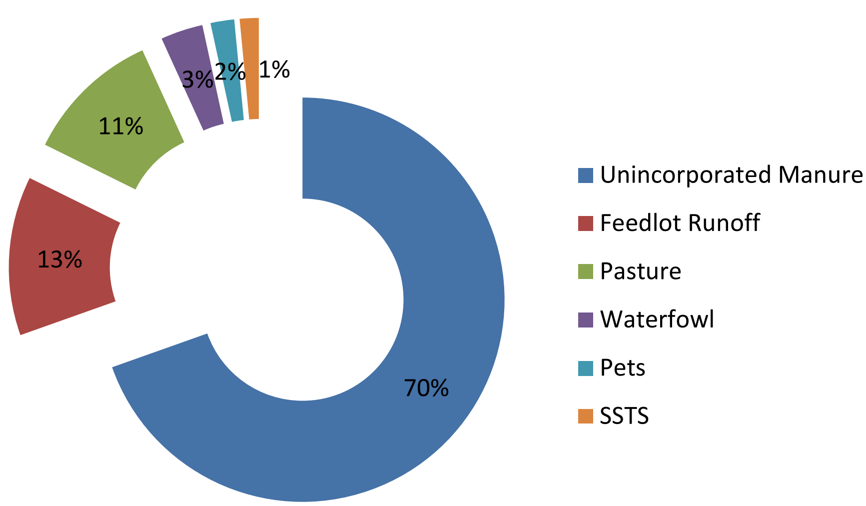

Figure 27. Estimated Percentage of Potential Sources Contributing Bacteria to the Watab River, South Fork

Potential *E. coli* Contributing Areas

The final step in the bacteria source assessment methodology developed for the TMDL Study was to determine which areas within the subwatershed have the highest potential to contribute *E. coli* to the stream. In agricultural subwatersheds the areas that have the highest potential to contribute *E. coli* to the stream are areas immediately adjacent to or hydrologically connected to streams where manure is applied or where animals are grazing. Refer to Figure 28 for the map of areas within the Watab River South Fork Subwatershed that have a high potential to contribute bacteria to the stream. These areas should be prioritized for implementation activities. The Priority Implementation Area in Figure 28 was determined by calculating a delivery factor that accounts for fate and transport factors such as proximity to surface waters, slope, imperviousness, and discharge to lakes prior to discharge to stream networks (refer to Section 4.2.6 of the TMDL Study for more specific information on how the delivery factor and Priority Implementation Area was calculated).

TMDL Allocations and Percent Reductions

Wasteload and load allocations for this subwatershed and the calculated percent reduction needed to meet the TMDL are summarized in Table 31. Load allocations indicate a sizable decrease needed for bacteria in runoff under moist, mid-range and dry flow conditions in the Watab River South Fork Subwatershed. The maximum percent reduction of bacteria load needed is 71%.

Table 31. South Fork Watab River Subwatershed TMDL and Percent Reductions Needed

Flow Regime	Existing Load (billion org/d)	Waste Load Allocations			LA (billion org/d)	MOS (billion org/d)	TMDL (billion org/d)	LA + MS4 WLA (billion org/d)	Estimated Reduction in Watershed Runoff (%)
		WWTFs (Total) (billion org/d)	Straight Pipes (billion org/d)	MS4 (billion org/d)					
High	ID	–	–	4.55	106	12.3	123	111	ID
Moist	82.9	–	–	1.9	44.3	5.13	51.3	46.2	44%
Mid-Range	84.7	–	–	1.02	23.7	2.75	27.5	24.7	71%
Dry	29.1	–	–	0.525	12.3	1.42	14.2	12.8	56%
Low	ID	–	–	0.278	6.48	0.751	7.51	6.76	ID

Key: WWTF-Waste Water Treatment Facility, MS4-Municipal Separate Storm Sewer System, MOS-Margin of Safety, LA-Load Allocation, org-organisms, d-day, ID-Insufficient Data, IDUL-Impairment due to upstream load, EQN-Based on the equation found on page 104 in the TMDL Study, WLA-Waste Load Allocation

Regulated Entities

The regulated entities within this subwatershed are shown in Table 32.

Table 32. Regulated Entities within the Watab River, South Fork Subwatershed

Regulated Entity	Permit #
St Joseph City	MS400125
St Joseph Township	MS400157
Stearns County	MS400159

Implementation Plan

The findings of the bacteria source assessment suggest that application of poultry manure that is not appropriately incorporated into the soils is the largest of the likely bacteria sources to the Watab River South Fork Subwatershed. Specifically, land immediately surrounding Watab River South Fork has been assessed as a high risk area for surface applied manure. Based on the source assessment and the TMDL the **target goal is up to a 71% reduction** of bacteria for this subwatershed. In other flow regimes the target goal is lower. The following is the magnitude of reductions to the major potential sources of bacteria that would be necessary within the watershed to meet the 71% goal. Given this level of reduction it will likely take 20+ years of active management for the Watab River South Fork to meet water quality standards for *E. coli*.

- Eliminate 80% of the bacteria coming from manure that is not appropriately incorporated into the soil.
- Eliminate 80% of the bacteria coming from feedlots with inadequate runoff controls.
- Eliminate 100% of the SSTS that are an imminent threat to public health by bringing septic systems into compliance with standards.
- Eliminate 50% of the bacteria load from grazing livestock.

Priority Actions

As a result of the analyses for bacteria sources and contributing areas, the primary focus of implementation for this subwatershed will be to prevent unincorporated manure from reaching the stream and to reduce runoff from feedlots. This can be done by land application with incorporation or by treating manure prior to land application and implementing feedlot runoff controls, respectively.

There are likely other contributors of bacteria that may not have been captured in the analyses above due to a lack of documentation. In many cases, local knowledge of bacteria sources may provide superior guidance for determining how to reduce bacteria loading to impaired stream reaches. Addressing additional sources within the Watab River South Fork Subwatershed that are likely contributing *E. coli* to a lesser degree are also included in the implementation plan since the needed reduction is high in this subwatershed (see Rural Subwatersheds for more information). Below are the priority actions that are recommended for the Watab River South Fork Subwatershed.

- Identify and map potential and known sources that are directly contributing bacteria to waterbodies using local knowledge, windshield surveys, and interviews with landowners, etc. Note that mapping sources is a distinct activity from monitoring.

- Continue baseline monitoring of the stream reach and add additional monitoring stations along the stream reach and tributaries to help pinpoint potential sources of bacteria. Refer to the monitoring section for further recommendations.
- Reduce direct sources of bacteria, such as livestock that have access to streams, installing fences around streams within pastures, or providing water sources within pastures to reduce the frequency of livestock from entering streams.
- Promote the use of manure injection or incorporation of manure on all land where manure is applied. Target land areas near the stream and ditches and tile intakes first. Alternatively, treat manure to reduce bacteria concentrations prior to land application.
- Promote good manure application and treatment practices such as:
    - Applying manure to relatively dry fields;
    - Avoiding steep sloping areas;
    - Avoiding areas near water bodies;
    - Avoiding vulnerable locations for spreading manure;
    - Avoiding areas prone to flooding;
    - Avoiding applying on frozen soil.
- Implement and enforce feedlot runoff controls.
- Install filter strips around fields, especially where streams are present, to prevent bacteria-laden runoff from reaching streams; buffer strips should also be installed along ditches within fields that flow directly to streams. Priority should be given to BMPs that provide multiple benefits.
- Ensure that all local feedlot, SSTS, septage and pet-waste ordinances within the subwatershed are stringent enough so that rivers and streams will meet State water quality standards.
- Ensure that ordinances are enforced, through regular inspection and monitoring.
- Conduct septic inspections and make sure all systems that are imminent threats are brought into compliance.
- Conduct education and outreach to ensure that ordinances and BMPs are understood and followed.
- Ensure septage application is in compliance with state laws and local ordinances.

Table 33 lists the priority actions described above along with a recommended timeframe for implementation and estimated costs. The timeframe that is provided is based on priority of implementation, and efforts will likely be ongoing once the action has been implemented. Action items are listed in order of importance. Also included in Table 33 are priority actions that are simply good practices to follow in all subwatersheds regardless of the magnitude of the source/activity they address. Note that some of these practices may have already been initiated within the subwatershed; if that is the case, continue with them and enhance them where necessary. Note that the costs are provided for context and not as an estimate of the total expenditure needed to meet any specified reduction in bacteria.

Refer to Appendix A for the entities responsible for implementing source controls and treatment BMPs in this subwatershed.

Table 33. Priority actions Watab River South Fork Subwatershed

Priority Timeframe[1]	Action	Estimated Effectiveness of Practice[2] (up to)	Estimated Magnitude in Watershed	Implementation Cost[3]
High	Limit livestock from accessing streams/waterbodies by fencing or providing alternative water sources Livestock Stream Access Control	100%	Unknown	$0.70-1.50/ linear feet of fencing $3-6/cubic yard to construct a pond as an alternative water source
High	Promote land application of manure with incorporation Land application w/ incorporation	70%	4,000 – 5,500 acres of cultivated cropland	$12/acre
High	Promote good manure application and treatment practices (see text above) Manure Management	Varies by practice	4,000 – 5,500 acres of cultivated cropland	NA
High	Implement feedlot runoff control and manure management at existing feedlots Feedlot Runoff Control	100%	~2,300 Animal Units (AU)	$8-24/AU
High	Install vegetated buffers around fields where manure is applied as well as grazed lands Filter Strips	92%	~48 acres (assume 10 miles of stream; 20ft buffer)	$600-1000/acre
Medium	Identify and map any location with potential bacteria sources Monitoring	NA	NA	Staff time
Medium	Adopt, enforce, and ensure that all local feedlot, SSTS, septage and pet-waste ordinances within the subwatershed are enforced through regular inspection and monitoring and are stringent enough so that rivers and streams will meet State water quality standards Federal, State, and Local Requirements	100%	NA	Staff time
Medium	Conduct outreach and education to ensure ordinances and BMPs are followed Outreach/Education	NA	NA	Staff time
Medium	Conduct septic system inspections as warranted and bring septic systems into compliance with standards Septic (SSTS) Maintenance	100%	~5 systems	$200-300 (inspection)$7,500 per system (if replacement required)

Priority Timeframe[1]	Action	Estimated Effectiveness of Practice[2] (up to)	Estimated Magnitude in Watershed	Implementation Cost[3]
Low	Ensure ordinances are followed and enforced for septage application Septage	NA	NA	Staff time
Low	Regularly monitor stream and inspect all significant sources that have the potential to release bacteria Monitoring	NA	NA	Staff time

[1] Priority is based on recommended timeframe to continue or start (not complete) implementation activities: High = 1-2 years, Medium = 2-5 years, Low = 5-10 years.
[2] Estimated effectiveness of practice refers to the reduction of bacteria concentrations in runoff to receiving waterbodies.
[3] Costs based on NRCS EQIP Payment Schedules
http://www.nrcs.usda.gov/wps/portal/nrcs/detail/mn/programs/financial/?cid=stelprdb1245512

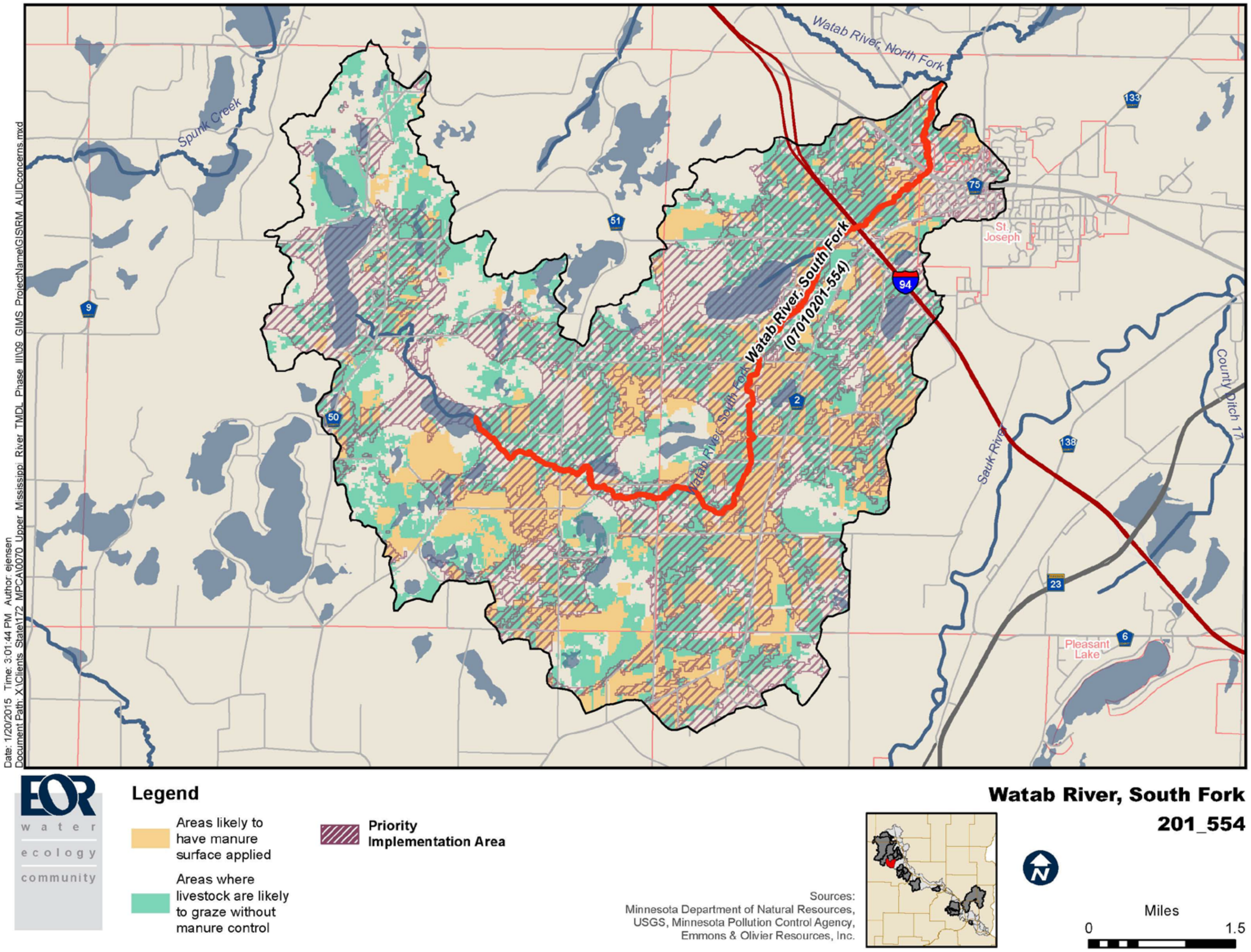

Figure 28. Areas with highest risk for transport of bacteria into streams and rivers to be targeted for initial implementation (hatched areas). Refer to Potential E. coli Contributing Areas to determine how Priority Implementation Areas were determined.

County Ditch 13 (07010201-564) Subwatershed

Reach Description: Bakers Lake to Watab River

County Ditch 13, a tributary of the Watab River (Watab River (07010201-528) Subwatershed), is impaired for aquatic recreation due to *E. coli*. The subwatershed is located within Priority Areas A and B of the St Cloud Source Water Protection Area (Figure 2). Monitoring conducted in 2010 and 2011 indicated elevated levels of *E. coli* throughout the monitored period with exceedances of the water quality standard occurring in every month with at least five samples from June through September. *E. coli* counts ranged from 123 to 1,553 org/100 ml and monthly geometric means ranged from 192 to 553 org/100 ml (a summary of water quality monitoring data can be found in Appendix D of the TMDL Study). Plotting *E. coli* levels against stream flow, as is shown in the load duration curves in Figure 6.16 on page 126 of the TMDL Study, show that exceedances occur at all flow conditions (e.g. high, moist, mid, dry, low) where there is monitoring data.

Production of *E. coli* in Subwatershed

As described in the TMDL Study and in Table 35 below, the Total Maximum Daily Load for County Ditch 13 is divided into point (permitted) sources and nonpoint (non-permitted) sources. In the County Ditch 13 Subwatershed, point sources of *E. coli* are limited to MS4s (Table 36). For nonpoint sources, the majority of the land use in this watershed is in agricultural use (Table 34).

Table 34. County Ditch 13 Subwatershed Land uses

Land use	%
Pasture / Hay	32%
Cultivated Crops	24%
Deciduous Forest	21%
Emergent Herbaceous Wetland	9%
Developed Open Space	6%
Grassland / Herbaceous	5%
Table only includes land uses that are > 1% of the land area	

In developing the TMDL Study a desktop analysis was conducted to determine the potential sources of *E. coli* within each subwatershed and estimate the relative contribution of each source. The process, referred to as a bacteria source assessment, is described in Section 4 of the TMDL Study beginning on page 45. In the County Ditch 13 Subwatershed the vast majority of the *E. coli* is likely produced from livestock with slight contributions from humans and from pets and wildlife (Figure 29). Further analysis of livestock numbers suggest that poultry is the type of livestock that produces the most *E. coli* in this subwatershed followed by hogs and cattle (Figure 29). The fraction of *E. coli* from various sources of livestock in the pie chart is determined by the total animal units estimated within the subwatershed and takes into account the size discrepancy of the various types of livestock as well as the differences in the amount of bacteria within their waste.

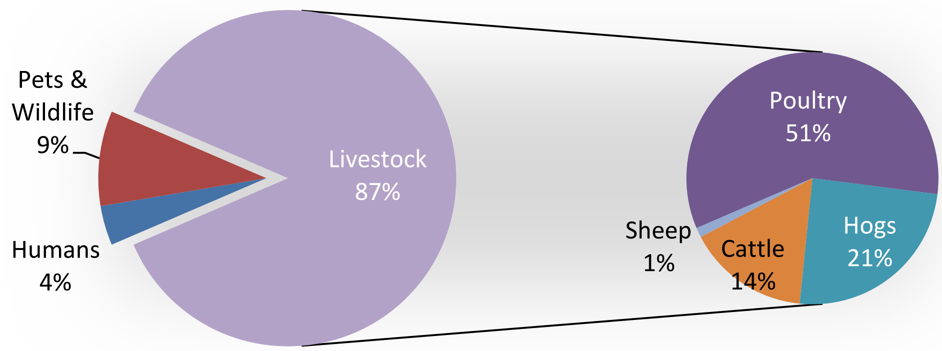

Figure 29. Bacteria production in the County Ditch 13 Subwatershed

Sources Contributing *E. coli* to the Stream Reach

In addition to determining the relative magnitude of *E. coli* sources within the watershed it is important to consider the factors that lead to the *E. coli* being delivered to the stream. The second step in the bacteria source assessment is to evaluate the connection between *E. coli* production, how it is handled on the landscape and how it is ultimately delivered to the stream. In the case of the County Ditch 13 Subwatershed, where poultry is identified as the main potential bacteria source followed by hogs and cattle, the primary activity by which the bacteria becomes available to wash into the stream is through manure application to fields where the manure is not immediately incorporated into the soil (Figure 30). Other mechanisms include runoff from feedlots (that do not have adequate controls) and from animals on pasture.

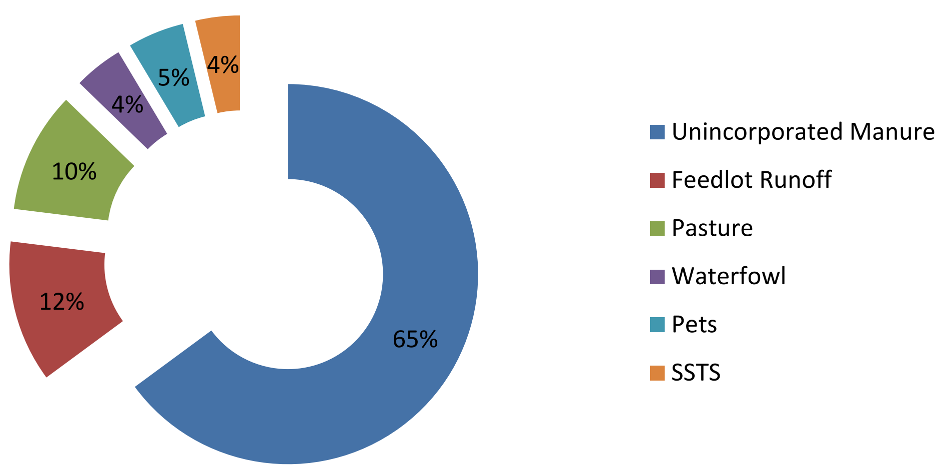

Figure 30. Estimated Percentage of Potential Sources Contributing Bacteria to County Ditch 13

Potential *E. coli* Contributing Areas

The final step in the bacteria source assessment methodology developed for the TMDL Study was to determine which areas within the subwatershed have the highest potential to contribute *E. coli* to the stream. In agricultural subwatersheds the areas that have the highest potential to contribute *E. coli* to the stream are areas immediately adjacent to or hydrologically connected to streams where manure is applied or where animals are grazing. Refer to Figure 31 for the map of areas within the Ditch 13 Subwatershed that have a high potential to contribute bacteria to the stream. These areas should be prioritized for implementation activities. The Priority Implementation Area in Figure 31 was determined by calculating a delivery factor that accounts for fate and transport factors such as proximity to surface waters, slope, imperviousness, and discharge to lakes prior to discharge to stream networks (refer to Section 4.2.6 of the TMDL Study for more specific information on how the delivery factor and Priority Implementation Area was calculated).

TMDL Allocations and Percent Reductions

Wasteload and load allocations for this subwatershed and the calculated percent reduction needed to meet the TMDL are summarized in Table 35. Load allocations indicate a sizable decrease needed for bacteria in runoff under moist, mid-range and dry flow conditions in the County Ditch 13 Subwatershed. The maximum percent reduction of bacteria load needed is 77%.

Table 35. County Ditch 13 Subwatershed TMDL and Percent Reductions Needed

Flow Regime	Existing Load (billion org/d)	Waste Load Allocations: WWTFs (Total) (billion org/d)	Waste Load Allocations: Straight Pipes (billion org/d)	Waste Load Allocations: MS4 (billion org/d)	LA (billion org/d)	MOS (billion org/d)	TMDL (billion org/d)	LA + MS4 WLA (billion org/d)	Estimated Reduction in Watershed Runoff (%)
High	ID	–	–	2.91	27.3	3.36	33.6	30.2	ID
Moist	23	–	–	1.22	11.5	1.41	14.1	12.7	45%
Mid-Range	29.7	–	–	0.653	6.12	0.753	7.53	6.77	77%
Dry	9.52	–	–	0.338	3.17	0.39	3.9	3.51	63%
Low	ID	–	–	0.179	1.68	0.206	2.06	1.86	ID

Key: WWTF-Waste Water Treatment Facility, MS4-Municipal Separate Storm Sewer System, MOS-Margin of Safety, LA-Load Allocation, org-organisms, d-day, ID–Insufficient Data, IDUL–Impairment due to upstream load, EQN–Based on the equation found on page 104 in the TMDL Study, WLA–Waste Load Allocation

Regulated Entities

The regulated entities within this subwatershed are shown in Table 36.

Table 36. Regulated Entities within the County Ditch 13 Subwatershed

Regulated Entity	Permit #
Brockway Township	MS400068
Le Sauk Township	MS400143
Sartell City	MS400048

Implementation Plan

The findings of the bacteria source assessment suggest that application of poultry manure that is not appropriately incorporated into the soils is the largest of the likely bacteria sources to the County Ditch 13 Subwatershed. Specifically, land immediately surrounding County Ditch 13 has been assessed as a high risk area for surface applied manure. Based on the source assessment and the TMDL the **target goal is up to a 77% reduction** of bacteria for this subwatershed. In other flow regimes the target goal is lower. The following is the magnitude of reductions to the major potential sources of bacteria that would be necessary within the watershed to meet the 77% goal. Given this level of reduction it will likely take 20+ years of active management for the Spunk Creek to meet water quality standards for *E. coli*.

- Eliminate 90% of the bacteria coming from manure that is not appropriately incorporated into the soil.
- Eliminate 90% of the bacteria coming from feedlots with inadequate controls.
- Eliminate 100% of the SSTS that are an imminent threat to public health by bringing septic systems into compliance with standards.
- Eliminate 60% of the bacteria load from grazing livestock.

Priority Actions

As a result of the analyses for bacteria sources and contributing areas, the primary focus of implementation for this subwatershed will be to prevent unincorporated manure from reaching the stream and to reduce runoff from feedlots. This can be done by land application with incorporation or by treating manure prior to land application and implementing feedlot runoff controls, respectively.

There are likely other contributors of bacteria that may not have been captured in the analyses above due to a lack of documentation. In many cases, local knowledge of bacteria sources may provide superior guidance for determining how to reduce bacteria loading to impaired stream reaches. Addressing additional sources within the County Ditch 13 Subwatershed that are likely contributing *E. coli* to a lesser degree are also included in the implementation plan since the needed reduction is high in this subwatershed (see Rural Subwatersheds for more information). Below are the priority actions that are recommended for the County Ditch 13 Subwatershed.

- Identify and map potential and known sources that are directly contributing bacteria to waterbodies using local knowledge, windshield surveys, and interviews with landowners, etc. Note that mapping sources is a distinct activity from monitoring.

- Continue baseline monitoring of the stream reach and add additional monitoring stations along the stream reach and tributaries to help pinpoint potential sources of bacteria. Refer to the monitoring section for further recommendations.
- Reduce direct sources of bacteria, such as livestock that have access to streams, installing fences around streams within pastures, or providing water sources within pastures to reduce the frequency of livestock from entering streams.
- Promote the use of manure injection or incorporation of manure on all land where manure is applied. Target land areas near the stream and ditches and tile intakes first. Alternatively, treat manure to reduce bacteria concentrations prior to land application.
- Promote good manure application and treatment practices such as:
    - Applying manure to relatively dry fields;
    - Avoiding steep sloping areas;
    - Avoiding areas near water bodies;
    - Avoiding vulnerable locations for spreading manure;
    - Avoiding areas prone to flooding;
    - Avoiding applying on frozen soil.
- Implement and enforce feedlot runoff controls.
- Install filter strips around fields, especially where streams are present, to prevent bacteria-laden runoff from reaching streams; buffer strips should also be installed along ditches within fields that flow directly to streams. Priority should be given to BMPs that provide multiple benefits.
- Ensure that all local feedlot, SSTS, septage and pet-waste ordinances within the subwatershed are stringent enough so that rivers and streams will meet State water quality standards.
- Ensure that ordinances are enforced, through regular inspection and monitoring.
- Conduct septic inspections and make sure all systems that are imminent threats are brought into compliance.
- Conduct education and outreach to ensure that ordinances and BMPs are understood and followed.
- Ensure septage application is in compliance with state laws and local ordinances.

Table 37 lists the priority actions described above along with a recommended timeframe for implementation and estimated costs. The timeframe that is provided is based on priority of implementation, and efforts will likely be ongoing once the action has been implemented. Action items are listed in order of importance. Also included in Table 37 are priority actions that are simply good practices to follow in all subwatersheds regardless of the magnitude of the source/activity they address. Note that some of these practices may have already been initiated within the subwatershed; if that is the case, continue with them and enhance them where necessary. Note that the costs are provided for context and not as an estimate of the total expenditure needed to meet any specified reduction in bacteria.

Refer to Appendix A for the entities responsible for implementing source controls and treatment BMPs in this subwatershed.

Table 37. Priority actions for County Ditch 13 Subwatershed

Priority Timeframe[1]	Action	Estimated Effectiveness of Practice[2] (up to)	Estimated Magnitude in Watershed	Implementation Cost[3]
High	Identify and map any location with potential bacteria sources Monitoring	NA	NA	Staff time
High	Limit livestock from accessing streams/waterbodies by fencing or providing alternative water sources Livestock Stream Access Control	100%	Unknown	$0.70-1.50/ linear feet of fencing $3-6/ cu yard to construct a pond as an alternative water source
High	Promote land application of manure with incorporation Land application w/ incorporation	70%	500 – 2,000 acres of cultivated cropland	$12/acre
High	Promote good manure application and treatment practices (see text above) Manure Management	Varies by practice	500 – 2,000 acres of cultivated cropland	NA
High	Implement feedlot runoff control and manure management at existing feedlots Feedlot Runoff Control	100%	~600 Animal Units (AU)	$8-24/AU
High	Install vegetated buffers around fields where manure is applied as well as grazed lands Filter Strips	92%	~10 acres (assume 2 miles of stream; 20ft buffer)	$600-1000/acre
Medium	Adopt and enforce strict standards for SSTS, pet waste, feedlot runoff, and septage application Federal, State, and Local Requirements	100%	NA	Staff time
Medium	Conduct outreach and education to ensure ordinances and BMPs are followed and understood Outreach/Education	NA	NA	Staff time
Medium	Conduct septic system inspections as warranted and bring septic systems into compliance with standards Septic (SSTS) Maintenance	100%	~5 systems	$200-300 (inspection) $7,500 per system (if replacement required)
Low	Ensure ordinances are followed and enforced for septage application Septage	NA	NA	Staff time

Priority Timeframe[1]	Action	Estimated Effectiveness of Practice[2] (up to)	Estimated Magnitude in Watershed	Implementation Cost[3]
Low	Regularly monitor stream and inspect all significant sources that have the potential to release bacteria Monitoring	NA	NA	Staff time

[1] Priority is based on recommended timeframe to continue or start (not complete) implementation activities: High = 1-2 years, Medium = 2-5 years, Low = 5-10 years.
[2] Estimated effectiveness of practice refers to the reduction of bacteria concentrations in runoff to receiving waterbodies.
[3] Costs based on NRCS EQIP Payment Schedules
http://www.nrcs.usda.gov/wps/portal/nrcs/detail/mn/programs/financial/?cid=stelprdb1245512

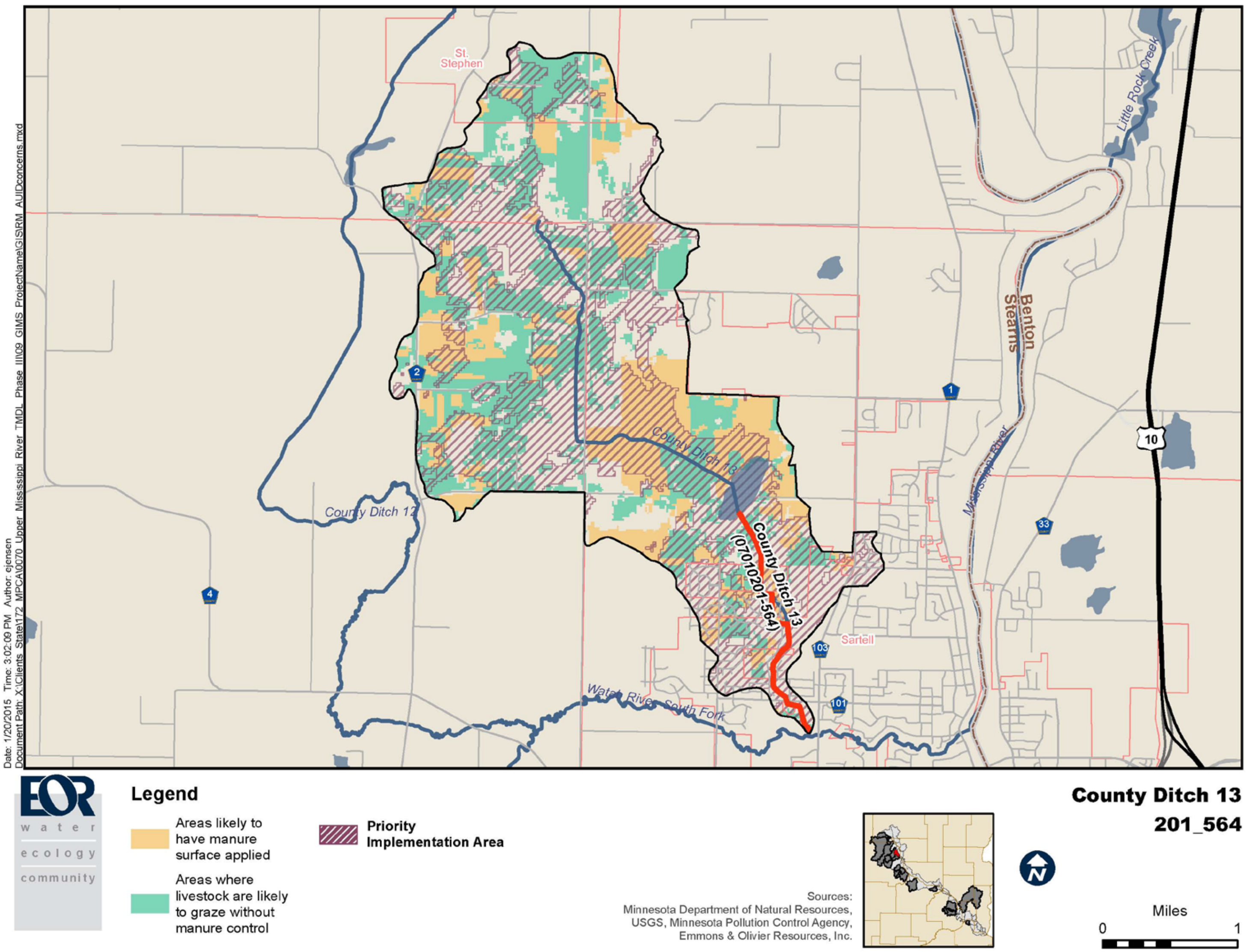

Figure 31. Areas with highest risk for transport of bacteria into streams and rivers to be targeted for initial implementation (hatched areas) (refer to Potential E. coli Contributing Areas to determine how Priority Implementation Areas were determined)

Unnamed Creek (07010203-528) Subwatershed

Reach Description: T121 R2W S19, south line to Mississippi River

Unnamed Creek is a tributary of the Mississippi River and is impaired for aquatic recreation due to *E. coli*. The subwatershed is located within Priority Area B of the Minneapolis and St. Paul Source Water Protection Areas (Figure 3). Monitoring conducted in 2010 and 2011 indicated elevated levels of *E. coli* throughout the growing season with exceedances of the water quality standard occurring in every month with at least five samples from April through October except April. *E. coli* counts ranged from 4 to 17,000 org/100 ml and monthly geometric means ranged from 59 to 1,170 org/100 ml (a summary of water quality monitoring data can be found in Appendix D of the TMDL Study). Plotting *E. coli* levels against stream flow, as is shown in the load duration curves in Figure 6.25 on page 135 of the TMDL Study, show that exceedances occur at all flow conditions (e.g. high, moist, mid, dry, low) where there is monitoring data.

Production of *E. coli* in Subwatershed

As described in the TMDL Study and in Table 39 below, the Total Maximum Daily Load for Unnamed Creek is divided into point (permitted) sources and nonpoint (non-permitted) sources. In the Unnamed Creek Subwatershed, the Albertville and Otsego Wastewater Treatment Facilities and MS4s (Table 40) are the point sources of *E. coli*. For nonpoint sources, the majority of the land in this subwatershed is in agricultural use (Table 38).

Table 38. Unnamed Creek Subwatershed Land uses

Land use	%
Cultivated Crops	51%
Pasture / Hay	25%
Developed Open Space	5%
Developed Low Intensity	5%
Emergent Herbaceous Wetland	5%
Deciduous Forest	3%
Developed Medium Intensity	2%
Open Water	2%
Table only includes land uses that are > 1% of the land area	

In developing the TMDL Study a desktop analysis was conducted to determine the potential sources of *E. coli* within each subwatershed and estimate the relative contribution of each source. The process, referred to as a bacteria source assessment, is described in Section 4 of the TMDL Study beginning on page 45. In the Unnamed Creek Subwatershed *E. coli* is likely produced from livestock, humans, pets, and wildlife in relatively equal magnitude (Figure 32). Further analysis of livestock numbers suggest that poultry followed by cattle and hogs is the type of livestock that produces the most *E. coli* in this subwatershed (Figure 32). The fraction of *E. coli* from various sources of livestock in the pie chart is determined by the total animal units estimated within the subwatershed and takes into account the size discrepancy of the various types of livestock as well as the differences in the amount of bacteria within their waste. During the monitoring phase of the project, fluoride was detected in this reach which is indicative of septic/wastewater.

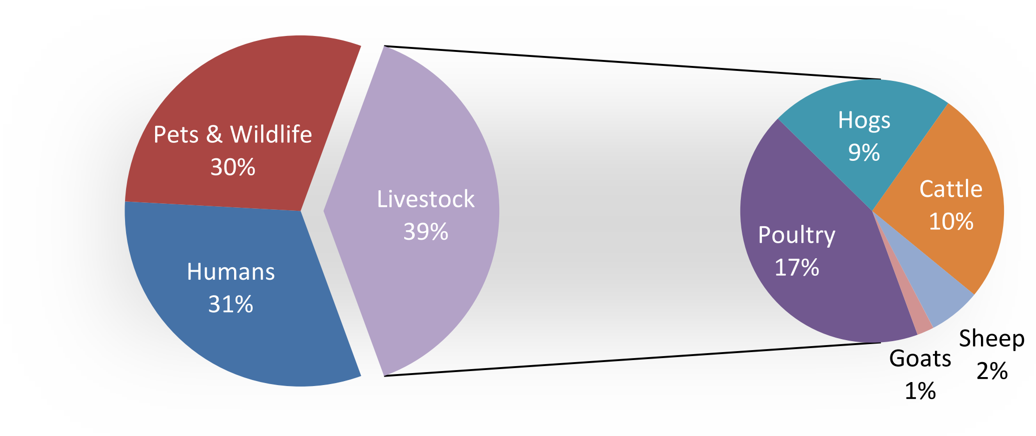

Figure 32. Bacteria production in the Unnamed Creek Subwatershed

As another tool, a Microbial Source Tracking (MST) analysis was conducted as part of this TMDL Study. MST analysis relies on the genetic coding, or markers, found within bacteria samples to determine the source of the bacteria. In the Unnamed Creek Subwatershed the MST analysis found cattle markers in the base flow sample that was taken in June 2011 but not in the storm event sample that was taken in April 2011. Both water samples were also tested for swine and human/pet markers but these markers were not present in the water samples on those dates. Fluoride (an additional indicator of human sources) was found in both samples. Due to the nature of bacteria caution must be exercised with use of the MST findings. The analysis can not be used to conclusively dismiss any given source of bacteria. The MST findings can only be applied to the source of bacteria found in that specific sample of water.

