Vermillion River Watershed Restoration and Protection Strategy (WRAPS) Report

Mississippi River – Lake Pepin Major Watershed

September 2015
Updated June 2017

Vermillion River watershed reflecting life

Minnesota Pollution Control Agency

CLEAN WATER LAND & LEGACY AMENDMENT

wq-ws4-14a

Project Partners

The following organizations and agencies contributed to the development of the Vermillion River Watershed Restoration and Protection Strategies document.

City of Apple Valley

City of Burnsville

City of Farmington

City of Lakeville

Dakota County Soil and Water Conservation District

Local Counties

Metropolitan Council Environmental Services

Minnesota Department of Agriculture

Minnesota Department of Natural Resources

Minnesota Department of Transportation

Minnesota Pollution Control Agency

Scott County Soil and Water Conservation District

University of Minnesota Extension Services

Vermillion River Watershed Joint Powers Organization

Wenck Associates, Inc.

*Note Regarding Legislative Charge

The science, analysis and strategy development described in this report began before accountability provisions were added to the Clean Water Legacy Act in 2013 (MS114D); thus, this report does not address all of those provisions. When this watershed is revisited (according to the 10-year cycle), the information will be updated according to the statutorily required elements of a Watershed Restoration and Protection Strategy Report.

Table of Contents

Tables

Figures

Key Terms

Assessment Unit Identifier (AUID): The unique water body identifier for each river reach comprised of the USGS eight-digit HUC plus a three-character code unique within each HUC.

Aquatic life impairment: The presence and vitality of aquatic life is indicative of the overall water quality of a stream. A stream is considered impaired for impacts to aquatic life if the fish Index of Biotic Integrity (IBI), macroinvertebrate IBI, dissolved oxygen, turbidity, or certain chemical standards are not met.

Aquatic recreation impairment: Streams are considered impaired for impacts to aquatic recreation if fecal bacteria standards are not met. Lakes are considered impaired for impacts to aquatic recreation if total phosphorus, chlorophyll-a, or Secchi disc depth standards are not met.

Aquatic consumption impairment – Lakes and streams are considered impaired based on fish tissue samples which are analyzed to determine the current levels of a chemical in the aquatic community. These impairments are based on the pollutant type (mercury, PCBs, etc.) which can be toxic to human health if ingested beyond the recommended levels. Guidelines for safe human consumption are issued by the Minnesota Department of Health for how often certain fish can be safely eaten.

Hydrologic Unit Code (HUC): A Hydrologic Unit Code (HUC) is assigned by the USGS for each watershed. HUCs are organized in a nested hierarchy by size. For example, the Mississippi River Basin is assigned a HUC-4 of 0704 and the Mississippi River – Lake Pepin Watershed is assigned a HUC-8 of 0704001.

Impairment: Water bodies are listed as impaired if water quality standards are not met for designated uses including: aquatic life, aquatic recreation, and aquatic consumption.

Index of Biotic integrity (IBI): A method for describing the condition of a waterbody using characteristics of aquatic communities, such as the types of fish and invertebrates found in the waterbody. It is expressed as a numerical value between 0 (lowest quality) to 100 (highest quality).

Pollutant: The Clean Water Act Sec. 502(6) describes a pollutant as dredged spoil, solid waste, incinerator residue, sewage, garbage, sewage sludge, munitions, chemical wastes, biological materials, radioactive materials, heat, wrecked or discarded equipment, rock, sand, cellar dirt, and industrial, municipal, and agricultural waste discharged into water. Another way of looking at is, a substance that makes land, water, air, etc., dirty and not safe or suitable to use: something that causes pollution. Example of Pollutants include: Phosphorus, Sediment, Nitrogen, and Temperature.

Protection: This term is used to characterize actions taken in watersheds of waters not known to be impaired to maintain conditions and beneficial uses of the waterbodies.

Restoration: This term is used to characterize actions taken in watersheds of impaired waters to improve conditions, eventually to meet water quality standards and achieve beneficial uses of the waterbodies.

Source (or Pollutant Source): This term is distinguished from 'stressor' to mean only those actions, places or entities that deliver/discharge pollutants (e.g., sediment, phosphorus, nitrogen, pathogens).

Stressor (or Biological Stressor): This is a broad term that includes both pollutant sources and non-pollutant sources or factors (e.g., altered hydrology, dams preventing fish passage) that adversely impact aquatic life.

Total Maximum Daily Load (TMDL): A calculation of the maximum amount of a pollutant that may be introduced into a surface water and still ensure that applicable water quality standards for that water are met. A TMDL is the sum of the wasteload allocation for point sources, a load allocation for nonpoint sources and natural background, an allocation for future growth (i.e., reserve capacity), and a margin of safety as defined in the Code of Federal Regulations.

Executive Summary

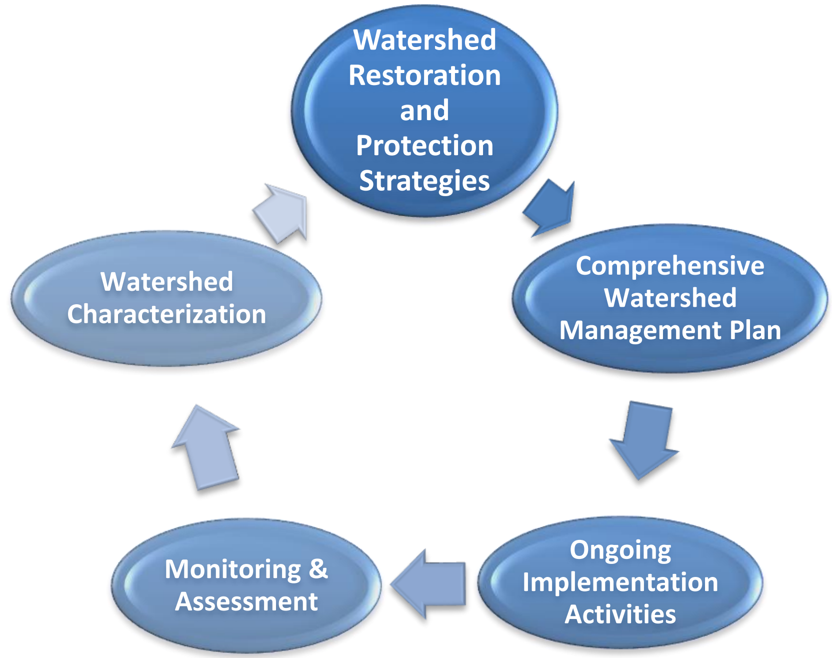
The Vermillion River Watershed, which is a subwatershed in the Mississippi River – Lake Pepin 8 digit Hydrologic Unit (HUC) is located in the Lower Mississippi River Basin. It is an approximately 364 square mile watershed in Scott, Dakota and Goodhue Counties. The watershed drains to the Vermillion River and ultimately the Mississippi River near Lock and Dam 3 northwest of Red Wing, Minnesota.

The Vermillion Watershed has one river turbidity impairment; 12 river/stream bacteria impairments; and nutrient impairments for two lakes, Alimagnet and East Lake. Agricultural runoff, stormwater runoff and stream bank erosion are having negative effects on the watershed's water quality. Agricultural and livestock activities and urban development in the watershed have resulted in runoff that carries excess phosphorus, sediment, and bacteria into bodies of water that degrades water quality and is harmful to aquatic life.

The intent of this Watershed Restoration and Protection Strategy (WRAPS) report was to develop a scientifically-based restoration and protection strategy for the Vermillion River Watershed. This WRAPS summarizes past efforts to monitor water quality, identifies impaired water bodies and those in need of protection, and identifies strategies for restoring and protecting water quality in the watershed. The strategies included in this report target point and non-point sources of pollution and include reducing streambank erosion, reducing in-lake nutrients, and improving stormwater management to help improve water quality in the watershed.

In June of 2017, this WRAPS report was updated to include additional strategies to improve the management of urban drainage, reduce sediment, and reduce runoff volume. These new strategies can be found in the strategies tables in section 3.

What is the WRAPS Report?



The State of Minnesota has adopted a "watershed approach" to address the state's 81 "major" watersheds (denoted by 8-digit hydrologic unit code or HUC). This watershed approach incorporates **water quality assessment, watershed analysis, civic engagement, planning**, **implementation**, and **measurement of results** into a 10-year cycle that addresses both restoration and protection.

As part of the watershed approach, waters not meeting state standards are still listed as impaired and Total Maximum Daily Load (TMDL) studies are performed, as they have been in the past, but in addition the watershed approach process facilitates a more cost-effective and comprehensive characterization of multiple water bodies and overall watershed health. A key aspect of this effort is to develop and utilize watershed-scale models and other tools to help state agencies, local governments and other watershed stakeholders determine how to best proceed with restoring and protecting lakes and streams. This report summarizes past assessment and diagnostic work and outlines ways to prioritize actions and strategies for continued implementation.

Purpose

- Support local working groups and jointly develop scientifically-supported restoration and protection strategies to be used for subsequent implementation planning
- Summarize Watershed Approach work done to date including the following reports:
  - *Regional TMDL Evaluation of Fecal Coliform Bacteria Impairments in the Lower Mississippi River Basin - 2006*
  - *Lower Vermillion River Watershed Turbidity TMDL - 2009*
  - *Vermillion River Watershed Monitoring and Assessment - 2012*
  - *Vermillion River Watershed Biotic Stressor Identification - 2013*
  - *Vermillion River Watershed Total Maximum Daily Load Study - 2015*

Scope

- Impacts to aquatic recreation and impacts to aquatic life in streams
- Impacts to aquatic recreation in lakes

Audience

- Local working groups (local governments, SWCDs, watershed management groups, etc.)
- State agencies (MPCA, DNR, BWSR, etc.)

1. Watershed Background & Description

The Vermillion River Watershed covers 364 square miles in portions of Dakota County (307 square miles), Goodhue County (38 square miles) and Scott County (19 square miles). The Vermillion River Watershed is a subwatershed of the Mississippi River – Lake Pepin 8-digit hydrologic unit (HUC) located in the Lower Mississippi River Basin. The headwaters of the Vermillion River lie in the southeastern corner of Scott County in an area that was historically hardwood forest. From this location the river meanders northeast a total of 28 miles, skirting the southern edge of the Twin Cities Metropolitan Area, before reaching the falls at Hastings. Below the Hastings Falls, the river splits into the Vermillion Slough, which periodically flows north a short distance to the Mississippi River and the Vermillion River that continues south for another 20 miles before draining into the Mississippi near the city of Red Wing. From the headwaters to the mouth of the Vermillion River there is a 420 foot elevation change with an abrupt 90 foot drop at the falls in Hastings.

The Vermillion River supports a naturally reproducing population of brown trout. A portion of the main stem of the upper Vermillion River and some of its tributaries, beginning in the southeast corner of Lakeville and central Eureka Township and stretching east through Farmington and Empire Township to a point just east of Highway 52 in Vermillion Township, have been designated as trout streams (class 2A waters) by the Minnesota Department of Natural Resources (DNR) (Figure 1).

The headwaters of the Vermillion River occur within the North Central Hardwood Forest (NCHF) ecoregion, but the majority of the watershed is in the Western Cornbelt Plains (WCBP) ecoregion. Well-drained, silty or loamy soils are prevalent throughout much of the watershed, resulting in high rates of infiltration in its undeveloped areas. Annual recharge of surficial aquifers in the Vermillion River Watershed has been estimated to be 6-8 inches per year or roughly 19-25% of the annual precipitation (Chapman et al. 2008).

Cropland is currently the predominant land cover in the Vermillion River Watershed, accounting for 43% of the watershed (Table 1, Figure 2). However, that percentage has been steadily declining in recent years as agricultural land is being converted to residential, commercial, and industrial development. A majority of livestock animals and feedlots are concentrated in the southern two-thirds of the watershed (Figure 3).

For the purposes of this report, the Vermillion River Watershed was subdivided into eight major subwatersheds, which include: North Creek, Middle Creek, South Creek, Upper Mainstem, South Branch, Middle Mainstem, Lower Mainstem and the Mississippi Direct.

Table 1. Land Cover in the Vermillion River Watershed.

Land Cover Category	Acres	Percent
Cropland	100,756	43%
Developed	45,556	19%
Grassland/Pasture	32,744	14%
Forest	27,597	12%

Wetlands	17,835	8%
Open Water	8,688	4%

Source: 2013 National Agriculture Statistics Service (NASS)

Additional Vermillion River Watershed Resources

Vermillion River Watershed Joint Powers Organization (VRWJPO)

Vermillion River Watershed Thermal Trading Project -VRWJPO

Vermillion River Watershed Restoration and Protection Strategy Webpage - MPCA

Mississippi River – Lake Pepin Watershed webpage - MPCA

Vermillion River Watershed Monitoring and Assessment Report - MPCA

Vermillion River Watershed Stressor Identification Report

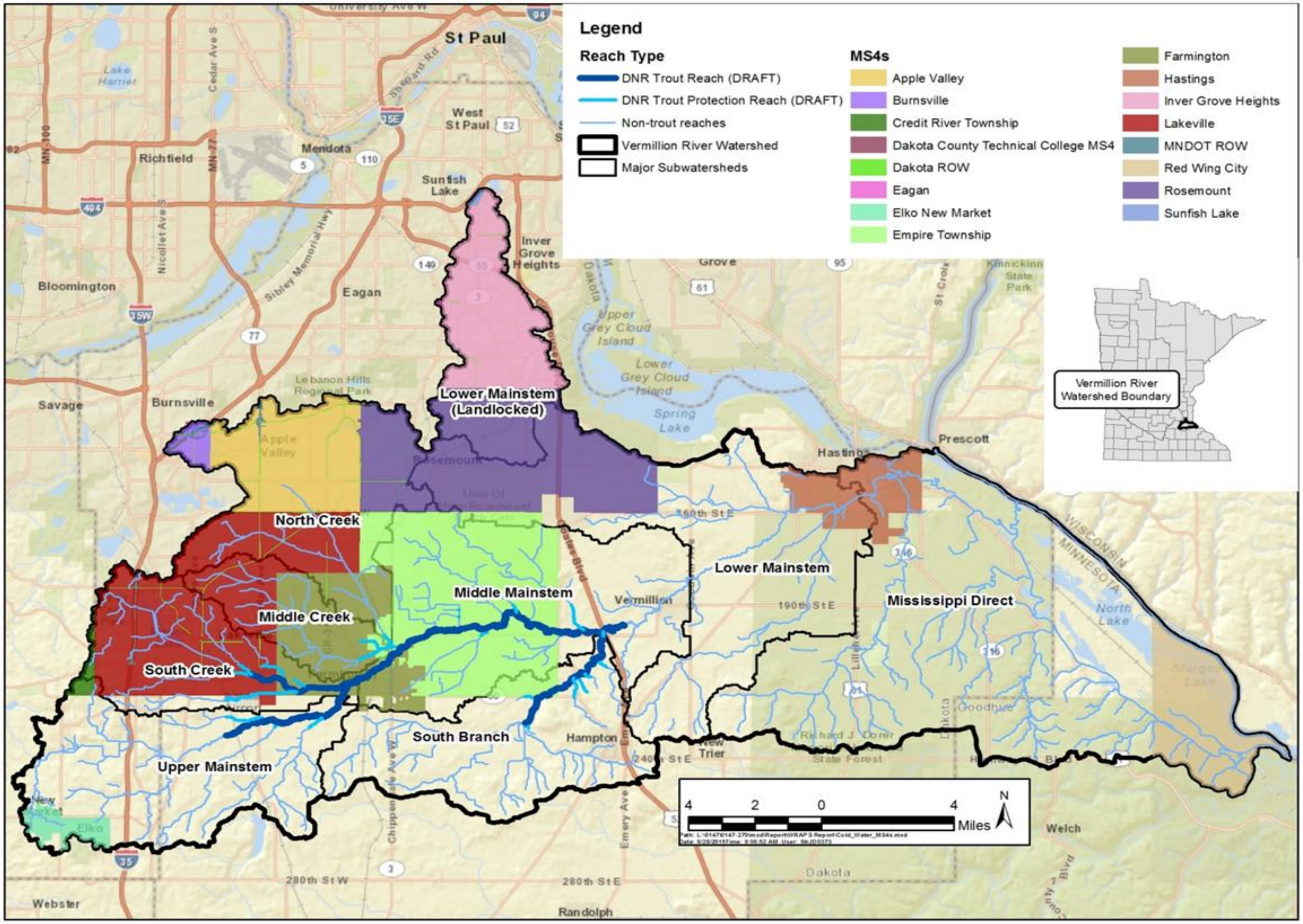


Figure 1. Coldwater Streams and Municipal Separate Storm Sewer Systems (MS4s) in the Vermillion River Watershed. (Note: The MN DNR Trout Reaches and Trout Protection Reaches are currently Draft.)

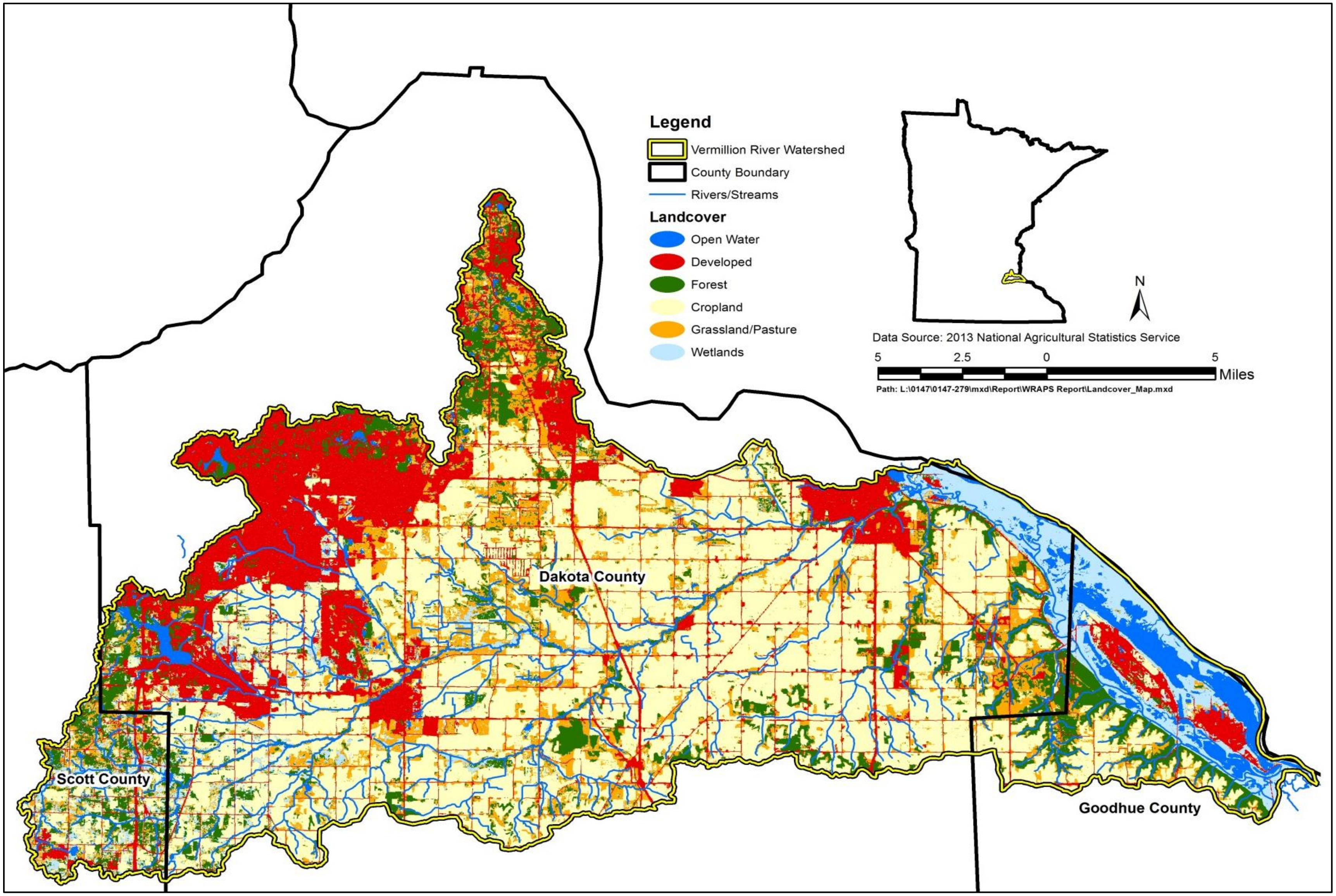


Figure 2. Land Cover in the Vermillion River Watershed (Source: 2013 NASS)

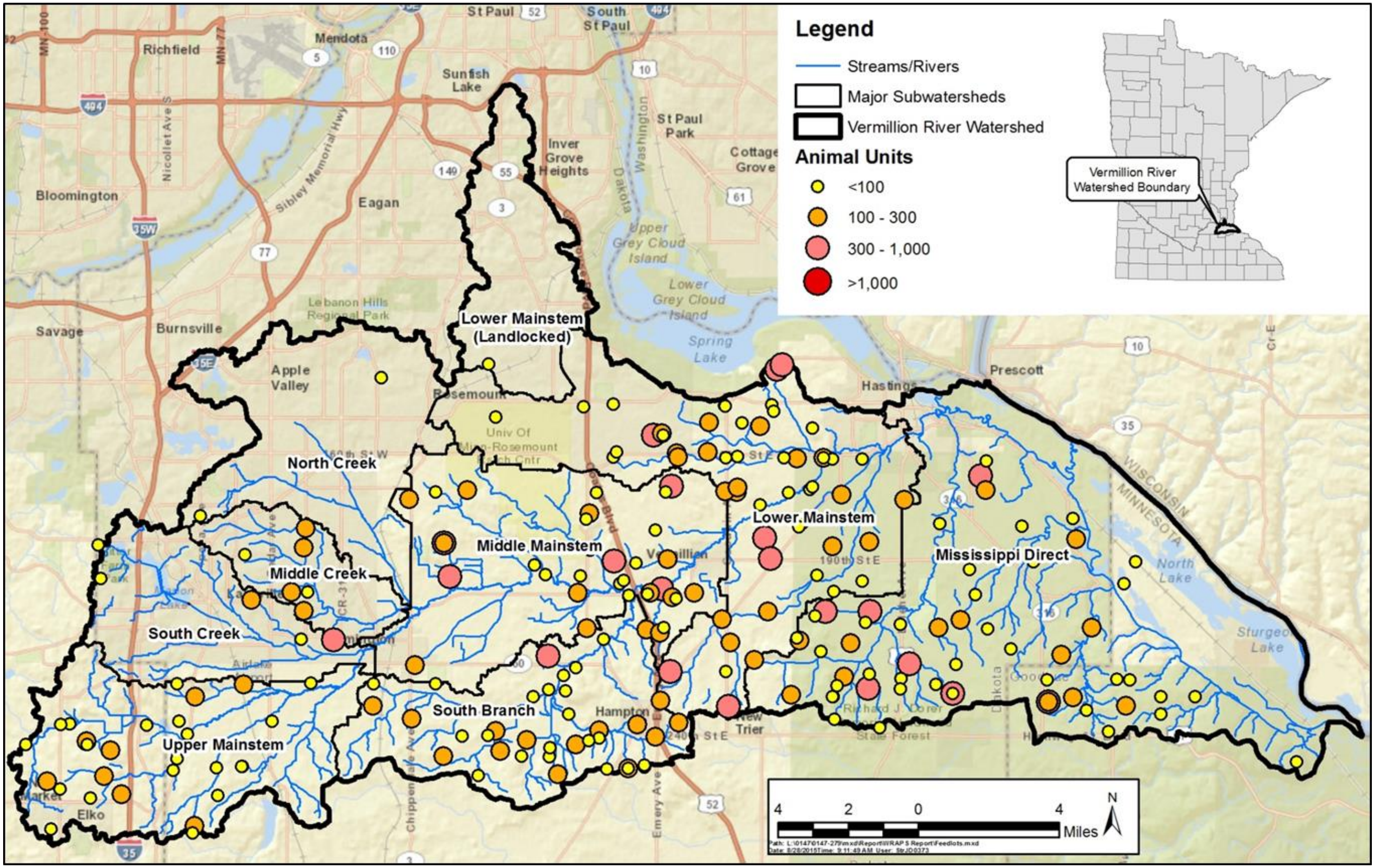


Figure 3. MPCA Registered Feedlots in the Vermillion River Watershed.