Sources Contributing *E. coli* to the Stream Reach

In addition to determining the relative magnitude of *E. coli* sources within the watershed it is important to consider the factors that lead to the *E. coli* being delivered to the stream. The second step in the bacteria source assessment is to evaluate the connection between *E. coli* production, how it is handled on the landscape, and how it is ultimately delivered to the stream. In the case of the Unnamed Creek Subwatershed, according to the source assessment, the primary potential source of bacteria to the stream is from failed septic systems (Figure 33). Other mechanisms include runoff from manure application to fields where the manure is not immediately incorporated into the soil and from pets and wildlife.

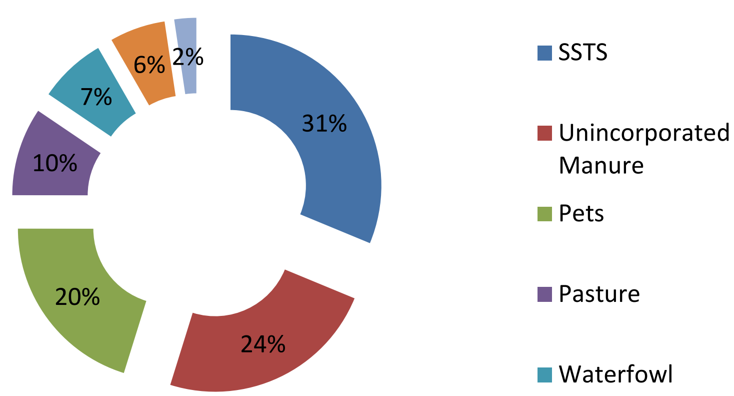

Figure 33. Estimated Percentage of Potential Sources Contributing Bacteria to Unnamed Creek

Potential *E. coli* Contributing Areas

The final step in the bacteria source assessment methodology developed for the TMDL Study was to determine which areas within the subwatershed have the highest potential to contribute *E. coli* to the stream. In agricultural subwatersheds the areas that have the highest potential to contribute *E. coli* to the stream are areas immediately adjacent to or hydrologically connected to streams where manure is applied or where animals are grazing. Refer to Figure 34 for the map of areas within the Unnamed Creek Subwatershed that have a high potential to contribute bacteria to the stream. These areas should be prioritized for implementation activities. The Priority Implementation Area in Figure 34 was determined by calculating a delivery factor that accounts for fate and transport factors such as proximity to surface waters, slope, imperviousness, and discharge to lakes prior to discharge to stream networks (refer to Section 4.2.6 of the TMDL Study for more specific information on how the delivery factor and Priority Implementation Area was calculated).

TMDL Allocations and Percent Reductions

Wasteload and load allocations for this subwatershed and the calculated percent reduction needed to meet the TMDL are summarized in Table 39. Allocations indicate a moderate decrease needed for bacteria in runoff under high, moist, and mid-range flow conditions in this subwatershed. The maximum percent reduction of bacteria load needed is 66%.

Table 39. Unnamed Creek Subwatershed TMDL and Percent Reductions Needed

Flow Regime	Existing Load (billion org/d)	Waste Load Allocations			LA (billion org/d)	MOS (billion org/d)	TMDL (billion org/d)	LA + MS4 WLA (billion org/d)	Estimated Reduction in Watershed Runoff (%)
		WWTFs (Total) (billion org/d)	Straight Pipes (billion org/d)	MS4 (billion org/d)					
High	169	7.86	–	6.83	50.6	7.25	72.5	57.4	66%
Moist	43.3	7.86	–	2.38	17.7	3.1	31	20.1	54%
Mid-Range	15.6	7.86	–	0.671	4.97	1.5	15	5.64	64%
Dry	ID	7.86	–	0.0982	0.727	0.965	9.65	0.825	ID
Low	ID	EQN	–	EQN	EQN	0.622	6.22	EQN	ID

Key: WWTF-Waste Water Treatment Facility, MS4-Municipal Separate Storm Sewer System, MOS-Margin of Safety, LA-Load Allocation, org-organisms, d-day, ID-Insufficient Data, IDUL-Impairment due to upstream load, EQN-Based on the equation found on page 104 in the TMDL Study, WLA-Waste Load Allocation

Regulated Entities

The regulated entities within this subwatershed are shown in Table 40.

Table 40. Regulated Entities within the Unnamed Creek Subwatershed

Regulated Entity	Permit #
Albertville WWTF	MN0050954
Otsego West WWTF	MN0066257
Otsego City	MS400243
St Michael City	MS400246

Implementation Plan

The findings of the bacteria source assessment suggest that human sources, such as SSTS, and application of poultry manure that is not appropriately incorporated into the soils are the largest of the likely *E. coli* sources to the Unnamed Creek Subwatershed. Specifically, land immediately surrounding Unnamed Creek has been assessed as a high risk area for surface applied manure. Based on the source assessment and the TMDL the **target goal is up to a 66% reduction** of bacteria for this subwatershed. In other flow regimes the target goal is lower. The following is the magnitude of reductions to the major potential sources of bacteria that would be necessary within the watershed to meet the 66% goal. Given this level of reduction it will likely take 20+ years of active management for the Two River to meet water quality standards for *E. coli*.

- Eliminate 85% of the bacteria coming from manure that is not appropriately incorporated into the soil.
- Eliminate 95% of the bacteria coming from feedlots with inadequate controls.
- Eliminate 100% of the SSTS that are an imminent threat to public health by bringing septic systems into compliance with standards.
- Eliminate 60% of the bacteria load from grazing livestock.

Priority Actions

As a result of the analyses for bacteria sources and contributing areas, the primary focus of implementation for this subwatershed will be to eliminate all SSTS that pose an imminent public health threat, prevent unincorporated manure from reaching the stream, and to reduce pet waste. This can be done by adopting and enforcing strict SSTS ordinances, land application with incorporation or by treating manure prior to land application, and by adopting and enforcing strict pet waste ordinances, respectively.

In addition to the primary sources of bacteria, there are likely other contributors of bacteria that may not have been captured in the analyses above due to a lack of documentation. In many cases, local knowledge of bacteria sources may provide superior guidance for determining how to reduce bacteria loading to impaired stream reaches. Addressing additional sources within the Unnamed Creek Subwatershed that are likely contributing *E. coli* to a lesser degree are also included in the implementation plan since the needed reduction is high in this subwatershed (see Rural Subwatersheds for more information). Below are the priority actions that are recommended for the Unnamed Creek subwatershed.

- Identify and map potential and known sources that are directly contributing bacteria to waterbodies using local knowledge, windshield surveys, and interviews with landowners, etc. Note that mapping sources is a distinct activity from monitoring.
- Continue baseline monitoring of the stream reach and add additional monitoring stations along the stream reach and tributaries to help pinpoint potential sources of bacteria. Refer to the monitoring section for further recommendations.
- Reduce direct sources of bacteria, such as livestock that have access to streams, installing fences around streams within pastures, or providing water sources within pastures to reduce the frequency of livestock from entering streams.
- Ensure that all local feedlot, SSTS, septage and pet-waste ordinances within the subwatershed are stringent enough so that rivers and streams will meet State water quality standards.
- Ensure that ordinances are enforced, through regular inspection and monitoring.
- Conduct septic inspections and make sure all systems that are imminent threats are brought into compliance.
- Promote the use of manure injection or incorporation of manure on all land where manure is applied. Target land areas near the stream and ditches and tile intakes first. Alternatively, treat manure to reduce bacteria concentrations prior to land application.
- Promote good manure application and treatment practices such as:
    - Applying manure to relatively dry fields;
    - Avoiding steep sloping areas;
    - Avoiding areas near water bodies;
    - Avoiding vulnerable locations for spreading manure;
    - Avoiding areas prone to flooding;
    - Avoiding applying on frozen soil.
- Implement and enforce feedlot runoff controls.
- Install filter strips around fields, especially where streams are present, to prevent bacteria-laden runoff from reaching streams; buffer strips should also be installed along ditches within fields that flow directly to streams. Priority should be given to BMPs that provide multiple benefits.
- Conduct education and outreach to ensure that ordinances and BMPs are understood and followed.
- Ensure septage application is in compliance with state laws and local ordinances.

Table 41 lists the priority actions described above along with a recommended timeframe for implementation and estimated costs. The timeframe that is provided is based on priority of implementation, and efforts will likely be ongoing once the action has been implemented. Action items are listed in order of importance. Also included Table 41are priority actions that are simply good practices to follow in all subwatersheds regardless of the magnitude of the source/activity they address. Note that some of these practices may have already been initiated within the subwatershed; if that is the case, continue with them and enhance them where necessary. Note that the costs are provided for context and not as an estimate of the total expenditure needed to meet any specified reduction in bacteria.

Refer to Appendix A for the entities responsible for implementing source controls and treatment BMPs in this subwatershed.

Table 41. Priority actions for Unnamed Creek Subwatershed

Priority Timeframe[1]	Action	Estimated Effectiveness of Practice[2] (up to)	Estimated Magnitude in Watershed	Implementation Cost[3]
High	Limit livestock from accessing streams/waterbodies by fencing or providing alternative water sources Livestock Stream Access Control	100%	Unknown	$0.70-1.50/ linear feet of fencing $3-6/ cu yard to construct a pond as an alternative water source
High	Adopt and enforce strict septic and pet waste ordinances Litter and Animal Waste Control	100%	NA	Staff time
High	Conduct septic system inspections as warranted and bring septic systems into compliance with standards Septic (SSTS) Maintenance	100%	~ 44 systems	$200-300 (inspection) $7,500 per system (if replacement required)
High	Promote land application of manure with incorporation Land application w/ incorporation	70%	2,000 – 5,000 acres of cultivated cropland	$12/acre
High	Promote good manure application and treatment practices (see text above) Manure Management	Varies by practice	2,000 – 5,000 acres of cultivated cropland	NA
Medium	Identify and map any location with potential bacteria sources Monitoring	NA	NA	Staff time
Medium	Implement feedlot runoff control and manure management at existing feedlots Feedlot Runoff Control	100%	~175 Animal Units (AU)	$8-24/AU
Medium	Ensure that all local feedlot ordinances within the subwatershed are enforced through regular inspection and monitoring and are stringent enough so that rivers and streams will meet State water quality standards.	100%	NA	Staff time
Medium	Install vegetated buffers around fields where manure is applied as well as grazed lands Filter Strips	92%	~15 acres (assume 3 miles of stream; 20ft buffer)	$600-1000/acre

Priority Timeframe[1]	Action	Estimated Effectiveness of Practice[2] (up to)	Estimated Magnitude in Watershed	Implementation Cost[3]
Medium	Conduct outreach and education to ensure ordinances and BMPs are followed and understood Outreach/Education	NA	NA	Staff time
Low	Septage application should be incorporated (follow guidelines found in the MPCA guidance document Septage Removal and Disposal) Septage	70%	2,000 – 5,000 acres of cultivated cropland	$12/acre
Low	Regularly monitor stream and inspect all significant sources that have the potential to release bacteria Monitoring	NA	NA	Staff time

[1] Priority is based on recommended timeframe to continue or start (not complete) implementation activities: High = 1-2 years, Medium = 2-5 years, Low = 5-10 years.
[2] Estimated effectiveness of practice refers to the reduction of bacteria concentrations in runoff to receiving waterbodies.
[3] Costs based on NRCS EQIP Payment Schedules
http://www.nrcs.usda.gov/wps/portal/nrcs/detail/mn/programs/financial/?cid=stelprdb1245512

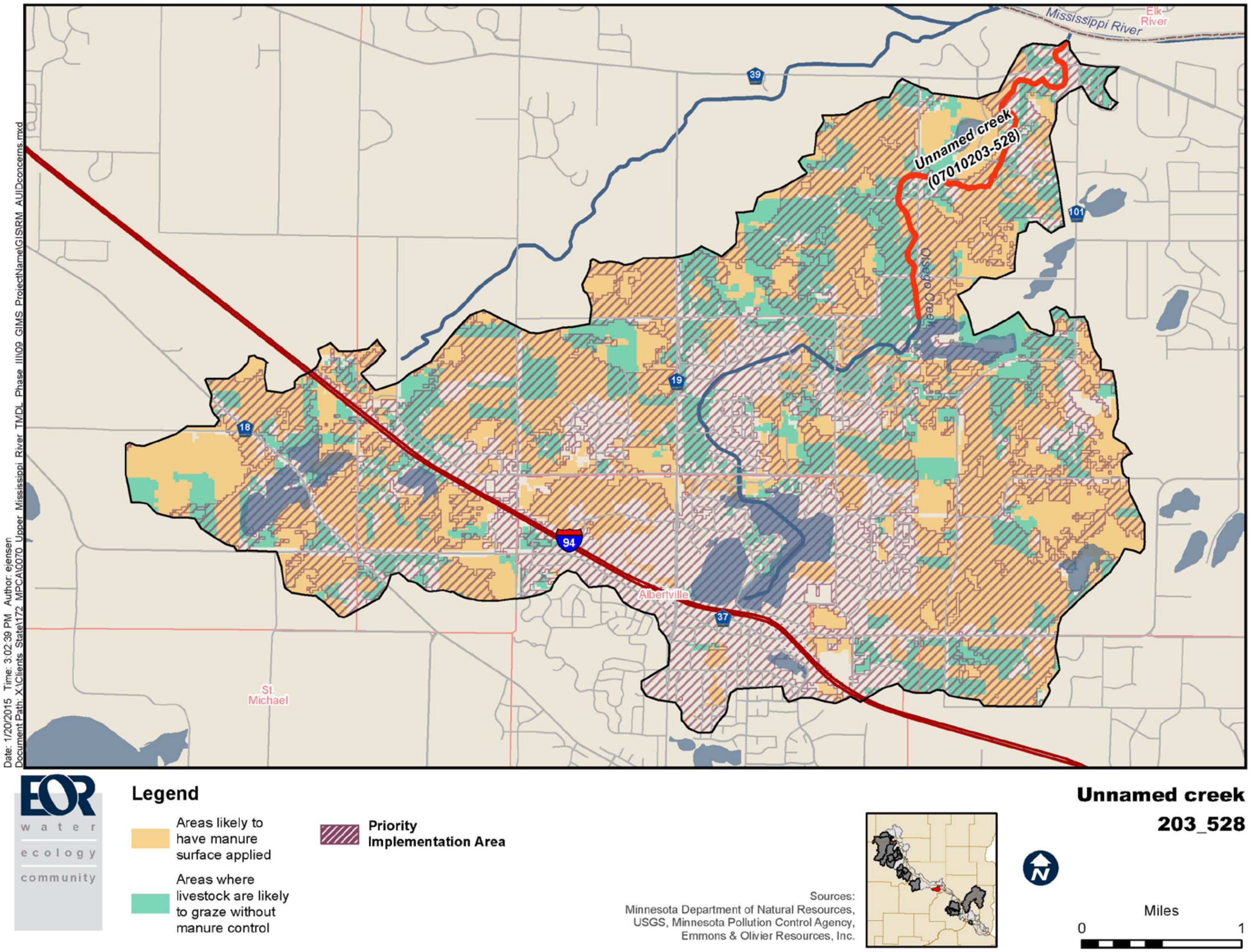

Figure 34. Areas with highest risk for transport of bacteria into streams and rivers to be targeted for initial implementation (hatched areas) (refer to Potential E. coli Contributing Areas to determine how Priority Implementation Areas were determined)

Silver Creek (07010203-557) Subwatershed

Reach Description: Locke Lake to Mississippi River

Silver Creek is a tributary of the Mississippi River and is impaired for aquatic recreation due to *E. coli*. The subwatershed is located within Priority Area B of the Minneapolis and St. Paul Source Water Protection Areas (Figure 3). Monitoring conducted in 2010 and 2011 indicated elevated levels of *E. coli* in the month of August with no exceedances of the water quality standard occurring in any other month with at least five samples from April through October. *E. coli* counts ranged from 1 to 650 org/100 ml and monthly geometric means ranged from 2 to 94 org/100 ml (a summary of water quality monitoring data can be found in Appendix D of the TMDL Study). Plotting *E. coli* levels against stream flow, as is shown in the load duration curves in Figure 6.26 on page 136 of the TMDL Study, show that exceedances occur at all flow conditions (e.g. high, moist, mid, dry, low) where there is monitoring data. The largest reductions in bacteria required by the TMDL are in low flow conditions (Table 43).

Production of *E. coli* in Subwatershed

As described in the TMDL Study and in Table 43 below, the Total Maximum Daily Load for Silver Creek is divided into point (permitted) sources and nonpoint (non-permitted) sources. In the Silver Creek Subwatershed, there are no point sources of *E. coli*. For nonpoint sources, the majority of the land use in this watershed is in agricultural use (Table 42).

Table 42. Silver Creek Subwatershed Land uses

Land use	%
Cultivated Crops	41%
Deciduous Forest	16%
Pasture / Hay	13%
Open Water	9%
Emergent Herbaceous Wetland	6%
Developed Open Space	6%
Grassland / Herbaceous	5%
Shrub/Scrub	3%
Table only includes land uses that are > 1% of the land area	

In developing the TMDL Study a desktop analysis was conducted to determine the potential sources of *E. coli* within each subwatershed and estimate the relative contribution of each source. The process, referred to as a bacteria source assessment, is described in Section 4 of the TMDL Study beginning on page 45. In the Silver Creek Subwatershed the majority of the *E. coli* is likely produced from livestock with moderate contributions from humans and from pets and wildlife (Figure 35). Further analysis of livestock numbers suggest that poultry is the type of livestock that produces the most *E. coli* in this subwatershed followed by cattle and hogs (Figure 35). The fraction of *E. coli* from various sources of livestock in the pie chart is determined by the total animal units estimated within the subwatershed and takes into account the size discrepancy of the various types of livestock as well as the differences in the amount of bacteria within their waste.

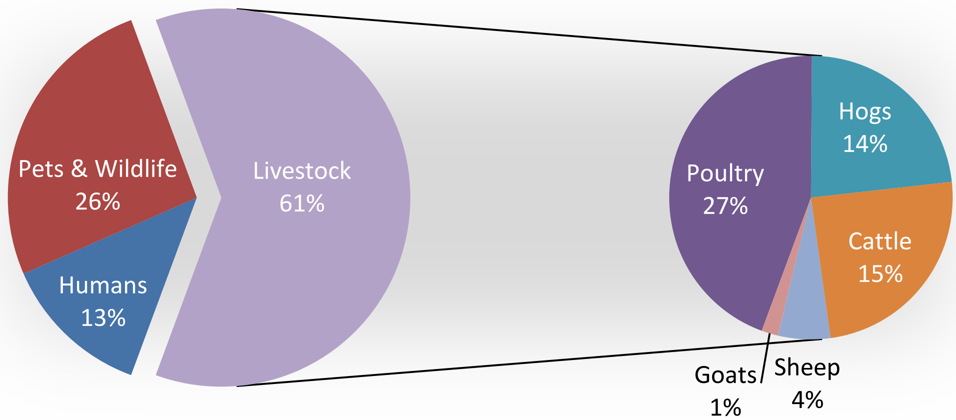

Figure 35. Bacteria production in the Silver Creek Subwatershed

Sources Contributing *E. coli* to the Stream Reach

In addition to determining the relative magnitude of *E. coli* sources within the watershed it is important to consider the factors that lead to the *E. coli* being delivered to the stream. The second step in the bacteria source assessment is to evaluate the connection between *E. coli* production, how it is handled on the landscape and how it is ultimately delivered to the stream. In the case of the Silver Creek Subwatershed, where poultry is identified as the main potential bacteria source followed by cattle and hogs, the primary activity by which the bacteria becomes available to wash into the stream is through manure application to fields where the manure is not immediately incorporated into the soil (Figure 36). Other mechanisms include animals on pasture, direct input of fecal matter from waterfowl, pets, and wildlife, failing septic systems, and from feedlots that do not have adequate controls.

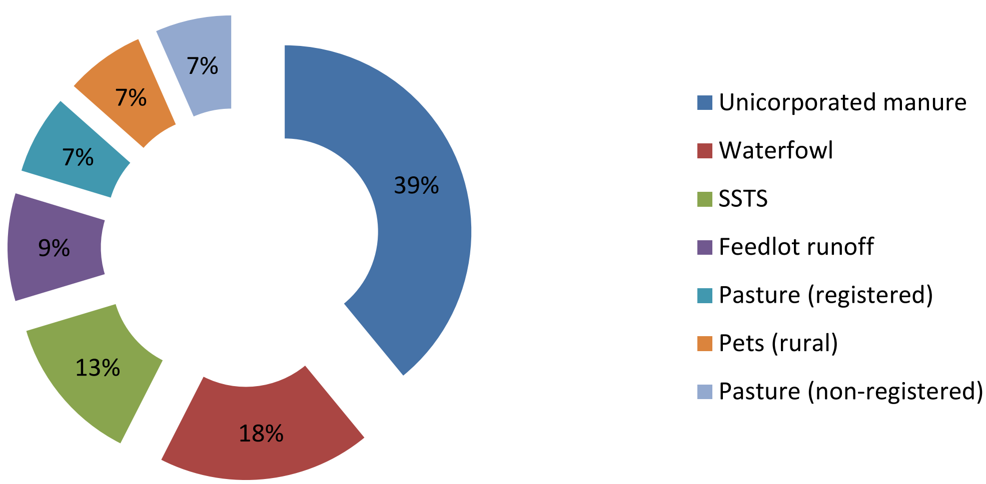

Figure 36. Estimated Percentage of Potential Sources Contributing Bacteria to Silver Creek

Potential *E. coli* Contributing Areas

The final step in the bacteria source assessment methodology developed for the TMDL Study was to determine which areas within the subwatershed have the highest potential to contribute *E. coli* to the stream. In agricultural subwatersheds the areas that have the highest potential to contribute *E. coli* to the stream are areas immediately adjacent to or hydrologically connected to streams where manure is applied or where animals are grazing. Refer to Figure 37 for the map of areas within the Silver Creek Subwatershed that have a high potential to contribute bacteria to the stream. These areas should be prioritized for implementation activities. The Priority Implementation Area in Figure 37 was determined by calculating a delivery factor that accounts for fate and transport factors such as proximity to surface waters, slope, imperviousness, and discharge to lakes prior to discharge to stream networks (refer to Section 4.2.6 of the TMDL Study for more specific information on how the delivery factor and Priority Implementation Area was calculated).

TMDL Allocations and Percent Reductions

Wasteload and load allocations for this subwatershed and the calculated percent reduction needed to meet the TMDL are summarized in Table 43. Load allocations indicate a moderate decrease needed for bacteria in runoff under low flow conditions and a small decrease needed for mid-range and dry flow conditions in the Silver Creek Subwatershed. The maximum percent reduction of bacteria load needed is 46%.

Table 43. Silver Creek Subwatershed TMDL and Percent Reductions Needed

Flow Regime	Existing Load (billion org/d)	Waste Load Allocations			LA (billion org/d)	MOS (billion org/d)	TMDL (billion org/d)	LA + MS4 WLA (billion org/d)	Estimated Reduction in Watershed Runoff (%)
		WWTFs (Total) (billion org/d)	Straight Pipes (billion org/d)	MS4 (billion org/d)					
High	38.1	–	–	–	266	29.5	295	266	0%
Moist	61.1	–	–	–	99	11	110	99	0%
Mid-Range	36.6	–	–	–	36	4	40	36	1.60%
Dry	14.2	–	–	–	11.6	1.29	12.9	11.6	18%
Low	10.8	–	–	–	5.81	0.65	6.46	5.81	46%

Key: WWTF-Waste Water Treatment Facility, MS4-Municipal Separate Storm Sewer System, MOS-Margin of Safety, LA-Load Allocation, org-organisms, d-day, ID-Insufficient Data, IDUL-Impairment due to upstream load, EQN-Based on the equation found on page 104 in the TMDL Study, WLA-Waste Load Allocation

Regulated Entities

There are no regulated entities within this subwatershed.

Implementation Plan

The findings of the bacteria source assessment suggest that application of poultry manure that is not appropriately incorporated into the soils is the largest of the likely *E. coli* sources to the Silver Creek Subwatershed. Specifically, land immediately surrounding Silver Creek has been assessed as a high risk area for surface applied manure. Based on the source assessment and the TMDL the **target goal is up to**

a 46% reduction of bacteria for this subwatershed. In other flow regimes the target goal is lower. The following is the magnitude of reductions to the major potential sources of bacteria that would be necessary within the watershed to meet the 46% goal. Given this level of reduction it will likely take 20+ years of active management for the Silver Creek to meet water quality standards for *E. coli*.

- Eliminate 60% of the bacteria coming from manure that is not appropriately incorporated into the soil.
- Eliminate 60% of the bacteria coming from feedlots with inadequate runoff controls.
- Eliminate 100% of the SSTS that are an imminent threat to public health by bringing septic systems into compliance with standards.
- Eliminate 20% of the bacteria load from grazing livestock.
- Eliminate 20% of the bacteria load from wildlife and waterfowl.

Priority Actions

As a result of the analyses for bacteria sources and contributing areas, the primary focus of implementation for this subwatershed will be to prevent unincorporated manure from reaching the stream. This can be done by land application with incorporation or by treating manure prior to land application.

There are likely other contributors of bacteria that may not have been captured in the analyses above due to a lack of documentation. In many cases, local knowledge of bacteria sources may provide superior guidance for determining how to reduce bacteria loading to impaired stream reaches. Addressing additional sources within the Silver Creek Subwatershed that are likely contributing *E. coli* to a lesser degree are also included in the implementation plan since the needed reduction is high in this subwatershed (see Rural Subwatersheds for more information). Below are the priority actions that are recommended for the Silver Creek subwatershed.

- Identify and map potential and known sources that are directly contributing bacteria to waterbodies using local knowledge, windshield surveys, and interviews with landowners, etc. Note that mapping sources is a distinct activity from monitoring.
- Continue baseline monitoring of the stream reach and add additional monitoring stations along the stream reach and tributaries to help pinpoint potential sources of bacteria. Refer to the monitoring section for further recommendations.
- Reduce direct sources of bacteria, such as livestock that have access to streams, installing fences around streams within pastures, or providing water sources within pastures to reduce the frequency of livestock from entering streams.
- Promote the use of manure injection or incorporation of manure on all land where manure is applied. Target land areas near the stream and ditches and tile intakes first. Alternatively, treat manure to reduce bacteria concentrations prior to land application.
- Promote good manure application and treatment practices such as:
  - Applying manure to relatively dry fields;
  - Avoiding steep sloping areas;
  - Avoiding areas near water bodies;
  - Avoiding vulnerable locations for spreading manure;
  - Avoiding areas prone to flooding;
  - Avoiding applying on frozen soil.

- Install unmowed vegetative filter strips along/around the stream to deter waterfowl from congregating fields.
- Implement and enforce feedlot runoff controls.
- Ensure that all local feedlot, SSTS, septage and pet-waste ordinances within the subwatershed are stringent enough so that rivers and streams will meet State water quality standards.
- Ensure that ordinances are enforced, through regular inspection and monitoring.
- Conduct septic inspections and make sure all systems that are imminent threats are brought into compliance.
- Conduct education and outreach to ensure that ordinances and BMPs are understood and followed.
- Ensure septage application is in compliance with state laws and local ordinances.

Table 44 lists the priority actions described above along with a recommended timeframe for implementation and estimated costs. The timeframe that is provided is based on priority of implementation, and efforts will likely be ongoing once the action has been implemented. Action items are listed in order of importance. Also included in Table 44 are priority actions that are simply good practices to follow in all subwatersheds regardless of the magnitude of the source/activity they address. Note that some of these practices may have already been initiated within the subwatershed; if that is the case, continue with them and enhance them where necessary. Note that the costs are provided for context and not as an estimate of the total expenditure needed to meet any specified reduction in bacteria.

Refer to Appendix A for the entities responsible for implementing source controls and treatment BMPs in this subwatershed.

Table 44. Priority actions for Silver Creek Subwatershed

Priority Timeframe[1]	Action	Estimated Effectiveness of Practice[2] (up to)	Estimated Magnitude in Watershed	Implementation Cost[3]
High	Limit livestock from accessing streams/waterbodies by fencing or providing alternative water sources Livestock Stream Access Control	100%	Unknown	$0.70-1.50/ linear feet of fencing $3-6/ cu yard to construct a pond as an alternative water source
High	Promote land application of manure with incorporation Land application w/ incorporation	70%	4,000 – 15,000 acres of cultivated cropland	$12/acre
High	Promote good manure application and treatment practices (see text above) Manure Management	Varies by practice	4,000 – 15,000 acres of cultivated cropland	NA
High	Implement feedlot runoff control and manure management at existing feedlots Feedlot Runoff Control	100%	~600 Animal Units (AU)	$8-24/AU

Priority Timeframe[1]	Action	Estimated Effectiveness of Practice[2] (up to)	Estimated Magnitude in Watershed	Implementation Cost[3]
High	Install vegetated buffers around fields where manure is applied as well as grazed lands Filter Strips	92%	~10 acres (assume 2 miles of stream; 20ft buffer)	$600-1000/acre
High	Adopt and enforce strict septic standards, and conduct septic system inspections as warranted and bring septic systems into compliance with standards Septic (SSTS) Maintenance	100%	~ 36 systems	$200-300 (inspection) $7,500 per system (if replacement required)
Medium	Adopt, enforce, and ensure that all local feedlot, SSTS, septage and pet-waste ordinances within the subwatershed are enforced through regular inspection and monitoring and are stringent enough so that rivers and streams will meet State water quality standards.	100%	NA	Staff time
Medium	Identify and map any location with potential bacteria sources Monitoring	NA	NA	Staff time
Medium	Conduct outreach and education to ensure ordinances and BMPs are followed and understood Outreach/Education	NA	NA	Staff time
Medium	Conduct outreach to producers to promote manure management practices that prevent the release of and/or treat manure to reduce bacteria concentrations Outreach/Education	NA	NA	Staff time
Medium	Septage application should be incorporated (follow guidelines found in the MPCA guidance document Septage Removal and Disposal)) Septage	70%	4,000 – 15,000 acres of cultivated cropland	$12/acre
Low	Regularly monitor stream and inspect all significant sources that have the potential to release bacteria Monitoring	NA	NA	Staff time

[1] Priority is based on recommended timeframe to continue or start (not complete) implementation activities: High = 1-2 years, Medium = 2-5 years, Low = 5-10 years.
[2] Estimated effectiveness of practice refers to the reduction of bacteria concentrations in runoff to receiving waterbodies.
[3] Costs based on NRCS EQIP Payment Schedules
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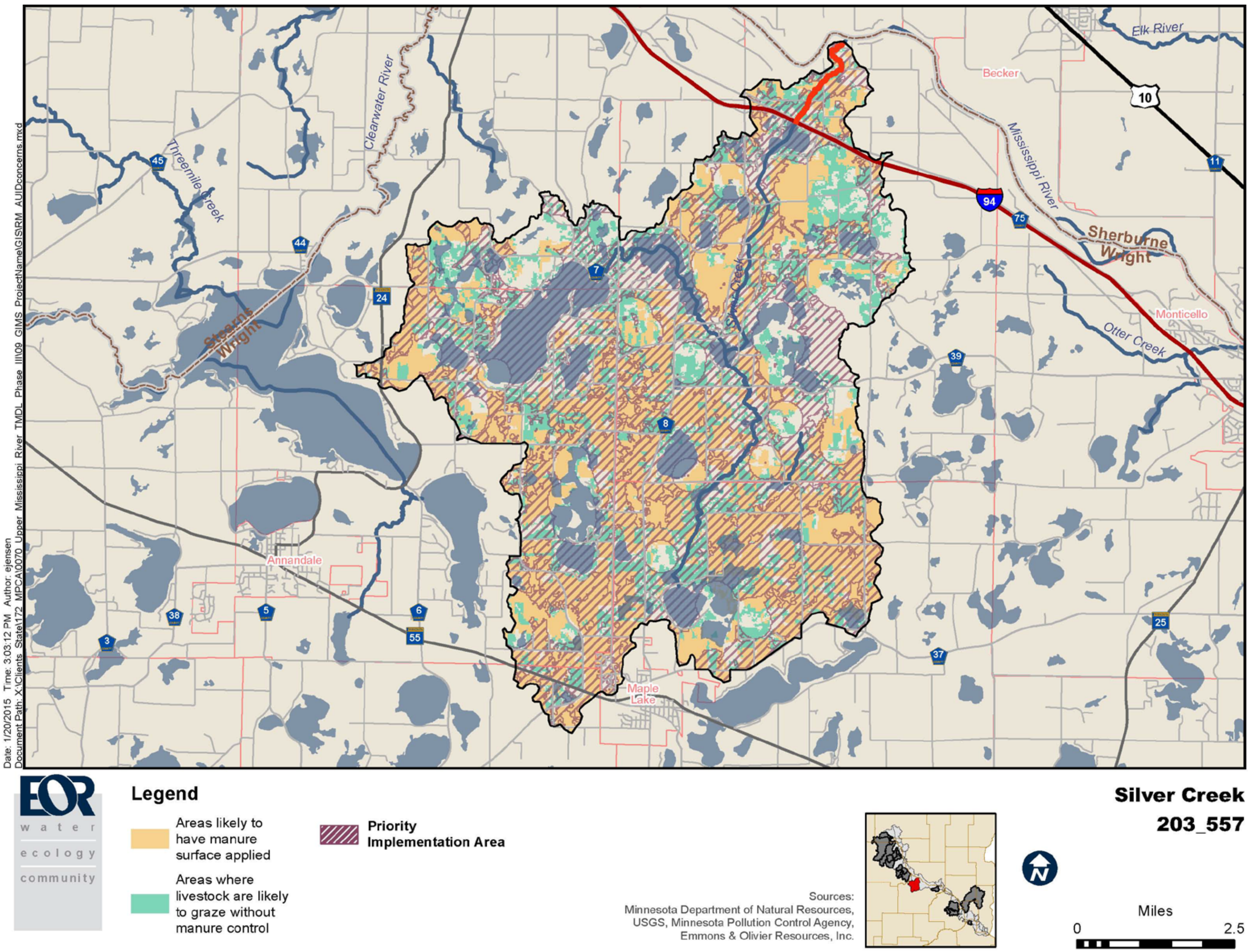

Figure 37. Areas with highest risk for transport of bacteria into streams and rivers to be targeted for initial implementation (hatched areas) (refer to Potential E. coli Contributing Areas to determine how Priority Implementation Areas were determined)

Unnamed Creek (Luxemburg Creek) (07010203-561) Subwatershed

Reach Description: T123 R28W S30, south line to Johnson Creek

Luxemburg Creek, a tributary of Johnson Creek, is impaired for aquatic recreation due to *E. coli*. The subwatershed is located within Priority Area B of the Minneapolis and St. Paul Source Water Protection Areas (Figure 3). Monitoring conducted in 2010 and 2011 indicated elevated levels of *E. coli* throughout the growing season with exceedances of the water quality standard occurring in every month with at least five samples from June through September. *E. coli* counts ranged from 101 to 2,420 org/100 ml and monthly geometric means ranged from 137 to 860 org/100 ml (a summary of water quality monitoring data can be found in Appendix D of the TMDL Study). Plotting *E. coli* levels against stream flow, as is shown in the load duration curves in Figure 6.27 on page 137 of the TMDL Study, show that exceedances occur at all flow conditions (e.g. high, moist, mid, dry, low) where there is monitoring data.

Production of *E. coli* in Subwatershed

As described in the TMDL Study and in Table 46 below, there are no point (permitted) sources of *E. coli* in the Luxemburg Creek Subwatershed. For nonpoint sources, the majority of the land use in this watershed is in agricultural use (Table 45).

Table 45. Unnamed Creek Luxemburg Creek) Subwatershed Land uses

Land use	%
Cultivated Crops	52%
Deciduous Forest	16%
Pasture / Hay	15%
Developed Open Space	5%
Emergent Herbaceous Wetland	5%
Grassland / Herbaceous	5%
Open Water	2%
Table only includes land uses that are > 1% of the land area	

In developing the TMDL Study a desktop analysis was conducted to determine the potential sources of *E. coli* within each subwatershed and estimate the relative contribution of each source. The process, referred to as a bacteria source assessment, is described in Section 4 of the TMDL Study beginning on page 45. In the Luxemburg Creek Subwatershed the vast majority of the *E. coli* is likely produced from livestock with slight contributions from humans and from pets and wildlife (Figure 38). Further analysis of livestock numbers suggest that poultry is the type of livestock that produces the most *E. coli* in this subwatershed followed by hogs and cattle (Figure 38). The fraction of *E. coli* from various sources of livestock in the pie chart is determined by the total animal units estimated within the subwatershed and takes into account the size discrepancy of the various types of livestock as well as the differences in the amount of bacteria within their waste.

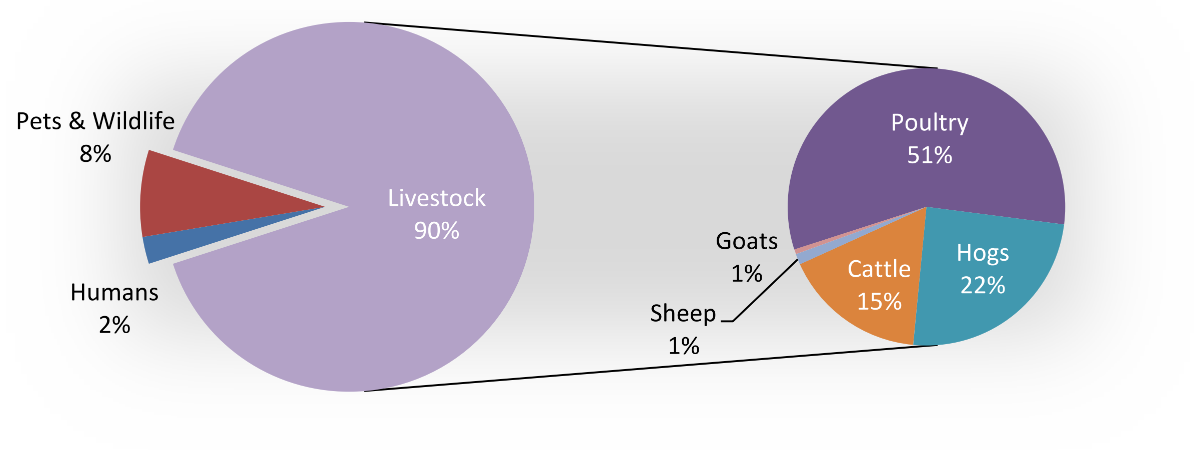

Figure 38. Bacteria production in the Unnamed Creek Subwatershed

Sources Contributing *E. coli* to the Stream Reach

In addition to determining the relative magnitude of *E. coli* sources within the watershed it is important to consider the factors that lead to the *E. coli* being delivered to the stream. The second step in the bacteria source assessment is to evaluate the connection between *E. coli* production, how it is handled on the landscape and how it is ultimately delivered to the stream. In the case of the Unnamed Creek Subwatershed, where poultry is identified as the main potential bacteria source followed by hogs and cattle, the primary activity by which the bacteria becomes available to wash into the stream is through manure application to fields where the manure is not immediately incorporated into the soil (Figure 39). Other mechanisms include runoff from feedlots (that do not have adequate controls) and from animals on pasture.

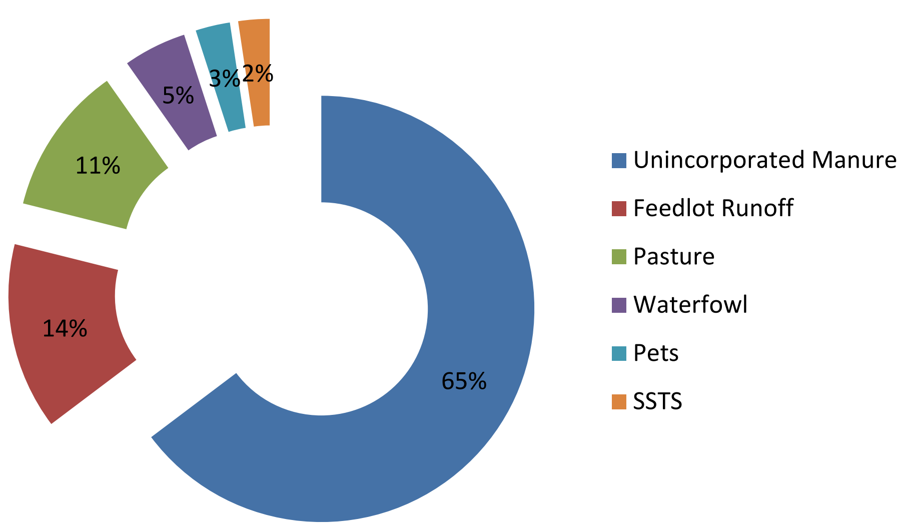

Figure 39. Estimated Percentage of Potential Sources Contributing Bacteria to Unnamed Creek (Luxemburg Creek)

Potential *E. coli* Contributing Areas

The final step in the bacteria source assessment methodology developed for the TMDL Study was to determine which areas within the subwatershed have the highest potential to contribute *E. coli* to the stream. In agricultural subwatersheds the areas that have the highest potential to contribute *E. coli* to the stream are areas immediately adjacent to or hydrologically connected to streams where manure is applied or where animals are grazing. Refer to Figure 40 for the map of areas within the Luxemburg Creek Subwatershed that have a high potential to contribute bacteria to the stream. These areas should be prioritized for implementation activities. The Priority Implementation Area in Figure 40 was determined by calculating a delivery factor that accounts for fate and transport factors such as proximity to surface waters, slope, imperviousness, and discharge to lakes prior to discharge to stream networks (refer to Section 4.2.6 of the TMDL Study for more specific information on how the delivery factor and Priority Implementation Area was calculated).

TMDL Allocations and Percent Reductions

Wasteload and load allocations for this subwatershed and the calculated percent reduction needed to meet the TMDL are summarized in Table 46. Load allocations indicate a moderate decrease needed for bacteria in runoff under moist, mid-range and dry flow conditions in the Luxemburg Creek Subwatershed. The maximum percent reduction of bacteria load needed is 76%.

Table 46. Unnamed Creek (Luxemburg Creek) Subwatershed TMDL and Percent Reductions Needed

Flow Regime	Existing Load (billion org/d)	Waste Load Allocations			LA (billion org/d)	MOS (billion org/d)	TMDL (billion org/d)	LA + MS4 WLA (billion org/d)	Estimated Reduction in Watershed Runoff (%)
		WWTFs (Total) (billion org/d)	Straight Pipes (billion org/d)	MS4 (billion org/d)					
High	ID	–	–	–	56.9	6.32	63.2	56.9	ID
Moist	53.7	–	–	–	23.9	2.65	26.5	23.9	56%
Mid-Range	52.8	–	–	–	12.8	1.42	14.2	12.8	76%
Dry	21	–	–	–	6.6	0.733	7.33	6.6	69%
Low	ID	–	–	–	3.48	0.387	3.87	3.48	ID

Key: WWTF-Waste Water Treatment Facility, MS4-Municipal Separate Storm Sewer System, MOS-Margin of Safety, LA-Load Allocation, org-organisms, d-day, ID-Insufficient Data, IDUL-Impairment due to upstream load, EQN-Based on the equation found on page 104 in the TMDL Study, WLA-Waste Load Allocation

Regulated Entities

There are no regulated entities within this subwatershed.

Implementation Plan

The findings of the bacteria source assessment suggest that application of poultry manure that is not appropriately incorporated into the soils is the largest of the likely bacteria sources to the Unnamed Creek Subwatershed. Specifically, land immediately surrounding Unnamed Creek has been assessed as a high risk area for surface applied manure. Based on the source assessment and the TMDL the **target goal is up to a 76% reduction** of bacteria for this subwatershed. In other flow regimes the target goal is lower. The following is the magnitude of reductions to the major potential sources of bacteria that would be necessary within the watershed to meet the 76% goal. Given this level of reduction it will likely take 20+ years of active management for the Unnamed Creek to meet water quality standards for *E. coli*.

- Eliminate 90% of the bacteria coming from manure that is not appropriately incorporated into the soil.
- Eliminate 90% of the bacteria coming from feedlots with inadequate controls.
- Eliminate 100% of the SSTS that are an imminent threat to public health by bringing septic systems into compliance with standards.
- Eliminate 40% of the bacteria load from grazing livestock.

Priority Actions

As a result of the analyses for bacteria sources and contributing areas, the primary focus of implementation for this subwatershed will be to prevent unincorporated manure from reaching the stream and to reduce runoff from feedlots. This can be done by land application with incorporation or by treating manure prior to land application and implementing feedlot runoff controls, respectively.

There are likely other contributors of bacteria that may not have been captured in the analyses above due to a lack of documentation. In many cases, local knowledge of bacteria sources may provide superior guidance for determining how to reduce bacteria loading to impaired stream reaches. Addressing additional sources within the Unnamed Creek Subwatershed that are likely contributing *E. coli* to a lesser degree are also included in the implementation plan since the needed reduction is high in this subwatershed (see Rural Subwatersheds for more information). Below are the priority actions that are recommended for the Unnamed Creek Subwatershed.

- Identify and map potential and known sources that are directly contributing bacteria to waterbodies using local knowledge, windshield surveys, and interviews with landowners, etc. Note that mapping sources is a distinct activity from monitoring.
- Continue baseline monitoring of the stream reach and add additional monitoring stations along the stream reach and tributaries to help pinpoint potential sources of bacteria. Refer to the monitoring section for further recommendations.
- Reduce direct sources of bacteria, such as livestock that have access to streams, installing fences around streams within pastures, or providing water sources within pastures to reduce the frequency of livestock from entering streams.
- Promote the use of manure injection or incorporation of manure on all land where manure is applied. Target land areas near the stream and ditches and tile intakes first. Alternatively, treat manure to reduce bacteria concentrations prior to land application.
- Promote good manure application and treatment practices such as:
    - Applying manure to relatively dry fields;
    - Avoiding steep sloping areas;
    - Avoiding areas near water bodies;
    - Avoiding vulnerable locations for spreading manure;
    - Avoiding areas prone to flooding;
    - Avoiding applying on frozen soil.
- Implement and enforce feedlot runoff controls.
- Install filter strips around fields, especially where streams are present, to prevent bacteria-laden runoff from reaching streams; buffer strips should also be installed along ditches within fields that flow directly to streams. Priority should be given to BMPs that provide multiple benefits.

- Ensure that all local feedlot, SSTS, septage and pet-waste ordinances within the subwatershed are stringent enough so that rivers and streams will meet State water quality standards.
- Ensure that ordinances are enforced, through regular inspection and monitoring.
- Conduct septic inspections and make sure all systems that are imminent threats are brought into compliance.
- Conduct education and outreach to ensure that ordinances and BMPs are understood and followed.
- Ensure septage application is in compliance with state laws and local ordinances.

Table 47 lists the priority actions described above along with a recommended timeframe for implementation and estimated costs. The timeframe that is provided is based on priority of implementation, and efforts will likely be ongoing once the action has been implemented. Action items are listed in order of importance. Also included in Table 47 are priority actions that are simply good practices to follow in all subwatersheds regardless of the magnitude of the source/activity they address. Note that some of these practices may have already been initiated within the subwatershed; if that is the case, continue with them and enhance them where necessary. Note that the costs are provided for context and not as an estimate of the total expenditure needed to meet any specified reduction in bacteria.

Refer to Appendix A for the entities responsible for implementing source controls and treatment BMPs in this subwatershed.

Table 47. Priority actions for Unnamed Creek (Luxemburg Creek) Subwatershed

Priority Timeframe[1]	Action	Estimated Effectiveness of Practice[2] (up to)	Estimated Magnitude in Watershed	Implementation Cost[3]
High	Limit livestock from accessing streams/waterbodies by fencing or providing alternative water sources Livestock Stream Access Control	100%	Unknown	\$0.70-1.50/ linear feet of fencing \$3-6/ cu yard to construct a pond as an alternative water source
High	Promote land application of manure with incorporation Land application w/ incorporation	70%	1,000 – 5,500 acres of cultivated cropland	\$12/acre
High	Promote good manure application and treatment practices (see text above) Manure Management	Varies by practice	1,000 – 5,500 acres of cultivated cropland	NA
High	Implement feedlot runoff control and manure management at existing feedlots Feedlot Runoff Control	100%	~650 Animal Units (AU)	\$8-24/AU

Priority Timeframe[1]	Action	Estimated Effectiveness of Practice[2] (up to)	Estimated Magnitude in Watershed	Implementation Cost[3]
High	Install vegetated buffers around fields where manure is applied as well as grazed lands Filter Strips	92%	~27 acres (Assume 5.5 miles of stream; 20ft buffer)	$600-1000/acre
High	Conduct septic system inspections as warranted and bring septic systems into compliance with standards Septic (SSTS) Maintenance	100%	?	$200-300 (inspection) $7,500 per system (if replacement required)
Medium	Identify and map any location with potential bacteria sources Monitoring	NA	NA	Staff time
Medium	Adopt, enforce, and ensure that all local feedlot, SSTS, septage and pet-waste ordinances within the subwatershed are enforced through regular inspection and monitoring and are stringent enough so that rivers and streams will meet State water quality standards.	100%	NA	Staff time
Medium	Conduct outreach and education to ensure ordinances are followed Outreach/Education	NA	NA	Staff time
Low	Ensure ordinances are followed and enforced for septage application Septage	NA	NA	Staff time
Low	Regularly monitor stream and inspect all significant sources that have the potential to release bacteria Monitoring	NA	NA	Staff time

[1] Priority is based on recommended timeframe to continue or start (not complete) implementation activities: High = 1-2 years, Medium = 2-5 years, Low = 5-10 years.
[2] Estimated effectiveness of practice refers to the reduction of bacteria concentrations in runoff to receiving waterbodies.
[3] Costs based on NRCS EQIP Payment Schedules
http://www.nrcs.usda.gov/wps/portal/nrcs/detail/mn/programs/financial/?cid=stelprdb1245512

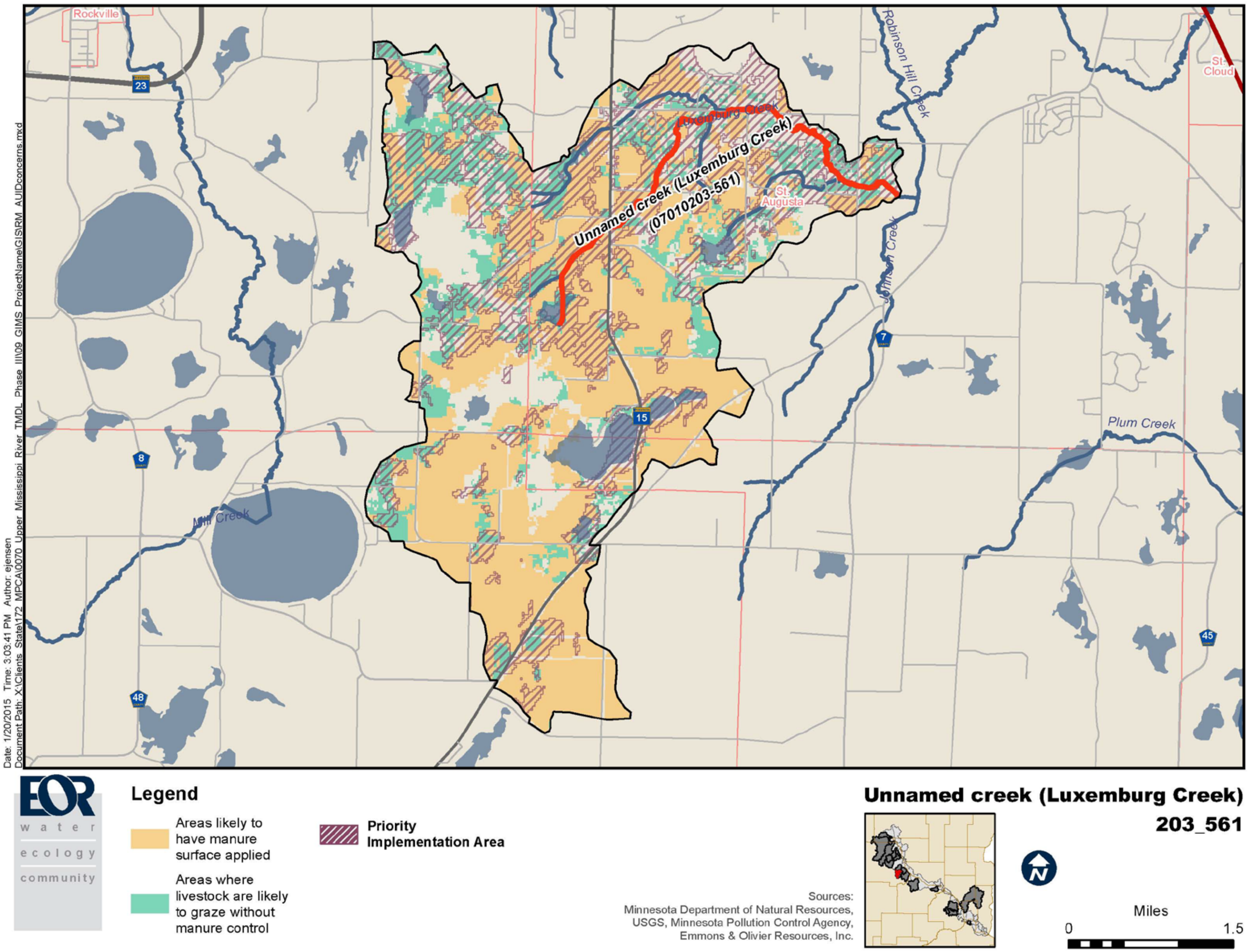

Figure 40. Areas with highest risk for transport of bacteria into streams and rivers to be targeted for initial implementation (hatched areas) (refer to Potential E. coli Contributing Areas to determine how Priority Implementation Areas were determined)

Plum Creek (07010203-572) Subwatershed

Reach Description: Warner Lake to Mississippi River

Plum Creek, a tributary of the Mississippi River, is impaired for aquatic recreation due to *E. coli*. The subwatershed is located within Priority Area B of the Minneapolis and St. Paul Source Water Protection Areas (Figure 3). Monitoring conducted in 2010 and 2011 indicated elevated levels of *E. coli* throughout the growing season with exceedances of the water quality standard occurring in every month with at least five samples from June through September except June. *E. coli* counts ranged from 32 to 2,420 org/100 ml and monthly geometric means ranged from 119 to 613 org/100 ml (a summary of water quality monitoring data can be found in Appendix D of the TMDL Study). Plotting *E. coli* levels against stream flow, as is shown in the load duration curves in Figure 6.28 on page 138 of the TMDL Study, show that exceedances occur at all flow conditions (e.g. high, moist, mid, dry, low) where there is monitoring data.

Production of *E. coli* in Subwatershed

As described in the TMDL Study and in Table 49 below, the Total Maximum Daily Load for Plum Creek is divided into point (permitted) sources and nonpoint (non-permitted) sources. In the Plum Creek Subwatershed, point sources of *E. coli* are limited to MS4s (Table 50). For nonpoint sources, the majority of the land use in this watershed is in agricultural use (Table 48).

Table 48. Plum Creek Subwatershed Land uses

Land use	%
Cultivated Crops	38%
Deciduous Forest	22%
Pasture / Hay	15%
Emergent Herbaceous Wetland	8%
Grassland / Herbaceous	7%
Developed Open Space	5%
Open Water	3%
Table only includes land uses that are > 1% of the land area	

In developing the TMDL Study a desktop analysis was conducted to determine the potential sources of *E. coli* within each subwatershed and estimate the relative contribution of each source. The process, referred to as a bacteria source assessment, is described in Section 4 of the TMDL Study beginning on page 45. In the Plum Creek Subwatershed the vast majority of the *E. coli* is likely produced from livestock with slight contributions from humans and from pets and wildlife.

Sources Contributing *E. coli* to the Stream Reach

In addition to determining the relative magnitude of *E. coli* sources within the watershed it is important to consider the factors that lead to the *E. coli* being delivered to the stream. The second step in the bacteria source assessment is to evaluate the connection between *E. coli* production, how it is handled on the landscape and how it is ultimately delivered to the stream. In the case of the Plum Creek Subwatershed, where livestock manure is identified as the main potential bacteria source, the primary activity by which the bacteria becomes available to wash into the stream is through manure application to fields where the manure is not immediately incorporated into the soil. Other mechanisms include runoff from feedlots (that do not have adequate controls) and from animals on pasture.

The Plum Creek Neighborhood Network (PCNN**)** in cooperation with the Stearns Soil & Water Conservation District (Stearns SWCD) requested that the following information be included verbatim in this section of the Implementation Plan. Information provided by the PCNN is as follows:

> *The PCNN, a volunteer group of property owners in Lynden Township, Stearns County MN., obtained water samples, for determining the levels of E. coli in Plum Creek reach (07010203-572), from Warner Lake to the Mississippi River in the summers of 2014 and 2015. The PCNN notes that consistently the levels of E. coli increase from Warner Lake to the monitoring point at Franklin Road.*
>
> *Summer mean values (provided by PCNN)*

	Warner Lake	*CR 75*	*Franklin Road*
2014	*16*	*77*	*97*
2015	*21*	*62*	*100*

> *The PCNN notes that the E. coli levels have increased five (5) times both years from Warner Lake to Franklin Road. Plum creek flows through Dallas and Feldges Lakes before entering Warner Lake. The PCNN suspects that the reduction in flow velocity allows the E. coli in the sediment particles to settle to the bottom and the Ultra Violet light from the sun has an opportunity to reduce the level. Therefore, as the monitoring data indicated, the level exiting Warner Lake is very low and can thus be considered a "starting point" for the E. coli impaired reach.*
>
> *Plum Creek reach (07010203-572) was excavated, re-channelized, and straightened in 1970 when Interstate 94 was built. This changed the flow direction and velocity of the creek and is an important factor in the streambed sediment and waterborne E. coli levels relationship.*
>
> *Upon recommendation of Dr. Michael Sadowsky, Director, Biotechnology Institute, University of MN, DNA identification samples were obtained at Franklin Road and sent to Source Molecular* http://www.sourcemolecular.com *for analysis. The E. coli levels were 387 org/per 100ml (after a rain event 9/8/2015), 307 org/per 100ml on 9/11/2015, and 145 org/per 100ml 9/14/15. The DNA identification samples were taken on 9/15/2015. The data suggested the monitoring point was "impaired" during the sample event. The results of the three tests were negative for poultry, ruminant and human DNA.*
>
> *"There were no pastured animals, feedlots or manure application in the watershed either summer (2014-2015)".*
>
> *The PCNN "has not yet identified what the producers of the E. coli are, but we (PCNN) have reliable, acceptable data on what it is not". In the 1.1 mile reach of Plum Creek, with and without storm events the levels of E. coli increases between Warner Lake and Franklin Road.*

Potential *E. coli* Contributing Areas

The final step in the bacteria source assessment methodology developed for the TMDL Study was to determine which areas within the subwatershed have the highest potential to contribute *E. coli* to the stream. In agricultural subwatersheds the areas that have the highest potential to contribute *E. coli* to the stream are areas immediately adjacent to or hydrologically connected to streams where manure is applied or where animals are grazing. Refer to Figure 41 for the map of areas within the Plum Creek Subwatershed that have a high potential to contribute bacteria to the stream. These areas should be prioritized for implementation activities. The Priority Implementation Area in Figure 41 was determined by calculating a delivery factor that accounts for fate and transport factors such as proximity to surface waters, slope, imperviousness, and discharge to lakes prior to discharge to stream networks (refer to Section 4.2.6 of the TMDL Study for more specific information on how the delivery factor and Priority Implementation Area was calculated).

TMDL Allocations and Percent Reductions

Wasteload and load allocations for this subwatershed and the calculated percent reduction needed to meet the TMDL are summarized in Table 49. Load allocations indicate a moderate decrease needed for bacteria in runoff under mid-range flow conditions in the Plum Creek Subwatershed. The maximum percent reduction of bacteria load needed is 43%. Note - Locally led monitoring efforts by the Plum Creek Neighborhood Network (PCNN) in 2014 concluded that higher *E. coli* concentrations were present in samples collected during or after storm events.

Table 49. Plum Creek Subwatershed TMDL and Percent Reductions Needed

Flow Regime	Existing Load (billion org/d)	Waste Load Allocations			LA (billion org/d)	MOS (billion org/d)	TMDL (billion org/d)	LA + MS4 WLA (billion org/d)	Estimated Reduction in Watershed Runoff (%)
		WWTFs (Total) (billion org/d)	Straight Pipes (billion org/d)	MS4 (billion org/d)					
High	ID	–	–	0.024	109	12.1	121	109	ID
Moist	41.5	–	–	0.01	45.5	5.06	50.6	45.5	0%
Mid-Range	43.1	–	–	0.00537	24.4	2.71	27.1	24.4	43%
Dry	11.8	–	–	0.00277	12.6	1.4	14	12.6	0%
Low	ID	–	–	0.00147	6.67	0.741	7.41	6.67	ID

Key: WWTF-Waste Water Treatment Facility, MS4-Municipal Separate Storm Sewer System, MOS-Margin of Safety, LA-Load Allocation, org-organisms, d-day, ID-Insufficient Data, IDUL-Impairment due to upstream load, EQN-Based on the equation found on page 104 in the TMDL Study, WLA-Waste Load Allocation

Regulated Entities

The regulated entities within this subwatershed are shown in Table 50.

Table 50. Regulated Entities within the Plum Creek Subwatershed

Regulated Entity	Permit #
St. Cloud City	MS400052

Implementation Plan

The findings of the bacteria source assessment suggest that application of livestock manure that is not appropriately incorporated into the soils is the largest of the likely bacteria sources to the Plum Creek Subwatershed. Specifically, land immediately surrounding Plum Creek has been assessed as a high risk area for surface applied manure. Based on the source assessment and the TMDL the **target goal is up to a 43% reduction** of bacteria for this subwatershed. In other flow regimes the target goal is lower. The following is the magnitude of reductions to the major potential sources of bacteria that would be necessary within the watershed to meet the 43% goal. Given this level of reduction it will likely take 20+ years of active management for the Plum Creek to meet water quality standards for *E. coli*.

- Eliminate 50% of the bacteria coming from manure that is not appropriately incorporated into the soil.
- Eliminate 50% of the bacteria coming from feedlots with inadequate controls.
- Eliminate 100% of the SSTS that are an imminent threat to public health by bringing septic systems into compliance with standards.
- Eliminate 50% of the bacteria load from grazing livestock.

Priority Actions

As a result of the analyses for bacteria sources and contributing areas, the primary focus of implementation for this subwatershed will be to prevent unincorporated manure from reaching the stream and to reduce runoff from feedlots. This can be done by land application with incorporation or by treating manure prior to land application and implementing feedlot runoff controls, respectively.

There are likely other contributors of bacteria that may not have been captured in the analyses above due to a lack of documentation. In many cases, local knowledge of bacteria sources may provide superior guidance for determining how to reduce bacteria loading to impaired stream reaches. Addressing additional sources within the Plum Creek Subwatershed that are likely contributing *E. coli* to a lesser degree are also included in the implementation plan since the needed reduction is high in this subwatershed (see Rural Subwatersheds for more information). Below are the priority actions that are recommended for the Plum Creek Subwatershed.

- Identify and map potential and known sources that are directly contributing bacteria to waterbodies using local knowledge, windshield surveys, and interviews with landowners, etc. Note that mapping sources is a distinct activity from monitoring.

- Continue baseline monitoring of the stream reach and add additional monitoring stations along the stream reach and tributaries to help pinpoint potential sources of bacteria. Refer to the monitoring section for further recommendations.
- Reduce direct sources of bacteria, such as livestock that have access to streams, installing fences around streams within pastures, or providing water sources within pastures to reduce the frequency of livestock from entering streams.
- Promote the use of manure injection or incorporation of manure on all land where manure is applied. Target land areas near the stream and ditches and tile intakes first. Alternatively, treat manure to reduce bacteria concentrations prior to land application.
- Promote good manure application and treatment practices such as:
    - Applying manure to relatively dry fields;
    - Avoiding steep sloping areas;
    - Avoiding areas near water bodies;
    - Avoiding vulnerable locations for spreading manure;
    - Avoiding areas prone to flooding;
    - Avoiding applying on frozen soil.
- Implement and enforce feedlot runoff controls.
- Install filter strips around fields, especially where streams are present, to prevent bacteria-laden runoff from reaching streams; buffer strips should also be installed along ditches within fields that flow directly to streams. Priority should be given to BMPs that provide multiple benefits.
- Ensure that all local feedlot, SSTS, septage and pet-waste ordinances within the subwatershed are stringent enough so that rivers and streams will meet State water quality standards.
- Ensure that ordinances are enforced, through regular inspection and monitoring.
- Conduct septic inspections and make sure all systems that are imminent threats are brought into compliance.
- Conduct education and outreach to ensure that ordinances and BMPs are understood and followed.
- Ensure septage application is in compliance with state laws and local ordinances.

The Plum Creek Neighborhood Network (PCNN**)** in cooperation with the Stearns Soil & Water Conservation District (Stearns SWCD) requested that the following information be included verbatim in this section of the Implementation Plan. Information provided by the PCNN is as follows:

*<u>Priority Actions - provided by the Plum Creek Neighborhood Network (PCNN).</u> Since 2013 the PCNN have been actively involved in water quality efforts within this subwatershed, working towards the goal of restoring Plum Creek (07010203-572). **"**The Primary Mission of the Plum Creek Neighborhood Network is to collect E. coli level data at the MPCA designated monitoring stations, at County Road 75 and Franklin Road, to be able to remove Plum Creek from the list of Impaired Waters". Their priority actions are noted in their comments on the draft Plan as follows;*

Proposed further investigation (PCNN)

1. Reduce volume and velocity of storm water runoff from culverts into Plum Creek and reduce velocity and concentration of storm water runoff under CR 143.
2. Repair erosion breach in MNDOT buffer north of I 94.
3. Investigate septic system at Warner Lake Conference center. (Found to be certifiable 4/2015)

4. Encourage landowner and renter to use crop management erosion control. (Vegetative buffers in crop fields).
5. Engineer storm water divergence from field culverts into Plum Creek to reduce turbulence or remove culverts."
6. Diagnostic stream(geomorphology analysis/sediment(stream bed) contribution analysis.

With the help of the following national bacteria authorities and their papers and the lead from the Stearns County Soil and Water Conservation District, the PCNN will develop a plan for 2016. It will be directed to the erosion control of surface water, analyzing the underground water flows to the creek, and how it affects the E. coli sediment in the bottom of the creek. From that we will try to locate the producers of the E. coli.

www.usawaterquality.org (Pachepsky, Shelton, Coppock, 2010) "The effect of the direct bacterial input from pasturelands to surface water can be significantly overrated if the streambed bacterial contribution is ignored."

"Sediment imbedded E. coli, as a water quality indicator bacteria in freshwater streams, have been largely overlooked."

www.ars.usda.gov (Pachepsky, Shelton 2011)
"Re-suspension of sediment, caused by being disturbed, aeriated, or agitated, rather than runoff from surrounding lands, can create noticeable elevation E.coli concentration in water."

Scholes 2008
The explicit recognition of the importance of the sediment as an E. coli reservoir makes it imperative the development of treatments specifically aimed on the reduction of the E. coli concentrations in the sediment.

Robin Brinkmeyer 2015
Distribution and persistence of Escherichia coli and Enterococci in stream bed and bank sediments from two urban streams in Houston, TX
H I G H L I G H T S
• Streambed and bank sediments were found to be a significant source of E. coli and enterococci bacteria to the water column.
• Viable E. coli and enterococci exist as deep as 60 cm in sediments.
• Sediments dominated by sand contained highest concentrations of fecal indicator bacteria.
• DNA fingerprinting analysis challenged the assumption that sediment resuspension only occurs in high flow conditions.
• Water quality goals may not be achievable due to an endless supply of fecal indicator bacteria from sediments.

Dr. Michael Sadowsky
Director Biotechnology Institute
Distinguished McKnight Professor
University of Minnesota
Geographic isolation of Escherichia coli genotypes in sediments and water of the Seven Mile Creek —
H I G H L I G H T S
• Sediment E. coli are in dynamic equilibrium with the water column.

- *Temperature and floods impact E. coli populations at the Seven Mile Creek.*
- *Geographic isolation results in the presence of unique of E. coli genotypes.*
- *E. coli can grow and become naturalized to sediments and water at Seven Mile Creek.*

Email from Dr. Yakov Pachepsky [Yakov.Pachepsky@ARS.USDA.GOV]

Wed 10/28/2015 10:38 AM
Jerry:
"My guess is that the increase in E. coli concentrations happens because of so called hyporheic exchange. Bacteria are coming from bottom sediment during the base-flow. They are either pushed out from sediment with the groundwater flow, or they go themselves in search of better conditions, or the top of sediment is getting gently rinsed during the base flow"

Email from Dr. Charles Nelson, retired Hydrologist, St Cloud State University and a member of PCNN.
"The best monitoring would be wells or piezometers that are actually in the study area. These monitoring sites would measure the true groundwater movement.
Because you have stated that you are most interested in how groundwater may be interacting with Plum Creek...the best method would be installing mini-piezometers into the stream bed. I would be willing to build/install/monitor the mini-piezometers if you want. They are cheap and easy to build...as long as the stream levels are fairly shallow they are easy to install...and the creek reach is quite accessible from Cty 75. So monitoring would consist of wading in the stream to each unit and measuring the water levels."

Table 51 lists the priority actions described in this section along with a recommended timeframe for implementation and estimated costs. The timeframe that is provided is based on priority of implementation, and efforts will likely be ongoing once the action has been implemented. Action items are listed in order of importance. Also included in Table 51 are priority actions that are simply good practices to follow in all subwatersheds regardless of the magnitude of the source/activity they address. Note that some of these practices may have already been initiated within the subwatershed; if that is the case, continue with them and enhance them where necessary. Note that the costs are provided for context and not as an estimate of the total expenditure needed to meet any specified reduction in bacteria

Refer to Appendix A for the entities responsible for implementing source controls and treatment BMPs in this subwatershed.

Table 51. Priority actions for Plum Creek Subwatershed

Priority Timeframe[1]	Action	Estimated Effectiveness of Practice[2] (up to)	Estimated Magnitude in Watershed	Implementation Cost[3]
High	Limit livestock from accessing streams/waterbodies by fencing or providing alternative water sources Livestock Stream Access Control	100%	Unknown	$0.70-1.50/ linear feet of fencing $3-6/ cu yard to construct a pond as an alternative water source

Priority Timeframe[1]	Action	Estimated Effectiveness of Practice[2] (up to)	Estimated Magnitude in Watershed	Implementation Cost[3]
High	Promote land application of manure with incorporation Land application w/ incorporation	70%	2,500 – 7,500 acres of cultivated cropland	$12/acre
High	Promote good manure application and treatment practices (see text above) Manure Management	Varies by practice	2,500 – 7,500 acres of cultivated cropland	NA
High	Implement feedlot runoff control and manure management at existing feedlots Feedlot Runoff Control	100%	~1,400 Animal Units (AU)	$8-24/AU
High	Install vegetated buffers around fields where manure is applied as well as grazed lands Filter Strips	92%	~12 acres (assume 2.5 miles of stream; 20ft buffer)	$600-1000/acre
High	Conduct septic system inspections as warranted and bring septic systems into compliance with standards Septic (SSTS) Maintenance	100%	?	$200-300 (inspection) $7,500 per system (if replacement required)
Medium	Ensure that all local feedlot, SSTS, septage and pet-waste ordinances within the subwatershed are enforced through regular inspection and monitoring and are stringent enough so that rivers and streams will meet State water quality standards. Federal, State, and Local Requirements	100%	NA	Staff time
Medium	Identify and map any location with potential bacteria sources Monitoring	NA	NA	Staff time
Medium	Adopt and enforce strict ordinances for SSTS, pet waste, feedlot runoff, and septage application Federal, State, and Local Requirements	100%	NA	Staff time
Medium	Conduct outreach and education to ensure ordinances and BMPs are followed and understood Outreach/Education	NA	NA	Staff time

Priority Timeframe[1]	Action	Estimated Effectiveness of Practice[2] (up to)	Estimated Magnitude in Watershed	Implementation Cost[3]
Low	Ensure ordinances are followed and enforced for septage application Septage	NA	NA	Staff time
Low	Regularly monitor stream and inspect all significant sources that have the potential to release bacteria Monitoring	NA	NA	Staff time

[1] Priority is based on recommended timeframe to continue or start (not complete) implementation activities: High = 1-2 years, Medium = 2-5 years, Low = 5-10 years.
[2] Estimated effectiveness of practice refers to the reduction of bacteria concentrations in runoff to receiving waterbodies.
[3] Costs based on NRCS EQIP Payment Schedules
http://www.nrcs.usda.gov/wps/portal/nrcs/detail/mn/programs/financial/?cid=stelprdb1245512

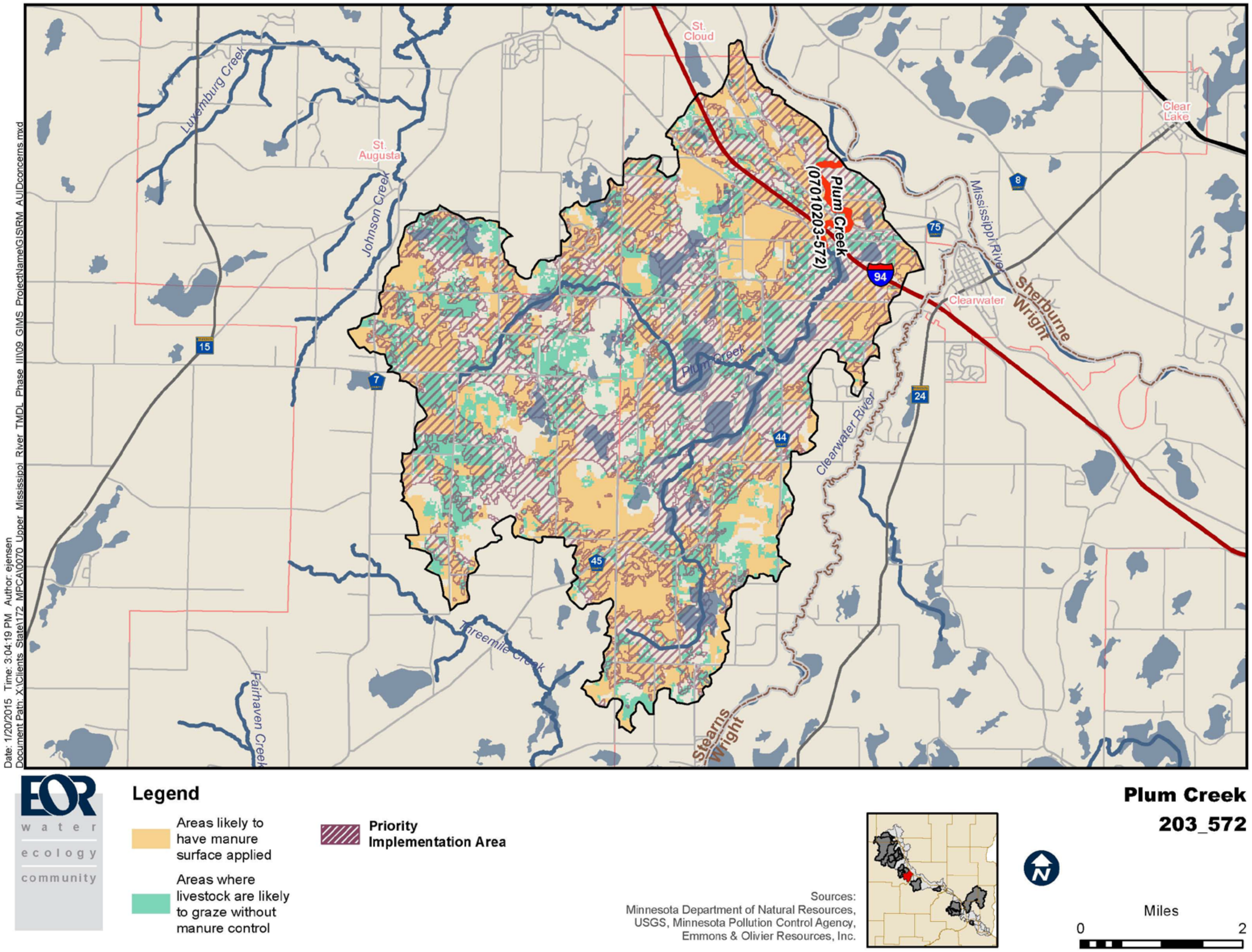

Figure 41. Areas with highest risk for transport of bacteria into streams and rivers to be targeted for initial implementation (hatched areas) (refer to Potential E. coli Contributing Areas to determine how Priority Implementation Areas were determined)

Johnson Creek (Meyer Creek) 635 (07010203-635) Subwatershed

Reach Description: Unnamed Creek to Unnamed Creek

Johnson Creek (Meyer Creek) (07010203-635), a tributary of the Mississippi River, is impaired for aquatic recreation due to *E. coli*. The subwatershed is located within Priority Area B of the Minneapolis and St. Paul Source Water Protection Areas (Figure 3). Another reach of Johnson Creek (Meyer Creek) 639 (07010203-639) is also impaired for *E. coil*. Monitoring conducted in 2010 and 2011 indicated elevated levels of *E. coli* throughout the growing season with exceedances of the water quality standard occurring in every month with at least five samples from June through September. *E. coli* counts ranged from 58 to 2,420 org/100 ml and monthly geometric means ranged from 309 to 1,300 org/100 ml (a summary of water quality monitoring data can be found in Appendix D of the TMDL Study). Plotting *E. coli* levels against stream flow, as is shown in the load duration curves in Figure 6.31 on page 141 of the TMDL Study, show that exceedances occur at all flow conditions (e.g. high, moist, mid, dry, low) where there is monitoring data.