2. Watershed Conditions

Stream condition throughout the watershed was assessed using a range of parameters including fish and macroinvertebrate index of biotic integrity (IBI), fecal coliform and *E. coli*, dissolved oxygen (DO) and turbidity and total suspended solids (TSS). Water quality measurements from streams were compared to state water quality standards. Stream conditions and impairment assessment for all assessed reaches in the Vermillion River Watershed are summarized in Section 2.1. Although the Vermillion River supports brown trout, the river's main stem and several tributaries and lakes are impaired for high levels of turbidity, bacteria and nutrients. All of the lake water quality impairments, 12 bacteria impairments and one turbidity impairment are concentrated in the upper portion of the watershed between the headwaters and the city of Vermillion (Figure 4). There are only a limited number of impairments in the lower portion of the watershed near Hastings, Minnesota.

All of the streams and lakes in the Vermillion River Watershed that have been placed on the State of Minnesota's 303(d) list of impaired waters have received TMDL allocations which are summarized in section 2.4 of this report. Some of the waterbodies in the Vermillion River Watershed are impaired for mercury; however, this report does not cover toxic pollutants. For more information on mercury impairments see the statewide mercury TMDL at: http://www.pca.state.mn.us/wfhy9efl. If you would like more information on other pollutants of concern, like toxics, visit the MPCA's Website, or see the website "How's the Water? – Pollutants and Emerging Concerns", which is also on the MPCA's website.

One of the objectives of this Watershed Restoration and Protection Strategy (WRAPS) report is to identify waterbodies in need of protection. Protection efforts target waters that have been assessed and fully support aquatic life or recreation, as well as waters that have not been assessed. Additional details describing protection considerations are discussed in Sections 2.5 and 3.3 of this report.

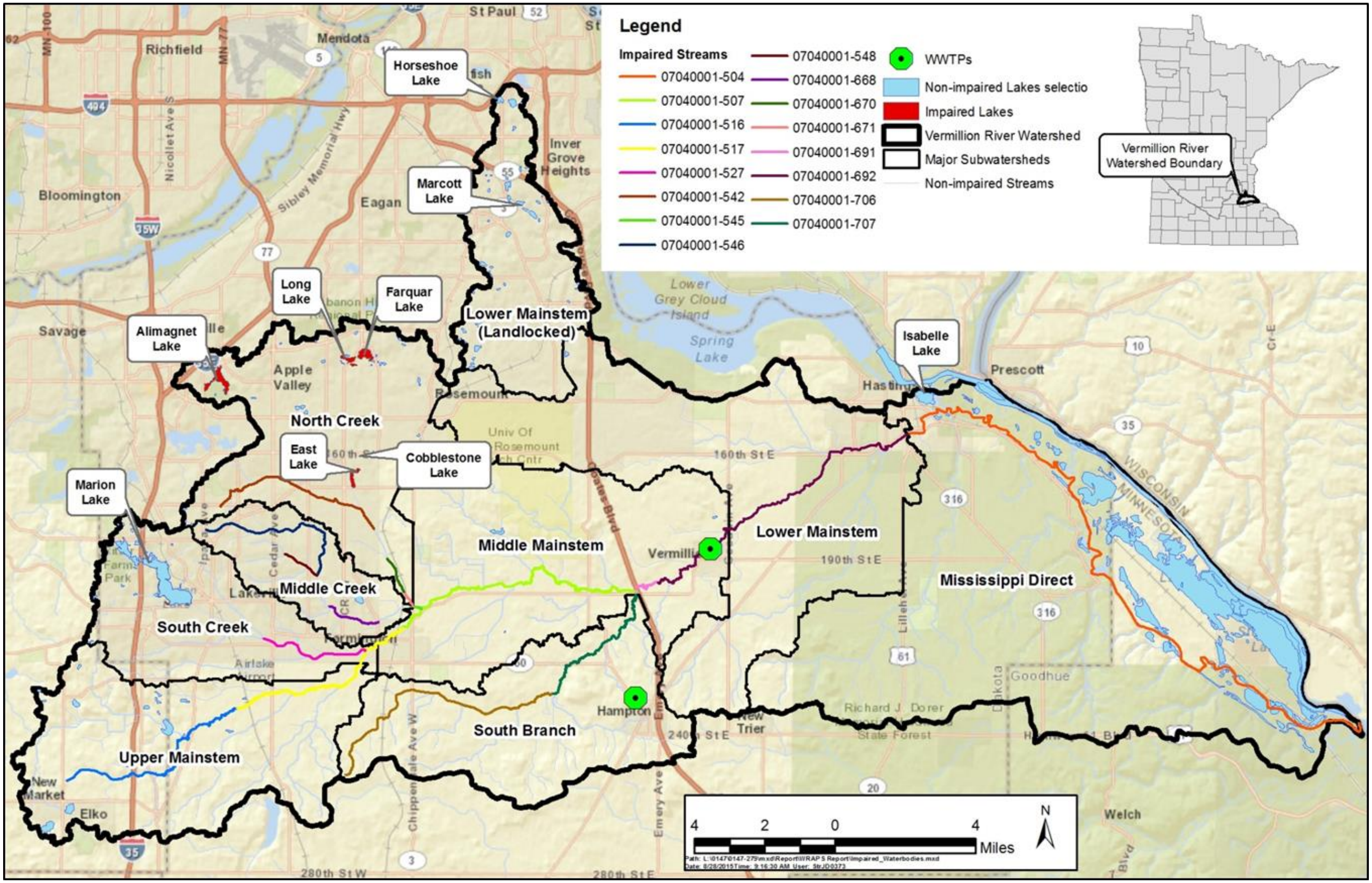


Figure 4. Vermillion River Watershed Lakes, Stream Reaches, and Impaired Waterbodies.

2.1 Condition Status

This section summarizes impairment assessment for streams and lakes in the Vermillion River Watershed. Waters that are not listed as impaired will be subject to protection efforts (see Section 2.5 and Section 3.3).

Streams

In 2008, the MPCA undertook an intensive monitoring effort of the Vermillion River Watershed's surface waters. Biological monitoring was conducted at fifteen locations along the Vermillion River and its tributaries. At two locations along the Vermillion River, water chemistry samples were collected during the summer of 2008 and 2009. In addition to the 2008 and 2009 monitoring, the Vermillion River Watershed Joint Powers Organization (VRWJPO), local Soil and Water Conservation Districts (SWCDs), Metropolitan Council Environmental Services (MCES), cities, counties, and lake associations have conducted periodic and routine sampling for conventional pollutants at various main-stem and tributary monitoring stations throughout the watershed. Through these sampling efforts, nine reaches have been assessed for biotic integrity and one (669) was found to fully support aquatic life (Table 2). Five of the assessed reaches were identified as impaired for aquatic life. Three other reaches exceeded the aquatic life criteria and are potentially impaired; however more data needs to be collected to determine this. Additionally, twelve reaches were identified as impaired for fecal coliform/*E. coli* bacteria and two reaches are impaired for turbidity.

As discussed previously, the Vermillion River supports a naturally reproducing population of brown trout. Brown trout are not a native species to Minnesota or the Vermillion, so the Vermillion River does not receive points within the fish IBI for the native coldwater species metric due to their presence. Brown trout are a sensitive species within the coldwater IBI and the Vermillion River does receive points for their presence. Based on review of historical records it is not certain if native coldwater fish such as brook trout ever existed in the Vermillion River Watershed. As a result, there has been some disagreement over whether Minnesota's Southern class 2A coldwater stream IBI metrics are appropriate for the Vermillion River. In 2011, the VRWJPO made a request to the MPCA for a site specific fish IBI standard for the entire Vermillion River Watershed. The VRWJPO's stance was advocating for development of specific standards that are protective of the brown trout fishery, but not those of a 2A waterbody. The VRWJPO is still pursuing a site specific standard, and will continue to advocate for establishing one that is appropriate for the Vermillion River Watershed.

Table 2. Assessment Status of Stream Reaches in the Vermillion River Watershed. Presented (mostly) from Upstream to Downstream.

Major Subwatershed	AUID (Last 3 digits)	Stream (Class)	Reach Description	Aquatic Life								Aq. Rec
				Fish IBI	Macroinvertebrate IBI	Dissolved Oxygen	Turbidity/TSS	Chloride	pH	NH_3	Pesticide	Bacteria
Upper Mainstem	516	Vermillion River (2B)	Headwaters to T113 R20W S8, east line	Exp	Exp	IF	Sup	Sup	Sup	Sup	NA	Imp
Upper Mainstem	517	Vermillion River (2A)	T113 R20W S9, west line to T114 R19 S31, north line	Imp	Imp	Imp	Imp	Sup	Sup	Sup	NA	Imp
Middle Mainstem	507	Vermillion River (2A)	T114 R19W S30, south line to S. Branch Vermillion R.	Imp	Imp	Sup	Sup	Sup	Sup	Sup	Sup	Exp
South Creek	527	South Creek (2A)	Unnamed Creek to Vermillion R.	Imp	Imp	Sup	Sup	Sup	Sup	Sup	Sup	Imp
Middle Creek	546	Middle Creek (2B)	Headwaters to Unnamed Cr.	NA	NA	NA	NA	NA	NA	NA	NA	Imp
Middle Creek	548	Middle Creek (2B)	Unnamed Cr. to Unnamed Cr.	NA	NA	NA	NA	NA	NA	NA	NA	Imp
Middle Creek	668	Middle Creek (2B)	Unnamed Cr. to T114 R20W S25, east line	NA	NA	NA	NA	NA	NA	NA	NA	Imp
Middle Creek	669	Middle Creek (2B)	R19W S30, west line to Unnamed Cr.	Sup	Sup	NA	NA	NA	NA	NA	NA	NA
North Creek	542	North Creek (2B)	Headwaters to Unnamed Cr.	NA	NA	NA	Sup	NA	NA	NA	NA	Imp
North Creek	670	North Creek (2B)	Unnamed Cr. to T114 R19W S19, south line	NA	NA	NA	NA	NA	NA	NA	NA	Imp
North Creek	671	North Creek (2A)	T114 R19W S30, north line to Middle Cr.	NA	NA	Exp	Exp	Sup	Sup	IF	NA	Imp
North Creek	545	North Creek (2A)	Middle Cr. to Vermillion R.	NA	NA	Imp	IF	Sup	Sup	IF	NA	Imp
South Branch Vermillion	706	South Branch (2B)	Headwaters to T113 R19W S2, east line	Sup	Exp	NA	NA	NA	NA	NA	NA	Imp
South Branch Vermillion	707	South Branch (2A)	T113 R19W S1, west line to T114 R18W S29, north line	Exp	Exp	IF	Exp	Sup	Sup	Sup	NA	Imp
Lower Mainstem	692	Vermillion River (2B)	T114 R18W S21, west line to Hastings Dam	Imp	Exp	Sup	Sup	Sup	Sup	Sup	NA	Exp
Mississippi Direct	504	Vermillion River (2B)	Hastings Dam to Mississippi R.	Sup	Imp	IF	Imp	Sup	Sup	Sup	NA	IF

Abbreviations and colors for assessment status: IBI = indices of biological integrity; NA (no color) = Not assessed/no data; IMP (red) = does not meet the water quality standard and therefore, is impaired; IF (yellow) = Insufficient information; Sup (green) = meets IBI or water quality standards/criteria; Exp (orange) = exceeds criteria, potential impairment

Lakes

Lakes are not a prominent feature of the Vermillion River Watershed. Most of the large (>100 acres) lakes in the watershed occur along the Mississippi River corridor and maintain surface water connections to the Mississippi and/or Vermillion Rivers. All of the lakes in the Vermillion River Watershed are classified as class 2B waters for which aquatic life and recreation are the protected beneficial uses. Minnesota standards for all class 2 waters states "…there shall be no material increase in undesirable slime growths or aquatic plants including algae." Class 2B lakes are assessed based on ecoregion specific numeric water quality standards for total phosphorus (TP), chlorophyll-a (chl-*a*), and secchi transparency depth. To be listed as impaired, a lake must not meet water quality standards for TP and either chl-*a* or secchi depth. Of the seven lakes in the Vermillion River Watershed that were assessed, four were identified as being impaired (Table 3). All of the impaired lakes in the Vermillion River Watershed were addressed as part of the Long and Farquar Lakes Nutrient TMDL (Bonestroo 2009) and the Vermillion River Watershed TMDL (MPCA 2015) studies.