Production of *E. coli* in Subwatershed

As described in the TMDL Study and in Table 53 below, the Total Maximum Daily Load for Johnson Creek (Meyer Creek) 635 is divided into point (permitted) sources and nonpoint (non-permitted) sources. In the Johnson Creek (Meyer Creek) 635 Subwatershed, there are no point sources of *E. coli*. For nonpoint sources, the majority of the land use in this watershed is in agricultural use (Table 52).

Table 52. Johnson Creek (Meyer Creek) 635 Subwatershed Land uses

Land use	%
Cultivated Crops	49%
Deciduous Forest	22%
Pasture / Hay	12%
Grassland / Herbaceous	7%
Developed Open Space	4%
Emergent Herbaceous Wetland	4%
Table only includes land uses that are > 1% of the land area	

In developing the TMDL Study a desktop analysis was conducted to determine the potential sources of *E. coli* within each subwatershed and estimate the relative contribution of each source. The process, referred to as a bacteria source assessment, is described in Section 4 of the TMDL Study beginning on page 45. In the Johnson Creek (Meyer Creek) 635 Subwatershed the vast majority of the *E. coli* is likely produced from livestock with slight contributions from humans and from pets and wildlife (Figure 5). Further analysis of livestock numbers suggest that poultry is the type of livestock that produces the most *E. coli* in this subwatershed followed by hogs and cattle (Figure 42). The fraction of *E. coli* from various sources of livestock in the pie chart is determined by the total animal units estimated within the subwatershed and takes into account the size discrepancy of the various types of livestock as well as the differences in the amount of bacteria within their waste.

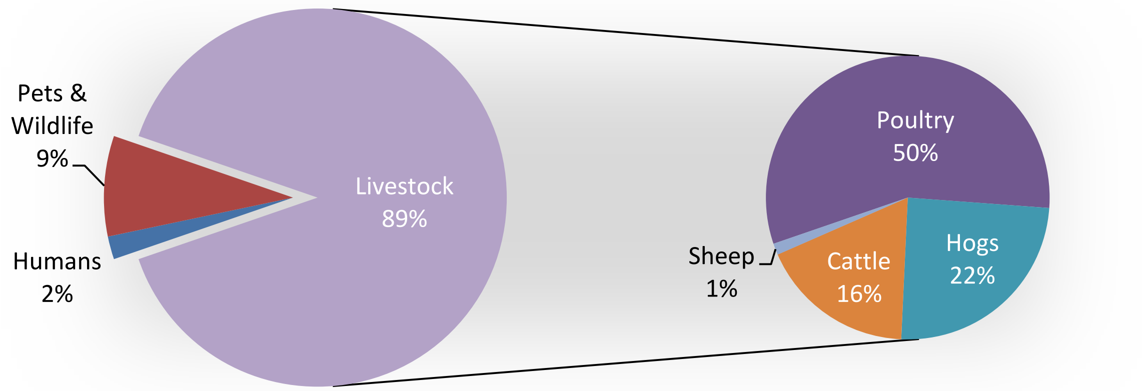

Figure 42. Bacteria production in the Johnson Creek (Meyer Creek) 635 Subwatershed

Sources Contributing *E. coli* to the Stream Reach

In addition to determining the relative magnitude of *E. coli* sources within the watershed it is important to consider the factors that lead to the *E. coli* being delivered to the stream. The second step in the bacteria source assessment is to evaluate the connection between *E. coli* production, how it is handled on the landscape and how it is ultimately delivered to the stream. In the case of the Johnson Creek (Meyer Creek) 635 Subwatershed, where poultry is identified as the main potential bacteria source followed by hogs and cattle, the primary activity by which the bacteria becomes available to wash into the stream is through manure application to fields where the manure is not immediately incorporated into the soil (Figure 43). Other mechanisms include runoff from feedlots (that do not have adequate controls) and from animals on pasture.

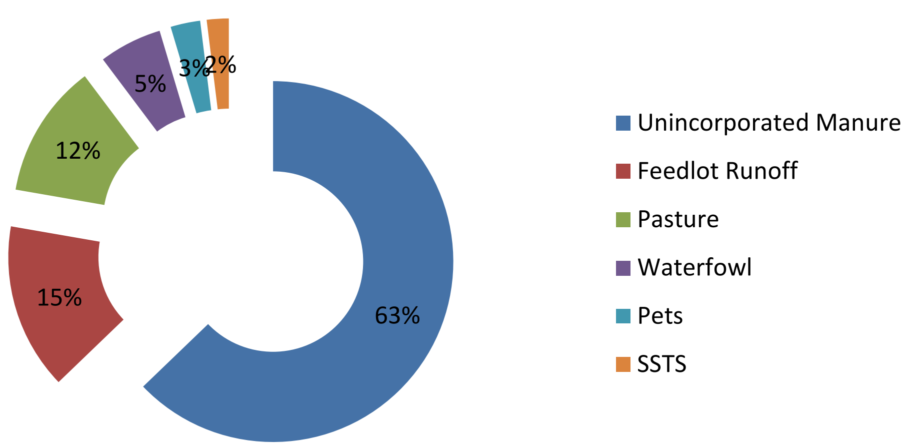

Figure 43. Estimated Percentage of Potential Sources Contributing Bacteria to Johnson Creek (Meyer Creek) 635

Potential *E. coli* Contributing Areas

The final step in the bacteria source assessment methodology developed for the TMDL Study was to determine which areas within the subwatershed have the highest potential to contribute *E. coli* to the stream. In agricultural subwatersheds the areas that have the highest potential to contribute *E. coli* to the stream are areas immediately adjacent to or hydrologically connected to streams where manure is applied or where animals are grazing. Refer to Figure for the map of areas within the Johnson Creek (Meyer Creek) 635 Subwatershed that have a high potential to contribute bacteria to the stream. These areas should be prioritized for implementation activities. The Priority Implementation Area in Figure was determined by calculating a delivery factor that accounts for fate and transport factors such as proximity to surface waters, slope, imperviousness, and discharge to lakes prior to discharge to stream networks (refer to Section 4.2.6 of the TMDL Study for more specific information on how the delivery factor and Priority Implementation Area was calculated).

TMDL Allocations and Percent Reductions

Wasteload and load allocations for this subwatershed and the calculated percent reduction needed to meet the TMDL are summarized in Table 53. Load allocations indicate a sizable decrease needed for bacteria in runoff under moist, mid-range and dry flow conditions in the Johnson Creek (Meyer Creek) 635 Subwatershed. The maximum percent reduction of bacteria load needed is 89%.

Table 53. Johnson Creek (Meyer Creek) 635 Subwatershed TMDL and Percent Reductions Needed

Flow Regime	Existing Load (billion org/d)	Waste Load Allocations			LA (billion org/d)	MOS (billion org/d)	TMDL (billion org/d)	LA + MS4 WLA (billion org/d)	Estimated Reduction in Watershed Runoff (%)
		WWTFs (Total) (billion org/d)	Straight Pipes (billion org/d)	MS4 (billion org/d)					
High	ID	–	–	–	32.4	3.6	36	32.4	ID
Moist	118	–	–	–	13.6	1.51	15.1	13.6	89%
Mid-Range	41.9	–	–	–	7.2	0.8	8	7.2	83%
Dry	12.4	–	–	–	3.75	0.417	4.17	3.75	70%
Low	ID	–	–	–	1.99	0.221	2.21	1.99	ID

Key: WWTF-Waste Water Treatment Facility, MS4-Municipal Separate Storm Sewer System, MOS-Margin of Safety, LA-Load Allocation, org-organisms, d-day, ID-Insufficient Data, IDUL-Impairment due to upstream load, EQN-Based on the equation found on page 104 in the TMDL Study, WLA-Waste Load Allocation

Regulated Entities

There are no regulated entities within this subwatershed.

Implementation Plan

The findings of the bacteria source assessment suggest that application of poultry manure that is not appropriately incorporated into the soils is the largest of the likely bacteria sources to the Johnson Creek (Meyer Creek) 635 Subwatershed. Specifically, land immediately surrounding Johnson Creek (Meyer Creek) 635 has been assessed as a high risk area for surface applied manure. Based on the source assessment and the TMDL the **target goal is up to an 89% reduction** of bacteria for this subwatershed.

In other flow regimes the target goal is lower. The following is the magnitude of reductions to the major potential sources of bacteria that would be necessary within the watershed to meet the 89% goal. Given this level of reduction it will likely take 20+ years of active management for the Johnson Creek (Meyer Creek) 635 to meet water quality standards for *E. coli*.

- Eliminate 95% of the bacteria coming from manure that is not appropriately incorporated into the soil.
- Eliminate 95% of the bacteria coming from feedlots with inadequate controls.
- Eliminate 100% of the SSTS that are an imminent threat to public health by bringing septic systems into compliance with standards.
- Eliminate 90% of the bacteria load from grazing livestock.
- Eliminate 90% of the bacteria load from wildlife.

Priority Actions

As a result of the analyses for bacteria sources and contributing areas, the primary focus of implementation for this subwatershed will be to prevent unincorporated manure from reaching the stream and to reduce runoff from feedlots. This can be done by land application with incorporation or by treating manure prior to land application and implementing feedlot runoff controls, respectively.

There are likely other contributors of bacteria that may not have been captured in the analyses above due to a lack of documentation. In many cases, local knowledge of bacteria sources may provide superior guidance for determining how to reduce bacteria loading to impaired stream reaches. Addressing additional sources within the Johnson Creek (Meyer Creek) Subwatershed that are likely contributing *E. coli* to a lesser degree are also included in the implementation plan since the needed reduction is high in this subwatershed (see Rural Subwatersheds for more information). Below are the priority actions that are recommended for the Johnson Creek (Meyer Creek) 635 Subwatershed.

- Identify and map potential and known sources that are directly contributing bacteria to waterbodies using local knowledge, windshield surveys, and interviews with landowners, etc. Note that mapping sources is a distinct activity from monitoring.
- Continue baseline monitoring of the stream reach and add additional monitoring stations along the stream reach and tributaries to help pinpoint potential sources of bacteria. Refer to the monitoring section for further recommendations.
- Reduce direct sources of bacteria, such as livestock that have access to streams, installing fences around streams within pastures, or providing water sources within pastures to reduce the frequency of livestock from entering streams.
- Promote the use of manure injection or incorporation of manure on all land where manure is applied. Target land areas near the stream and ditches and tile intakes first. Alternatively, treat manure to reduce bacteria concentrations prior to land application.
- Promote good manure application and treatment practices such as:
    - Applying manure to relatively dry fields;
    - Avoiding steep sloping areas;
    - Avoiding areas near water bodies;
    - Avoiding vulnerable locations for spreading manure;
    - Avoiding areas prone to flooding;
    - Avoiding applying on frozen soil.
- Implement and enforce feedlot runoff controls.

- Install filter strips around fields, especially where streams are present, to prevent bacteria-laden runoff from reaching streams; buffer strips should also be installed along ditches within fields that flow directly to streams. Priority should be given to BMPs that provide multiple benefits.
- Deter waterfowl congregation on and near streams by maintaining unmowed filter strips and vegetation around and along streams.
- Ensure that all local feedlot, SSTS, septage and pet-waste ordinances within the subwatershed are stringent enough so that rivers and streams will meet State water quality standards.
- Ensure that ordinances are enforced, through regular inspection and monitoring.
- Conduct septic inspections and make sure all systems that are imminent threats are brought into compliance.
- Conduct education and outreach to ensure that ordinances and BMPs are understood and followed.
- Ensure septage application is in compliance with state laws and local ordinances.

Table 54 lists the priority actions described above along with a recommended timeframe for implementation and estimated costs. The timeframe that is provided is based on priority of implementation, and efforts will likely be ongoing once the action has been implemented. Action items are listed in order of importance. Also included in Table 54 are priority actions that are simply good practices to follow in all subwatersheds regardless of the magnitude of the source/activity they address. Note that some of these practices may have already been initiated within the subwatershed; if that is the case, continue with them and enhance them where necessary. Note that the costs are provided for context and not as an estimate of the total expenditure needed to meet any specified reduction in bacteria.

Refer to Appendix A for the entities responsible for implementing source controls and treatment BMPs in this subwatershed.

Table 54. Priority actions for Johnson Creek (Meyer Creek) 635 Subwatershed

Priority Timeframe[1]	Action	Estimated Effectiveness of Practice[2] (up to)	Estimated Magnitude in Watershed	Implementation Cost[3]
High	Limit livestock from accessing streams/waterbodies by fencing or providing alternative water sources Livestock Stream Access Control	100%	Unknown	$0.70-1.50/ linear feet of fencing $3-6/ cu yard to construct a pond as an alternative water source
High	Promote land application of manure with incorporation Land application w/ incorporation	70%	500 – 3,000 acres of cultivated cropland	$12/acre
High	Promote good manure application and treatment practices (see text above) Manure Management	Varies by practice	500 – 3,000 acres of cultivated cropland	NA
High	Implement feedlot runoff control and manure management at existing feedlots Feedlot Runoff Control	100%	~370 Animal Units (AU)	$8-24/AU
High	Install vegetated buffers around fields where manure is applied as well as grazed lands. Deter waterfowl congregation on and near streams by maintaining unmowed filter strips and vegetation around and along streams Filter Strips	92%	~5 acres (assume 1 mile of stream; 20ft buffer)	$600-1000/acre
High	Conduct septic system inspections as warranted and bring septic systems into compliance with standards Septic (SSTS) Maintenance	100%	?	$200-300 (inspection) $7,500 per system (if replacement required)
Medium	Identify and map any location with potential bacteria sources Monitoring	NA	NA	Staff time
Medium	Adopt and ensure that all local feedlot, SSTS, septage and pet-waste ordinances within the subwatershed are enforced through regular inspection and monitoring and are stringent enough so that rivers and streams will meet State water quality standards. Federal, State, and Local Requirements	100%	NA	Staff time

Priority Timeframe[1]	Action	Estimated Effectiveness of Practice[2] (up to)	Estimated Magnitude in Watershed	Implementation Cost[3]
Medium	Conduct outreach and education to ensure ordinances and BMPs are followed and understood Outreach/Education	NA	NA	Staff time
Low	Ensure ordinances are followed and enforced for septage application Septage	NA	NA	Staff time
Low	Regularly monitor stream and inspect all significant sources that have the potential to release bacteria Monitoring	NA	NA	Staff time

[1] Priority is based on recommended timeframe to continue or start (not complete) implementation activities: High = 1-2 years, Medium = 2-5 years, Low = 5-10 years.
[2] Estimated effectiveness of practice refers to the reduction of bacteria concentrations in runoff to receiving waterbodies.
[3] Costs based on NRCS EQIP Payment Schedules
http://www.nrcs.usda.gov/wps/portal/nrcs/detail/mn/programs/financial/?cid=stelprdb1245512

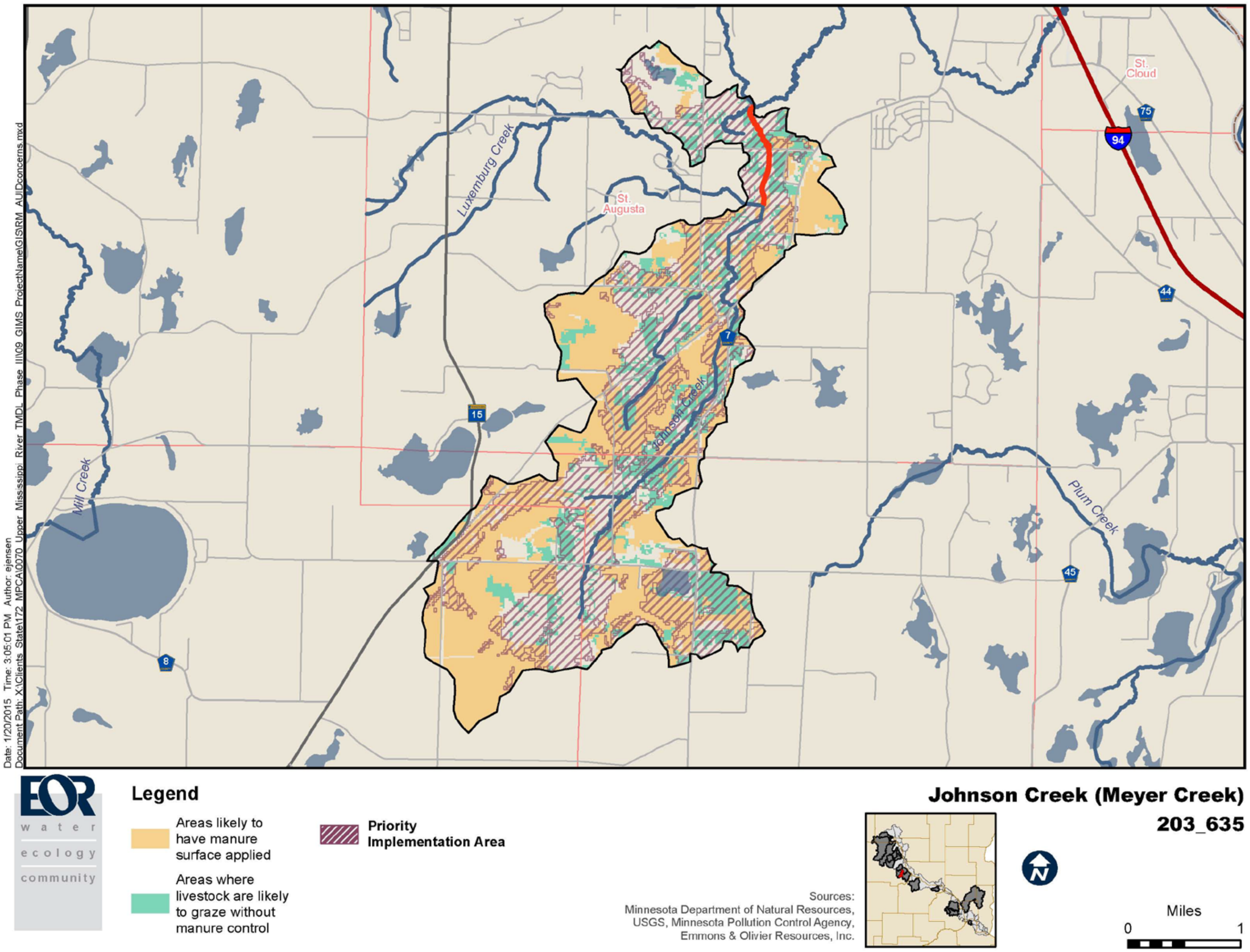

Figure 44. Areas with highest risk for transport of bacteria into streams and rivers to be targeted for initial implementation (hatched areas) (refer to Potential E. coli Contributing Areas to determine how Priority Implementation Areas were determined)

Johnson Creek (Meyer Creek) 639 (07010203-639) Subwatershed

Reach Description: T123 R28W S 14, west line to Mississippi River

Johnson Creek (Meyer Creek) (07010203-639), a tributary of the Mississippi River, is impaired for aquatic recreation due to *E. coli*. The subwatershed is located within Priority Area B of the Minneapolis and St. Paul Source Water Protection Areas (Figure 3). Johnson Creek (Meyer Creek) 635 (07010203-635) is also impaired for *E. coli*. Monitoring conducted in 2010 and 2011 indicated elevated levels of *E. coli* throughout the growing season with exceedances of the water quality standard occurring in every month with at least five samples from April through October except April. *E. coli* counts ranged from 11 to 24,000 org/100 ml and monthly geometric means ranged from 83 to 3,090 org/100 ml (a summary of water quality monitoring data can be found in Appendix D of the TMDL Study). Plotting *E. coli* levels against stream flow, as is shown in the load duration curves in Figure 6.32 on page 142 of the TMDL Study, show that exceedances occur at all flow conditions (e.g. high, moist, mid, dry, low) where there is monitoring data.

Production of *E. coli* in Subwatershed

As described in the TMDL Study and in Table 56 below, the Total Maximum Daily Load for Johnson Creek (Meyer Creek) 639 is divided into point (permitted) sources and nonpoint (non-permitted) sources. In the Johnson Creek (Meyer Creek) 639 Subwatershed, point sources of *E. coli* are limited to MS4s (Table 57). For nonpoint sources, the majority of the land use in this watershed is in agricultural use (Table 55).

Table 55. Johnson Creek (Meyer Creek) 639 Subwatershed Land uses

Land use	%
Cultivated Crops	41%
Pasture / Hay	21%
Deciduous Forest	14%
Emergent Herbaceous Wetland	9%
Grassland / Herbaceous	5%
Developed Open Space	5%
Table only includes land uses that are > 1% of the land area	

In developing the TMDL Study a desktop analysis was conducted to determine the potential sources of *E. coli* within each subwatershed and estimate the relative contribution of each source. The process, referred to as a bacteria source assessment, is described in Section 4 of the TMDL Study beginning on page 45. In the Johnson Creek Subwatershed the vast majority of the *E. coli* is likely produced from livestock with slight contributions from humans and from pets and wildlife (Figure 45Figure). Further analysis of livestock numbers suggest that poultry is the type of livestock that produces the most *E. coli* in this subwatershed followed by hogs and cattle. The fraction of *E. coli* from various sources of livestock in the pie chart is determined by the total animal units estimated within the subwatershed and takes into account the size discrepancy of the various types of livestock as well as the differences in the amount of bacteria within their waste.

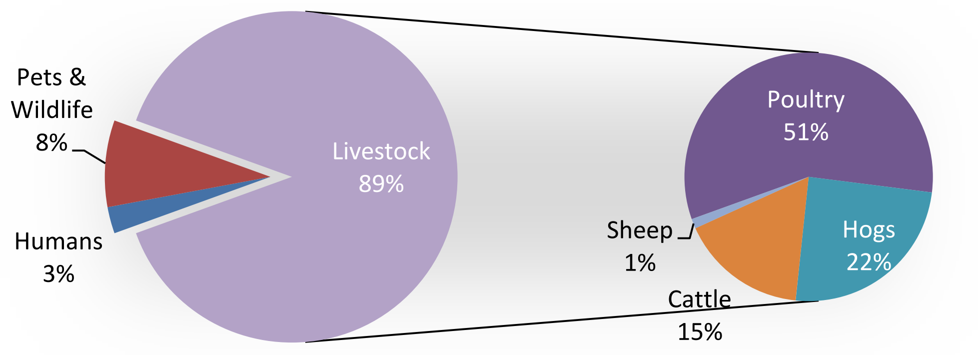

Figure 45. Bacteria production in the Johnson Creek (Meyer Creek) 639 Subwatershed

As another tool, a Microbial Source Tracking (MST) analysis was conducted as part of this TMDL Study. MST analysis relies on the genetic coding, or markers, found within bacteria samples to determine the source of the bacteria. In the Johnson Creek (Meyer Creek) 639 Subwatershed the MST analysis found cattle markers in both storm event samples that were taken (June 2011 and April 2012) and in both baseflow samples that were taken (June 2011 and September 2011). Swine markers were also found in the June 2011 storm event sample. All water samples were also tested for human/pet markers but these markers were not present in the water samples on those dates. Due to the nature of bacteria caution must be exercised with use of the MST findings. The analysis can not be used to conclusively dismiss any given source of bacteria. The MST findings can only be applied to the source of bacteria found in that specific sample of water.

Sources Contributing *E. coli* to the Stream Reach

In addition to determining the relative magnitude of *E. coli* sources within the watershed it is important to consider the factors that lead to the *E. coli* being delivered to the stream. The second step in the bacteria source assessment is to evaluate the connection between *E. coli* production, how it is handled on the landscape and how it is ultimately delivered to the stream. In the case of the Johnson Creek 639 Subwatershed, where poultry is identified as the main potential bacteria source, the primary activity by which the bacteria becomes available to wash into the stream is through manure application to fields where the manure is not immediately incorporated into the soil (Figure 46). Other mechanisms include runoff from feedlots (that do not have adequate controls) and from animals on pasture.

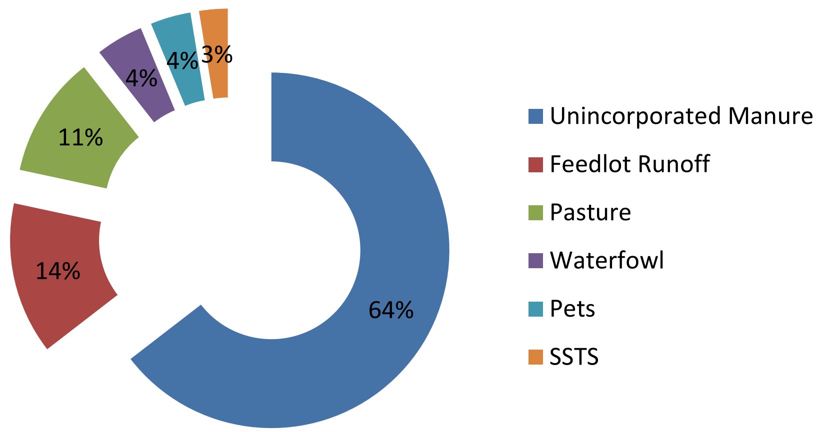

Figure 46. Estimated Percentage of Potential Sources Contributing Bacteria to Johnson Creek (Meyer Creek) 639

Potential *E. coli* Contributing Areas

The final step in the bacteria source assessment methodology developed for the TMDL Study was to determine which areas within the subwatershed have the highest potential to contribute *E. coli* to the stream. In agricultural subwatersheds the areas that have the highest potential to contribute *E. coli* to the stream are areas immediately adjacent to or hydrologically connected to streams where manure is applied or where animals are grazing. Refer to Figure for the map of areas within the Johnson Creek (Meyer Creek) 639 Subwatershed that have a high potential to contribute bacteria to the stream. These areas should be prioritized for implementation activities. The Priority Implementation Area in Figure was determined by calculating a delivery factor that accounts for fate and transport factors such as proximity to surface waters, slope, imperviousness, and discharge to lakes prior to discharge to stream networks (refer to Section 4.2.6 of the TMDL Study for more specific information on how the delivery factor and Priority Implementation Area was calculated).

TMDL Allocations and Percent Reductions

Wasteload and load allocations for this subwatershed and the calculated percent reduction needed to meet the TMDL are summarized in Table 56. Load allocations indicate a sizable decrease needed for bacteria in runoff under all assessed flow conditions in the Johnson Creek (Meyer Creek) 639 Subwatershed. The maximum percent reduction of bacteria load needed is 97%.

Table 56. Johnson Creek (Meyer Creek) 639 Subwatershed TMDL and Percent Reductions Needed

Flow Regime	Existing Load (billion org/d)	Waste Load Allocations			LA (billion org/d)	MOS (billion org/d)	TMDL (billion org/d)	LA + MS4 WLA (billion org/d)	Estimated Reduction in Watershed Runoff (%)
		WWTFs (Total) (billion org/d)	Straight Pipes (billion org/d)	MS4 (billion org/d)					
High	720	–	–	3.12	88.7	10.2	102	91.8	87%
Moist	1520	–	–	1.32	37.5	4.31	43.1	38.8	97%
Mid-Range	678	–	–	0.701	19.9	2.29	22.9	20.6	97%
Dry	399	–	–	0.364	10.3	1.19	11.9	10.7	97%
Low	ID	–	–	0.193	5.49	0.631	6.31	5.68	ID

Key: WWTF-Waste Water Treatment Facility, MS4-Municipal Separate Storm Sewer System, MOS-Margin of Safety, LA-Load Allocation, org-organisms, d-day, ID-Insufficient Data, IDUL-Impairment due to upstream load, EQN-Based on the equation found on page 104 in the TMDL Study, WLA-Waste Load Allocation

Regulated Entities

The regulated entities within this subwatershed are shown in Table 57.

Table 57. Regulated Entities within the Johnson Creek (Meyer Creek) 639 Subwatershed

Regulated Entity	Permit #
St. Cloud City	MS400052

Implementation Plan

The findings of the bacteria source assessment suggest that application of poultry manure that is not appropriately incorporated into the soils is the largest of the likely bacteria sources to the Johnson Creek Subwatershed. Specifically, land immediately surrounding Johnson Creek has been assessed as a high risk area for surface applied manure. Based on the source assessment and the TMDL the **target goal is up to a 97% reduction** of bacteria for this subwatershed. The following is the magnitude of reductions to the major potential sources of bacteria that would be necessary within the watershed to meet the 97% goal. Given this level of reduction it will likely take 20+ years of active management for the Johnson Creek to meet water quality standards for *E. coli*.

- Eliminate 98% of the bacteria coming from manure that is not appropriately incorporated into the soil.
- Eliminate 97% of the bacteria coming from feedlots with inadequate controls.
- Eliminate 100% of the SSTS that are an imminent threat to public health by bringing septic systems into compliance with standards.
- Eliminate 97% of the bacteria load from grazing livestock.
- Eliminate 98% of the bacteria load from wildlife.

Priority Actions

As a result of the analyses for bacteria sources and contributing areas, the primary focus of implementation for this subwatershed will be to prevent unincorporated manure from reaching the stream and to reduce runoff from feedlots. This can be done by land application with incorporation or by treating manure prior to land application and implementing feedlot runoff controls, respectively.

There are likely other contributors of bacteria that may not have been captured in the analyses above due to a lack of documentation. In many cases, local knowledge of bacteria sources may provide superior guidance for determining how to reduce bacteria loading to impaired stream reaches. Addressing additional sources within the Johnson Creek Subwatershed that are likely contributing *E. coli* to a lesser degree are also included in the implementation plan since the needed reduction is high in this subwatershed (see Rural Subwatersheds for more information). Below are the priority actions that are recommended for the Johnson Creek (Meyer Creek) 639 Subwatershed.

- Identify and map potential and known sources that are directly contributing bacteria to waterbodies using local knowledge, windshield surveys, and interviews with landowners, etc. Note that mapping sources is a distinct activity from monitoring.
- Continue baseline monitoring of the stream reach and add additional monitoring stations along the stream reach and tributaries to help pinpoint potential sources of bacteria. Refer to the monitoring section for further recommendations.
- Reduce direct sources of bacteria, such as livestock that have access to streams, installing fences around streams within pastures, or providing water sources within pastures to reduce the frequency of livestock from entering streams.
- Promote the use of manure injection or incorporation of manure on all land where manure is applied. Target land areas near the stream and ditches and tile intakes first. Alternatively, treat manure to reduce bacteria concentrations prior to land application.
- Promote good manure application and treatment practices such as:
    - Applying manure to relatively dry fields;
    - Avoiding steep sloping areas;
    - Avoiding areas near water bodies;
    - Avoiding vulnerable locations for spreading manure;
    - Avoiding areas prone to flooding;
    - Avoiding applying on frozen soil;
- Implement and enforce feedlot runoff controls.
- Install filter strips around fields, especially where streams are present, to prevent bacteria-laden runoff from reaching streams; buffer strips should also be installed along ditches within fields that flow directly to streams. Priority should be given to BMPs that provide multiple benefits.
- Ensure that all local feedlot, SSTS, septage and pet-waste ordinances within the subwatershed are stringent enough so that rivers and streams will meet State water quality standards.
- Ensure that ordinances are enforced, through regular inspection and monitoring.
- Conduct septic inspections and make sure all systems that are imminent threats are brought into compliance.
- Conduct education and outreach to ensure that ordinances and BMPs are understood and followed.
- Ensure septage application is in compliance with state laws and local ordinances.

Table 58 lists the priority actions described above along with a recommended timeframe for implementation and estimated costs. The timeframe that is provided is based on priority of implementation, and efforts will likely be ongoing once the action has been implemented. Action items are listed in order of importance. Also included in Table 58 are priority actions that are simply good practices to follow in all subwatersheds regardless of the magnitude of the source/activity they address. Note that some of these practices may have already been initiated within the subwatershed; if that is the case, continue with them and enhance them where necessary. Note that the costs are provided for context and not as an estimate of the total expenditure needed to meet any specified reduction in bacteria.

Refer to Appendix A for the entities responsible for implementing source controls and treatment BMPs in this subwatershed.

Table 58. Priority actions for Johnson Creek (Meyer Creek) 639 Subwatershed

Priority Timeframe[1]	Action	Estimated Effectiveness of Practice[2] (up to)	Estimated Magnitude in Watershed	Implementation Cost[3]
High	Limit livestock from accessing streams/waterbodies by fencing or providing alternative water sources Livestock Stream Access Control	100%	Unknown	$0.70-1.50/ linear feet of fencing $3-6/ cu yard to construct a pond as an alternative water source
High	Promote land application of manure with incorporation Land application w/ incorporation	70%	1,500 – 4,500 acres of cultivated cropland	$12/acre
High	Promote good manure application and treatment practices (see text above) Manure Management	Varies by practice	1,500 – 4,500 acres of cultivated cropland	NA
High	Implement feedlot runoff control and manure management at existing feedlots Feedlot Runoff Control	100%	~900 Animal Units (AU)	$8-24/AU
High	Install vegetated buffers around fields where manure is applied as well as grazed lands Filter Strips	92%	~31 acres (assume 6.5 miles of stream; 20ft buffer)	$600-1000/acre
High	Conduct septic system inspections as warranted and bring septic systems into compliance with standards Septic (SSTS) Maintenance	100%	?	$200-300 (inspection) $7,500 per system (if replacement required)

Priority Timeframe[1]	Action	Estimated Effectiveness of Practice[2] (up to)	Estimated Magnitude in Watershed	Implementation Cost[3]
Medium	Identify and map any location with potential bacteria sources Monitoring	NA	NA	Staff time
Medium	Medium Adopt and ensure that all local feedlot, SSTS, septage and pet-waste ordinances within the subwatershed are enforced through regular inspection and monitoring and are stringent enough so that rivers and streams will meet State water quality standards. Federal, State, and Local Requirements	100%	NA	Staff time
Medium	Conduct outreach and education to ensure ordinances and BMPs are followed and understood Outreach/Education	NA	NA	Staff time
Low	Ensure ordinances are followed and enforced for septage application Septage	NA	NA	Staff time
Low	Regularly monitor stream and inspect all significant sources that have the potential to release bacteria Monitoring	NA	NA	Staff time

[1] Priority is based on recommended timeframe to continue or start (not complete) implementation activities: High = 1-2 years, Medium = 2-5 years, Low = 5-10 years.
[2] Estimated effectiveness of practice refers to the reduction of bacteria concentrations in runoff to receiving waterbodies.
[3] Costs based on NRCS EQIP Payment Schedules
http://www.nrcs.usda.gov/wps/portal/nrcs/detail/mn/programs/financial/?cid=stelprdb1245512

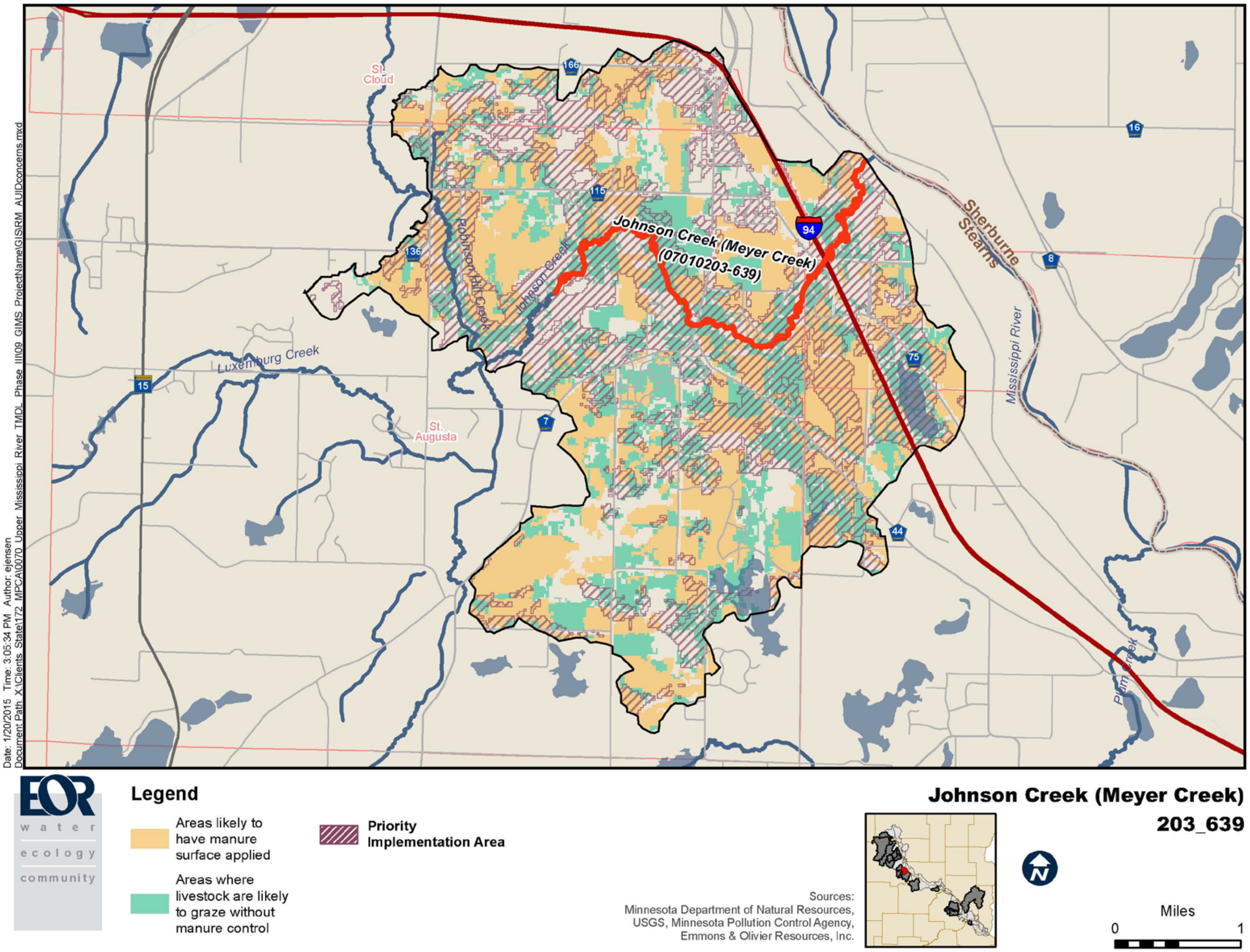

Figure 47. Areas with highest risk for transport of bacteria into streams and rivers to be targeted for initial implementation (hatched areas) (refer to Potential *E. coli* Contributing Areas to determine how Priority Implementation Areas were determined)

Unnamed Creek (Robinson Hill Creek) (07010203-724) Subwatershed

Reach Description: CD 14 to CSAH 136

Unnamed Creek (Robinson Hill Creek), a tributary of Johnson Creek, is impaired for aquatic recreation due to *E. coli*. The subwatershed is located within Priority Area B of the Minneapolis and St. Paul Source Water Protection Areas (Figure 3). Monitoring conducted in 2010 and 2011 indicated elevated levels of *E. coli* throughout the growing season with exceedances of the water quality standard occurring in every month with at least five samples from June through September. *E. coli* counts ranged from 73 to 2,420 org/100 ml and monthly geometric means ranged from 179 to 444 org/100 ml (a summary of water quality monitoring data can be found in Appendix D of the TMDL Study). Plotting *E. coli* levels against stream flow, as is shown in the load duration curves in Figure 6.33 on page 143 of the TMDL Study, show that exceedances occur at all flow conditions (e.g. high, moist, mid, dry, low) where there is monitoring data.

Production of *E. coli* in Subwatershed

As described in the TMDL Study and in Table 60 below, the Total Maximum Daily Load for Unnamed Creek (Robinson Hill Creek) is divided into point (permitted) sources and nonpoint (non-permitted) sources. In the Unnamed Creek (Robinson Hill Creek) Subwatershed, point sources of *E. coli* are limited to MS4s (Table 61). For nonpoint sources, the majority of the land use in this watershed is in agricultural use (Table 59).

Table 59. Unnamed Creek (Robinson Hill Creek) Subwatershed Land uses

Land use	%
Cultivated Crops	31%
Pasture / Hay	27%
Deciduous Forest	19%
Emergent Herbaceous Wetland	7%
Developed Open Space	6%
Grassland / Herbaceous	5%
Developed Low Intensity	2%
Table only includes land uses that are > 1% of the land area	

In developing the TMDL Study a desktop analysis was conducted to determine the potential sources of *E. coli* within each subwatershed and estimate the relative contribution of each source. The process, referred to as a bacteria source assessment, is described in Section 4 of the TMDL Study beginning on page 45. In the Robinson Hill Creek Subwatershed the vast majority of the *E. coli* is likely produced from livestock with slight contributions from humans and from pets and wildlife (Figure 48). Further analysis of livestock numbers suggest that poultry is the type of livestock that produces the most *E. coli* in this subwatershed (Figure 48). The fraction of *E. coli* from various sources of livestock in the pie chart is determined by the total animal units estimated within the subwatershed and takes into account the size discrepancy of the various types of livestock as well as the differences in the amount of bacteria within their waste.

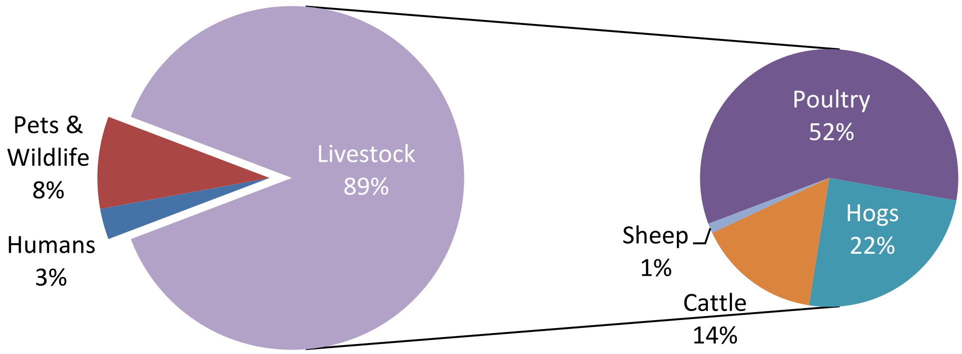

Figure 48. Bacteria production in the Unnamed Creek (Robinson Hill Creek) Subwatershed

Sources Contributing *E. coli* to the Stream Reach

In addition to determining the relative magnitude of *E. coli* sources within the watershed it is important to consider the factors that lead to the *E. coli* being delivered to the stream. The second step in the bacteria source assessment is to evaluate the connection between *E. coli* production, how it is handled on the landscape and how it is ultimately delivered to the stream. In the case of the Robinson Hill Creek Subwatershed, where poultry is identified as the main potential bacteria source followed by hogs and cattle, the primary activity by which the bacteria becomes available to wash into the stream is through manure application to fields where the manure is not immediately incorporated into the soil (Figure 49). Other mechanisms include runoff from feedlots (that do not have adequate controls) and from animals on pasture.

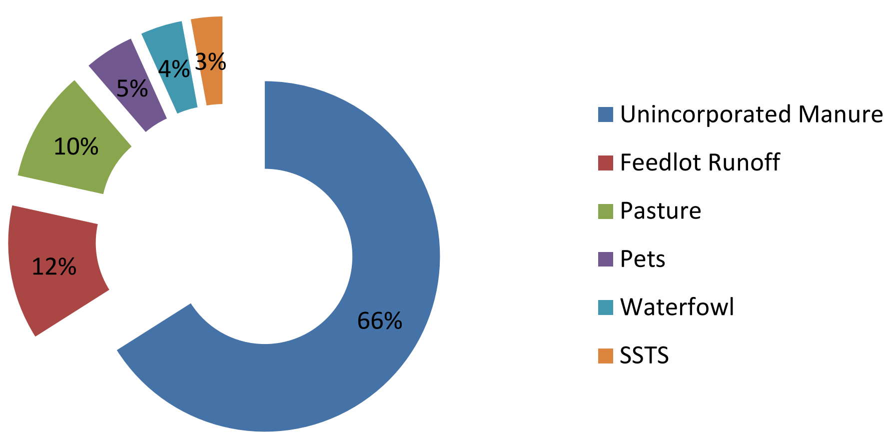

Figure 49. Estimated Percentage of Potential Sources Contributing Bacteria to Unnamed Creek (Robinson Hill Creek)

Potential *E. coli* Contributing Areas

The final step in the bacteria source assessment methodology developed for the TMDL Study was to determine which areas within the subwatershed have the highest potential to contribute *E. coli* to the stream. In agricultural subwatersheds the areas that have the highest potential to contribute *E. coli* to the stream are areas immediately adjacent to or hydrologically connected to streams where manure is applied or where animals are grazing. Refer to Figure for the map of areas within the Robinson Hill Creek Subwatershed that have a high potential to contribute bacteria to the stream. These areas should be prioritized for implementation activities. The Priority Implementation Area in Figure was determined by calculating a delivery factor that accounts for fate and transport factors such as proximity to surface waters, slope, imperviousness, and discharge to lakes prior to discharge to stream networks (refer to Section 4.2.6 of the TMDL Study for more specific information on how the delivery factor and Priority Implementation Area was calculated).

TMDL Allocations and Percent Reductions

Wasteload and load allocations for this subwatershed and the calculated percent reduction needed to meet the TMDL are summarized in Table 60. Load allocations indicate a moderate decrease needed for bacteria in runoff under moist, mid-range and dry flow conditions in the Robinson Hill Creek Subwatershed. The maximum percent reduction of bacteria load needed is 71%.

Table 60. Unnamed Creek (Robinson Hill Creek) Subwatershed TMDL and Percent Reductions Needed

Flow Regime	Existing Load (billion org/d)	Waste Load Allocations			LA (billion org/d)	MOS (billion org/d)	TMDL (billion org/d)	LA + MS4 WLA (billion org/d)	Estimated Reduction in Watershed Runoff (%)
		WWTFs (Total) (billion org/d)	Straight Pipes (billion org/d)	MS4 (billion org/d)					
High	ID	–	–	4.06	50.4	6.05	60.5	54.5	ID
Moist	48.6	–	–	1.69	21.1	2.53	25.3	22.8	53%
Mid-Range	42.8	–	–	0.911	11.3	1.36	13.6	12.2	71%
Dry	13.7	–	–	0.47	5.85	0.702	7.02	6.32	54%
Low	ID	–	–	0.249	3.09	0.371	3.71	3.34	ID

Key: WWTF-Waste Water Treatment Facility, MS4-Municipal Separate Storm Sewer System, MOS-Margin of Safety, LA-Load Allocation, org-organisms, d-day, ID-Insufficient Data, IDUL-Impairment due to upstream load, EQN-Based on the equation found on page 104 in the TMDL Study, WLA-Waste Load Allocation

Regulated Entities

The regulated entities within this subwatershed are shown in Table 61.

Table 61. Regulated Entities within the Unnamed Creek (Robinson Hill Creek) Subwatershed

Regulated Entity	Permit #
MnDOT Outstate District	MS400180
St Cloud City	MS400052
Stearns County	MS400159
Waite Park City	MS400127

Implementation Plan

The findings of the bacteria source assessment suggest that application of poultry manure that is not appropriately incorporated into the soils is the largest of the likely bacteria sources to the Unnamed Creek Subwatershed. Specifically, land immediately surrounding Unnamed Creek has been assessed as a high risk area for surface applied manure. Based on the source assessment and the TMDL the **target goal is up to a 71% reduction** of bacteria for this subwatershed. In other flow regimes the target goal is lower. The following is the magnitude of reductions to the major potential sources of bacteria that would be necessary within the watershed to meet the 71% goal. Given this level of reduction it will likely take 20+ years of active management for the Unnamed Creek to meet water quality standards for *E. coli*.

- Eliminate 85% of the bacteria coming from manure that is not appropriately incorporated into the soil.
- Eliminate 85% of the bacteria coming from feedlots with inadequate controls.
- Eliminate 100% of the SSTS that are an imminent threat to public health by bringing septic systems into compliance with standards.
- Eliminate 60% of the bacteria load from grazing livestock.

Priority Actions

As a result of the analyses for bacteria sources and contributing areas, the primary focus of implementation for this subwatershed will be to prevent unincorporated manure from reaching the stream and to reduce runoff from feedlots. This can be done by land application with incorporation or by treating manure prior to land application and implementing feedlot runoff controls, respectively.

There are likely other contributors of bacteria that may not have been captured in the analyses above due to a lack of documentation. In many cases, local knowledge of bacteria sources may provide superior guidance for determining how to reduce bacteria loading to impaired stream reaches. Addressing additional sources within the Unnamed Creek Subwatershed that are likely contributing *E. coli* to a lesser degree are also included in the implementation plan since the needed reduction is high in this subwatershed (see Rural Subwatersheds for more information). Below are the priority actions that are recommended for the Unnamed Creek Subwatershed.

- Identify and map potential and known sources that are directly contributing bacteria to waterbodies using local knowledge, windshield surveys, and interviews with landowners, etc. Note that mapping sources is a distinct activity from monitoring.

- Continue baseline monitoring of the stream reach and add additional monitoring stations along the stream reach and tributaries to help pinpoint potential sources of bacteria. Refer to the monitoring section for further recommendations.
- Reduce direct sources of bacteria, such as livestock that have access to streams, installing fences around streams within pastures, or providing water sources within pastures to reduce the frequency of livestock from entering streams.
- Promote the use of manure injection or incorporation of manure on all land where manure is applied. Target land areas near the stream and ditches and tile intakes first. Alternatively, treat manure to reduce bacteria concentrations prior to land application.
- Promote good manure application and treatment practices such as:
    - Applying manure to relatively dry fields;
    - Avoiding steep sloping areas;
    - Avoiding areas near water bodies;
    - Avoiding vulnerable locations for spreading manure;
    - Avoiding areas prone to flooding;
    - Avoiding applying on frozen soil.
- Implement and enforce feedlot runoff controls.
- Install filter strips around fields, especially where streams are present, to prevent bacteria-laden runoff from reaching streams; buffer strips should also be installed along ditches within fields that flow directly to streams. Priority should be given to BMPs that provide multiple benefits.
- Ensure that all local feedlot, SSTS, septage and pet-waste ordinances within the subwatershed are stringent enough so that rivers and streams will meet State water quality standards.
- Ensure that ordinances are enforced, through regular inspection and monitoring.
- Conduct septic inspections and make sure all systems that are imminent threats are brought into compliance.
- Conduct education and outreach to ensure that ordinances and BMPs are understood and followed.
- Ensure septage application is in compliance with state laws and local ordinances.

Table 62 lists the priority actions described above along with a recommended timeframe for implementation and estimated costs. The timeframe that is provided is based on priority of implementation, and efforts will likely be ongoing once the action has been implemented. Action items are listed in order of importance. Also included in Table 62 are priority actions that are simply good practices to follow in all subwatersheds regardless of the magnitude of the source/activity they address. Note that some of these practices may have already been initiated within the subwatershed; if that is the case, continue with them and enhance them where necessary. Note that the costs are provided for context and not as an estimate of the total expenditure needed to meet any specified reduction in bacteria.

Refer to Appendix A for the entities responsible for implementing source controls and treatment BMPs in this subwatershed.

Table 62. Priority actions for Unnamed Creek (Robinson Hill Creek) Subwatershed

Priority Timeframe[1]	Action	Estimated Effectiveness of Practice[2] (up to)	Estimated Magnitude in Watershed	Implementation Cost[3]
High	Limit livestock from accessing streams/waterbodies by fencing or providing alternative water sources Livestock Stream Access Control	100%	Unknown	$0.70-1.50/ linear feet of fencing $3-6/ cu yard to construct a pond as an alternative water source
High	Promote land application of manure with incorporation Land application w/ incorporation	70%	2,000 – 3,500 acres of cultivated cropland	$12/acre
High	Promote good manure application and treatment practices (see text above) Manure Management	Varies by practice	2,000 – 3,500 acres of cultivated cropland	NA
High	Implement feedlot runoff control and manure management at existing feedlots Feedlot Runoff Control	100%	~1,100 Animal Units (AU)	$8-24/AU
High	Install vegetated buffers around fields where manure is applied as well as grazed lands Filter Strips	92%	~22 acres (assume 4.5 miles of stream; 20ft buffer)	$600-1000/acre
High	Conduct septic system inspections as warranted and bring septic systems into compliance with standards Septic (SSTS) Maintenance	100%	?	$200-300 (inspection) $7,500 per system (if replacement required)
Medium	Identify and map any location with potential bacteria sources Monitoring	NA	NA	Staff time
Medium	Adopt and enforce strict ordinances for SSTS, pet waste, feedlot runoff, and septage application Federal, State, and Local Requirements	100%	NA	Staff time
Medium	Conduct outreach and education to ensure ordinances and BMPs are followed and understood Outreach/Education	NA	NA	Staff time
Low	Ensure ordinances are followed and enforced for septage application Septage	NA	NA	Staff time

Priority Timeframe[1]	Action	Estimated Effectiveness of Practice[2] (up to)	Estimated Magnitude in Watershed	Implementation Cost[3]
Low	Regularly monitor stream and inspect all significant sources that have the potential to release bacteria Monitoring	NA	NA	Staff time

[1] Priority is based on recommended timeframe to continue or start (not complete) implementation activities: High = 1-2 years, Medium = 2-5 years, Low = 5-10 years.
[2] Estimated effectiveness of practice refers to the reduction of bacteria concentrations in runoff to receiving waterbodies.
[3] Costs based on NRCS EQIP Payment Schedules
http://www.nrcs.usda.gov/wps/portal/nrcs/detail/mn/programs/financial/?cid=stelprdb1245512

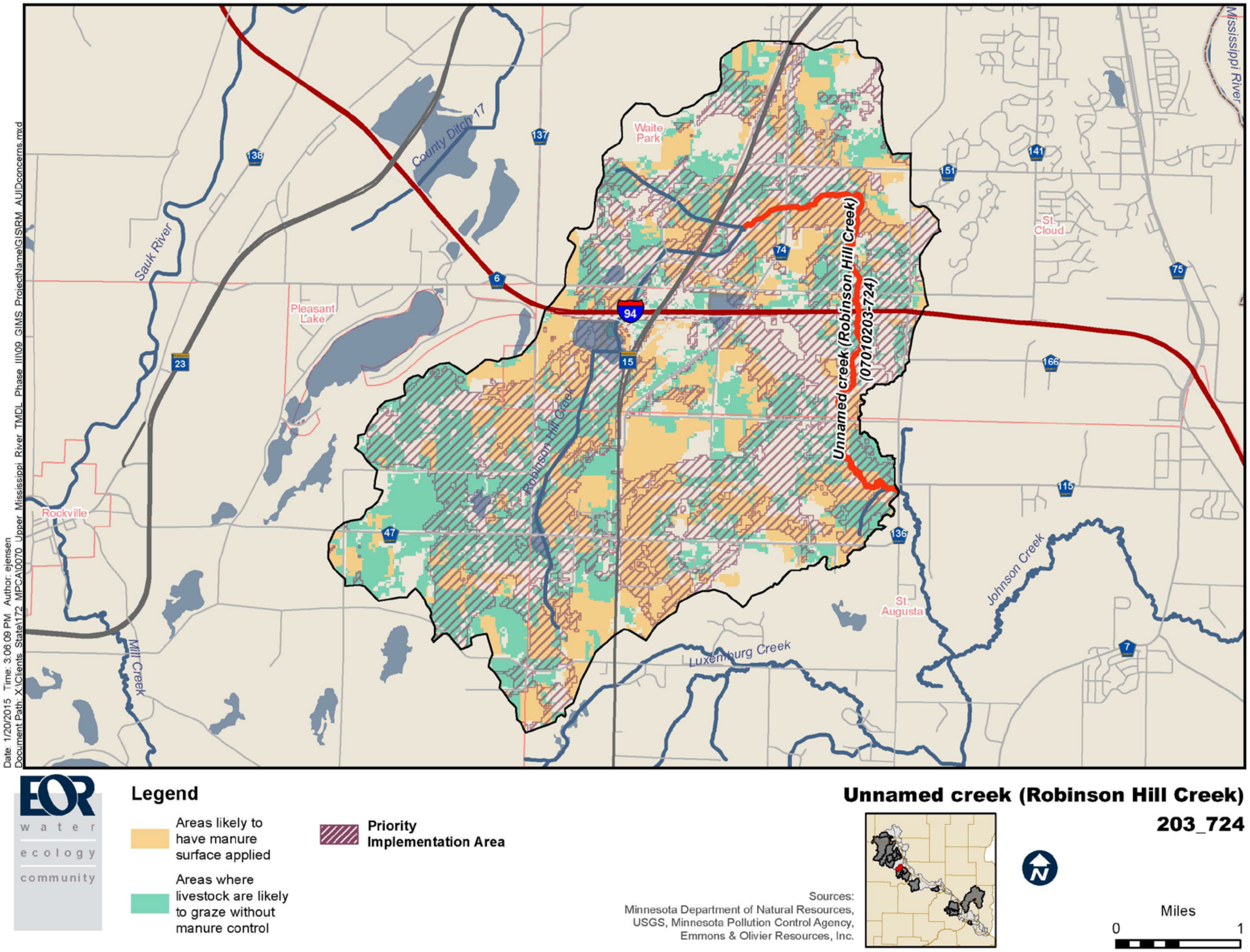

Figure 50. Areas with highest risk for transport of bacteria into streams and rivers to be targeted for initial implementation (hatched areas) (refer to Potential E. coli Contributing Areas to determine how Priority Implementation Areas were determined)

Shingle Creek (County Ditch 13) (07010206-506) Subwatershed

Description: Headwaters (Eagle Creek/Bass Creek) to Mississippi River

Shingle Creek is a tributary of the Mississippi River and is impaired for aquatic recreation due to *E. coli*. The subwatershed is located within Priority Areas A and B of the Minneapolis and St. Paul Source Water Protection Areas (Figure 4). Monitoring conducted from 2007 to 2011 indicated elevated levels of *E. coli* throughout the growing season with exceedances of the water quality standard occurring in every month with at least five samples from April through October except April. *E. coli* counts ranged from 10 to 27,000 org/100 ml and monthly geometric means ranged from 36 to 439 org/100 ml (a summary of water quality monitoring data can be found in Appendix D of the TMDL Study). Plotting *E. coli* levels against stream flow, as is shown in the load duration curves in Figure 6.47 on page 155 of the TMDL Study, show that exceedances occur at all flow conditions (e.g. high, moist, mid, dry, low) where there is monitoring data.

Production of *E. coli* in Subwatershed

As described in the TMDL Study and in Table 64, the Total Maximum Daily Load for Shingle Creek is divided into point (permitted) sources and nonpoint (non-permitted) sources. In the Shingle Creek Subwatershed the point (permitted) sources of *E. coli* are limited to the MS4s (Table 65). ”Developed” categories from the National Land Cover Dataset (NLCD) were used to approximate the MS4 regulated areas (see page 102 of the TMDL Study) and account for 84% of the land area in this watershed (Figure and Table 63). “Undeveloped” categories were used to approximate nonpoint (non-permitted) sources of *E. coli*.

Table 63. Shingle Creek Subwatershed Land uses

Land use	%
Developed Low Intensity	37%
Developed Medium Intensity	21%
Developed Open Space	14%
Developed High Intensity	12%
Deciduous Forest	4%
Open Water	4%
Barren Land	3%
Emergent Herbaceous Wetland	3%
Table only includes land uses that are > 1% of the land area	

In developing the TMDL Study a desktop analysis was conducted to determine the potential sources of *E. coli* within each subwatershed and estimate the relative contribution of each source. The process, referred to as a bacteria source assessment, is described in Section 4 of the TMDL Study beginning on page 45. In the Shingle Creek Subwatershed the vast majority of the *E. coli* is likely produced from pets and wildlife with a smaller amount attributed to humans.

As another tool, a Microbial Source Tracking (MST) analysis was conducted as part of this TMDL Study. MST analysis relies on the genetic coding, or markers, found within bacteria samples to determine the source of the bacteria. In the Shingle Creek Subwatershed, the MST analysis found human/pet markers (note this marker is more indicative of a human source but does corroborate the findings of the desktop analysis that pets are a likely source), as well as cattle markers in predominantly urban land use areas. Due to the nature of bacteria caution must be exercised with use of the MST findings. The analysis can not be used to conclusively dismiss any given source of bacteria. The MST findings can only be applied to the source of bacteria found in that specific sample of water.

Sources Contributing *E. coli* to the Stream Reach

In addition to determining the relative magnitude of *E. coli* sources within the watershed it is important to consider the factors that lead to the *E. coli* being delivered to the stream. The second step in the bacteria source assessment was to evaluate the connection between *E. coli* production, how it is handled on the landscape and how it is ultimately delivered to the stream. In the case of the Shingle Creek Subwatershed, where pets are identified as the most likely bacteria source followed by wildlife and humans, the most probable mechanism by which the bacteria becomes delivered to the stream is from runoff through stormwater conveyances in the urban area. Other mechanisms include stormwater runoff that includes wildlife waste and direct input of fecal matter into streams from waterfowl, as well as leaking SSTS.

TMDL Allocations and Percent Reductions

Wasteload and load allocations for this subwatershed and the calculated percent reduction needed to meet the TMDL are summarized in Table 64. Load allocations indicate a moderate to sizable decrease needed for bacteria in runoff under most flow conditions in the Shingle Creek Subwatershed. The maximum percent reduction of bacteria load needed is 69%.

Table 64. Shingle Creek (County Ditch 13) Subwatershed TMDL and Percent Reductions Needed

Flow Regime	Existing Load (bil org/d)	Waste Load Allocations			LA (bil org/d)	MOS (bil org/d)	TMDL (bil org/d)	LA + MS4 WLA (bil org/d)	Est. Reduction in Watershed Runoff (%)
		WWTFs (Total) (bil org/d)	Straight Pipes (bil org/d)	MS4 (bil org/d)					
High	602	–	–	202	34.9	26.3	263	237	61%
Moist	142	–	–	68.4	12	8.93	89.3	80.4	43%
Mid-Range	87.9	–	–	22.9	4.05	2.99	29.9	27	69%
Dry	11.1	–	–	8.19	1.44	1.07	10.7	9.63	13%
Low	4.91	–	–	1.33	0.238	0.174	1.74	1.57	68%

Key: WWTF-Waste Water Treatment Facility, MS4-Municipal Separate Storm Sewer System, MOS-Margin of Safety, LA-Load Allocation, org-organisms, d-day, ID-Insufficient Data, IDUL-Impairment due to upstream load, EQN-Based on the equation found on page 104 in the TMDL Study, WLA-Waste Load Allocation

Regulated Entities

The regulated entities within this subwatershed are shown in Table 65.

Table 65. Regulated Entities within the Shingle Creek (County Ditch 13) Subwatershed

Regulated Entity	Permit #
Brooklyn Center City	MS400006
Brooklyn Park City	MS400007
Crystal City	MS400012
Hennepin County	MS400138
Hennepin Technical College Brooklyn Park	MS400198
Maple Grove City	MS400102
Minneapolis Municipal Storm Water	MN0061018
MnDOT Metro District	MS400170
New Hope City	MS400039
North Hennepin Community College	MS400205
Osseo City	MS400043
Plymouth City	MS400112
Robbinsdale City	MS400046

Implementation Plan

The findings of the bacteria source assessment suggest that pet waste could be the largest source of *E. coli* to Shingle Creek. Based on the source assessment and the TMDL the **target goal is up to 69% reduction** of bacteria for this subwatershed but is lower in other flow regimes. The following is the magnitude of reductions to the major potential sources of bacteria that would be necessary within the watershed to meet the 69% goal. Given this level of reduction it will likely take 20+ years of active management for Shingle Creek to meet water quality standards for *E. coli*.

- Reduce 50-75% of the bacteria load from pets and wildlife.
- Eliminate 100% of the SSTS that are an imminent threat to public health by bringing septic systems into compliance with standards.

Priority Actions

As a result of the analyses for bacteria sources and contributing areas, the primary focus of implementation for this subwatershed will be to prevent or limit the amount of pet and wildlife waste that runs off into stormwater conveyance systems and Shingle Creek. The second tier of implementation activities will be the traditional BMPs that are used for stormwater treatment which are found to be effective at bacteria removal in urban subwatersheds.

There are likely other contributors of bacteria that may not have been captured in the analyses above due to a lack of documentation. In many cases, local knowledge of bacteria sources may provide superior guidance for determining how to reduce bacteria loading to impaired stream reaches. Addressing additional sources within the Shingle Creek Subwatershed that are likely contributing *E. coli* to a lesser degree are also included in the implementation plan since the needed reduction is high in this subwatershed (see Urban Subwatersheds for more information). Below are the priority actions that are recommended for the Shingle Creek Subwatershed.

- Map and identify specific locations where pets and wildlife would be contributing bacteria to water resources. For example, identify dog parks or areas where ducks/geese congregate in the subwatershed and how these areas relate to the stormwater conveyance system and stream. Note that mapping sources is a distinct activity from monitoring.
- Maintain/develop and enforce strict pet waste ordinances.
- Conduct public outreach to ensure that pet owners pick up pet waste and comply with pet waste ordinances.
- Implement an inspection and monitoring program to regularly assess potential sources and conveyance systems (stormwater outfalls) to reduce bacteria loading from dry weather flows. Refer to the monitoring section for further recommendations.
- Implement infiltration BMPs such as bioinfiltration/ bioretention systems (e.g. raingardens without underdrains); a secondary choice would be filtration BMPs such as biofiltration BMPs that may also remove bacteria, albeit to a lesser degree than infiltration BMPs. In both cases BMPs should be prioritized based on proximity to potential bacteria sources.
- Install filter strips/buffers near waterbodies to deter waterfowl from congregating and conduct public outreach on wildlife feeding.
- Direct flow pathways between contributing areas (e.g., dog parks) to infiltration/treatment basins or away from impervious areas to prevent direct pathway to receiving waters.
- Priority should be given to BMPs that provide multiple benefits.
- Ensure SSTS ordinances are up-to-date and enforced.
- Develop, implement, and enforce a program to detect and eliminate illicit discharges.

Table 66 lists the priority actions described above along with a recommended timeframe for implementation and estimated costs. The timeframe that is provided is based on priority of implementation, and efforts will likely be ongoing. Action items are listed in order of importance. Also included in Table 66 are priority actions that are simply good practices to follow in all subwatersheds regardless of the magnitude of the source/activity they address. Note that some of these practices may have already been initiated within the subwatershed; if that is the case, continue with them and enhance them where necessary. Note that the costs are provided for context and not as an estimate of the total expenditure needed to meet any specified reduction in bacteria.

Refer to Appendix A for the entities responsible for implementing source controls and treatment BMPs in this subwatershed.

Table 66. Priority Actions for Shingle Creek Subwatershed

Priority Timeframe[1]	Action	Estimated Effectiveness of Practice[2] (up to)	Estimated Magnitude in Watershed	Implementation Cost[3]
High	Identify and map potential bacteria hotspots Monitoring			Staff time

Priority Timeframe[1]	Action	Estimated Effectiveness of Practice[2] (up to)	Estimated Magnitude in Watershed	Implementation Cost[3]
High	Update and enforce pet waste ordinances Litter and Animal Waste Control		~23,000 acres developed land but target near stream first	Staff time
High	Conduct public outreach to ensure that pet owners pick up pet waste and comply with pet waste ordinances. Litter and Animal Waste Control			Staff time
High	Direct flow pathways between contributing areas to infiltration/treatment basins or away from impervious areas to prevent direct pathway to receiving waters.			
High	Develop, implement, and enforce a program to detect and eliminate illicit discharges			
High	Inspect/ monitor stormwater outfalls to reduce dry weather flow (see Urban Subwatersheds) Monitoring			Staff time
Medium	Install Filtration/Biofiltration BMPs where feasible Filtration/ Biofiltration	35%		$8,000-20,000/ac
Low	Install filter strips/buffers near waterbodies to deter waterfowl from congregating and conduct public outreach on wildlife feeding Filter Strips	91%	~53 acres (assume 11 miles of stream; 20ft buffer)	$600-1,000/acre of buffer
Low	Conduct septic system inspections as warranted and bring all imminent threat to public health septic systems into compliance with ordinances Septic (SSTS) Maintenance	100%	~ 22 systems	$200-300 (inspection) $7,500 per system (if replacement required)

[1] Priority is based on recommended timeframe to continue or start (not complete) implementation activities: High = 1-2 years, Medium = 2-5 years, Low = 5-10 years.
[2] Estimated effectiveness of practice refers to the reduction of bacteria concentrations in runoff to receiving waterbodies.
[3] Costs based on NRCS EQIP Payment Schedules http://www.nrcs.usda.gov/wps/portal/nrcs/detail/mn/programs/financial/?cid=stelprdb1245512
[4] Consult with PCA staff on whether a given action can be applied towards your individual MS4 Permit.

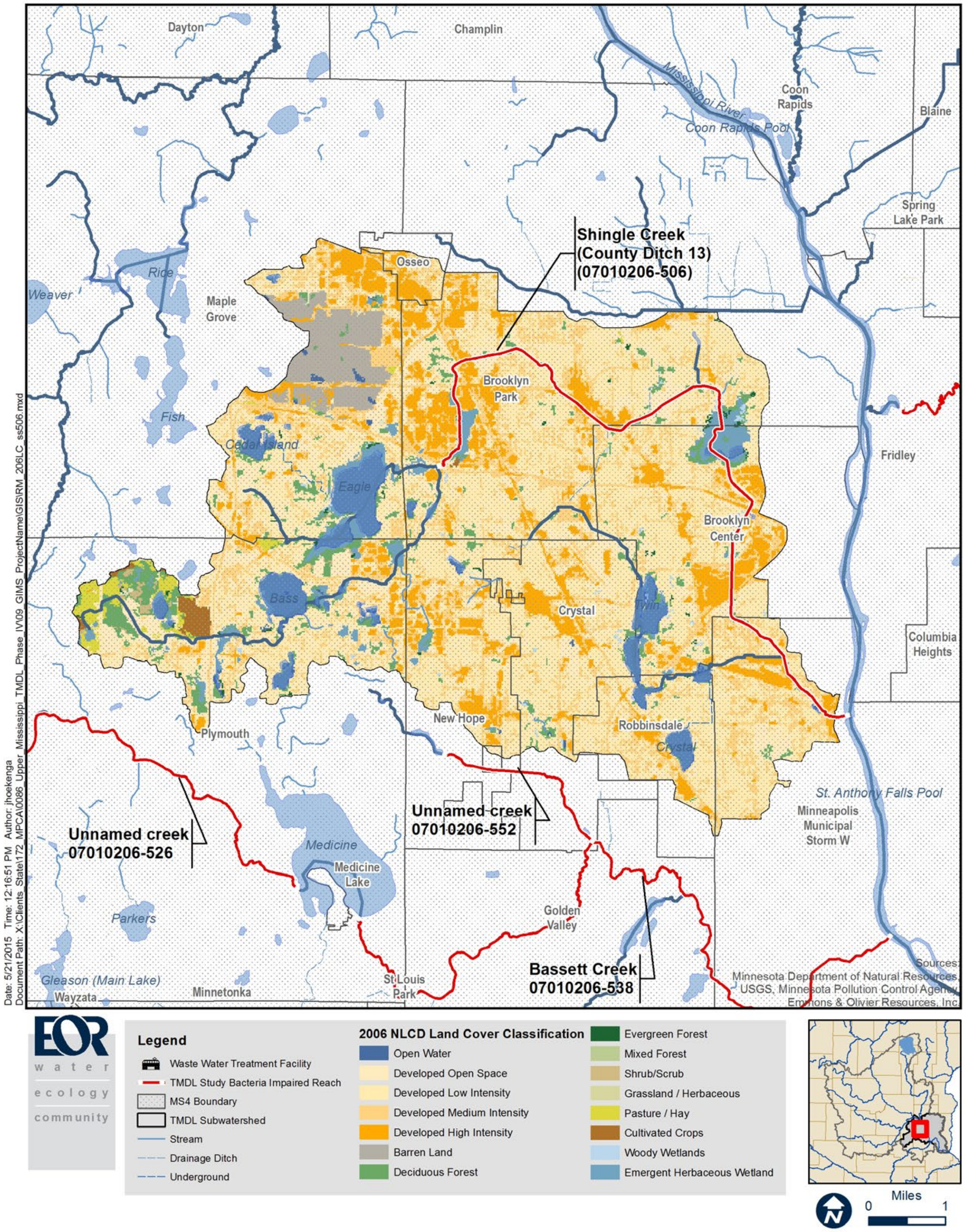

Figure 51. Land use cover in Shingle Creek Subwatershed

Unnamed Creek (Plymouth Creek) (07010206-526) Subwatershed

Description: Headwaters to Medicine Lake

Unnamed Creek (Plymouth Creek), hereafter Plymouth Creek, is the headwaters of Bassett Creek (Bassett Creek (07010206-538) Subwatershed). Plymouth Creek is impaired for aquatic recreation due to *E. coli*. The subwatershed is located within Priority Area B of the Minneapolis and St. Paul Source Water Protection Areas (Figure 4). Monitoring conducted from 2007 to 2011 indicated elevated levels of *E. coli* throughout the growing season with exceedances of the water quality standard occurring in every month with at least five samples from June through September except June. *E. coli* counts ranged from 3 to 2,400 org/100 ml and monthly geometric means ranged from 82 to 304 org/100 ml (a summary of water quality monitoring data can be found in Appendix D of the TMDL Study). Plotting *E. coli* levels against stream flow, as is shown in the load duration curves in Figure 6.61 on page 167 of the TMDL Study, show that exceedances occur at all flow conditions (e.g. high, moist, mid, dry, low) where there is monitoring data.

Production of *E. coli* in Subwatershed

As described in the TMDL Study and in Table 68, the Total Maximum Daily Load for Plymouth Creek is divided into point (permitted) sources and nonpoint (non-permitted) sources. In the Plymouth Creek Subwatershed the point (permitted) sources of *E. coli* are limited to the MS4s. "Developed" categories from the National Land Cover Dataset (NLCD) were used to approximate the MS4 regulated areas (see page 102 of the TMDL) and account for 84% of the land area in this watershed (Table 67 and Figure 52). "Undeveloped" categories were used to approximate nonpoint (non-permitted) sources of *E. coli*.

Table 67. Plymouth Creek Subwatershed Land uses

Land use	%
Developed Low Intensity	31%
Developed Medium Intensity	24%
Developed Open Space	16%
Developed High Intensity	13%
Deciduous Forest	7%
Emergent Herbaceous Wetland	4%
Open Water	2%
Table only includes land uses that are > 1% of the land area	

In developing the TMDL Study a desktop analysis was conducted to determine the potential sources of *E. coli* within each subwatershed and estimate the relative contribution of each source. The process, referred to as a bacteria source assessment, is described in Section 4 of the TMDL Study beginning on page 45. In the Plymouth Creek Subwatershed the vast majority of the *E. coli* is likely produced from pets and wildlife with a smaller amount attributed to humans.

Sources Contributing *E. coli* to the Stream Reach

In addition to determining the relative magnitude of *E. coli* sources within the watershed it is important to consider the factors that lead to the *E. coli* being delivered to the stream. The second step in the bacteria source assessment was to evaluate the connection between *E. coli* production, how it is handled on the landscape and how it is ultimately delivered to the stream. In the case of the Plymouth Creek Subwatershed, where pets are identified as the most likely bacteria source followed by wildlife and human sources, the most probable mechanism by which the bacteria becomes delivered to the stream is from runoff through stormwater conveyances in the urban area. Other mechanisms include direct input of fecal matter into streams from waterfowl.