Table 3. Assessment Status of Lakes in the Vermillion River Watershed. Presented (mostly) from Upstream to Downstream.

Major Subwatershed	Lake ID	Lake	Aquatic Recreation
North Creek	19-0021	Alimagnet	Imp
	19-0022	Long	Imp
	19-0023	Farquar	Imp
	19-0349	East	Imp
South Creek	19-0026	Marion	Sup
Middle Mainstem	19-0342	Unnamed	IF
Mississippi Direct	19-0004	Isabelle	IF
Closed Basin	19-0041	Marcott	Sup
	19-0051	Horseshoe	Sup

Abbreviations and colors for assessment status: NA (no color) = Not assessed/no data; Imp (red) = impaired and does not support aquatic recreation numeric standards; IF (yellow) = Insufficient information to make an assessment; Sup (green) = fully supporting aquatic recreation numeric standards

2.2 Water Quality Trends

Historic water chemistry data has been collected at several stations throughout the Vermillion River Watershed through a joint effort by the Dakota County SWCD and VRWJPO (Dakota County SWCD 2013). The MCES has also collected water chemistry data at three main-stem Vermillion River monitoring stations since 1976. The data collected by MCES are currently being analyzed for trends using United States Geological Survey's (USGS) QWTREND program which adjusts for flow and seasonality, and are based on median flow conditions. Preliminary results of the trend analysis indicate concentrations of several pollutants, such as TSS, TP and BOD, have exhibited decreasing trends over the most recent 10 year period. It is believed the decreasing trends may at least partially be attributed to improvements (2006) and re-routing (2008) of the Empire WWTP effluent to the Mississippi River. Monitoring data collected by Dakota County SWCD and VRWJPO along the Vermillion River main stem and several major tributaries show some pollutant concentrations have increased in recent years. For example, nitrate concentration measured during baseflow conditions in the South Branch Vermillion, and the main-stem Vermillion River downstream of South Branch, have steadily increased since 2009 (Dakota County SWCD 2013). The Dakota County SWCD/VRWJPO and MCES monitoring programs should continue to be supported so these trends can be further developed and analyzed to help prioritize BMP efforts and monitor changes in the watershed.

The Minnesota Pollution Control Agency (MPCA) also looks for trends in the transparency data collected annually on lakes and streams. A minimum of eight years of data is required to provide a statistically significant trend; for this analysis a Seasonal Kendall Test is run using the statistical package “R”. None of the stream sites in the Vermillion River Watershed had sufficient data for analysis. In 2012, six lakes met the minimum data requirements; of those Farquar Lake had a declining trend in transparency while Lake Marion and Unnamed (Valley) Lake have improving trends in transparency.

Since the MPCA competed the Vermillion River Watershed Assessment report newer data and information has been collected on many of the waterbodies. For instance, Farquar Lake over the last five years has shown an increased trend in transparency (city of Apple Valley). Statistical data from the 1990’s may have skewed the original data due to Copper Sulfate treatments to the lake.

2.3 Stressors and Sources

In order to develop appropriate strategies for restoring or protecting waterbodies, the stressors and/or sources impacting or threatening them must be identified and evaluated. Biological stressor identification is done for streams with either fish or macroinvertebrate biota impairments and encompasses both evaluation of pollutants and non-pollutant-related factors as potential stressors (e.g. altered hydrology, fish passage, habitat). Pollutant source assessments are done where a biological stressor ID process identifies a pollutant as a stressor as well as for the typical pollutant impairment listings. This section provides further detail on stressors and pollutant sources in the Vermillion River Watershed.

Stressors of Biologically-Impaired Stream Reaches

There are six stream reaches in the Vermillion River Watershed impaired for aquatic life due to poor biological communities. In order to identify probable stressors causing these impairments, an intensive field survey and data evaluation was conducted by the MPCA and Wenck Associates, Inc. The resulting report, titled the Vermillion River Watershed Stressor Identification Report (Wenck Associates 2013), provides detailed information and weight of evidence analysis to link stressors to the impairments. Potential candidate causes of the impairments that were ruled out based on a review of available data include: pH; chloride toxicity; pesticides; and heavy metals toxicity. The following stressors that are potential candidate causes were examined in more detail: turbidity/TSS; loss of habitat due to excess deposited and bedded sediment; stream temperature; low dissolved oxygen (DO) concentrations; nitrate; degraded riparian habitat; loss of connectivity and altered hydrology, both due to ditching in the watershed and on the stream itself. Table 4 summarizes the primary stressors for the Vermillion River impaired reaches identified in the Vermillion River Watershed Stressor Identification Report.

Overall there was only one reach where a Total Maximum Daily Load (TMDL) was developed for a primary stressor (reach -517, Upper Mainstem Vermillion River), that stressor was Turbidity/Sediment. While the other reaches had numerous stressors, not one stressor alone was causing enough stressor to warrant a TMDL. Other stressors like habitat and riparian disturbances are not stressors that TMDLs can be developed for. While a TMDL may not have been developed for each impairment, actions to address the identified stressors were included in the Restoration and Protection Strategies section of this report.

Table 4. Stressors to Aquatic Life in Biologically Impaired Reaches in the Vermillion River Watershed.

Major Subwatershed	AUID (Last 3 digits)	Stream	Reach Description	Biological Impairment	Stressors							
					Temperature	Dissolved Oxygen	Nitrate	Turbidity/Sedimentation	Connectivity, fish Passage (dams/falls)	Altered Hydrology	Habitat	Riparian Disturbance
Upper Mainstem	517	Vermillion River (2A)	T113 R20W S9, west line to T114 R19 S31, north line	Fish	◎	◎		●		○	○	○
				Macroinvert		◎		●		○	○	○
Middle Mainstem	507	Vermillion River (2A)	T114 R19W S30, south line to S. Branch Vermillion R.	Fish				◎	○	○		○
				Macroinvert				◎		○	○	○
South Creek	527	South Creek (2A)	Unnamed Creek to Vermillion R.	Fish	◎	◎		◎	○	○	◎	○
				Macroinvert		◎		●		○	◎	○
Middle Creek	668	Middle Creek (2B)	Unnamed Cr. to T114 R20W S25, east line	Fish				◎		○		○
				Macroinvert				◎		○	◎	○
South Branch Vermillion	707	South Branch (2A)	T113 R19W S1, west line to T114 R18W S29, north line	Fish		○	◎	◎		○	○	○
				Macroinvert			◎	◎		○	○	○
Lower Mainstem	692	Vermillion River (2B)	T114 R18W S21, west line to Hastings Dam	Fish			○	●		○		○

Key: ● = High ◎ = Moderate ○ = Low Blank = not a primary stressor

Pollutant sources

Pollutant sources vary by subwatershed and by stream segment depending on permitted point source dischargers, upstream loading/conditions, near-reach land use and other nonpoint sources throughout the watershed. Potential pollutant sources in the impaired stream/lake watersheds were identified and discussed in the Regional TMDL Evaluation of Fecal Coliform Bacteria Impairments in the Lower Mississippi River Basin (MPCA 2006), Long and Farquar Lakes Nutrient TMDL (Bonestroo 2009), Lower Vermillion Watershed Turbidity TMDL (Tetra Tech 2009), and the Vermillion River Watershed TMDL

(MPCA 2015) reports and are summarized in Table 6 through 8. There are currently 13 regulated Phase II Municipal Storm Sewer System (MS4) General Permit holders in the Vermillion River Watershed (Table 5). These MS4 communities cover approximately 43% (158 square miles) of the watershed and are primarily situated in the upper portion of the watershed (Figure 1).

The Vermillion Wastewater Treatment Plant (WWTP) and Hampton WWTP are currently the only active WWTP's which discharge to the Vermillion River (Figure 4). The Vermillion WWTP is located downstream of the major impairments in the upper portion of the watershed as it discharges to the Vermillion River in the Middle Mainstem subwatershed. The Hampton WWTP discharges to a tributary of the South Branch Vermillion River and received bacteria wasteload allocations for one impaired reach (707) in the South Branch River as part of the Vermillion River Watershed TMDL study (MPCA 2015). This facility is currently meeting its TMDL allocation requirements and no load reductions are required. The Metropolitan Council Empire WWTP (Empire WWTP) and the Elko New Market WWTP are also located within the Vermillion River Watershed; however these facilities moved their discharge locations to the Mississippi River in 2008. Based on data collected from stations upstream and downstream of Empire WWTP's former outfall on the Vermillion River, immediate improvements in water quality and temperature were observed on this section of the river after the outfall was moved (MPCA 2012).

Table 5. Regulated MS4s and WWTPs in the Vermillion River by Major Subwatershed.

Point Source			Major Subwatershed(s)								
Name	**Permit #**	**Type**	North Creek	Middle Creek	South Creek	Upper Mainstem	Middle Mainstem	Lower Mainstem	Mississippi Direct	South Branch	**Notes**
City of Apple Valley	MS400074	Municipal Stormwater	X								Turbidity allocations Tetra Tech, 2009); nutrient allocations (Bonestroo, 2009); bacteria and nutrient allocations (MPCA, 2006 and MPCA, 2015)
City of Burnsville	MS400076	Municipal Stormwater	X								Turbidity allocations Tetra Tech, 2009); bacteria allocations (MPCA, 2006); nutrient allocations (MPCA, 2015)
Credit River Township	MS400131	Municipal Stormwater			X	X					Turbidity and bacteria allocations (MPCA, 2015)
Dakota County	MS400132	Municipal Stormwater	X	X	X		X				Turbidity allocations (Tetra Tech, 2009); nutrient allocations (Bonestroo, 2009); turbidity, bacteria and nutrient allocations (MPCA, 2015)
City of Eagan	MS400014	Municipal Stormwater	X								Bacteria allocations (MPCA, 2006); nutrient allocations (MPCA, 2015)
City of Elko New Market	MS400237	Municipal Stormwater				X					Turbidity and bacteria allocations (MPCA, 2015)

Point Source			Major Subwatershed(s)								
Name	**Permit #**	**Type**	North Creek	Middle Creek	South Creek	Upper Mainstem	Middle Mainstem	Lower Mainstem	Mississippi Direct	South Branch	**Notes**
Empire Township	MS400135	Municipal Stormwater	X	X			X	X		X	Turbidity allocations (Tetra Tech, 2009); turbidity, bacteria and nutrient allocations (MPCA, 2006 and MPCA, 2015)
City of Farmington	MS400090	Municipal Stormwater	X	X	X	X	X			X	Turbidity allocations (Tetra Tech, 2009); turbidity and bacteria allocations (MPCA, 2006 and MPCA, 2015)
City of Hastings	MS400240	Municipal Stormwater						X	X		Bacteria allocations (MPCA, 2006); turbidity allocations (Tetra Tech, 2009)
City of Lakeville	MS400099	Municipal Stormwater	X	X	X	X		X			Turbidity allocations (Tetra Tech, 2009); turbidity, bacteria and nutrient allocations (MPCA, 2006 and MPCA, 2015)
MNDOT (Metro)	MS400170	Municipal Stormwater	X	X	X		X			X	Turbidity allocations (Tetra Tech, 2009); bacteria and nutrient allocations (MPCA, 2015)
City of Red Wing	MS400235	Municipal Stormwater							X		
City of Rosemount	MS400117	Municipal Stormwater	X				X	X			Turbidity allocations (Tetra Tech, 2009); bacteria allocations (MPCA, 2006); nutrient allocations (Bonestroo, 2009); nutrient allocations (MPCA, 2015)
Hampton WWTP	MN0021946	Municipal wastewater								X	Bacteria allocations (MPCA, 2006 and MPCA, 2015). Typical bacteria effluent concentrations do not exceed reporting limits or TMDL requirements
Vermillion WWTP	MN0025101	Municipal wastewater					X				Bacteria allocations (MPCA, 2006); turbidity allocations (Tetra Tech, 2009). This facility discharges below the major impairments in the upper portion of the watershed

Table 6. Potential nonpoint Sources in the Vermillion River Watershed. (Relative magnitudes of contributing sources are indicated based on the results of TMDL studies).

HUC-10 Subwatershed	Stream/Reach (AUID) or Lake (ID)	Pollutant	Pollutant Sources*													
			Fertilizer & manure run-off	Livestock in riparian areas	Failing septic systems	Wildlife	Upland soil erosion	Stormwater ponds	Runoff from urban stormwater and near-shore development	In-channel Wetlands	Internal Loading (sediments)	Atmosphere	Point Sources (WWTFs)	Forest Land	Upstream Lake(s); Upstream reaches	Streambank/Channel
Upper Mainstem	Vermillion River (516)	Bacteria	**◯**	**◯**	○	○				?						
	Vermillion River (517)	Bacteria	**◯**		○	○			○						●	
		TSS					●		○						?	**◯**
		DO													●	
South Creek	South Creek (527)	Bacteria	**◯**	○	○	○		?	**◯**						?	
Middle Creek	Middle Creek (546)	Bacteria	●	●	○	○		?	**◯**							
	Middle Creek (548)	Bacteria	●	●	○	○				?					**◯**	
	Middle Creek (668)	Bacteria	**◯**		○	○				?					●	
North Creek	Farquar Lake (19-0023)	Nutrients							●		●					
	Long Lake (19-0022)	Nutrients							●		●					
	Alimagnet Lake (19-0021)	Nutrients							●		●					
	East Lake (19-0349)	Nutrients							●		●					
	North Creek (542)	Bacteria	○		○	○		?	●	?						
	North Creek (670)	Bacteria	**◯**		○	○		?	○	?					●	
	North Creek (671)	Bacteria	**◯**		○	○			○						●	
	North Creek (545)	Bacteria	●		○	○		?	○						●	
		DO													●	
South Branch Vermillion River	South Branch (706)	Bacteria	●	**◯**	○	○				?						
	South Branch (707)	Bacteria	●	**◯**	○	○		?							●	
Mississippi Direct	Vermillion River (504)	TSS							○				○		●	

Key: ● = High **◯** = Moderate ○ = Low ? = present, but contribution to impairment unknown Blank = not a primary source

* Relative magnitudes of contributing sources are indicated based on results from TMDL studies

2.4 TMDL Summary

There are 4 impaired lakes and 15 impaired stream reaches in the Vermillion River Watershed that have received allocations through various TMDL studies. TMDL allocations and pollutant load reductions from current conditions for each lake and stream reach are summarized in Table 7 and Table 8. Section 3 of this report discusses tools to identify and target the high priority pollutant loading areas and recommended restoration strategies to achieve the reductions required for these impaired lakes and/or stream reaches.

Table 7. Allocations Summary for all completed Lake TMDLs in the Vermillion River Watershed.

			Allocations (lbs/year)									
			Wasteload Allocation			***Load Allocation***				***MOS***	***RC***	
Major Subwatershed	**Lake (ID)**	**Pollutant**	WWTPs	Construction & Industrial Stormwater	MS4 Communities	Watershed Load	Internal Load	Upstream Lakes	Atmosphere	Margin of Safety	Reserve Capacity	Percent Reduction[1]
North Creek	Long Lake (19-0022)	TP	--	--	60	--	54	--	9	--	--	24%
	Farquar Lake (19-0023)	TP	--	--	96	--	150	--	17	9	--	36%
	Alimagnet Lake (19-0021)	TP	--	3.5	111.7	--	77.2	--	26.1	11.5	--	43%
	East Lake (19-0349)	TP	--	14.1	446.5	--	45.3	58.3	10.2	30.2	--	42%

[1] Total percent reduction (all sources) from existing conditions needed to meet TMDL allocations

Table 8. Allocation Summary for all completed Stream TMDLs in the Vermillion River Watershed.

				***E. coli* & fecal coliform allocations (billions org./day)** **Sediment Allocations (lbs/day)**						
				Wasteload Allocation			***Load Allocation***		***MOS***	
Major Subwater-shed	**Stream/Reach (AUID)**	**Pollutant**	**Flow Zone**	WWTPs	Construction & Industrial Stormwater	MS4 Communities	Watershed Load	Upstream Reach(es)	Margin of Safety	Percent Reduction[1]
North Creek	North Creek (542)	*E. coli*	Very High	--	--	34.7	--	85.4	6.3	46%
			High	--	--	14.1	--	34.7	2.6	79%
			Mid	--	--	7.5	--	18.4	1.4	88%
			Low	--	--	4.4	--	10.7	0.8	92%
			Very Low	--	--	2.4	--	6.0	0.4	91%
	North Creek (670)	*E. coli*	Very High	--	--	54.6	--	85.4	7.4	41%
			High	--	--	22.2	--	34.7	3.0	0%
			Mid	--	--	11.8	--	18.4	1.6	28%
			Low	--	--	6.9	--	10.7	0.9	10%

Major Subwater-shed	Stream/Reach (AUID)	Pollutant	Flow Zone	*E. coli* & fecal coliform allocations (billions org./day) Sediment Allocations (lbs/day)						Percent Reduction[1]
				Wasteload Allocation			***Load Allocation***		***MOS***	
				WWTPs	Construction & Industrial Stormwater	MS4 Communities	Watershed Load	Upstream Reach(es)	Margin of Safety	
			Very Low	--	--	3.8	--	6.0	0.5	51%
	North Creek (671)	*E. coli*	Very High	--	--	55.1		85.4	7.4	56%
	North Creek (671)	*E. coli*	High	--	--	22.4		34.7	3.0	0%
	North Creek (671)	*E. coli*	Mid	--	--	11.9		18.4	1.6	4%
	North Creek (671)	*E. coli*	Low	--	--	6.9		10.7	0.9	12%
	North Creek (671)	*E. coli*	Very Low	--	--	3.8		6.0	0.5	56%
	North Creek (545)	*E. coli*	Very High	--	--	159.3	--	85.4	12.9	62%
	North Creek (545)	*E. coli*	High	--	--	51.5	--	34.7	4.5	26%
	North Creek (545)	*E. coli*	Mid	--	--	26.9	--	18.4	2.4	39%
	North Creek (545)	*E. coli*	Low	--	--	14.4	--	10.7	1.3	2%
	North Creek (545)	*E. coli*	Very Low	--	--	6.3	--	6.0	0.6	49%
Middle Creek	Middle Creek (548)	*E. coli*	Very High	--	--	23.1	--	--	1.2	--
Middle Creek	Middle Creek (548)	*E. coli*	High	--	--	6.3	--	--	0.3	38%
Middle Creek	Middle Creek (548)	*E. coli*	Mid	--	--	2.6	--	--	0.1	65%
Middle Creek	Middle Creek (548)	*E. coli*	Low	--	--	1.3	--	--	0.1	80%
Middle Creek	Middle Creek (548)	*E. coli*	Very Low	--	--	0.5	--	--	<0.1	84%
Middle Creek	Middle Creek (546)	*E. coli*	Very High	--	--	37.1	--	--	2.0	--
Middle Creek	Middle Creek (546)	*E. coli*	High	--	--	10.1	--	--	0.5	77%
Middle Creek	Middle Creek (546)	*E. coli*	Mid	--	--	4.2	--	--	0.2	82%
Middle Creek	Middle Creek (546)	*E. coli*	Low	--	--	2.0	--	--	0.1	92%
Middle Creek	Middle Creek (546)	*E. coli*	Very Low	--	--	0.7	--	--	<0.1	94%
Middle Creek	Middle Creek (668)	*E. coli*	Very High	--	--	92.1	--	--	4.9	--
Middle Creek	Middle Creek (668)	*E. coli*	High	--	--	29.7	--	--	1.6	33%
Middle Creek	Middle Creek (668)	*E. coli*	Mid	--	--	15.1	--	--	0.8	86%
Middle Creek	Middle Creek (668)	*E. coli*	Low	--	--	6.4	--	--	0.3	--
Middle Creek	Middle Creek (668)	*E. coli*	Very Low	--	--	2.0	--	--	0.1	--
South Creek	South Creek (527)	*E. coli*	Very High	--	--	63.1	17.8	42.1	6.5	77%
South Creek	South Creek (527)	*E. coli*	High	--	--	29.6	8.3	19.7	3.0	0%
South Creek	South Creek (527)	*E. coli*	Mid	--	--	20.5	5.8	13.7	2.1	0%
South Creek	South Creek (527)	*E. coli*	Low	--	--	15.8	4.4	10.5	1.6	0%
South Creek	South Creek (527)	*E. coli*	Very Low	--	--	9.8	2.8	6.6	1.0	0%
Upper Mainstem	Vermillion River (516)	*E. coli*	Very High	--	--	18.6	115.9	--	7.1	71%
Upper Mainstem	Vermillion River (516)	*E. coli*	High	--	--	7.7	48.2	--	2.9	5%
Upper Mainstem	Vermillion River (516)	*E. coli*	Mid	--	--	6.2	38.6	--	2.4	22%
Upper Mainstem	Vermillion River (516)	*E. coli*	Low	--	--	3.8	23.4	--	1.4	62%
Upper Mainstem	Vermillion River (516)	*E. coli*	Very Low	--	--	1.8	10.9	--	0.7	80%
Upper Mainstem	Vermillion River (517)	*E. coli*	Very High	--	--	100.5	241.2	50.8	21.0	73%
Upper Mainstem	Vermillion River (517)	*E. coli*	High	--	--	42.4	101.8	21.4	8.9	34%
Upper Mainstem	Vermillion River (517)	*E. coli*	Mid	--	--	21.5	51.6	10.9	4.5	58%
Upper Mainstem	Vermillion River (517)	*E. coli*	Low	--	--	12.7	30.5	6.4	2.7	55%
Upper Mainstem	Vermillion River (517)	*E. coli*	Very Low	--	--	8.4	20.1	4.2	1.7	71%
Upper Mainstem	Vermillion River (517)	TSS	Very High	--	141.9	1,172.4	2,744.5	592.1	244.8	50%
Upper Mainstem	Vermillion River (517)		High	--	62.3	514.8	1,205.1	260.0	107.5	9%