TMDL Allocations and Percent Reductions

Wasteload and load allocations for this subwatershed and the calculated percent reduction needed to meet the TMDL are summarized in Table 68. Load allocations indicate a moderate to sizable decrease needed for bacteria in runoff under most flow conditions in the Plymouth Creek Subwatershed. The maximum percent reduction of bacteria load needed is 74%.

Table 68. Plymouth Creek Subwatershed TMDL and Percent Reductions Needed

Flow Regime	Existing Load (billion org/d)	Waste Load Allocations			LA (billion org/d)	MOS (billion org/d)	TMDL (billion org/d)	LA + MS4 WLA (billion org/d)	Estimated Reduction in Watershed Runoff (%)
		WWTFs (Total) (billion org/d)	Straight Pipes (billion org/d)	MS4 (billion org/d)					
High	149	–	–	61.1	11.2	8.03	80.3	72.3	51%
Moist	48.6	–	–	24.3	4.4	3.19	31.9	28.7	41%
Mid-Range	40.7	–	–	8.83	1.61	1.16	11.6	10.4	74%
Dry	2.45	–	–	3.89	0.707	0.511	5.11	4.6	0%
Low	ID	–	–	1.59	0.295	0.209	2.09	1.89	ID

Key: WWTF-Waste Water Treatment Facility, MS4-Municipal Separate Storm Sewer System, MOS-Margin of Safety, LA-Load Allocation, org-organisms, d-day, ID-Insufficient Data, IDUL-Impairment due to upstream load, EQN-Based on the equation found on page 104 in the TMDL Study, WLA-Waste Load Allocation

Regulated Entities

The regulated entities within this subwatershed are shown in Table 69.

Table 69. Regulated Entities within the Unnamed Creek (Plymouth Creek) Subwatershed

Regulated Entity	Permit #
Hennepin County	MS400138
MnDOT Metro District	MS400170
Minnetonka City	MS400035
Plymouth City	MS400112

Implementation Plan

The findings of the bacteria source assessment suggest that pet waste could be the largest source of *E. coli* to Plymouth Creek followed by wildlife and human sources. Based on the source assessment and the TMDL the **target goal is up to 74% reduction** of bacteria for this subwatershed but is lower in other flow regimes. The following is the magnitude of reductions to the major potential sources of bacteria that would be necessary within the watershed to meet the 74% goal. Specifically, reduce 50-80% of the bacteria load from pets and wildlife. Given this level of reduction it will likely take 20+ years of active management for Plymouth Creek to meet water quality standards for *E. coli*.

Priority Actions

As a result of the analyses for bacteria sources and contributing areas, the primary focus of implementation for this subwatershed will be to prevent or limit the amount of pet and wildlife waste that runs off into stormwater conveyance systems and Plymouth Creek. The second tier of implementation activities will be the traditional BMPs that are used for stormwater treatment which are found to be effective at bacteria removal in urban subwatersheds.

There are likely other contributors of bacteria that may not have been captured in the analyses above due to a lack of documentation. In many cases, local knowledge of bacteria sources may provide superior guidance for determining how to reduce bacteria loading to impaired stream reaches. Addressing additional sources within Plymouth Creek Subwatershed that are likely contributing *E. coli* to a lesser degree are also included in the implementation plan since the needed reduction is high in this subwatershed (see Urban Subwatersheds for more information). Below are the priority actions that are recommended for the Plymouth Creek Subwatershed.

Below are the priority actions that are recommended for this subwatershed:

- Map and identify specific locations where pets and wildlife would be contributing bacteria to water resources. For example, identify dog parks or areas where ducks/geese congregate in the subwatershed and how these areas relate to the stormwater conveyance system and stream. Note that mapping sources is a distinct activity from monitoring.
- Maintain/develop and enforce strict pet waste ordinances.
- Conduct public outreach to ensure that pet owners pick up pet waste and comply with ordinances.
- Implement an inspection and monitoring program to regularly assess potential sources and conveyance systems (stormwater outfalls) to reduce bacteria loading from dry weather flows. Refer to the monitoring section for further recommendations.
- Implement infiltration BMPs such as bioinfiltration/ bioretention systems (e.g. raingardens without underdrains); a secondary choice would be filtration BMPs such as biofiltration BMPs that may also remove bacteria, albeit to a lesser degree than infiltration BMPs. In both cases BMPs should be prioritized based on proximity to potential bacteria sources.
- Install filter strips/buffers near waterbodies to deter waterfowl from congregating and conduct public outreach on wildlife feeding.
- Direct flow pathways between contributing areas (e.g., dog parks) to infiltration/treatment basins or away from impervious areas to prevent direct pathway to receiving waters.
- Priority should be given to BMPs that provide multiple benefits.
- Develop, implement, and enforce a program to detect and eliminate illicit discharges.

- Determine if septic systems are located in priority subwatershed areas (identified through mapping efforts) and if onsite inspections are warranted. It is recommended to work with county staff as necessary to identify imminent threats. Make sure all systems that are imminent threats are brought into compliance.

Table 70 lists the priority actions described above along with a recommended timeframe for implementation and estimated costs. The timeframe that is provided is based on priority of implementation, and efforts will likely be ongoing once the action has been implemented. Action items are listed in order of importance. Also included in Table 70 are priority actions that are simply good practices to follow in all subwatersheds regardless of the magnitude of the source/activity they address. Note that some of these practices may have already been initiated within the subwatershed; if that is the case, continue with them and enhance them where necessary. Note that the costs are provided for context and not as an estimate of the total expenditure needed to meet any specified reduction in bacteria.

Refer to Appendix A for the entities responsible for implementing source controls and treatment BMPs in this subwatershed.

Table 70. Priority Actions for Plymouth Creek Subwatershed

Priority Timeframe[1]	Action	Estimated Effectiveness of Practice[2] (up to)	Estimated Magnitude in Watershed	Implementation Cost[3]
High	Identify and map potential bacteria hotspots Monitoring			Staff time
High	Update and enforce pet waste ordinances Litter and Animal Waste Control		~6,500 acres developed land	Staff time
High	Conduct public outreach to ensure that pet owners pick up pet waste and comply with pet waste ordinances. Litter and Animal Waste Control			Staff time
High	Inspect/ monitor stormwater outfalls to reduce dry weather flow (i.e. conditions that promote bacteria growth) Monitoring			Staff time
High	Direct flow pathways between contributing areas to infiltration/treatment basins or away from impervious areas to prevent direct pathway to receiving waters.			

Priority Timeframe[1]	Action	Estimated Effectiveness of Practice[2] (up to)	Estimated Magnitude in Watershed	Implementation Cost[3]
High	Develop, implement, and enforce a program to detect and eliminate illicit discharges			
Medium	Install Filtration/Biofiltration BMPs where feasible Filtration/ Biofiltration	35%		$8,000-20,000/ac
Low	Install buffers near waterbodies Filter Strips	91%	~29 acres (assume 6 miles of steam; 20ft buffer)	$600-1,000/acre of buffer
Low	Determine if septic systems are located in priority subwatershed areas (identified through mapping efforts) and if onsite inspections are warranted. It is recommended to work with county staff as necessary to identify imminent threats. Make sure all systems that are imminent threats are brought into compliance. Septic (SSTS) Maintenance			

[1] Priority is based on recommended timeframe to continue or start (not complete) implementation activities: High = 1-2 years, Medium = 2-5 years, Low = 5-10 years.
[2] Estimated effectiveness of practice refers to the reduction of bacteria concentrations in runoff to receiving waterbodies.
[3] Costs based on NRCS EQIP Payment Schedules http://www.nrcs.usda.gov/wps/portal/nrcs/detail/mn/programs/financial/?cid=stelprdb1245512
[4] Consult with PCA staff on whether a given action can be applied towards your individual MS4 Permit.

Note that in June 2014 there was a sanitary sewer spill to Bassett Creek following excess rainfall. Many cities are working with the Metropolitan Council to address infiltration/inflow (I/I) issues. The contribution of bacteria to surface waters through I/I is unknown. More information can be found at http://www.metrocouncil.org/Wastewater-Water/Funding-Finance/Rates-Charges/MCES-Inflow-and-Infiltration-(I-I)-Program.aspx.

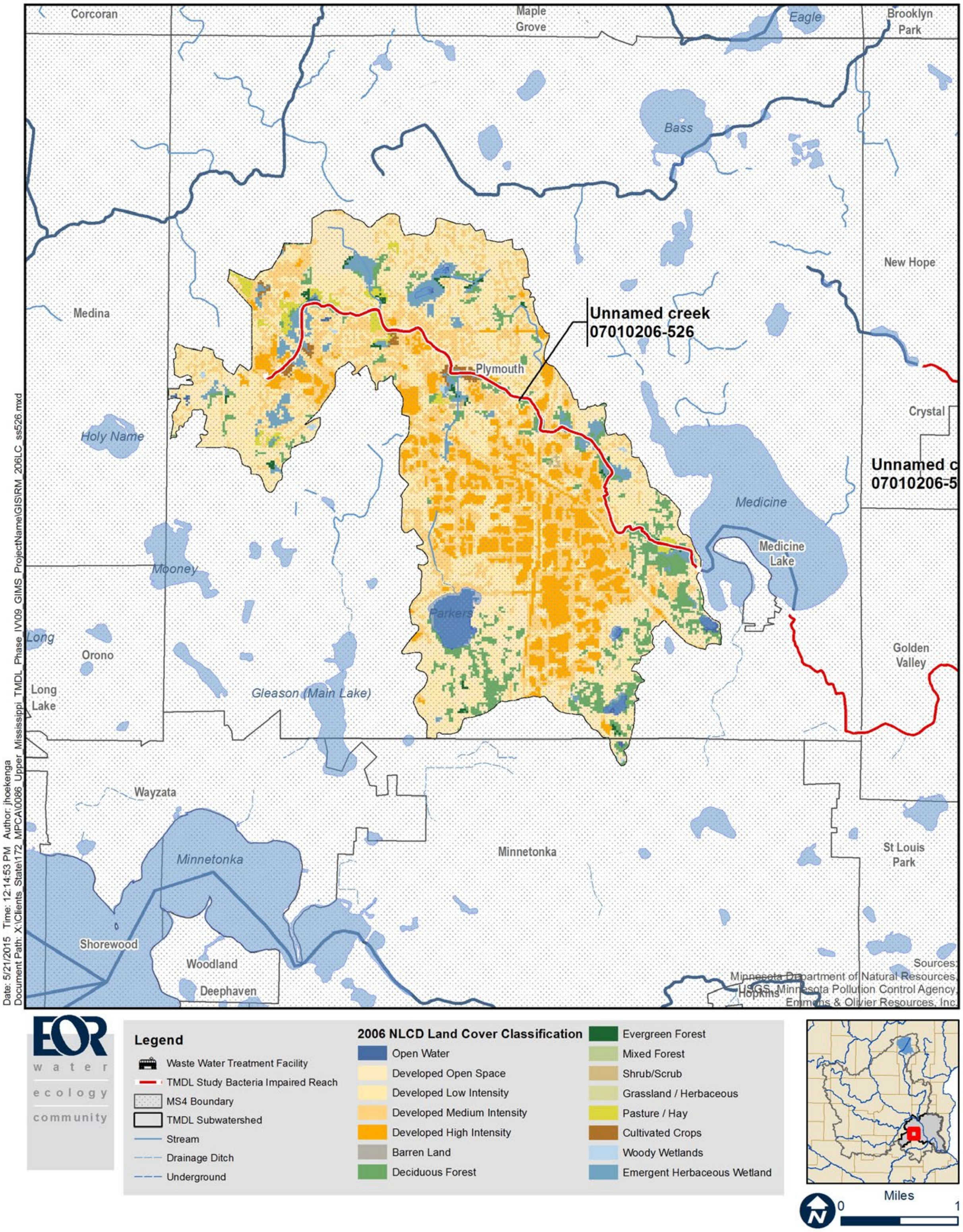

Figure 52. Land use cover in Plymouth Creek Subwatershed

Bassett Creek (07010206-538) Subwatershed

Description: Medicine Lake to Mississippi River

Bassett Creek is a tributary of the Mississippi River, and the subwatershed is located within Priority Area B of the Minneapolis and St. Paul Source Water Protection Areas (Figure 4). Bassett Creek is impaired for aquatic recreation due to fecal coliform data that was collected in 2008. Monitoring conducted from 2007 to 2011 indicated elevated levels of *E. coli* throughout the growing season with exceedances of the water quality standard occurring July through October. Unnamed Creek (North Branch, Bassett Creek) (07010206-552) is also impaired for *E. coli*. *E. coli* counts ranged from 816 to 2,420 org/100 ml and monthly geometric means ranged from 51 to 386 org/100 ml (a summary of water quality monitoring data can be found in Appendix D of the TMDL Study). Plotting *E. coli* levels against stream flow, as is shown in the load duration curves in Figure 6.63 on page 169 of the TMDL Study, show that some exceedances occur at all flow conditions (e.g. high, moist, mid, dry, low) where there is monitoring data. TMDL reductions are required for high, dry, and low flow conditions (Table 57).

Production of *E. coli* in Subwatershed

As described in the TMDL Study and in Table 72, the Total Maximum Daily Load for Bassett Creek is divided into point (permitted) sources and nonpoint (non-permitted) sources. In the Bassett Creek Subwatershed the point sources of *E. coli* are limited to the MS4s. For nonpoint sources, the majority of this subwatershed is a highly urbanized area with developed land uses accounting for 61% of its area as shown in Table 71 and Figure 53. "Developed" categories from the National Land Cover Dataset (NLCD) were used to approximate the MS4 regulated areas (see page 102 of the TMDL). "Undeveloped" categories were used to approximate nonpoint (non-permitted) sources of *E. coli*.

Table 71. Bassett Creek Subwatershed Land uses

Land use	%
Developed Low Intensity	35%
Developed Open Space	17%
Developed Medium Intensity	16%
Deciduous Forest	11%
Developed High Intensity	10%
Open Water	7%
Emergent Herbaceous Wetland	2%
Table only includes land uses that are > 1% of the land area	

In developing the TMDL Study a desktop analysis was conducted to determine the potential sources of *E. coli* within each subwatershed and estimate the relative contribution of each source. The process, referred to as a bacteria source assessment, is described in Section 4 of the TMDL Study beginning on page 45. In the Bassett Creek Subwatershed the vast majority of the *E. coli* is likely produced from pets and wildlife with a smaller amount attributed to humans.

As another tool, a Microbial Source Tracking (MST) analysis was conducted as part of this TMDL Study. MST analysis relies on the genetic coding, or markers, found within bacteria samples to determine the source of the bacteria. In the Bassett Creek Subwatershed the MST analysis found human/pet markers (note this marker is more indicative of a human source) in the storm event sample that was taken in June 2011 but not in the baseflow sample that was taken in September 2011. Due to the nature of bacteria caution must be exercised with use of the MST findings. The analysis can not be used to conclusively dismiss any given source of bacteria. The MST findings can only be applied to the source of bacteria found in that specific sample of water.

Sources Contributing *E. coli* to the Stream Reach

In addition to determining the relative magnitude of *E. coli* sources within the watershed it is important to consider the factors that lead to the *E. coli* being delivered to the stream. The second step in the bacteria source assessment was to evaluate the connection between *E. coli* production, how it is handled on the landscape and how it is ultimately delivered to the stream. In the case of the Bassett Creek Subwatershed, where pets are identified as the most likely bacteria source followed by wildlife and human sources, the most probable mechanism by which the bacteria becomes delivered to the stream is from runoff through stormwater conveyances in the urban area. Other mechanisms include stormwater runoff that includes wildlife waste and direct input of fecal matter into streams from waterfowl.

TMDL Allocations and Percent Reductions

Wasteload and load allocations for this subwatershed and the calculated percent reduction needed to meet the TMDL are summarized in Table 72. Load allocations indicate a moderate to sizable decrease needed for bacteria in runoff under most flow conditions in the Bassett Creek Subwatershed. The maximum percent reduction of bacteria load needed is 79%.

Table 72. Bassett Creek Subwatershed TMDL and Percent Reductions Needed

Flow Regime	Existing Load (billion org/d)	Waste Load Allocations			LA (billion org/d)	MOS (billion org/d)	TMDL (billion org/d)	LA + MS4 WLA (billion org/d)	Estimated Reduction in Watershed Runoff (%)
		WWTFs (Total) (billion org/d)	Straight Pipes (billion org/d)	MS4 (billion org/d)					
High	861	–	–	138	39.8	19.7	197	178	79%
Moist	23.1	–	–	54.1	15.6	7.74	77.4	69.7	0%
Mid-Range	4.4	–	–	19.9	5.67	2.84	28.4	25.6	0%
Dry	19.4	–	–	10.6	3.03	1.51	15.1	13.6	30%
Low	7.3	–	–	3.56	1.03	0.509	5.1	4.59	37%

Key: WWTF-Waste Water Treatment Facility, MS4-Municipal Separate Storm Sewer System, MOS-Margin of Safety, LA-Load Allocation, org-organisms, d-day, ID-Insufficient Data, IDUL-Impairment due to upstream load, EQN-Based on the equation found on page 104 in the TMDL Study, WLA-Waste Load Allocation

Regulated Entities

The regulated entities within this subwatershed are shown in Table 73.

Table 73. Regulated Entities within the Bassett Creek Subwatershed

Regulated Entity	Permit #
Crystal City	MS400012
Golden Valley City	MS400021
Hennepin County	MS400138
Medicine Lake City	MS400104
Minneapolis Municipal Storm Water	MN0061018
Minnetonka City	MS400035
MnDOT Metro District	MS400170
New Hope City	MS400039
Plymouth City	MS400112
Robbinsdale City	MS400046
St Louis Park City	MS400053

Implementation Plan

The findings of the bacteria source assessment suggest that pet waste could be the largest source of *E. coli* to Bassett Creek followed by wildlife and human sources. Based on the source assessment and the TMDL the **target goal is up to 79% reduction** of bacteria for this subwatershed but is lower in other flow regimes. The following is the magnitude of reductions to the major potential sources of bacteria that would be necessary within the watershed to meet the 79% goal. Specifically, reduce 70-80% of the bacteria load from pets and wildlife and humans. Given this level of reduction it will likely take 20+ years of active management for Bassett Creek to meet water quality standards for *E. coli*.

Priority Actions

As a result of the analyses for bacteria sources and contributing areas, the primary focus of implementation for this subwatershed will be to prevent or limit the amount of pet and wildlife waste that runs off into stormwater conveyance systems and the Bassett Creek. The second tier of implementation activities will be the traditional BMPs that are used for stormwater treatment which are found to be effective at bacteria removal in urban subwatersheds.

There are likely other contributors of bacteria that may not have been captured in the analyses above due to a lack of documentation. In many cases, local knowledge of bacteria sources may provide superior guidance for determining how to reduce bacteria loading to impaired stream reaches. Addressing additional sources within the Bassett Creek Subwatershed that are likely contributing *E. coli* to a lesser degree are also included in the implementation plan since the needed reduction is high in this subwatershed (see Urban Subwatersheds for more information). Below are the priority actions that are recommended for the Bassett Creek Subwatershed.

- Map and identify specific locations where pets and wildlife would be contributing bacteria to water resources. For example, identify dog parks or areas where wildlife congregate in the subwatershed and how these areas relate to the stormwater conveyance system and stream. Note that mapping sources is a distinct activity from monitoring.

- Maintain/develop and enforce strict pet waste ordinances.
- Conduct public outreach to ensure that pet owners pick up pet waste and comply with ordinances.
- Implement an inspection and monitoring program to regularly assess potential sources and conveyance systems (stormwater outfalls) to reduce bacteria loading from dry weather flows. Refer to the monitoring section for further recommendations.
- Implement infiltration BMPs such as bioinfiltration/ bioretention systems (e.g. raingardens without underdrains); a secondary choice would be filtration BMPs such as biofiltration BMPs that may also remove bacteria, albeit to a lesser degree than infiltration BMPs. In both cases BMPs should be prioritized based on proximity to potential bacteria sources.
- Install filter strips/buffers near waterbodies to deter waterfowl from congregating and conduct public outreach on wildlife feeding.
- Direct flow pathways between contributing areas (e.g., dog parks) to infiltration/treatment basins or away from impervious areas to prevent direct pathway to receiving waters.
- Priority should be given to BMPs that provide multiple benefits.
- Develop, implement, and enforce a program to detect and eliminate illicit discharges.
- Determine if septic systems are located in priority subwatershed areas (identified through mapping efforts) and if onsite inspections are warranted. It is recommended to work with county staff as necessary to make sure all systems that are imminent threats are brought into compliance.

Table 74 lists the priority actions described above along with a recommended timeframe for implementation and estimated costs. The timeframe that is provided is based on priority of implementation, and efforts will likely be ongoing once the action has been implemented. Action items are listed in order of importance. Also included in Table 74 are priority actions that are simply good practices to follow in all subwatersheds regardless of the magnitude of the source/activity they address. Note that some of these practices may have already been initiated within the subwatershed; if that is the case, continue with them and enhance them where necessary. Note that the costs are provided for context and not as an estimate of the total expenditure needed to meet any specified reduction in bacteria.

Refer to Appendix A for the entities responsible for implementing source controls and treatment BMPs in this subwatershed.

Table 74. Priority Actions for Bassett Creek Subwatershed

Priority Timeframe[1]	Action	Estimated Effectiveness of Practice[2] (up to)	Estimated Magnitude in Watershed	Implementation Cost[3]
High	Identify and map potential bacteria hotspots Monitoring			Staff time
High	Update and enforce pet waste ordinances Litter and Animal Waste Control		~12,500 acres developed land	Staff time
High	Conduct public outreach to ensure that pet owners pick up pet waste and comply with pet waste ordinances. Litter and Animal Waste Control			Staff time
High	Install Filtration/Biofiltration BMPs where feasible Filtration/ Biofiltration	35%		$8,000-20,000/ac
High	Direct flow pathways between contributing areas to infiltration/treatment basins or away from impervious areas to prevent direct pathway to receiving waters.			
High	Develop, implement, and enforce a program to detect and eliminate illicit discharges			
Medium	Inspect/ monitor stormwater outfalls to reduce dry weather flow (i.e. conditions that promote bacteria growth) Monitoring			Staff time

Medium	Install filter strips or other applicable BMPs near waterbodies Filter Strips	91%	~63 acres (assume 13 miles of stream; 20ft buffer)	$600-1,000/acre of buffer
Low	Determine if septic systems are located in priority subwatershed areas (identified through mapping efforts) and if onsite inspections are warranted. It is recommended to work with county staff as necessary to identify imminent threats. Make sure all systems that are imminent threats are brought into compliance. Septic (SSTS) Maintenance			

[1] Priority is based on recommended timeframe to continue or start (not complete) implementation activities: High = 1-2 years, Medium = 2-5 years, Low = 5-10 years.
[2] Estimated effectiveness of practice refers to the reduction of bacteria concentrations in runoff to receiving waterbodies.
[3] Costs based on NRCS EQIP Payment Schedules
http://www.nrcs.usda.gov/wps/portal/nrcs/detail/mn/programs/financial/?cid=stelprdb1245512
[4] Consult with PCA staff on whether a given action can be applied towards your individual MS4 Permit.

Note that in June 2014 there was a sanitary sewer spill to Bassett Creek following excess rainfall. Many cities are working with the Metropolitan Council to address infiltration/inflow (I/I) issues. The contribution of bacteria to surface waters through I/I is unknown. More information can be found at http://www.metrocouncil.org/Wastewater-Water/Funding-Finance/Rates-Charges/MCES-Inflow-and-Infiltration-(I-I)-Program.aspx

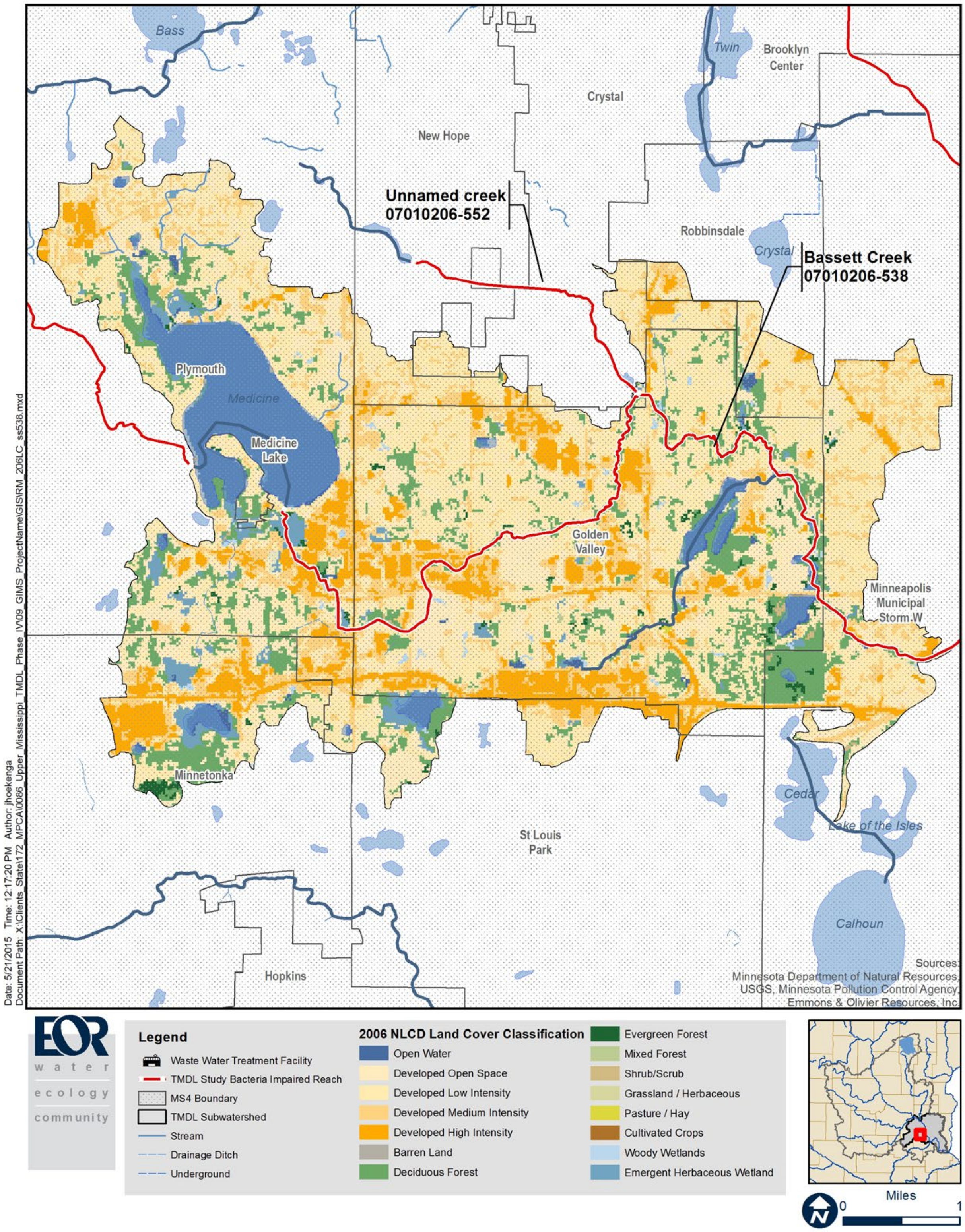

Figure 53. Land use cover in Bassett Creek Subwatershed

Unnamed Creek (Interstate Valley Creek) (07010206-542) Subwatershed

Description: Unnamed Creek to Mississippi River

Unnamed Creek (Interstate Valley Creek), hereafter Interstate Valley Creek, is a tributary of the Mississippi River and is impaired for aquatic recreation due to *E. coli*. The subwatershed is located within Priority Area B of the Minneapolis and St. Paul Source Water Protection Areas (Figure 4). Monitoring conducted from 2007 to 2011 indicated elevated levels of *E. coli* throughout the growing season with exceedances of the water quality standard occurring in every month with at least five samples from June through August. *E. coli* counts ranged from 16 to 2,400 org/100 ml and monthly geometric means ranged from 51 to 516 org/100 ml (a summary of water quality monitoring data can be found in Appendix D of the TMDL Study). Plotting *E. coli* levels against stream flow, as is shown in the load duration curves in Figure 6.64 on page 170 of the TMDL Study, show that exceedances occur at all flow conditions (e.g. high, moist, mid, dry, low) where there is monitoring data. However, the TMDL requires bacteria reductions for high, moist, and low flow conditions (Table 60).

Production of *E. coli* in Subwatershed

As described in the TMDL Study and in Table 76, the Total Maximum Daily Load for Interstate Valley Creek is divided into point (permitted) sources and nonpoint (non-permitted) sources. In the Unnamed Creek (Interstate Valley Creek) Subwatershed the point sources of *E. coli* are limited to the MS4s. For nonpoint sources, this subwatershed is an urbanized area with developed land uses accounting for 39% of its area as shown in Table 75 and Figure 54. "Developed" categories from the National Land Cover Dataset (NLCD) were used to approximate the MS4 regulated areas (see page 102 of the TMDL). "Undeveloped" categories were used to approximate nonpoint (non-permitted) sources of *E. coli*.

Table 75. Interstate Valley Creek Subwatershed Land uses

Land use	%
Developed Open Space	27%
Developed Low Intensity	26%
Deciduous Forest	22%
Developed Medium Intensity	11%
Open Water	5%
Developed High Intensity	2%
Table only includes land uses that are > 1% of the land area	

In developing the TMDL Study a desktop analysis was conducted to determine the potential sources of *E. coli* within each subwatershed and estimate the relative contribution of each source. The process, referred to as a bacteria source assessment, is described in Section 4 of the TMDL Study beginning on page 45. In the Interstate Valley Creek Subwatershed the vast majority of the *E. coli* is likely produced from pets and wildlife with a smaller amount attributed to humans.

As another tool, a Microbial Source Tracking (MST) analysis was conducted as part of this TMDL Study. MST analysis relies on the genetic coding, or markers, found within bacteria samples to determine the source of the bacteria. All water samples were tested for human/pet markers. In the Interstate Valley

Creek Subwatershed the MST analysis found no markers in the baseflow sample that was taken in June 2011 or the storm event sample that was taken in April 2012. Due to the nature of bacteria caution must be exercised with use of the MST findings. The analysis can not be used to conclusively dismiss any given source of bacteria. The MST findings can only be applied to the source of bacteria found in that specific sample of water.

Sources Contributing *E. coli* to the Stream Reach

In addition to determining the relative magnitude of *E. coli* sources within the watershed it is important to consider the factors that lead to the *E. coli* being delivered to the stream. The second step in the bacteria source assessment was to evaluate the connection between *E. coli* production, how it is handled on the landscape and how it is ultimately delivered to the stream. In the case of the Interstate Valley Creek Subwatershed, where pets are identified as the most likely bacteria source followed by wildlife and human sources, the most probable mechanism by which the bacteria becomes delivered to the stream is from runoff through stormwater conveyances in the urban area (Table 75). Other mechanisms include direct input of fecal matter into streams from wildlife.

TMDL Allocations and Percent Reductions

Wasteload and load allocations for this subwatershed and the calculated percent reduction needed to meet the TMDL are summarized in Table 76. Load allocations indicate a moderate to sizable decrease needed for bacteria in runoff under most flow conditions in the Interstate Valley Creek Subwatershed. The maximum percent reduction of bacteria load needed is 57%.

Table 76. Interstate Valley Creek Subwatershed TMDL and Percent Reductions Needed

Flow Regime	Existing Load (billion org/d)	Waste Load Allocations			LA (billion org/d)	MOS (billion org/d)	TMDL (billion org/d)	LA + MS4 WLA (billion org/d)	Estimated Reduction in Watershed Runoff (%)
		WWTFs (Total) (billion org/d)	Straight Pipes (billion org/d)	MS4 (billion org/d)					
High	57.7	–	–	26.9	13	4.43	44.3	39.9	31%
Moist	37.6	–	–	10.8	5.23	1.78	17.8	16	57%
Mid-Range	4.7	–	–	4.08	1.97	0.672	6.72	6.05	0%
Dry	1.43	–	–	1.2	0.578	0.198	1.98	1.78	0%
Low	0.27	–	–	0.12	0.0578	0.0198	0.198	0.178	33%

Key: WWTF-Waste Water Treatment Facility, MS4-Municipal Separate Storm Sewer System, MOS-Margin of Safety, LA-Load Allocation, org-organisms, d-day, ID-Insufficient Data, IDUL-Impairment due to upstream load, EQN-Based on the equation found on page 104 in the TMDL Study, WLA-Waste Load Allocation

Regulated Entities

The regulated entities within this subwatershed are shown in Table 77.

Table 77. Regulated Entities within the Unnamed Creek (Interstate Valley Creek) Subwatershed

Regulated Entity	Permit #
Dakota County	MS400132
Inver Grove Heights City	MS400096
Lilydale City	MS400028
Mendota Heights City	MS400034
MnDOT Metro District	MS400170
Sunfish Lake City	MS400055
West St Paul City	MS400059

Implementation Plan

The findings of the bacteria source assessment suggest that pet waste could be the largest source of *E. coli* to Interstate Valley Creek followed by wildlife and human sources. Based on the source assessment and the TMDL the **target goal is up to 57% reduction** of bacteria for this subwatershed but is lower in other flow regimes. The following is the magnitude of reductions to the major potential sources of bacteria that would be necessary within the watershed to meet the 57% goal. Given this level of reduction it will likely take 20+ years of active management for the Unnamed Creek to meet water quality standards for *E. coli*.

- Reduce 60-65% of the bacteria load from pets and wildlife.
- Eliminate 100% of the SSTS that are an imminent threat to public health by bringing into compliance with SSTS standards.

Priority Actions

As a result of the analyses for bacteria sources and contributing areas, the primary focus of implementation for this subwatershed will be to prevent or limit the amount of pet, wildlife and human waste that runs off into stormwater conveyance systems and the Interstate Valley Creek. The second tier of implementation activities will be the traditional BMPs that are used for stormwater treatment which are found to be effective at bacteria removal in urban subwatersheds.

There are likely other contributors of bacteria that may not have been captured in the analyses above due to a lack of documentation. In many cases, local knowledge of bacteria sources may provide superior guidance for determining how to reduce bacteria loading to impaired stream reaches. Addressing additional sources within the Interstate Valley Creek Subwatershed that are likely contributing *E. coli* to a lesser degree are also included in the implementation plan since the needed reduction is high in this subwatershed (see Urban Subwatersheds for more information). Below are the priority actions that are recommended for the Interstate Valley Creek Subwatershed.

- Map and identify specific locations where pets and wildlife would be contributing bacteria to water resources. For example, identify dog parks or areas where ducks/geese congregate in the

subwatershed and how these areas relate to the stormwater conveyance system and stream. Note that mapping sources is a distinct activity from monitoring.
- Maintain/develop and enforce strict pet waste ordinances.
- Conduct public outreach to ensure that pet owners pick up pet waste and comply with ordinances.
- Implement an inspection and monitoring program to regularly assess potential sources and conveyance systems (stormwater outfalls) to reduce bacteria loading from dry weather flows. Refer to the monitoring section for further recommendations.
- Implement infiltration BMPs such as bioinfiltration/ bioretention systems (e.g. raingardens without underdrains); a secondary choice would be filtration BMPs such as biofiltration BMPs that may also remove bacteria, albeit to a lesser degree than infiltration BMPs. In both cases BMPs should be prioritized based on proximity to potential bacteria sources.
- Install filter strips/buffers near waterbodies to deter waterfowl from congregating and conduct public outreach on wildlife feeding.
- Direct flow pathways between contributing areas (e.g., dog parks) to infiltration/treatment basins or away from impervious areas to prevent direct pathway to receiving waters.
- Priority should be given to BMPs that provide multiple benefits.
- Ensure SSTS ordinances are up-to-date and enforced.
- Develop, implement, and enforce a program to detect and eliminate illicit discharges.
- Investigate possible cross connections between sanitary and storm sewer pipes.
- Determine if septic systems are located in priority subwatershed areas (identified through mapping efforts) and if onsite inspections are warranted. It is recommended to work with county staff as necessary to identify imminent threats. Make sure all systems that are imminent threats are brought into compliance.

Table 78 lists the priority actions described above along with a recommended timeframe for implementation and estimated costs. The timeframe that is provided is based on priority of implementation, and efforts will likely be ongoing once the action has been implemented. Action items are listed in order of importance. Also included in Table 78 are priority actions that are simply good practices to follow in all subwatersheds regardless of the magnitude of the source/activity they address. Note that some of these practices may have already been initiated within the subwatershed; if that is the case, continue with them and enhance them where necessary. Note that the costs are provided for context and not as an estimate of the total expenditure needed to meet any specified reduction in bacteria.

Refer to Appendix A for the entities responsible for implementing source controls and treatment BMPs in this subwatershed.

Table 78. Priority Actions for Interstate Valley Creek Subwatershed

Priority Timeframe[1]	Action	Estimated Effectiveness of Practice[2] (up to)	Estimated Magnitude in Watershed	Implementation Cost[3]
High	Identify and map potential bacteria hotspots Monitoring			Staff time
High	Inspect/ monitor stormwater outfalls to reduce dry weather flow (i.e. conditions that promote bacteria growth) Monitoring			Staff time
High	Investigate possible cross connections between sanitary and storm sewer pipes			Staff time
High	Direct flow pathways between contributing areas to infiltration/treatment basins or away from impervious areas to prevent direct pathway to receiving waters.			
High	Develop, implement, and enforce a program to detect and eliminate illicit discharges			
Medium	Update and enforce pet waste ordinances Litter and Animal Waste Control		~4,500 acres developed land	Staff time
Medium	Conduct public outreach to ensure that pet owners pick up pet waste and comply with pet waste ordinances. Litter and Animal Waste Control			Staff time
Medium	Install Filtration/Biofiltration BMPs where feasible Filtration/ Biofiltration	35%		$8,000-20,000/ac

Low	Install filter strips or other applicable BMPs near waterbodies Filter Strips	91%	~4 acres (assume 0.75 miles of stream; 20ft buffer)	$8,000-20,000/acre
Low	Determine if septic systems are located in priority subwatershed areas (identified through mapping efforts) and if onsite inspections are warranted. It is recommended to work with county staff as necessary to identify imminent threats. Make sure all systems that are imminent threats are brought into compliance. Septic (SSTS) Maintenance	100%	~ 3 systems	$200-300 (inspection) $7,500 per system (if replacement required)

[1] Priority is based on recommended timeframe to continue or start (not complete) implementation activities: High = 1-2 years, Medium = 2-5 years, Low = 5-10 years.
[2] Estimated effectiveness of practice refers to the reduction of bacteria concentrations in runoff to receiving waterbodies.
[3] Costs based on NRCS EQIP Payment Schedules
http://www.nrcs.usda.gov/wps/portal/nrcs/detail/mn/programs/financial/?cid=stelprdb1245512
[4] Consult with PCA staff on whether a given action can be applied towards your individual MS4 Permit.

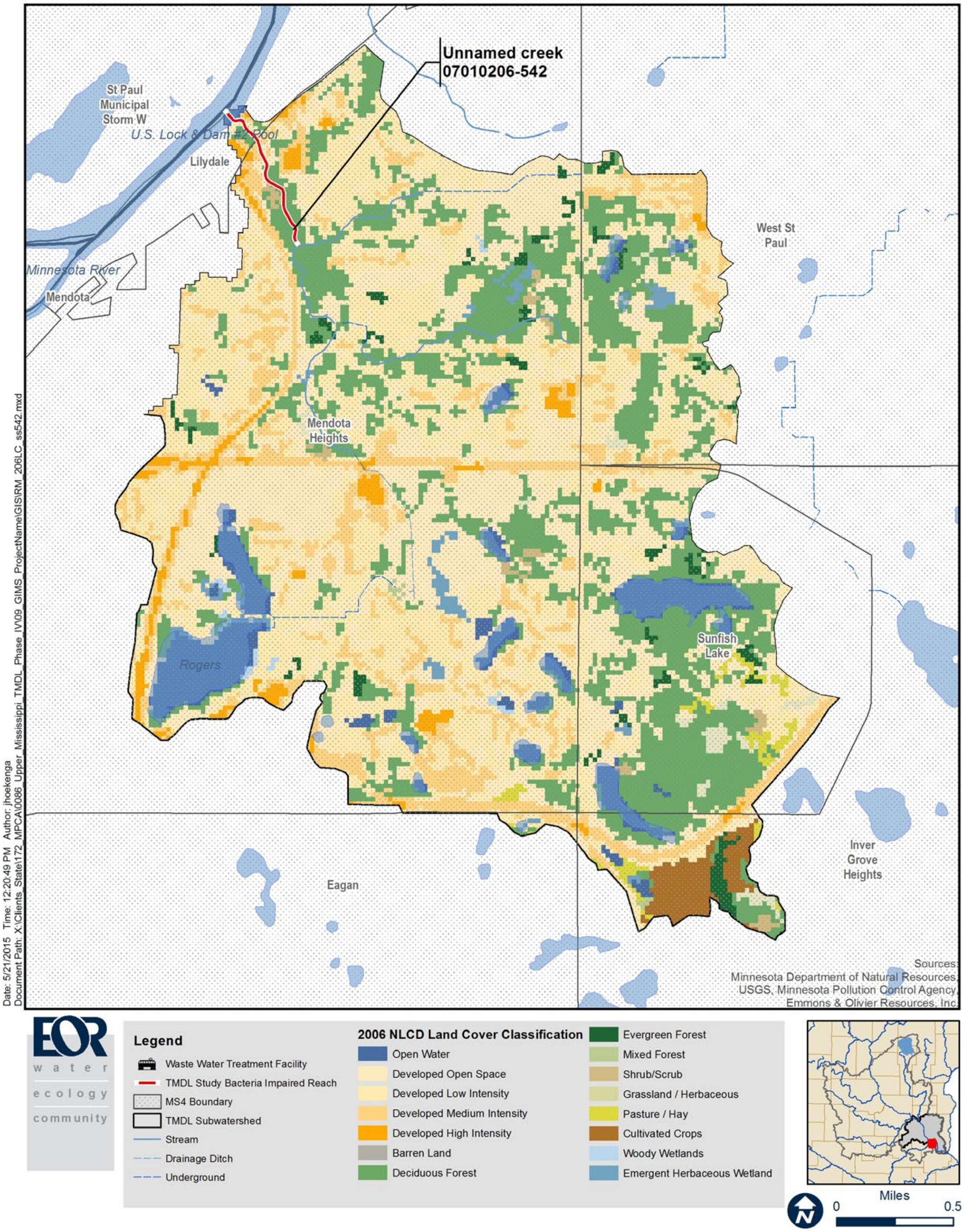

Figure 54. Land use cover in Interstate Valley Creek Subwatershed

Unnamed Creek (North Branch, Bassett Creek) (07010206-552) Subwatershed

Description: Unnamed Lake to Bassett Creek

Unnamed Creek (North Branch Bassett Creek), hereafter North Branch Bassett Creek, is a tributary of Bassett Creek (Bassett Creek (07010206-538) Subwatershed) and is impaired for aquatic recreation due to *E. coli*. The subwatershed is located within Priority Area B of the Minneapolis and St. Paul Source Water Protection Areas (Figure 4). Bassett Creek (07010206-538) is also impaired for *E. coli*. Monitoring conducted from 2007 to 2011 indicated elevated levels of *E. coli* throughout the growing season with exceedances of the water quality standard occurring in every month with at least five samples from April through October except April. *E. coli* counts ranged from 250 to 2,400 org/100 ml and monthly geometric means ranged from 531 to 1,510 org/100 ml (a summary of water quality monitoring data can be found in Appendix D of the TMDL Study). Plotting *E. coli* levels against stream flow, as is shown in the load duration curves in Figure 6.66 on page 172 of the TMDL Study, show that exceedances occur at all flow conditions (e.g. high, moist, mid, dry, low) where there is monitoring data.

Production of *E. coli* in Subwatershed

As described in the TMDL Study and in Table 80, the Total Maximum Daily Load for North Bassett Creek is divided into point (permitted) sources and nonpoint (non-permitted) sources. In the North Bassett Creek Subwatershed the point sources of *E. coli* are limited to the MS4s. For nonpoint sources, the majority of this subwatershed is a highly urbanized area with developed land uses accounting for 77% of its area as shown in Table 79 and Figure 55. "Developed" categories from the National Land Cover Dataset (NLCD) were used to approximate the MS4 regulated areas (see page 102 of the TMDL). "Undeveloped" categories were used to approximate nonpoint (non-permitted) sources of *E. coli*.

Table 79. North Branch Bassett Creek Subwatershed Land uses

Land use	%
Developed Low Intensity	50%
Developed Medium Intensity	20%
Developed Open Space	14%
Developed High Intensity	7%
Deciduous Forest	5%
Open Water	2%
Table only includes land uses that are > 1% of the land area	

In developing the TMDL Study a desktop analysis was conducted to determine the potential sources of *E. coli* within each subwatershed and estimate the relative contribution of each source. The process, referred to as a bacteria source assessment, is described in Section 4 of the TMDL Study beginning on page 45. In the North Branch Bassett Creek Subwatershed the vast majority of the *E. coli* is likely produced from pets with a smaller amount attributed to wildlife and waterfowl and human sources.

Sources Contributing *E. coli* to the Stream Reach

In addition to determining the relative magnitude of *E. coli* sources within the watershed it is important to consider the factors that lead to the *E. coli* being delivered to the stream. The second step in the bacteria source assessment was to evaluate the connection between *E. coli* production, how it is handled on the landscape and how it is ultimately delivered to the stream. In the case of the North Branch Bassett Creek Subwatershed pets are identified as the most likely bacteria source followed by wildlife and human sources, the most probable mechanism by which the bacteria becomes delivered to the stream is from runoff through stormwater conveyances in the urban area.

TMDL Allocations and Percent Reductions

Wasteload and load allocations for this subwatershed and the calculated percent reduction needed to meet the TMDL are summarized in Table 80. Allocations indicate a moderate to sizable decrease needed for bacteria in runoff under most flow conditions in the North Branch Bassett Creek Subwatershed. The maximum percent reduction of bacteria load needed is 92%

Table 80. North Branch Bassett Creek Subwatershed TMDL and Percent Reductions Needed

Flow Regime	Existing Load (billion org/d)	Waste Load Allocations			LA (billion org/d)	MOS (billion org/d)	TMDL (billion org/d)	LA + MS4 WLA (billion org/d)	Estimated Reduction in Watershed Runoff (%)
		WWTFs (Total) (billion org/d)	Straight Pipes (billion org/d)	MS4 (billion org/d)					
High	ID	–	–	26.7	2.21	3.21	32.1	28.9	ID
Moist	70.3	–	–	10.6	0.839	1.27	12.7	11.4	84%
Mid-Range	31.3	–	–	3.85	0.317	0.463	4.63	4.17	87%
Dry	12.2	–	–	1.69	0.145	0.204	2.04	1.84	85%
Low	9.7	–	–	0.692	0.0582	0.0833	0.833	0.75	92%

Key: WWTF-Waste Water Treatment Facility, MS4-Municipal Separate Storm Sewer System, MOS-Margin of Safety, LA-Load Allocation, org-organisms, d-day, ID-Insufficient Data, IDUL-Impairment due to upstream load, EQN-Based on the equation found on page 104 in the TMDL Study, WLA-Waste Load Allocation

Regulated Entities

The regulated entities within this subwatershed are shown in Table 81.

Table 81. Regulated Entities within the Unnamed Creek (North Branch, Bassett Creek) Subwatershed

Regulated Entity	Permit #
Crystal City	MS400012
Golden Valley City	MS400021
Hennepin County	MS400138
MnDOT Metro District	MS400170
New Hope City	MS400039
Plymouth City	MS400112

Implementation Plan

The findings of the bacteria source assessment suggest that pet waste could be the largest source of *E. coli* to North Branch Bassett Creek followed by wildlife and human sources. Based on the source assessment and the TMDL the **target goal is up to a 92% reduction** of bacteria for this subwatershed but is slightly lower in other flow regimes. The magnitude of reductions to the major potential sources of bacteria that would be necessary within the watershed to meet the 92% goal is a reduction of 90-95% of the bacteria load from pets, wildlife, and humans. Given this level of reduction it will likely take 20+ years of active management for North Branch Bassett Creek to meet water quality standards for *E. coli*.

Priority Actions

As a result of the analyses for bacteria sources and contributing areas, the primary focus of implementation for this subwatershed will be to prevent or limit the amount of pet, wildlife and human waste that runs off into stormwater conveyance systems and the North Branch Bassett Creek. The second tier of implementation activities will be the traditional BMPs that are used for stormwater treatment which are found to be effective at bacteria removal in urban subwatersheds.

There are likely other contributors of bacteria that may not have been captured in the analyses above due to a lack of documentation. In many cases, local knowledge of bacteria sources may provide superior guidance for determining how to reduce bacteria loading to impaired stream reaches. Addressing additional sources within the North Branch Bassett Creek Subwatershed that are likely contributing *E. coli* to a lesser degree are also included in the implementation plan since the needed reduction is high in this subwatershed (see Urban Subwatersheds for more information). Below are the priority actions that are recommended for the North Branch Bassett Creek Subwatershed.

- Map and identify specific locations where pets and wildlife would be contributing bacteria to water resources. For example, identify dog parks or areas where waterfowl congregate in the subwatershed and how these areas relate to the stormwater conveyance system and stream. Note that mapping sources is a distinct activity from monitoring.
- Maintain/develop and enforce strict pet waste ordinances.
- Conduct public outreach to ensure that pet owners pick up pet waste and comply with ordinances.

- Implement an inspection and monitoring program to regularly assess potential sources and conveyance systems (stormwater outfalls) to reduce bacteria loading from dry weather flows. Refer to the monitoring section for further recommendations.
- Implement infiltration BMPs such as bioinfiltration/ bioretention systems (e.g. raingardens without underdrains); a secondary choice would be filtration BMPs such as biofiltration BMPs that may also remove bacteria, albeit to a lesser degree than infiltration BMPs. In both cases BMPs should be prioritized based on proximity to potential bacteria sources.
-
- Install filter strips/buffers near waterbodies to deter waterfowl from congregating and conduct public outreach on wildlife feeding.
- Direct flow pathways between contributing areas (e.g., dog parks) to infiltration/treatment basins or away from impervious areas to prevent direct pathway to receiving waters. Priority should be given to BMPs that provide multiple benefits.
- Develop, implement, and enforce a program to detect and eliminate illicit discharges.
- Determine if septic systems are located in priority subwatershed areas (identified through mapping efforts) and if onsite inspections are warranted. It is recommended to work with county staff as necessary to identify imminent threats. Make sure all systems that are imminent threats are brought into compliance.

Table 82 lists the priority actions described above along with a recommended timeframe for implementation and estimated costs. The timeframe that is provided is based on the priority of implementation, and efforts will likely be ongoing once the action has been implemented. Action items are listed in order of importance. Also included in Table 82 are priority actions that are simply good practices to follow in all subwatersheds regardless of the magnitude of the source/activity they address. Note that some of these practices may have already been initiated within the subwatershed; if that is the case, continue with them and enhance them where necessary. Note that the costs are provided for context and not as an estimate of the total expenditure needed to meet any specified reduction in bacteria.

Refer to Appendix A for the entities responsible for implementing source controls and treatment BMPs in this subwatershed.

Table 82. Priority Actions for North Branch Bassett Creek Subwatershed

Priority Timeframe[1]	Action	Estimated Effectiveness of Practice[2] (up to)	Estimated Magnitude in Watershed	Implementation Cost[3]
High	Identify and map potential bacteria hotspots Monitoring			Staff time
High	Update and enforce pet waste ordinances Litter and Animal Waste Control		~2,500 acres developed land	Staff time

Priority Timeframe[1]	Action	Estimated Effectiveness of Practice[2] (up to)	Estimated Magnitude in Watershed	Implementation Cost[3]
High	Conduct public outreach to ensure that pet owners pick up pet waste and comply with pet waste ordinances. Litter and Animal Waste Control			Staff time
High	Install Filtration/Biofiltration BMPs where feasible Filtration/ Biofiltration	35%		$8,000-20,000/ac
High	Direct flow pathways between contributing areas to infiltration/treatment basins or away from impervious areas to prevent direct pathway to receiving waters.			
High	Develop, implement, and enforce a program to detect and eliminate illicit discharges			
Medium	Inspect/ monitor stormwater outfalls to reduce dry weather flow (i.e. conditions that promote bacteria growth) Monitoring			Staff time
Medium	Install filter strips/buffer BMPs or other applicable BMPs near waterbodies Filter Strips	91%	~12 acres (assume 2.5 miles of stream; 20ft buffer)	$600-1,000/acre of buffer
Low	Determine if septic systems are located in priority subwatershed areas (identified through mapping efforts) and if onsite inspections are warranted. It is recommended to work with county staff as necessary to identify imminent threats. Make sure all systems that are imminent threats are brought into compliance. Septic (SSTS) Maintenance			

[1] Priority is based on recommended timeframe to continue or start (not complete) implementation activities: High = 1-2 years, Medium = 2-5 years, Low = 5-10 years.
[2] Estimated effectiveness of practice refers to the reduction of bacteria concentrations in runoff to receiving waterbodies.
[3] Costs based on NRCS EQIP Payment Schedules
http://www.nrcs.usda.gov/wps/portal/nrcs/detail/mn/programs/financial/?cid=stelprdb1245512
[4] Consult with PCA staff on whether a given action can be applied towards your individual MS4 Permit.
Note that in June 2014 there was a sanitary sewer spill to Bassett Creek following excess rainfall. Many cities are working with the Metropolitan Council to address infiltration/inflow (I/I) issues. The contribution of bacteria to surface waters through I/I is unknown. More information can be found at http://www.metrocouncil.org/Wastewater-Water/Funding-Finance/Rates-Charges/MCES-Inflow-and-Infiltration-(I-I)-Program.aspx.

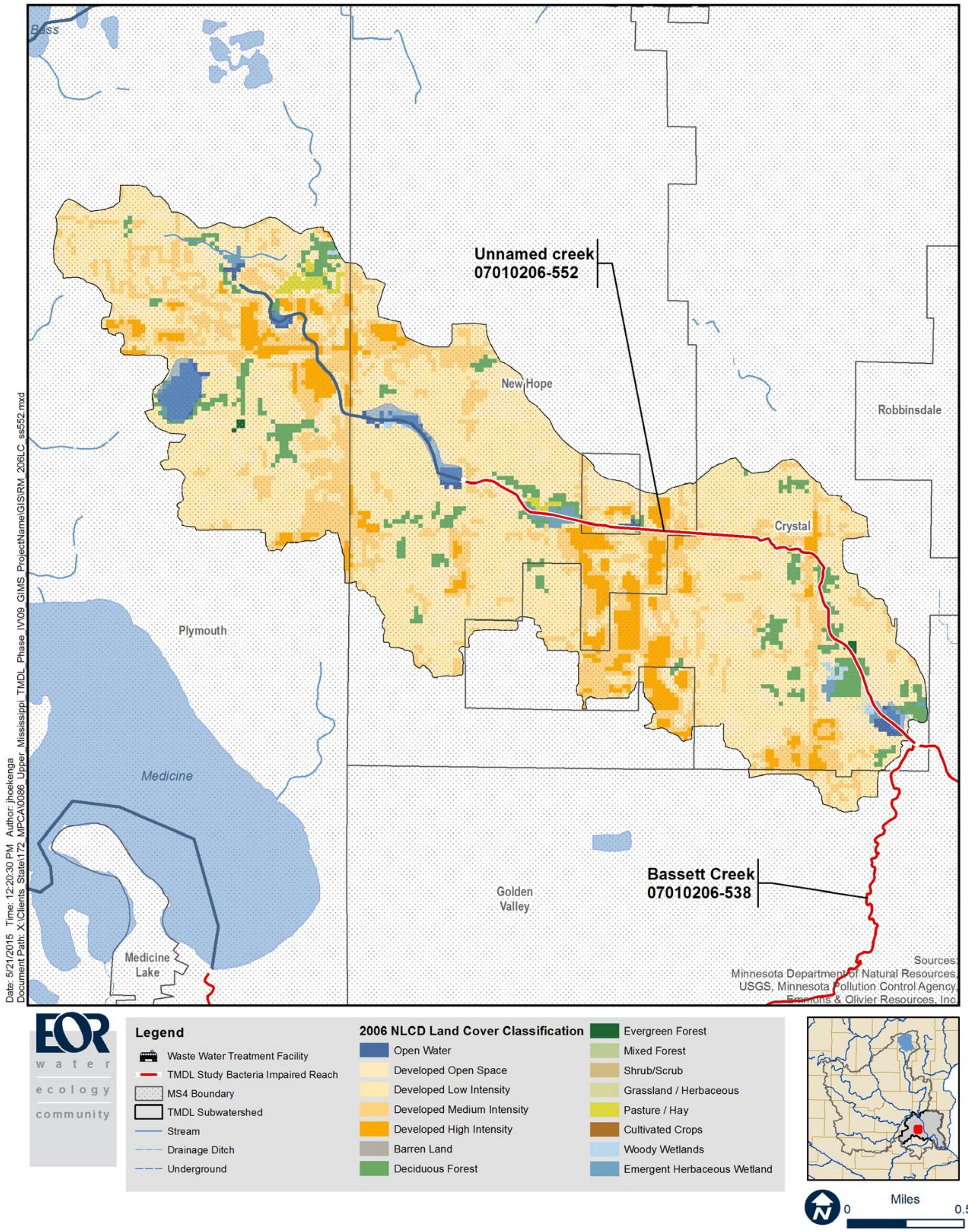

Figure 55. Land use cover in North Branch Bassett Creek Subwatershed

Rice Creek (07010206-584) Subwatershed

Description: Long Lake to Locke Lake

Rice Creek, a tributary of the Mississippi River which flows into Locke Lake, is impaired for aquatic recreation due to *E. coli*. The subwatershed is located within Priority Areas A and B of the Minneapolis and St. Paul Source Water Protection Areas (Figure 4). Monitoring conducted from 2007 to 2011 indicated elevated levels of *E. coli* throughout the growing season with exceedances of the water quality standard occurring in August and September. *E. coli* counts ranged from 36 to 1,600 org/100 ml and monthly geometric means ranged from 62 to 340 org/100 ml (a summary of water quality monitoring data can be found in Appendix D of the TMDL Study). Plotting *E. coli* levels against stream flow, as is shown in the load duration curves in Figure 6.70 on page 175 of the TMDL Study, show that exceedances occur at all flow conditions (e.g. high, moist, mid, dry, low) where there is monitoring data. Note that the highest reduction in bacteria is required under mid-range flow conditions (Table 66).

Production of *E. coli* in Subwatershed

As described in the TMDL Study and in Table 84, the Total Maximum Daily Load for Rice Creek is divided into point (permitted) sources and nonpoint (non-permitted) sources. In the Rice Creek Subwatershed the point sources of *E. coli* are limited to the MS4s. For nonpoint sources, the land use within the subwatershed includes open water and wetlands, and rural land uses including some cultivated cropland and pasture/hay land uses as shown in Table 83 and Figure 56Figure . "Developed" categories from the National Land Cover Dataset (NLCD) were used to approximate the MS4 regulated areas (see page 102 of the TMDL). "Undeveloped" categories were used to approximate nonpoint (non-permitted) sources of *E. coli*.

Table 83. Rice Creek Subwatershed Land uses

Land use	%
Pasture / Hay	16%
Emergent Herbaceous Wetland	14%
Deciduous Forest	14%
Developed Low Intensity	13%
Open Water	10%
Cultivated Crops	9%
Developed Open Space	8%
Developed Medium Intensity	7%
Grassland / Herbaceous	3%
Developed High Intensity	3%
Table only includes land uses that are > 1% of the land area	

In developing the TMDL Study a desktop analysis was conducted to determine the potential sources of *E. coli* within each subwatershed and estimate the relative contribution of each source. The process, referred to as a bacteria source assessment, is described in Section 4 of the TMDL Study beginning on page 45. In the Rice Creek Subwatershed the vast majority of the *E. coli* is likely produced from pets and wildlife with a moderate amount attributed to humans.

Sources Contributing *E. coli* to the Stream Reach

In addition to determining the relative magnitude of *E. coli* sources within the watershed it is important to consider the factors that lead to the *E. coli* being delivered to the stream. The second step in the bacteria source assessment was to evaluate the connection between *E. coli* production, how it is handled on the landscape and how it is ultimately delivered to the stream through stormwater conveyances and ditches. In the case of the Rice Creek Subwatershed pet and wildlife wastes are identified as the most likely potential bacteria source contributing to the stream reach. Other, smaller potential sources are human (e.g. failing septic systems).

TMDL Allocations and Percent Reductions

Wasteload and load allocations for this subwatershed and the calculated percent reduction needed to meet the TMDL are summarized in Table 84. Load allocations indicate a moderate to slight decrease is needed for bacteria in runoff under mid-range and moist flow conditions in the Rice Creek Subwatershed. The maximum percent reduction of bacteria load needed is 44%.

Table 84. Rice Creek Subwatershed TMDL and Percent Reductions Needed

Flow Regime	Existing Load (billion org/d)	Waste Load Allocations			LA (billion org/d)	MOS (billion org/d)	TMDL (billion org/d)	LA + MS4 WLA (billion org/d)	Estimated Reduction in Watershed Runoff (%)
		WWTFs (Total) (billion org/d)	Straight Pipes (billion org/d)	MS4 (billion org/d)					
High	684	–	–	396	819	135	1350	1220	0%
Moist	312	–	–	96.8	200	33	330	297	4.80%
Mid-Range	130	–	–	23.6	49.1	8.08	80.8	72.7	44%
Dry	ID	–	–	4.93	10.2	1.68	16.8	15.1	ID
Low	ID	–	–	1.75	3.64	0.599	5.99	5.39	ID

Key: WWTF-Waste Water Treatment Facility, MS4-Municipal Separate Storm Sewer System, MOS-Margin of Safety, LA-Load Allocation, org-organisms, d-day, ID-Insufficient Data, IDUL-Impairment due to upstream load, EQN-Based on the equation found on page 104 in the TMDL Study, WLA-Waste Load Allocation

Regulated Entities

The regulated entities within this subwatershed are shown in Table 85.

Table 85. Regulated Entities within the Rice Creek Subwatershed

Regulated Entity	Permit #
Anoka County	MS400066
Arden Hills City	MS400002
Birchwood Village City	MS400004
Blaine City	MS400075
Centerville City	MS400078

Regulated Entity	Permit #
Century College	MS400171
Circle Pines City	MS400009
Columbia Heights City	MS400010
Dellwood City	MS400084
Falcon Heights City	MS400018
Forest Lake City	MS400262
Fridley City	MS400019
Grant City	MS400091
Hennepin County	MS400138
Hugo City	MS400094
Lauderdale City	MS400026
Lexington City	MS400027
Lino Lakes City	MS400100
Mahtomedi City	MS400031
Minneapolis Municipal Storm Water	MN0061018
Minnesota Correctional-Lino Lakes	MS400177
MnDOT Metro District	MS400170
Mounds View City	MS400037
New Brighton City	MS400038
North Oaks City	MS400109
Ramsey County Public Works	MS400191
Roseville City	MS400047
Shoreview City	MS400121
Spring Lake Park City	MS400050
St Anthony Village City	MS400051
University of Minnesota – Twin Cities Campus	MS400212
White Bear Lake City	MS400060
White Bear Township	MS400163
Willernie City	MS400061
Washington County	MS400160

Implementation Plan

The findings of the bacteria source assessment suggest that pet waste could be the largest source of *E. coli* to Rice Creek followed by wildlife and human sources, and to a lesser extent livestock including cattle, sheep, and goats. Based on the source assessment and the TMDL the **target goal is up to a 44% reduction** of bacteria for this subwatershed but is lower in other flow regimes. The following is the magnitude of reductions to the major potential sources of bacteria that would be necessary within the watershed to meet the 44% goal. Given this level of reduction it will likely take 20+ years of active management for Rice Creek to meet water quality standards for *E. coli*.

- Reduce 30-35% of the bacteria load from pets and wildlife.
- Eliminate 100% of the SSTS that are an imminent threat to public health by bringing into compliance with SSTS standards.

Priority Actions

As a result of the analyses for bacteria sources and contributing areas, the primary focus of implementation for this subwatershed will be to prevent or limit the amount of pet, wildlife, human and livestock waste that runs off into stormwater conveyance systems and Rice Creek. The second tier of implementation activities will be the traditional BMPs that are used for stormwater treatment which are found to be effective at bacteria removal in urban subwatersheds.

There are likely other contributors of bacteria that may not have been captured in the analyses above due to a lack of documentation. In many cases, local knowledge of bacteria sources may provide superior guidance for determining how to reduce bacteria loading to impaired stream reaches. Addressing additional sources within the Rice Creek Subwatershed that are likely contributing *E. coli* to a lesser degree are also included in the implementation plan since the needed reduction is high in this subwatershed (see Urban Subwatersheds for more information). Below are the priority actions that are recommended for the Rice Creek Subwatershed.

- Map and identify specific locations where pets and wildlife would be contributing bacteria to water resources. For example, identify dog parks or areas where waterfowl congregate in the subwatershed and how these areas relate to the stormwater conveyance system and stream. Note that mapping sources is a distinct activity from monitoring.
- Maintain/develop and enforce strict pet waste ordinances.
- Conduct public outreach to ensure that pet owners pick up pet waste and comply with ordinances.
- Implement an inspection and monitoring program to regularly assess potential sources and conveyance systems (stormwater outfalls) to reduce bacteria loading from dry weather flows. Refer to the monitoring section for further recommendations.
- Implement infiltration BMPs such as bioinfiltration/ bioretention systems (e.g. raingardens without underdrains); a secondary choice would be filtration BMPs such as biofiltration BMPs that may also remove bacteria, albeit to a lesser degree than infiltration BMPs. In both cases BMPs should be prioritized based on proximity to potential bacteria sources.
- Install filter strips/buffers near waterbodies to deter waterfowl from congregating and conduct public outreach on wildlife feeding.
- Direct flow pathways between contributing areas (e.g., dog parks) to infiltration/treatment basins or away from impervious areas to prevent direct pathway to receiving waters.
- Priority should be given to BMPs that provide multiple benefits.
- Ensure SSTS ordinances are up-to-date and enforced.
- Develop, implement, and enforce a program to detect and eliminate illicit discharges.
- Determine if septic systems are located in priority subwatershed areas (identified through mapping efforts) and if onsite inspections are warranted. It is recommended to work with county staff as necessary to identify imminent threats. Make sure all systems that are imminent threats are brought into compliance.

Table 86 lists the priority actions described above along with a recommended timeframe for implementation and estimated costs. The timeframe that is provided is based on priority of implementation, and efforts will likely be ongoing once the action has been implemented. Action items are listed in order of importance. Also included in Table 86 are priority actions that are simply good practices to follow in all subwatersheds regardless of the magnitude of the source/activity they address. Note that some of these practices may have already been initiated within the subwatershed; if that is the case, continue with them and enhance them where necessary. Note that the costs are provided for context and not as an estimate of the total expenditure needed to meet any specified reduction in bacteria. The Rice Creek subwatershed is unique in that the watershed is a very large area and the impairment is in a very small segment of the stream at the very downstream end of the watershed. Because of these characteristics, efforts should be focused in the proximity of the impairment and the priorities for the watershed may vary from that provided here.

Refer to Appendix A for the entities responsible for implementing source controls and treatment BMPs in this subwatershed.

Table 86. Priority Actions for Rice Creek Subwatershed

Priority Timeframe[1]	Action	Estimated Effectiveness of Practice[2] (up to)	Estimated Magnitude in Watershed	Implementation Cost[3]
High	Identify and map potential bacteria hotspots Monitoring			Staff time
High	Update and enforce pet waste ordinances Litter and Animal Waste Control		~38,000 acres developed land	Staff time
High	Direct flow pathways between contributing areas to infiltration/treatment basins or away from impervious areas to prevent direct pathway to receiving waters.			
High	Develop, implement, and enforce a program to detect and eliminate illicit discharges			
Medium	Inspect/ monitor stormwater outfalls to reduce dry weather flow (i.e. conditions that promote bacteria growth) Monitoring			Staff time
Medium	Install Filtration/Biofiltration BMPs where feasible Filtration/ Biofiltration	35%		$8,000-20,000/ac
Low	Determine if septic systems are located in priority subwatershed areas (identified through mapping efforts) and if onsite inspections are warranted. It is recommended to work with county staff as necessary to identify imminent threats. Make sure all systems that are imminent threats are brought into compliance. Septic (SSTS) Maintenance	100%	~ 400 systems	$200-300 (inspection) $7,500 per system (if replacement required)

Priority Timeframe[1]	Action	Estimated Effectiveness of Practice[2] (up to)	Estimated Magnitude in Watershed	Implementation Cost[3]
Low	Install buffers or other applicable BMPs near waterbodies Filter Strips	91%	~28 acres (assume 5.75 miles of stream; 20ft buffer)	$600-1,000/acre of buffer

[1] Priority is based on recommended timeframe to continue or start (not complete) implementation activities: High = 1-2 years, Medium = 2-5 years, Low = 5-10 years.
[2] Estimated effectiveness of practice refers to the reduction of bacteria concentrations in runoff to receiving waterbodies.
[3] Costs based on NRCS EQIP Payment Schedules
http://www.nrcs.usda.gov/wps/portal/nrcs/detail/mn/programs/financial/?cid=stelprdb1245512
[4] Consult with PCA staff on whether a given action can be applied towards your individual MS4 Permit.

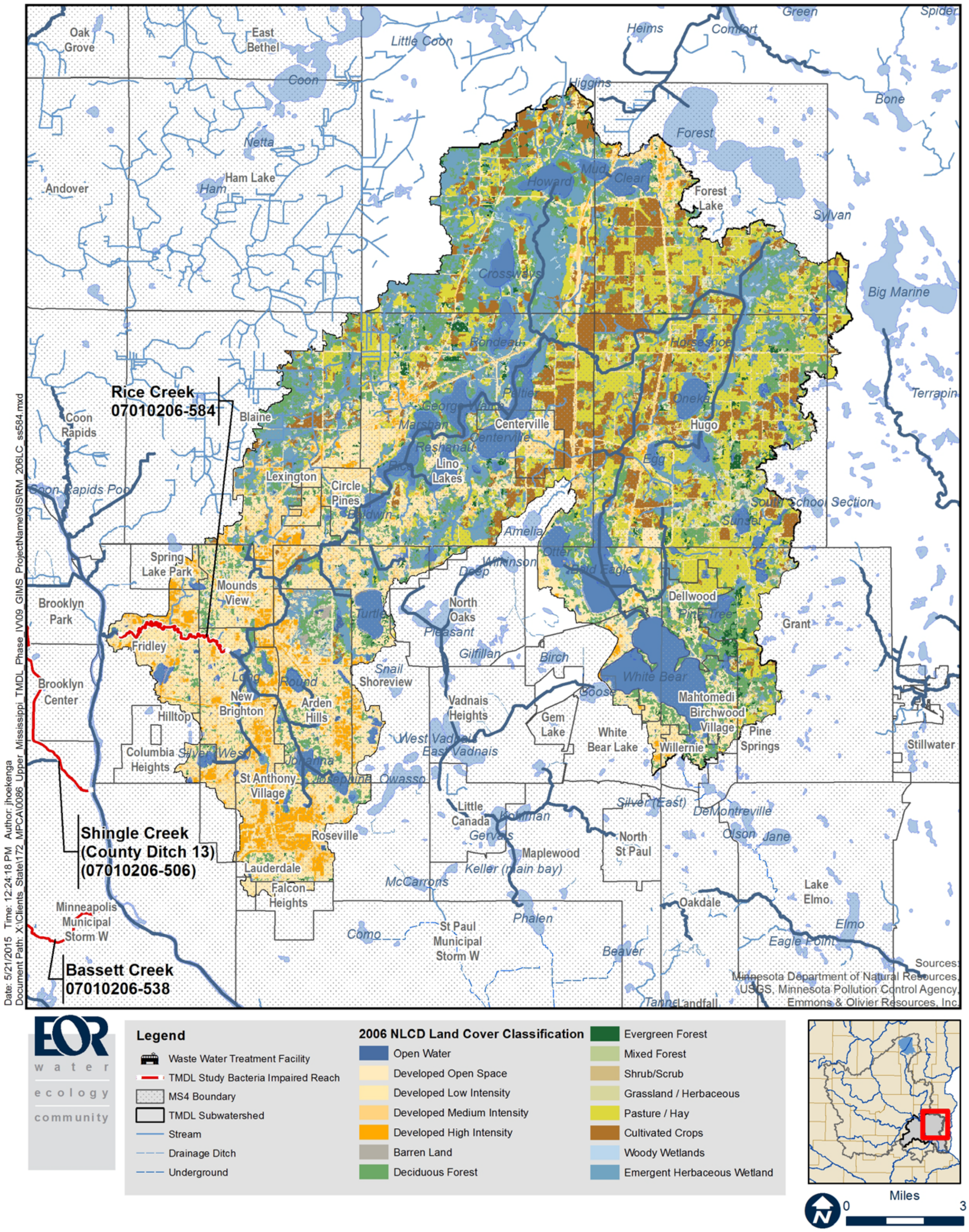

Figure 56. Land use cover in Rice Creek Subwatershed

Monitoring Plan

Monitoring will be partially accomplished through the MPCA Intensive Watershed Monitoring (IWM) approach which consists of a ten year cycle for assessing the waters of Minnesota. The steps of the approach include; monitoring waterbodies, assessment of the data to determine if waterbodies meet State water quality standards, and developing Total Maximum Daily Load studies and Watershed Restoration and Protection Strategy reports to assist implementation efforts. The monitoring is conducted by a combination of local, state and federal agencies and citizens. The entire process will be repeated every 10 years for each major watershed. Specifically as it relates to the TMDL and this Implementation Plan, the following major watersheds will be monitored in the years indicated; the Mississippi River–Twin Cities Watershed, 2020-2021, the Mississippi River–St. Cloud Watershed, 2019-2020, and the Mississippi River– Sartell Watershed, 2016-2017. Note that during the 2013-14 monitoring seasons, the MPCA also monitored *E. coli* in the Mississippi River from its headwaters in Itasca State Park down to St. Anthony Falls in Minneapolis with partners as part of this statewide process. New impairments for aquatic recreation due to high E. coli concentrations that are found during this monitoring will be incorporated into future TMDL and Watershed Restoration and Protection Strategy (WRAPS) documents.

In addition to the monitoring done in conjunction with the MPCA's IWM approach, it is anticipated that a significant amount of monitoring will be done by the local partners. Some of these partners have conducted *E. coli* and flow monitoring in the past and are likely to continue to monitor the resources that are of local importance. Note that Met Council is also very involved in monitoring efforts for some waterbodies in the Twin Cities Metro Area.

Protocols for *E. coli* sample collection

MPCA recommends following the statewide sampling protocols and guidelines that have already been established for monitoring *E. coli* in streams (*Guidance Manual for Assessing the Quality of Minnesota Surface Waters for Determination of Impairment: 305(b) Report and 303(d) List* available at http://www.pca.state.mn.us/publications/wq-iw1-04.pdf).

Field and Laboratory Analyses

The laboratory methods approved by the United States Environmental Protection Agency (EPA) and MPCA for analyzing water samples for *E. coli* can be found in Appendix D of the *Volunteer Service Monitoring Guide* found at http://www.pca.state.mn.us/water/monitoring-guide.html. In addition, a list of MDH certified laboratories can be found at https://apps.health.state.mn.us/eldo/public/accreditedlabs/labsearch.seam.

Reporting

All *E. coli* data (and other associated water quality data) should be submitted to EQuIS (http://www.pca.state.mn.us/xpc8yqd) within one year of data collection. Flow data collection should be coordinated with MPCA and the Minnesota Department of Natural Resources (DNR) in order to be submitted to the DNR and made available on the DNR/MPCA Cooperative Stream Gaging Website (http://www.dnr.state.mn.us/waters/csg/index.html).