Major Subwater-shed	Stream/Reach (AUID)	Pollutant	Flow Zone	***E. coli* & fecal coliform allocations (billions org./day) Sediment Allocations (lbs/day)**						Percent Reduction[1]
				Wasteload Allocation			***Load Allocation***		***MOS***	
				WWTPs	Construction & Industrial Stormwater	MS4 Communities	Watershed Load	Upstream Reach(es)	Margin of Safety	
			Mid	--	32.9	271.3	635	137.0	56.6	0%
			Low	--	18.77	155.0	362.9	78.3	32.4	0%
			Very Low	--	11.48	94.8	221.9	47.9	19.8	0%
South Branch	South Branch (706)	*E. coli*	Very High	--	--	0.5	131.2	--	6.9	--
			High	--	--	0.2	54.7	--	2.9	49%
			Mid	--	--	0.1	27.4	--	1.5	28%
			Low	--	--	<0.1	12.1	--	0.6	--
			Very Low	--	--	<0.1	2.5	--	0.1	--
	South Branch (707)	*E. coli*	Very High	0.8	--	16.6	199.4	--	11.5	55%
			High	0.8	--	6.9	82.2	--	4.8	24%
			Mid	0.8	--	3.9	46.0	--	2.7	36%
			Low	0.8	--	2.4	27.7	--	1.7	55%
			Very Low	0.8	--	0.3	2.4	--	0.2	--
Middle Mainstem	Vermillion River (507)	Fecal coliform	Very High	220.3	--	196.4	503.0	--	221.0	Not specified in study
			High	220.3	--	51.5	131.8	--	152.1	
			Mid	220.3	--	11.8	30.2	--	75.1	
			Low	--	--	--	--	--	--	
			Very Low	--	--	--	--	--	--	
Lower Mainstem	Vermillion River (506/692)	Fecal coliform	Very High	221.3	--	282.6	1,259.3	--	423.9	
			High	221.3	--	101.3	451.1	--	291.8	
			Mid	221.3	--	51.5	230.2	--	143.9	
			Low	221.3	--	9.8	43.3	--	110.8	
			Very Low	221.3	--	--	--	--	--	
Mississippi River Direct	Vermillion River (504)	TSS	Mode 0	328.5	--	2,010.6	11,583.1	3,258.4	--	36%
			Mode 1	328.5	--	12,464.9	121,551.9	20,686.0	--	70%

[1] Total percent reduction (all sources) from existing conditions needed to meet TMDL allocations

2.5 Protection Considerations

The previous sections identified and discussed several impaired water resources in the Vermillion River Watershed. There are currently several non-impaired water bodies throughout the Vermillion River Watershed that are threatened by decreased water quality, urban stormwater, agricultural runoff, increased flooding impacts and invasive species. The watershed is also home to several outstanding resources such as wildlife management areas and various state and county parks, forests and preservation areas. The VRWJPO, county SWCDs, Met Council, cities, counties and state agencies have been working collaboratively to monitor and assess water quality, biodiversity and ecology in a watershed-wide approach. Moving forward, protection efforts by these entities will become increasingly important to protect current water quality conditions from further degradation. Below is a short description of the major water quality concerns in Vermillion River Watershed. These concerns will be used to guide the identification and prioritization of the implementation strategies in Section 3.3.

Stream Temperature

The Vermillion River Watershed includes 49 miles of trout stream that supports a quality recreational fishery including trophy-sized brown trout. Brown trout, a non-native cold water species, need clean, cold and well-oxygenated water to survive but are more tolerant of temperatures warmer than native cold water species. As the human population in the Vermillion River Watershed grows each year, so do concerns of maintaining the ecological integrity of the watersheds cold water reaches. The VRWJPO has placed a major emphasis on monitoring stream temperature throughout the Vermillion River Watershed to determine and evaluate groundwater discharge to the river, identify reaches with inadequate shading, and which land cover types and practices are contributing heat to the river and its tributaries.

In 2006, the VRWJPO received a Targeted Watersheds Grant from the Environmental Protection Agency (EPA) to explore a “market trading” method to reduce the amount of warm water that flows into the Vermillion River. The study involved research into scientific, economic and regulatory issues related to the movement of heat in the watershed. Due to the complex nature of temperature variability based on its environment and its ability to equilibrate with its surroundings, it was determined that creating a market for thermal trading was not feasible. The VRWJPO allows thermal trading on a case-by-case basis, but it is not anticipated that a proposed trade would be forthcoming. Practices to mitigate, reduce, or eliminate the possibility of thermal runoff are much more effective than a trading program. These same practices are accepted and regularly utilized within this watershed to manage stormwater runoff. The VRWJPO has identified several effective strategies the VRWJPO and local stakeholders can use, such as implementing cooling practices at strategic locations; improve stream temperature monitoring and reconsidering design standards for specific stormwater Best Management Practices (BMPs).

In 2009, the VRWJPO, working in partnership with Dakota County SWCD and the MPCA received an EPA Section 319 grant to install demonstration sites with cooling BMPs for stormwater. The demonstration sites were located in the western half of the watershed and were within 1,000 feet of the Vermillion River or its tributaries. All sites were monitored to determine the temperature difference between water flowing into the practice and water flowing out. Most practices monitored were "mechanical" cooling practices, designed to reduce heat loading from urban landscapes, such as roads, parking lots, and commercial roofs. Results demonstrated the importance of BMPs that control the volume of water, usually by infiltrating stormwater back into the ground. These volume control/infiltration BMPs are the first and best choice for mitigating heat loads to the river. The demonstration project also highlighted the importance of shade in protecting streams from greater heat loading. A 58-percent tree canopy around a stormwater pond reduced the outflow temperature by 4.63 degrees C (40.33 degrees F) in comparison to an unshaded pond. Shading impervious surfaces, ponds, and (most importantly) stream banks is a long-term strategy -- trees take years to mature -- but they are relatively low in cost and reach peak effectiveness (largest canopy) during the hot summer months.

Buffers and Habitat Improvement

Riparian buffers are essential for maintaining high quality aquatic and riparian habitat. As part of its 2005 Watershed Management Plan, the VRWJPO developed a classification scheme for waterways and wetlands with associated standards for buffer widths. These standards were implemented to regulate all new development in the watershed including commercial, residential, and industrial construction along with road crossings, drainage systems and river and habitat restoration. The largest buffer is provided for the Conservation Corridor Lower and Upper Reaches with 150-ft average, and 100-ft minimum, buffer width. A 100-ft average and 65-ft minimum buffer width is required for Principal Connector channels in an Aquatic Corridor, and if the Principal Connector is a designated trout stream the buffer must be at least 100-ft. A 50-ft average and 35-ft minimum buffer width is required for Tributary Connector in the Aquatic Corridor. Water Quality Corridors require the smallest buffer at 30-ft average and 20-ft minimum widths (VRWJPO 2008).

During the 2015 Legislative session the Governor Mark Dayton's buffer initiative legislation was signed into state law as part of the Omnibus Environment and Agriculture Bill during the 2015 legislative session. This bill includes language modifying buffer rules to include enhanced implementation of existing 50-foot stream setbacks on all public waters, as well as expanded requirements for 16.5 foot buffers along certain ditches. In all cases, landowners may deploy alternative conservative practices, provided that comparable conservation outcomes are achieved. The initiative states the buffers and/or alternative practices must be in place on or before November 1, 2017 for public waters; and November 1, 2018 for public drainage systems. More information on the buffer initiative is available through BWSR's website: For more information on this new state law and how it will be implemented and enforced see the Board of Water and Soil Resources (BWSR) website: [http://bwsr.state.mn.us/buffers/BWSR - Buffers](http://bwsr.state.mn.us/buffers/).

As of 2013, vegetated buffers are intact and are at least 50 feet wide throughout most of the main-stem Vermillion River and primary tributaries identified as DNR protected water; however Minnesota buffer rules are not currently implemented by a small amount of the communities within the watershed. Moreover, vegetation quality of the buffers currently in place throughout the watershed could be improved. All of the Vermillion River fluvial and geomorphic assessment studies (Inter-fluve 2009, 2010, 2011, and 2012) identified buffer and riparian vegetation management as a primary restoration strategy for several main-stem and tributary reaches. Currently, much of the buffer and riparian areas are dominated by reed canary grass. Re-establishing species diversity and deep-rooted native vegetation in the buffer and riparian areas is very important to attracting macroinvertebrates, birds and other aquatic and riparian animal species.

The geomorphic assessment studies also identified improving buffer widths and setbacks in urban areas and along smaller tributary reaches as a high priority throughout the Vermillion River Watershed. Similarly, many of the non-DNR protected ditches and waterways throughout rural portions of the watershed contain very little or no vegetated buffer. Even though these features are not subject to Minnesota Rules, they should be targeted for buffer and riparian plantings.

Channel Restoration and Improvement

A significant portion of the original wetlands and waterways in the Vermillion River Watershed have been altered at some point which has resulted in that drainage being conveyed through straightened ditches and channelized stream segments. Ditches and channelized streams are generally deeper and more incised than natural streams and are intended to move flood water quickly by concentrating more of the flood flow in a large channel rather than across the floodplain. When altered streams and ditches are restored by adding sinuosity and natural channel dimensions, slope of the channel generally decreases and the stream may once again reconnect with its former floodplain.

Restoring floodplain connectivity slows the exit of water off the land and allows for greater infiltration, higher baseflows, lower stream temperatures and lower peak flood flows. Thus, restoring the geomorphic function of the altered stream segments through natural channel restoration can lead to dramatic improvements in habitat and water quality. The Minnesota DNR and local stakeholders have had success in recent years restoring ditched and straightened segments of the Vermillion River and its tributaries by adding sinuosity and improving channel dimensions, substrate and riparian vegetation.

The DNR, VRWJPO and other local partners will continue pursuing these types of restoration projects as funding and opportunities arise.

Wetland Restoration and Protection

Like other parts of southern Minnesota, the Vermillion River Watershed has less than 50% of its original wetlands remaining (BWSR 2004). The majority of wetlands that exist in the watershed today are confined to the Mississippi River floodplain as well as the riparian corridor of the Vermillion River and its tributaries. Wetlands are extremely important to the Vermillion River as they are able to store water allowing for infiltration, groundwater recharge, and water quality benefits. Many of the wetlands in the Vermillion River Watershed are highly connected to streams and riparian areas, being immediately adjacent to the river and tributaries. Modifications of wetlands to drain faster have implications on both water quality and downstream resources and water bodies. Stream flow becomes more variable, and thus habitat for biota can be degraded.

Ditching in wetlands may alter nutrient cycling and dissolved oxygen (DO) dynamics which can also have a significant impact on downstream biological communities. Significant emphasis needs to be placed on protecting, improving and restoring natural wetland conditions throughout the Vermillion River Watershed.

Groundwater Protection

The human population of the Vermillion River Watershed is dependent on the region's aquifers for almost 100% of the water it uses. The watershed's aquifers are also the primary source of groundwater that maintains the cool water temperatures in the Vermillion River and its tributaries. Groundwater yield varies throughout the watershed from less than 5 gallons per minute to over 2,000 gallons per minute. Since most of the surficial aquifers are composed of sand and gravel, water can move very quickly through them making them sensitive to pollution. Groundwater pollution, mainly in the form of nitrate, is a major concern in certain portions of the Vermillion River Watershed (Figure 5). High nitrate levels are a particular concern in the South Branch Vermillion River subwatershed and can be toxic to aquatic organisms.

In the South Branch Sub-watershed, the primary transport mechanism for nitrate loading to groundwater is agricultural production on soils with groundwater sensitivity to pollution. Upon application to a field, much of the nitrogen not utilized by plants leaches into the ground and either moves into nearby lakes, streams, wetlands and wells or is carried by tile drainage directly into the stream. This results in higher levels during baseflow or low flow conditions and lower concentrations during high flow conditions when it is diluted by surface runoff. Thus, agricultural production and associated BMPs to reduce nitrate concentrations in the Vermillion River Watershed need to focus on addressing the rate and timing of fertilizer application, nitrogen treatment practices, wetland restoration and vegetation changes (e.g. cover crops).

The Minnesota Department of Agriculture's (MDA) Nitrogen Fertilizer Management Plan (NFMP) provides the state's blueprint for prevention or minimization of the impacts of nitrogen fertilizer on groundwater. The strategies in the NFMP are based on voluntary BMPs, intended to engage local communities in protecting groundwater from nitrate contamination (MDA 2013).

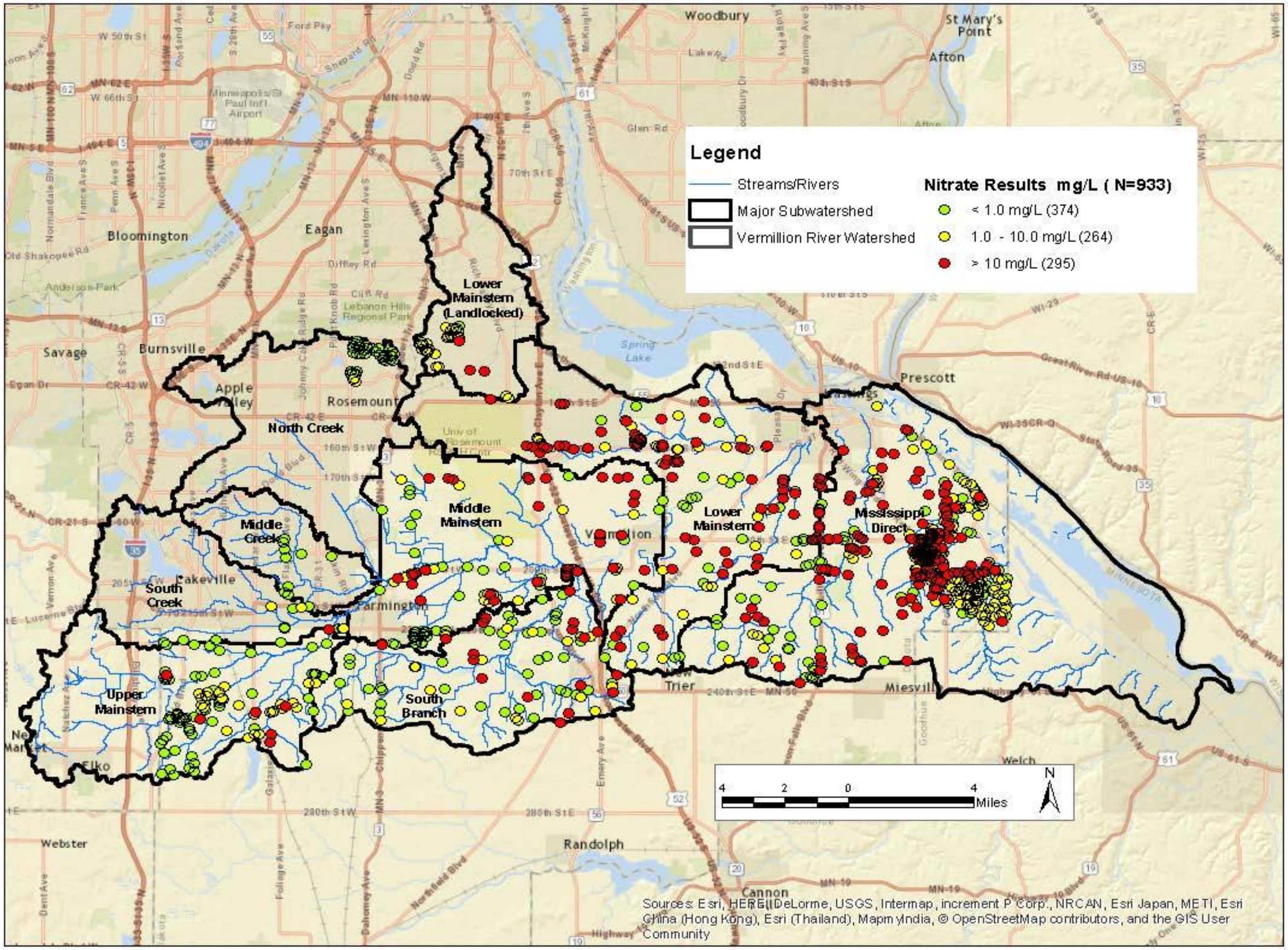


Figure 5. Groundwater Well Nitrate Concentrations in the Vermillion River Watershed.

Agricultural Soil and Nutrient Management

While a significant amount of land in the northwest portion of the watershed is currently being converted to urban development, cropland is still by far the largest land cover (43%) in the Vermillion River Watershed (Table 1). Tile drainage and ditching through crop and pasture land lower the groundwater table and improve the efficiency of runoff, carrying sediment and nutrients to streams, wetlands and lakes. Excess manure and fertilizer application, lack of conservation tillage and subsequent lack of crop residue, and lack of riparian buffers can increase the potential for field erosion and sediment and nutrient loading in agricultural areas. The Vermillion River Watershed currently has one reach (517) impaired for turbidity (TSS) in the Upper Vermillion River subwatershed. A majority of the watershed draining to this reach is agricultural land in rural portions of Dakota County and Scott County.

The TMDL study identified upland field erosion as the primary source of turbidity and TSS during high flow conditions. The Stressor Identification Report (Wenck 2013) also identified sediment as a primary stressor within the reaches impaired for fish and macroinvertebrates. Several portions of the Vermillion River, such as the South Branch subwatershed, have displayed high nitrate levels from groundwater and subsurface drainage from the practice of row crop agriculture where soils are left exposed without cover for much of the year. Thus, managing vegetation cover, soil loss and nutrient loading from agricultural areas is a high priority throughout the Vermillion River Watershed.

Urban Stormwater Management

Urban land currently accounts for approximately 19% of the land cover in the Vermillion River Watershed. Large portions of the North Creek, Middle Creek and South Creek subwatersheds are currently developed, or are being transitioned from cropland to urban/suburban development. Storm sewer systems in urban areas have the potential to deliver sediment and nutrients to surface waters from sediment build-up on impervious surfaces, pet waste, leaves, lawn clippings, fertilizers, automobiles and construction sites. Runoff from impervious surfaces also has the potential to deliver high temperature water to rivers and streams which is a major concern for Vermillion River's cold water reaches. All four nutrient impaired lakes in the Vermillion River Watershed are located in urban areas in the North Creek subwatershed. Similarly, several of the bacteria impaired reaches are located in predominately urban watersheds. Continuing to identify and implement urban BMPs to promote infiltration and treat stormwater is a major priority for the Vermillion River and its tributaries.

3. Prioritizing and Implementing Restoration and Protection

The Clean Water Legacy Act (CWLA) requires that WRAPS reports summarize priority areas for targeting actions to improve water quality, identify point sources and identify nonpoint sources of pollution with sufficient specificity to prioritize and geographically locate watershed restoration and protection actions. In addition, the CWLA requires including an implementation table of strategies and actions that are capable of cumulatively achieving needed pollution load reductions for point and nonpoint sources.

This section of the report provides the results of such strategy development and prioritization. Because much of the nonpoint source strategies outlined in this section rely on voluntary implementation by landowners, land users and residents of the watershed it is imperative to create social capital (trust, networks and positive relationships) with those who will be needed to voluntarily implement best management practices. Thus, effective ongoing civic engagement is fully a part of the overall plan for moving forward.

There are issues that are not addressed in the strategies tables, like limited local capacity and funding that can greatly affect the outcomes of this report. If resources like staff or funding are limited, or nonexistent, in the project area it is likely that the strategies and goals laid out in this report will take longer to achieve, if at all. Much of this work relies on reductions from non-regulated actions in the watershed, and in order to achieve those goals local relationships and trust need to be built where they may not currently exist. Therefore, it is important that as these actions are undertaken that all levels (Federal Government, State Government, Local Government, Non-profits, and landowners) continue to find ways to support local entities and individuals to ensure the waterbodies in the Vermillion River Watershed are restored and protected. If this support does not happen, achieving the TMDL reductions and strategies in this report are very unlikely.

3.1 Targeting of Geographic Areas

Targeting has been used at several scales to help identify priority areas in the Vermillion River Watershed. The following discussion begins at the state and basin scale and moves to smaller more focused areas based on the specific tools used for this project.

State and Mississippi Basin Scale

The *Minnesota Nutrient Reduction Strategy* was developed in response to concern about excessive nutrient levels that pose a substantial threat to Minnesota's lakes and rivers, as well as downstream waters including the Great Lakes, Lake Winnipeg, the Mississippi River, and the Gulf of Mexico. In recent decades, nutrient issues downstream of Minnesota have reached critical levels, including the effect of nutrients in the Gulf of Mexico which resulted in a dead zone, eutrophication issues in Lake Winnipeg, and algal blooms in the Great Lakes. Several state-level initiatives and actions highlighted the need for a statewide strategy that ties separate but related activities together to further progress in making nutrient reductions. Minnesota conducted both nitrogen and phosphorus assessments to identify nutrient source contributions. The main nutrient sources to the Mississippi River are phosphorus from agricultural cropland runoff, wastewater, and streambank erosion, and nitrogen from agricultural tile drainage and water leaving cropland via groundwater. The associated Phase I milestones for the

Mississippi River basin N and P are 20% and 35% reduction from baseline by 2025 respectively. Additional milestones call for 30% (N) and 45% (P) by 2035 and 45% reduction from baseline in N by 2045.

The *Nitrogen in Minnesota Surface Waters Strategy* was developed in response to a concern for human health when elevated nitrogen levels reach drinking water supplies. The 10 mg/l nitrate-N drinking water standard established for surface and groundwater drinking water sources and for cold water streams is exceeded in numerous wells and streams. As noted in the Nutrient Reduction study above, the concern about nitrogen (N) in surface waters has grown due to nitrogen's role in causing a large oxygen-depleted hypoxic zone in the Gulf of Mexico, and an increasing body of evidence showing toxic effects of nitrate on aquatic life. The purpose of this study was to provide an assessment of the science concerning N in Minnesota waters so that the results could be used for current and future planning efforts, thereby resulting in meaningful goals, priorities, and solutions.

More specifically, the purpose of this project was to characterize N loading to Minnesota's surface waters, and assess conditions, trends, sources, pathways, and potential BMPs to achieve nitrogen reductions in our waters. The nitrogen study contains a spreadsheet tool called the NBMP tool (NBMP is described in more detail in the Nitrogen Study Report Chapter F1). The NBMP tool was used in the Mississippi River - Lake Pepin Watershed (Appendix A) to develop watershed with actions based on local input.

Vermillion River Watershed

Various reports, datasets and GIS tools were developed through the Vermillion River Watershed assessment process and the TMDL studies that can be used to identify degraded waterbodies and potential areas to implement restoration and protection strategies. A summary of these resources is presented in the table below and Figure 6 through 10. These resources were developed by various groups and agencies including BSWR, The University of Minnesota Duluth, Minnesota DNR, VRWJPO, Dakota County SWCD, USDA, and several other agencies. More detailed information on each effort/tool can be obtained from the sources cited in Table 9. It is important to point out that these tools were developed using a wide range of input datasets with different restoration and protection initiatives in mind, ranging from stream shading to sediment and nutrient loading.