Frequency of sampling

Monitoring related to assessment of aquatic recreation use in streams/rivers is ideally recommended at least 5 times per month between April 1 and October 31 over multiple years. Where resources are limited, monitoring should occur at least 2-3 times per month for at least 3 months over a two year period. The 3 months to target should be between June and September, as these months generally show the highest bacteria levels, or also include the months that have shown the highest *E.coli* levels in the past. There should be at least a total of 15 observations over a two year period in the most recent 10 years. This monitoring should focus on each impaired stream/river reach that has an assigned AUID, but could also occur in reaches that are not impaired. Monitoring to help identify potential bacteria sources is recommended in multiple locations along a stream or river reach during the same day to capture differences in subwatersheds drainages.

Timing of sampling

Compliance to standards for monitoring should include sampling over low, average, and high stream flow conditions, as feasible. However these samples should not be biased by a certain season or flow condition. It is best to sample the same locations at the same time every year.

Sampling of stormwater systems during low flow periods, i.e. during dry weather can help to identify illicit discharges, including sanitary sewer discharges into the system.

Location of Sampling

Local monitoring efforts should focus on determining hot-spots of bacteria loading, i.e. downstream of likely sources such as feedlots or dog parks and on effectiveness of BMPs. In this way monitoring can be used to refine the implementation actions that are most appropriate.

Implementation Priorities and Schedule

As discussed above, various approaches to implementation are needed to address the variety of bacteria sources in the *Upper Mississippi River Bacteria TMDL Study and Protection Plan*.

Water quality standards for *E. coli* need to be met through implementation of BMPs that reduce bacteria loading. Reducing the major bacteria sources in each subwatershed are a key initial focus for implementation. Adaptive management will be used to refine strategies during the implementation process. In addition, bacteria reduction should be considered when designing BMPs for other purposes.

It is difficult to determine the schedule for the impaired streams to meet State water quality standards. Impaired streams that require up to a 50% reduction in bacteria loading could take more than 10 years to meet state water quality standards for *E. coli*. Impaired streams requiring more than a 50% reduction in bacteria loading could take more than 20 years of implementation efforts to meet water quality standards.

Other Monitoring Activities

Beyond the traditional water quality monitoring of streams and stormwater conveyances other monitoring activities should be done to identify bacteria loading issues. Many of these activities are described in Illicit Discharge Detection and Elimination: A Guidance Manual for Program Development and Technical Assessments, Center for Watershed Protection, http://cwp.org/online-watershed-library/cat_view/64-manuals-and-plans/79-illicit-discharge-detection-and-elimination.

Priority should also be given to identifying and mapping potential and known sources that are directly contributing bacteria to waterbodies using local knowledge, windshield surveys, and interviews with landowners, etc. Note that mapping sources is a distinct activity from monitoring.

Interim Milestones

The overall goal is for the streams in this project to meet water quality standards for *E. coli* in order to reduce the risk from illnesses from recreating in these waterbodies. In the interim, progress will be measured by the number of BMPs installed to reduce bacteria to these streams and data that shows positive trends for water quality. Progress can also be measured by efforts to monitor streams and conduct dry weather inspections of stormwater conveyances, adoption of pet waste ordinance, education outreach campaigns addressing wildlife feeding, etc.

Additional Research Needs

Some agricultural and urban stormwater BMPs have been shown to reduce bacterial loads to receiving waters by (a) reducing bacteria concentrations in discharged water, or (b) reducing total water discharge along with the associated bacterial load. Media filters and bioretention cells show promise in removing bacteria at the site-level. Nonetheless, other BMPs (even of the same type) may be ineffective or even contribute to increased bacteria concentrations in discharges. Analysis of site specific conditions reported in the literature and field studies may aid in the identification of factors that affect BMPs performance variability. Further performance assessments and field studies are needed for all BMP types to develop and refine bacteria removal performance estimates, to characterize bacteria fate and transport, and to define effective treatment processes. Ponds are especially variable, and research on retrofits that may effectively remove bacteria are important. Likewise, some amendments to sand filters and certain components of biofiltration BMPs may be effective for removal of bacteria and merit further study. It is important to use statistical methods of hypothesis testing and grouping/trend analysis to reinforce interpretations.[3]

Because of the widely variable results reported for bacteria in stormwater and for bacterial removal within a given BMP type, computer modeling should be undertaken with caution and incorporate significant variability in bacteria concentrations, loads, and removal in both untreated runoff (BMP influent) and treated stormwater (BMP effluent). Highly uncertain predictions for pathogen and indicator concentrations and fluxes have been reported when applying conventional water quality models to pathogen and fecal indicator transport.[1] Models should be kept simple, with results not reported in unrealistically precise terms.

Some recommended design elements for research on bacteria in stormwater include:[2,3]

- Inclusion of a greater numbers of storm events and within-storm samples, and analyses for EPAs currently recommended fecal indicator bacteria, in a range of geographical, climatic, and hydraulic conditions
    - To further develop statistically robust characterizations for all BMP types
    - To assess the effects of sediment resuspension on bacteria concentrations in effluent, including the relationship between total suspended solids (TSS) and bacteria
- Paired watershed studies of non-structural BMP practices such as pet waste controls, urban wildlife management programs, storm sewer cleaning, etc., could help to target source controls that are most effective in urban watersheds
- Assessments of BMP amendments such as iron, copper, and granular activated carbon (GAC) should be conducted to develop precise performance ranges for planning and modeling
- Continued studies to elucidate fate and transport topics such as the relationship between bacteria and grain sizes, nutrients, biofilms, and other factors
- Analysis of samples for EPAs relevant Ambient Water Quality Criteria using the most current analytical methods (e.g., advanced microbial methods such as qPCR).[2]

Stormwater Projects

A list of potential funding sources for stormwater projects can be found in the Minnesota Stormwater Manual. http://stormwater.pca.state.mn.us/index.php/Funding. The Legislative-Citizen Commission on Minnesota Resources (LCCMR) is another potential source for funding stormwater research projects. http://www.lccmr.leg.mn/funding_process/process_main.html

Note that this is not a comprehensive list of funding sources for stormwater research activities.

1. *Report Of The Experts Scientific Workshop On Critical Research Needs For The Development Of New Or Revised Recreational Water Quality Criteria*; US EPA: Warrenton, Virginia, 2007; http://water.epa.gov/scitech/swguidance/standards/criteria/health/recreation/upload/2007_06_26_criteria_recreation_experts_expertsWorkshop.pdf
2. Leisenring, M. L., Clary, J., and Hobson, P., International Stormwater BMP Database Pollutant Category Statistical Summary Report: Solids, Bacteria, Nutrients, and Metals. *International Stormwater BMP Database* 2014.34.
3. Clary, J., Jones, J., Urbonas, B., Quigley, M., Strecker, E., and Wagner, T., Can stormwater BMPs remove bacteria? New findings from the international stormwater BMP database. *Stormwater* 2008, *9.*

Outreach and Education

Outreach and educational efforts provide landowners with the resources they need to comply with ordinances and best management practices that maintain or improve water quality. An important aspect of this work is ensuring that there is adequate technical staff available to assist landowners and the public with reducing sources of bacterial contamination. Also, we recommend that LGUs allocate resources towards the production of educational materials and programs, such as demonstration sites and producer to producer mentoring programs.

Education

Education efforts focus on bringing greater awareness to the issues surrounding bacterial contamination and methods to reduce loading and transport of bacteria. Education efforts targeted to the general public are commonly used to provide information on the status of impacted waterways and address urban and rural sources of bacterial contamination. Education efforts may emphasize aspects such as cleaning up pet waste or managing the landscape to discourage nuisance congregations of wildlife and waterfowl. Education can also be targeted to municipalities, land managers, producers, and other groups who play a key role in the management of bacteria sources. LGUs are encouraged to refer to the priority areas mapped for each subwatershed when planning education and outreach efforts.

Urban Education

In urban areas, residents should be provided education on sources of bacterial contamination in urban stormwater, and how urban stormwater affects local water quality. For example, education should focus on reducing bacterial sources from pet and wildlife waste. Providing guidelines to reduce bacterial contamination in urban settings should include:

- Pet waste collection on/near impervious surfaces, in dog parks, and within riparian areas;
- Bans on feeding wildlife, especially in riparian areas; and
- Methods to deter wildlife from congregating on/near waterbodies and stormwater outfalls.

Rural Education

Sources of bacterial contamination in waterbodies in rural areas are most often due to livestock production (including feedlot and pasture management), manure and septage management, and failing septic systems. LGUs should provide training and educational materials to producers and landowners on the importance of reducing bacterial contamination in waterbodies from these sources. Some examples of educational topics are listed below.

- Ensure livestock producers are aware of all feedlot rules and laws.
- Provide environmentally sound and economically beneficial grazing practices in riparian areas.
- Encourage producers to work with grazing specialists on feedlot/pasture management and manure management.
- Provide information on and encourage the use of agricultural BMPs, such as buffer strips and fencing around riparian areas.
- Provide education on how to maintain SSTS, as well as inspect for or detect leaks.

Demonstration Sites

Demonstration sites are established by LGUs, landowners/producers, or agencies to demonstrate the performance of various urban and rural stormwater and best management practices. Hold field days to show demonstration sites to land managers, landowners, producers, and residents.

Funding Sources for Implementation Efforts

Below is a list of federal and state agencies with respective grants and other programs for funding water quality improvement projects and research. These agencies and programs are potential funding sources for landowners, producers, and LGUs. Links to the agency website or funding program are provided.

U.S. Department of Agriculture – Natural Resources Conservation Service (NRCS)

EQIP

The Environmental Quality Incentives Program (EQIP) is a voluntary program that provides financial and technical assistance to agricultural producers through contracts up to a maximum term of ten years in length. These contracts provide financial assistance to help plan and implement conservation practices that address natural resource concerns and for opportunities to improve soil, water, plant, animal, air and related resources on agricultural land and non-industrial private forestland. In addition, a purpose of EQIP is to help producers meet Federal, State, Tribal and local environmental regulations.

http://www.nrcs.usda.gov/wps/portal/nrcs/detail/mn/programs/financial/?cid=nrcs142p2_023506

Minnesota Department of Agriculture

AgBMP Loan Program

The AgBMP Loan Program provides low interest loans to farmers, rural landowners, and agriculture supply businesses to solve water quality problems. The program encourages implementation of Best Management Practices that prevent or reduce pollution problems, such as runoff from feedlots; erosion from farm fields and shoreline; and noncompliant septic systems and wells.

website at http://www.mda.state.mn.us/agbmploans

Conservation Funding Guide

The Conservation Funding Guide is a one-step tool Minnesota producers and landowners can use to learn about conservation practices, programs, and payments.

http://www.mda.state.mn.us/protecting/conservation/funding.aspx

Minnesota Pollution Control Agency

Section 319 Grants

Federal grant funding from the EPA as part of the Clean Water Act, Section 319. Grants awarded by MPCA to LGUs and other groups are to address nonpoint source pollution through implementation projects for waterbodies with approved TMDLs.

http://www.pca.state.mn.us/jsrib38

Clean Water Partnership

The state funded Clean Water Partnership Program awards grants and loans to local government units (LGUs) and other groups for work on projects that address nonpoint source pollution.

http://www.pca.state.mn.us/aj0rb37

Public Facilities Authority (PFA)

Wastewater and Stormwater Financial Assistance

Grants and loans are available to cities, counties, townships, and sanitary districts for assistance with wastewater and stormwater projects to meet TMDLs and SSTS.

http://www.pca.state.mn.us/tchyb21

Board of Soil and Water Resources

Clean Water Fund Grants

The Clean Water Fund was established with the purpose of protecting, enhancing, and restoring water quality in lakes, rivers, and streams in addition to protecting groundwater and drinking water sources from degradation. Below is a list of Clean Water Fund Programs available through BWSR.

http://www.bwsr.state.mn.us/cleanwaterfund/index.html

BWSR Projects and Practices

This grant program makes an investment in on-the-ground projects and practices that will protect or restore water quality in lakes, rivers or streams, or will protect groundwater or drinking water. Examples include stormwater practices, agricultural conservation, livestock waste management, lakeshore and stream bank stabilization, stream restoration, and SSTS upgrades.

BWSR Accelerated Implementation

Before on-the-ground clean water projects get implemented, there is the need for pre-project identification, planning and design. This grant invests in building capacity for local governments to accelerate on-the-ground projects that improve or protect water quality and perform above and beyond existing standards. Whether it is conducting inventories of potential pollutant sites, developing and using analytical targeting tools, providing technical assistance or increasing citizen interaction, local governments will be better prepared to increase the installation of water quality projects and practices after receiving these grants.

BWSR Community Partners

Everyone is responsible for making sure Minnesota's waters are clean. These sub-grant funds leverage the interest of non-governmental partners such as faith organizations, lake and river associations, boy/girl scout troops, and other civic groups, to install on-the ground projects that reduce runoff and keep water on the land. Examples include: rain gardens and shoreline restorations.

Buffer Initiatives

The buffer initiative relies on federal, state, and local financial and technical assistance options for landowners to implement buffers. The buffer initiative includes programs sponsored by:

The Farm Service Agency

- General Conservation Reserve Program (CRP)
- Continuous Conservation Reserve Program (CCRP)

Natural Resources Conservation Service (NRCS)

- Environmental Quality Incentives Program (EQIP)
- Conservation Stewardship Program (CSP)
- Agricultural Conservation Easement Program (ACEP)

U.S. Fish and Wildlife Service (USFWS)

- Partners for Fish & Wildlife Program

Board of Water and Soil Resources

- Reinvest In Minnesota Reserve Program
- Conservation Cost-Share Program

http://bwsr.state.mn.us/buffers/assets/lo-financial-options.pdf

State Cost-Share Program

The Erosion Control and Water Management Program, commonly known as the State Cost-Share Program, was created to provide funds to Soil and Water Conservation Districts to share the cost of systems or practices for erosion control, sedimentation control, or water quality improvements that are designed to protect and improve soil and water resources. Through the State Cost-Share Program, land occupiers can request financial and technical assistance from their local District for the implementation of conservation practices.

http://www.bwsr.state.mn.us/cs/index.html

Watershed Organizations and Soil & Water Conservation Districts

Several Watershed Districts, Watershed Management Organizations and Soil & Water Conservation Districts are located in the area. Many of these organizations have cost-share programs that help fund BMP implementation efforts. These organizations can also provide technical assistance in evaluating appropriate locations for BMPs, perform monitoring and collaborate on watershed management projects with their community partners.

Other Funding Sources

There are other potential sources of funding, such as private organizations that could be available for activities related to improving habitat and water quality.

Ducks Unlimited

http://www.ducks.org/

Trout Unlimited

http://www.tu.org/

Pheasants Forever

https://www.pheasantsforever.org/

National Wildlife Federation

http://www.nwf.org/

SSTS Loan Programs

Low-interest loan programs are commonly available to assist landowners in upgrading subsurface sewage treatment systems. As noted, these assistance programs are typically administered at the county level. For more information on community options for water infrastructure financing, please refer to http://www.pca.state.mn.us/index.php/view-document.html?gid=17147

Appendix A: Stakeholders

Regulated Sources

Regulated sources within the project area have the primary responsibility for reducing *E. coli* concentrations in the watershed areas that drain to the impaired reaches. Each of the regulated sources has been given either an individual wasteload allocation (WLA) as is the case for wastewater treatment facilities (see Table 7.2 of the Upper Mississippi River Bacteria TMDL and Protection Plan) or a categorical WLA as is the case for MS4 permit holders.

Guidance on the appropriate practices needed within each of the subwatersheds (based on the potential bacteria sources) was described within those specific sections starting on page 23 of this Plan.

Additional Partners

In addition to the organizations that have a regulatory role in implementing the TMDL there are numerous groups that either own land within a TMDL subwatershed or are involved with land-use management. These groups have varied roles, in some cases they are the lead entity coordinating watershed management activities and in other cases they may provide technical support on conservation practices. Beyond state and local governmental entities, individual landowners will play a critical role in implementing practices to reduce bacteria concentrations in the streams of the project area. There are additional partners such as Benton County that are involved with implementation but are outside of the TMDL subwatersheds.

Table 87. List of partners involved in watershed management

Partner (Permit #)	Subwatershed(s)
Albany WWTF MN0020575	South Two River (07010201-543)
Albany City (Non-MS4)	South Two River (07010201-543)
Albany Township (Non-MS4)	Spunk Creek (07010201-525) South Two River (07010201-543)
Albertville WWTF MN0050954	Unnamed Creek (07010203-528)
Albertville City (Non-MS4)	Unnamed Creek (07010203-528)
Albion Township (Non-MSA)	Silver Creek (07010203-557)
Anoka County (MS400066)	Rice Creek (07010206-584)
Anoka Conservation District	Rice Creek (07010206-584)
Arden Hills City (MS400002)	Rice Creek (07010206-584)
Avon WWTF MN0047325	Spunk Creek (07010201-525)

Partner (Permit #)	Subwatershed(s)
Avon City (Non-MS4)	Spunk Creek (07010201-525) Watab River, North Fork (07010201-529)
Avon Township (Non-MS4)	Spunk Creek (07010201-525) Watab River, North Fork (07010201-529) County Ditch 12 (07010201-537) South Two River (07010201-543) Watab River, South Fork (07010201-554)
Bassett Creek Watershed Management Organization	Unnamed Creek (Plymouth Creek) (07010206-526) Bassett Creek (07010206-538) Unnamed Creek (North Branch, Bassett Creek) (07010206-552)
Birchwood Village City (MS400004)	Rice Creek (07010206-584)
Blaine City (MS400075)	Rice Creek (07010206-584)
Bowlus WWTF MN0020923	South Two River (07010201-543)
Bowlus City (Non-MS4)	Little Two River (07010201-516) Two River (07010201-523) South Two River (07010201-543)
Brockway Township (MS400068)	Two River (07010201-523) Spunk Creek (07010201-525) County Ditch 12 (07010201-537) County Ditch 13 (07010201-564)
Brooklyn Center City (MS400006)	Shingle Creek (County Ditch 13) (07010206-506)
Brooklyn Park City (MS400007)	Shingle Creek (County Ditch 13) (07010206-506)
Centerville City (MS400078)	Rice Creek (07010206-584)
Century College (MS400171)	Rice Creek (07010206-584)
Circle Pines City (MS400009)	Rice Creek (07010206-584)
Clearwater Township (Non-MS4)	Silver Creek (07010203-557)
Collegeville Township (Non-MS4)	Spunk Creek (07010201-525) Watab River, North Fork (07010201-529) Watab River, South Fork (07010201-554)

Partner (Permit #)	Subwatershed(s)
Columbia Heights City (MS400010)	Rice Creek (07010206-584)
Columbus Township (Non-MS4)	Rice Creek (07010206-584)
Corinna Township (Non-MS4)	Silver Creek (07010203-557)
Crystal City (MS400012)	Shingle Creek (County Ditch 13) (07010206-506) Bassett Creek (07010206-538) Unnamed Creek (North Branch, Bassett Creek) (07010206-552)
Dakota County (MS400132)	Unnamed Creek (Interstate Valley Creek) (07010206-542)
Dakota County Soil and Water Conservation District	Unnamed Creek (Interstate Valley Creek) (07010206-542)
Dellwood City (MS400084)	Rice Creek (07010206-584)
Elmdale City (Non-MS4)	Little Two River (07010201-516) South Two River (07010201-543)
Elmdale Township (Non-MS4)	Little Two River (07010201-516) South Two River (07010201-543)
Fair Haven Township (Non-MS4)	Unnamed Creek (Luxemburg Creek) (07010203-561) Plum Creek (07010203-572) Johnson Creek (Meyer Creek) 635 (07010203-635)
Falcon Heights City (MS400018)	Rice Creek (07010206-584)
Farming Township (Non-MS4)	Spunk Creek (07010201-525) South Two River (07010201-543)
Forest Lake City (MS400262)	Rice Creek (07010206-584)
Fridley City (MS400019)	Rice Creek (07010206-584)
Golden Valley City (MS400021)	Bassett Creek (07010206-538) Unnamed Creek (North Branch, Bassett Creek) (07010206-552)
Grant City (MS400091)	Rice Creek (07010206-584)
Grey Eagle Township (Non-MS4)	South Two River (07010201-543)
Hennepin County (MS400138)	Shingle Creek (County Ditch 13) (07010206-506) Unnamed Creek (Plymouth Creek) (07010206-526)

Partner (Permit #)	Subwatershed(s)
	Bassett Creek (07010206-538) Unnamed Creek (North Branch, Bassett Creek) (07010206-552) Rice Creek (07010206-584)
Hennepin Conservation District	Shingle Creek (County Ditch 13) (07010206-506) Unnamed Creek (Plymouth Creek) (07010206-526) Bassett Creek (07010206-538) Unnamed Creek (North Branch, Bassett Creek) (07010206-552) Rice Creek (07010206-584)
Hennepin Technical College Brooklyn Park (MS400198)	Shingle Creek (County Ditch 13) (07010206-506)
Holding Township (Non-MS4)	Two River (07010201-523) Spunk Creek (07010201-525) South Two River (07010201-543)
Holdingford WWTF MN0023710	South Two River (07010201-543)
Holdingford City (Non-MS4)	South Two River (07010201-543)
Hugo City (MS400094)	Rice Creek (07010206-584)
Inver Grove Heights City (MS400096)	Unnamed Creek (Interstate Valley Creek) (07010206-542)
Krain Township (Non-MS4)	South Two River (07010201-543)
Lauderdale City (MS400026)	Rice Creek (07010206-584)
Le Sauk Township (MS400143)	Watab River (07010201-528) County Ditch 13 (07010201-564)
Lexington City (MS400027)	Rice Creek (07010206-584)
Lilydale City (MS400028)	Unnamed Creek (Interstate Valley Creek) (07010206-542)
Lino Lakes City (MS400100)	Rice Creek (07010206-584)
Lower Mississippi River Watershed Management Organization	Unnamed Creek (Interstate Valley Creek) (07010206-542)
Lynden Township (Non-MS4)	Plum Creek (07010203-572) Johnson Creek (Meyer Creek) 635 (07010203-635)
Mahtomedi City (MS400031)	Rice Creek (07010206-584)

Partner (Permit #)	Subwatershed(s)
Maine Prairie Township (Non-MS4)	Unnamed Creek (Luxemburg Creek) (07010203-561) Johnson Creek (Meyer Creek) 639 (07010203-639)
Maple Grove City (MS400102)	Shingle Creek (County Ditch 13) (07010206-506)
Maple Lake City (Non-MS4)	Silver Creek (07010203-557)
Maple Lake Township (Non-MS4)	Silver Creek (07010203-557)
May Township (Non-MS4)	Rice Creek (07010206-584)
Medicine Lake City (MS400104)	Bassett Creek (07010206-538)
Mendota Heights City (MS400034)	Unnamed Creek (Interstate Valley Creek) (07010206-542)
Millwood Township (Non-MS4)	South Two River (07010201-543)
Minneapolis Municipal Storm Water (MN0061018)	Shingle Creek (County Ditch 13) (07010206-506) Bassett Creek (07010206-538) Rice Creek (07010206-584)
Minnesota Correctional-Lino Lakes (MS400177)	Rice Creek (07010206-584)
Minnetonka City (MS400035)	Unnamed Creek (Plymouth Creek) (07010206-526) Bassett Creek (07010206-538)
MnDOT Metro District (MS400170)	Shingle Creek (County Ditch 13) (07010206-506) Unnamed Creek (Plymouth Creek) (07010206-526) Bassett Creek (07010206-538) Unnamed Creek (North Branch, Bassett Creek) (07010206-552) Rice Creek (07010206-584) Unnamed Creek (Interstate Valley Creek) (07010206-542)
MnDOT Outstate District (MS400180)	Unnamed Creek (Robinson Hill Creek) (07010203-724)
Monticello Township (Non-MS4)	Unnamed Creek (07010203-528)
Morrison County	Little Two River (07010201-516) Two River (07010201-523) Spunk Creek (07010201-525) South Two River (07010201-543)
Morrison County Soil and Water	Little Two River (07010201-516)

Partner (Permit #)	Subwatershed(s)
Conservation District	Two River (07010201-523) Spunk Creek (07010201-525) South Two River (07010201-543)
Mounds View City (MS400037)	Rice Creek (07010206-584)
New Brighton City (MS400038)	Rice Creek (07010206-584)
New Hope City (MS400039)	Shingle Creek (County Ditch 13) (07010206-506) Bassett Creek (07010206-538) Unnamed Creek (North Branch, Bassett Creek) (07010206-552)
New Scandia Township (Non-MS4)	Rice Creek (07010206-584)
North Hennepin Community College (MS400205)	Shingle Creek (County Ditch 13) (07010206-506)
North Oaks City (MS400109)	Rice Creek (07010206-584)
Oak Township (Non-MS4)	South Two River (07010201-543)
Order of St. Benedict WWTF MN0022411	Watab River, North Fork (07010201-529)
Osseo City (MS400043)	Shingle Creek (County Ditch 13) (07010206-506)
Otsego City (MS400243)	Unnamed Creek (07010203-528)
Otsego Township (Non-MS4)	Unnamed Creek (07010203-528)
Otsego West WWTF MN0066257	Unnamed Creek (07010203-528)
Pleasant Lake City (Non-MS4)	Unnamed Creek (Robinson Hill Creek) (07010203-724)
Plymouth City (MS400112)	Shingle Creek (County Ditch 13) (07010206-506) Unnamed Creek (Plymouth Creek) (07010206-526) Bassett Creek (07010206-538) Unnamed Creek (North Branch, Bassett Creek) (07010206-552)
Ramsey County Public Works (MS400191)	Rice Creek (07010206-584)
Ramsey Conservation District	Rice Creek (07010206-584)
Rice Creek Watershed District	Rice Creek (07010206-584)
Robbinsdale City (MS400046)	Shingle Creek (County Ditch 13) (07010206-506) Bassett Creek (07010206-538)

Partner (Permit #)	Subwatershed(s)
Rockville Township (Non-MS4)	Watab River, South Fork (07010201-554) Unnamed Creek (Luxemburg Creek) (07010203-561) Unnamed Creek (Robinson Hill Creek) (07010203-724)
Roseville City (MS400047)	Rice Creek (07010206-584)
Sartell City (MS400048)	Watab River (07010201-528) County Ditch 13 (07010201-564)
Sauk River Watershed District	Watab River, South Fork (07010201-554) Watab River (07010201-528) Unnamed Creek (Luxemburg Creek) (07010203-561) Unnamed Creek (Robinson Hill Creek) (07010203-724)
Shingle Creek Watershed Management Organization	Shingle Creek (County Ditch 13) (07010206-506)
Shoreview City (MS400121)	Rice Creek (07010206-584)
Silver Creek Township (Non-MS4)	Silver Creek (07010203-557)
South Two Rivers Watershed District	Two River (07010201-523) South Two River (07010201-543)
Spring Lake Park City (MS400050)	Rice Creek (07010206-584)
St. Anthony City (Non-MS4)	South Two River (07010201-543) Unnamed Creek (Luxemburg Creek) (07010203-561) Plum Creek (07010203-572) Johnson Creek (Meyer Creek) 635 (07010203-635) Johnson Creek (Meyer Creek) 639 (07010203-639) Unnamed Creek (Robinson Hill Creek) (07010203-724)
St Anthony Village City (MS400051)	Rice Creek (07010206-584)
St Cloud City (MS400052)	Watab River (07010201-528) Plum Creek (07010203-572) Johnson Creek (Meyer Creek) 635 (07010203-635) Unnamed Creek (Robinson Hill Creek) (07010203-724)
St Joseph City (MS400125)	Watab River (07010201-528) Watab River, South Fork (07010201-554)

Partner (Permit #)	Subwatershed(s)
St Joseph Township (MS400157)	Watab River (07010201-528) Watab River, South Fork (07010201-554) Watab River, North Fork (07010201-529)
St Louis Park City (MS400053)	Bassett Creek (07010206-538)
St. Martin Township (Non-MS4)	South Two River (07010201-543)
St Michael City (MS400246)	Unnamed Creek (07010203-528)
St. Stephen City (Non-MS4)	County Ditch 12 (07010201-537) County Ditch 13 (07010201-564)
St. Wendel Township (Non-MS4)	Spunk Creek (07010201-525) Watab River (07010201-528) Watab River, North Fork (07010201-529) County Ditch 12 (07010201-537) County Ditch 13 (07010201-564)
Stearns County (MS400159)	Watab River (07010201-528) Watab River, South Fork (07010201-554) Unnamed Creek (Robinson Hill Creek) (07010203-724)
Stearns County Soil and Water Conservation District	South Two River (07010201-543) Two River (07010201-523) Spunk Creek (07010201-525) Watab River (07010201-528) Watab River, North Fork (07010201-529) County Ditch 12 (07010201-537) Watab River, South Fork (07010201-554) County Ditch 13 (07010201-564) Unnamed Creek (Luxemburg Creek) (07010203-561) Plum Creek (07010203-572) Johnson Creek (Meyer Creek) 635 (07010203-635) Johnson Creek (Meyer Creek) 639 (07010203-639) Unnamed Creek (Robinson Hill Creek) (07010203-724)
Sunfish Lake City (MS400055)	Unnamed Creek (Interstate Valley Creek) (07010206-542)

Partner (Permit #)	Subwatershed(s)
Swan River Township (Non-MS4)	Little Two River (07010201-516)
Swanville Township (Non-MS4)	Little Two River (07010201-516)
Todd County	South Two River (07010201-543)
Todd County Soil and Water Conservation District	South Two River (07010201-543)
Two Rivers Township (Non-MS4)	Little Two River (07010201-516) Two River (07010201-523) South Two River (07010201-543) Spunk Creek (07010201-525)
University of Minnesota – Twin Cities Campus (MS400212)	Rice Creek (07010206-584)
Upsala WWTF MNG580053	Little Two River (07010201-516)
Upsala City (Non-MS4)	Little Two River (07010201-516) South Two River (07010201-543)
Waite Park City (MS400127)	Unnamed Creek (Robinson Hill Creek) (07010203-724)
Wakefield Township (Non-MS4)	Watab River, South Fork (07010201-554)
Washington County (MS400160)	Rice Creek (07010206-584)
Washington Conservation District	Rice Creek (07010206-584)
West St Paul City (MS400059)	Unnamed Creek (Interstate Valley Creek) (07010206-542)
White Bear Lake City (MS400060)	Rice Creek (07010206-584)
White Bear Township (MS400163)	Rice Creek (07010206-584)
Willernie City (MS400061)	Rice Creek (07010206-584)
Wright County	Unnamed Creek (07010203-528) Silver Creek (07010203-557)
Wright County Soil and Water Conservation District	Unnamed Creek (07010203-528) Silver Creek (07010203-557)

Appendix B: Best Management Practices

Best management practices that pertain to reducing bacteria concentrations in waterbodies have been compiled in Table 88. For each BMP, a list of the pollutants addressed as well as applicability to urban and rural locations is listed. Several links to additional sources of information for each BMP is also provided.

Table 88. BMPS for reducing bacteria concentrations in waterbodies.

BMP	Pollutant	Location	Links
Source Control BMPs			
Land application w/ incorporation	Bacteria, Nutrients, TSS	Rural	Applying Manure in Sensitive Areas, MPCA, NRCS http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs143_014819.pdf Effectiveness of Best Management Practices for Bacteria Removal Developed for the Upper Mississippi River Bacteria TMDL, MPCA http://www.pca.state.mn.us/index.php/view-document.html?gid=16328 Feedlots – Nutrient and Manure Management, MPCA http://www.pca.state.mn.us/index.php/topics/feedlots/feedlot-nutrient-and-manure-management.html Swine Manure Application Timing: Results of Experiments in Southern Minnesota, U of M Extension http://www.extension.umn.edu/agriculture/manure-management-and-air-quality/manure-application/docs/manure-timing.pdf

BMP	Pollutant	Location	Links
Litter and Animal Waste Control	Bacteria, Nutrients	Rural/urban	Minnesota Stormwater Manual: Pollution Prevention, MPCA http://stormwater.pca.state.mn.us/index.php/Pollution_prevention Better Site Designs http://stormwater.pca.state.mn.us/index.php/Better_site_design
Livestock Stream Access Control	Bacteria, Nutrients, TSS	Rural	Effectiveness of Best Management Practices for Bacteria Removal Developed for the Upper Mississippi River Bacteria TMDL, MPCA http://www.pca.state.mn.us/index.php/view-document.html?gid=16328 The Agricultural BMP Handbook for Minnesota: Livestock Exclusion/Fencing (p. 45), MDA http://www.eorinc.com/documents/AG-BMPHandbookforMN_09_2012.pdf
Manure Management	Bacteria, Nutrients	Rural	Applying Manure in Sensitive Areas, MPCA, NRCS http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs143_014819.pdf Feedlots – Nutrient and Manure Management, MPCA http://www.pca.state.mn.us/index.php/topics/feedlots/feedlot-nutrient-and-manure-management.html Best management practices for pathogen control in manure management systems, U of M Extension http://www.extension.umn.edu/agriculture/manure-management-and-air-quality/manure-pathogens/best-management-practices/

BMP	Pollutant	Location	Links
Monitoring	Bacteria, Nutrients, TSS	Rural/urban	Minnesota Stormwater Manual: Pollution Prevention, MPCA http://stormwater.pca.state.mn.us/index.php/Pollution_prevention
Septic (SSTS) Maintenance	Bacteria, Nutrients	Rural/urban	Minnesota Stormwater Manual: Pollution Prevention, MPCA http://stormwater.pca.state.mn.us/index.php/Pollution_prevention
Septage	Bacteria, Nutrients	Rural	MPCA Septage Removal and Disposal http://www.pca.state.mn.us/index.php/water/water-types-and-programs/subsurface-sewage-treatment-system-ssts/septage-removal-and-disposal.html EPA Title 40, Part 503 http://yosemite.epa.gov/r10/water.nsf/NPDES%2BPermits/Sewage%2BS825/$FILE/503-032007.pdf
Storm sewer and Sanitary sewer Maintenance	Bacteria, Nutrients	Rural/urban	Minnesota Stormwater Manual: Pollution Prevention, MPCA http://stormwater.pca.state.mn.us/index.php/Pollution_prevention
Wastewater System Maintenance	Bacteria, Nutrients, TSS	Rural/urban	Minnesota Stormwater Manual: Pollution Prevention, MPCA http://stormwater.pca.state.mn.us/index.php/Pollution_prevention
Wildlife Control	Bacteria, Nutrients	Rural/urban	Minnesota Stormwater Manual: Pollution Prevention, MPCA http://stormwater.pca.state.mn.us/index.php/Pollution_prevention
Avoidance BMPs			
Feedlot Runoff Control	Bacteria, Nutrients, TSS	Rural	Best Management Practices for Pathogen Control in Manure Management Systems, U of M Extension http://www.extension.umn.edu/agriculture/manure-management-and-air-quality/manure-pathogens/best-management-practices/ The Agricultural BMP Handbook for Minnesota: Feedlot Runoff Control (p. 121), MDA http://www.eorinc.com/documents/AG-BMPHandbookforMN_09_2012.pdf MDA Conservation Practices Feedlot Runoff Control System http://www.mda.state.mn.us/protecting/conservation/practices/feedlotrunoff.aspx

BMP	Pollutant	Location	Links
Filter Strips	Bacteria, Nutrients, TSS	Rural/urban	The Agricultural BMP Handbook for Minnesota: Filter Strips and Field Borders (p. 125), MDA http://www.eorinc.com/documents/AG-BMPHandbookforMN_09_2012.pdf BMP Effectiveness for Nutrients, Bacteria, Solids, Metals, and Runoff Volume, Stormwater Journal http://www.stormh2o.com/SW/Articles/BMP_Effectiveness_for_Nutrients_Bacteria_Solids_Me_16214.aspx Effectiveness of Best Management Practices for Bacteria Removal Developed for the Upper Mississippi River Bacteria TMDL, MPCA http://www.pca.state.mn.us/index.php/view-document.html?gid=16328
Treatment BMPs			
Filtration/ Biofiltration	Bacteria, Nutrients, TSS	Rural/urban	BMP Effectiveness for Nutrients, Bacteria, Solids, Metals, and Runoff Volume, Stormwater Journal http://www.stormh2o.com/SW/Articles/BMP_Effectiveness_for_Nutrients_Bacteria_Solids_Me_16214.aspx Effectiveness of Best Management Practices for Bacteria Removal Developed for the Upper Mississippi River Bacteria TMDL, MPCA http://www.pca.state.mn.us/index.php/view-document.html?gid=16328 Minnesota Stormwater Manual: Bioretention, MPCA http://stormwater.pca.state.mn.us/index.php/Bioretention International Stormwater Best Management Practices (BMP) Database Pollutant Category Summary Statistical Addendum: TSS, Bacteria, Nutrients, and Metals http://www.bmpdatabase.org/Docs/2012%20Water%20Quality%20Analysis%20Addendum/BMP%20Database%20Categorical_SummaryAddendumReport_Final.pdf
Constructed Wetlands	Bacteria, Nutrients, TSS	Rural/urban	The Agricultural BMP Handbook for Minnesota: Constructed Wetlands (p.146), MDA http://www.eorinc.com/documents/AG-BMPHandbookforMN_09_2012.pdf Effectiveness of Best Management Practices for Bacteria Removal Developed for the Upper Mississippi River Bacteria TMDL, MPCA http://www.pca.state.mn.us/index.php/view-document.html?gid=16328

BMP	Pollutant	Location	Links
Detention and Retention Ponds	Bacteria, Nutrients, TSS	Rural/urban	Stormwater Best Management Practices and Fecal Bacteria Reduction, City of Austin http://www.utexas.edu/law/centers/cppdr/services/Improving%20Streams%20web/HandoutsAndPresentations/Stormwater_BMPs_and_Fecal_Reduction.pdf The Agricultural BMP Handbook for Minnesota: Sediment Basins(p.134), MDA http://www.eorinc.com/documents/AG-BMPHandbookforMN_09_2012.pdf BMP Effectiveness for Nutrients, Bacteria, Solids, Metals, and Runoff Volume, Stormwater Journal http://www.stormh2o.com/SW/Articles/BMP_Effectiveness_for_Nutrients_Bacteria_Solids_Me_16214.aspx Effectiveness of Best Management Practices for Bacteria Removal Developed for the Upper Mississippi River Bacteria TMDL, MPCA http://www.pca.state.mn.us/index.php/view-document.html?gid=16328
UV Treatment	Bacteria	Rural/urban	International Stormwater Best Management Practices (BMP) Database Pollutant Category Summary: Fecal Indicator Bacteria http://www.bmpdatabase.org/Docs/BMP%20Database%20Bacteria%20Paper%20Dec%202010.pdf