Recently, the Minnesota DNR developed the Watershed Health Assessment Framework (WHAF) which provides a comprehensive overview of the ecological health of Minnesota's watersheds. The WHAF is based on a "whole-system" approach that explores how all parts of the system work together to provide a healthy watershed. The WHAF divides the watershed's ecological processes into five components: biology, connectivity, geomorphology, and hydrology and water quality. A suite of watershed health index scores have been calculated that represent many of the ecological relationships within and between the five components. These scores have been built into a statewide GIS database that is compared across Minnesota to provide a baseline health condition report for each of the 81 major watersheds in the state. The DNR has applied the condition report to larger (HUC-8) watersheds, and more recently has applied the framework at smaller (HUC-12) subwatershed levels. Moving forward, the WHAF will be a helpful resource in monitoring and assessing the health of the Vermillion River Watershed as restoration and protection practices are implemented.

Table 9. Prioritization and Targeting Tools available in the Vermillion River Watershed.

Tool	Description	How can the tool be used?	Notes	Link to Information and data
PONDNET and/or other urban watershed models	PONDNET is a spreadsheet model that routes flow, TSS, and TP through networks of wet detention ponds. Watershed runoff is estimated using land use-based runoff coefficients and pollutant loading is predicted using land use specific event mean concentrations.	PONDNET models have been developed for the City of Apple Valley and portions of Burnsville and Lakeville as part of the Vermillion Watershed lake TMDL studies and non-degradation review studies. These models, or other urban watershed models such as P8 or WinSLAMM, could be used to determine high potential TSS and TP loading areas in the urban portions of the watershed for BMP planning (Figure 6 and Figure 7).	Since many of the existing urban WQ models in the Vermillion River watershed were created as part of special studies, they may need to be updated and/or expanded to analyze other portions of the watershed	PONDNET P8 WinSLAMM
Vermillion River Fluvial Geomorphic Assessments	The VRWJPO contracted with Inter-Fluve Inc. to conduct eight fluvial geomorphic assessment studies on 156 miles of waterway throughout the Vermillion River Watershed. The primary focus of these studies was: to understand stream bank stability; identify grade control points, knickpoints and areas of accelerated erosion; characterize aquatic and riparian habitat throughout the several subwatersheds; and identify opportunities for restoring geomorphic processes and habitat conditions	Each geomorphic assessment study identified a list of potential projects for each subwatershed and assessed reach. The project list contains a ranking system so the projects can be prioritized based on feasibility, impact and cost. These assessment reports contain detailed documentation and analysis of each reach which can be used as reference tool for identifying restoration and protection projects throughout the watershed.	Assessments have been completed for North and Middle Creek, South Creek, Empire drainages, Etter Creek and Ravenna Coulees. Assessments have also been performed along individual reaches of the main-stem Vermillion River at biological monitoring stations	VRWJPO VRWJPO
Stream Shade Coefficient	The stream shade coefficient is a tool developed by the VRWJPO and Dakota County that uses the Area Solar Radiation tool in ArcGIS along with other raster overlays to identify areas of high and low solar radiation and shading throughout the watershed. To date, the tool has been developed for portions of the Middle Mainstem, Upper Mainstem, South Branch, South Creek, Middle Creek and North Creek Subwatersheds	This tool is currently used by the VRWJPO and other local stakeholders to identify riparian areas with high stream shading (low solar radiation/heating effect) and low shading (high solar radiation) to prioritize potential riparian shading and restoration projects (Figure 8 and Figure 9.	Contact VRWJPO for more information on this tool	VRWJPO

Revised Universal Soil Loss Equation (RUSLE) and Soil Erosion Risk Tool	RUSLE predicts the long term average annual rate of erosion on a field slope based on rainfall pattern, soil type, topography, land use and management practices. A soil erosion risk (similar to RUSLE) tool is available through the Ecological Ranking Tool (EBI) website and uses a subset of RUSLE to determine relative soil erosion risk values on a 0-100 point scale.	The RUSLE model provides an assessment of existing soil loss from upland sources and the potential to assess sediment loading through the application of BMPs. The Soil Erosion Risk Tool (Figure 10) provides users with a general sense of the highest potential areas of soil loss in a given watershed/subwatershed.	RUSLE results present maximum amount of soil loss that could be expected under existing conditions and do not represent sediment transport and loading to receiving waters.	RUSLE Soil Erosion Risk Tool
Ecological Ranking Tool (Environmental Benefit Index - EBI)	The EBI was developed using three GIS layers: soil erosion risk, water quality risk, and habitat quality. Locations on each layer are assigned a score from 0-100. The sum of all three layer scores (max of 300) is the EBI score. The higher the score, the higher the value in applying restoration or protection.	Any one of the three layers can be used separately or the sum of the layers (EBI) can be used to identify areas that are in line with local priorities. Raster calculator allows a user to make their own sum of the layers to better reflect local values. This layer was created with the intention to rank CRP and other critical lands on multiple ecological benefits simultaneously.	Figure 11 represents the top 5% of the priority land areas in the watershed based on the three data layers that go into GIS layers. The map below is not an aggregate of all the information in this table, but does use some information like the RUSLE and Soil Erosion Risk Tool as one of the three layers.. .	BWSR
Watershed Nitrogen Reduction Planning Tool (NBMP)	NBMP is an Excel spreadsheet tool that can be used to develop a framework to compare and optimize selection of BMPs for reducing nitrogen loads from the highest contributing sources and pathways.	This tool is intended to compare the effectiveness and cost potential of nine different BMPs that could be implemented to reduce nitrogen loading from cropland. The tool can be used by local resource managers to better understand the feasibility and cost of these BMPs.	Excel spreadsheet and information are available on the University of Minnesota Extension website (Appendix A)	Extension
Restorable Wetland Prioritization Tool	A GIS-based tool developed by the University of Minnesota Duluth and other agencies that uses readily available GIS data consisting of 5 primary layers. The final product is a map showing potential locations for wetland restorations throughout the watershed.	This tool may be used to help identify and prioritize potential wetland restoration areas based on soil type and existing land use.	The VRWJPO and Dakota County SWCD have developed a similar tool for the Upper Vermillion and South Branch subwatersheds. As or right now this data is only available for these parts of the watershed.	UMD Dakota SWCD
Minnesota Urban Heat Export Tool (MINUHET)	A model developed by the University of Minnesota that is used to assess temperature impacts of stormwater runoff on trout streams.	MINUHET can be used to estimate the change in temperature and/or heat created by a proposed development in the watershed. MINUHET can be used for analyses of single storm events or continuous climate data over several months.	Information available through the Saint Anthony Falls Laboratory (SAFL) website	SAFL

Prioritize, Target, and Measure Application (PTMApp)	A GIS-based tool that builds on general strategy types in local water plans by identifying implantable on-the-ground Best Management and Conservation Practices	PTMApp can be used by SWCDs, watershed districts, and local resource managers to: prioritize resources and water quality issues, target specific fields to place conservation practices and BMPs, measure expected water quality improvement and pollutant load reduction, establish tailored BMP scenarios and cost analysis, and create reports documenting the prioritization, targeting, and measuring process.	GIS based toolbar and information available through the Red River Basin Decision Information Network Website	PTMApp
The Agricultural Conservation Planning Framework (ACPF)	A GIS based tool that identifies locations where specific attributes are favorable for installation of agricultural BMP practices to control water flows and trap/treat nutrient losses in fields, at field edges, and in riparian zones. The tool provides an inventory of conservation alternatives that can be considered at the local and farm level. The input data required, including agricultural field boundaries, land use, soil survey information, and detailed (LiDAR-based) elevation data, are broadly available across Minnesota and the Midwest.	ACPF (along with PTMApp) can be used by local resource managers to identify and prioritize areas on the landscape where certain agricultural BMPs may work. BMPs available in this tool include: grassed waterways, contour buffer strips, nutrient removal wetlands, water and sediment control basins, and nitrogen bioreactors and other tile drainage BMPs. ACPF also includes a riparian analysis tool to help identify riparian management alternatives.	Due to data requirements and processing times, ACPF works best when applied at the 12-digit HUC subwatershed scale.	ACPF

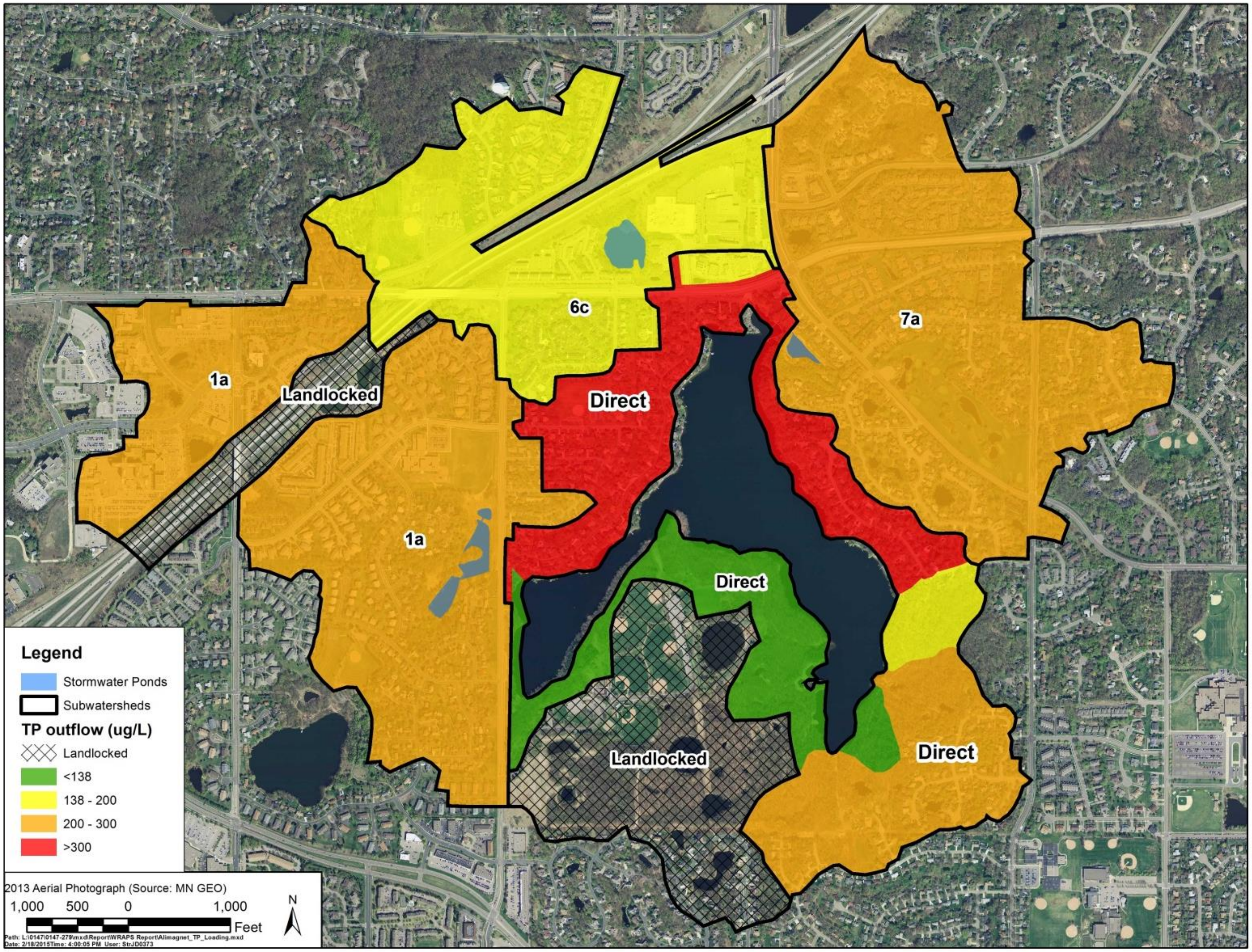


Figure 6. PONDNET Predicted Phosphorus Runoff Concentrations in the Alimagnet Lake Watershed.

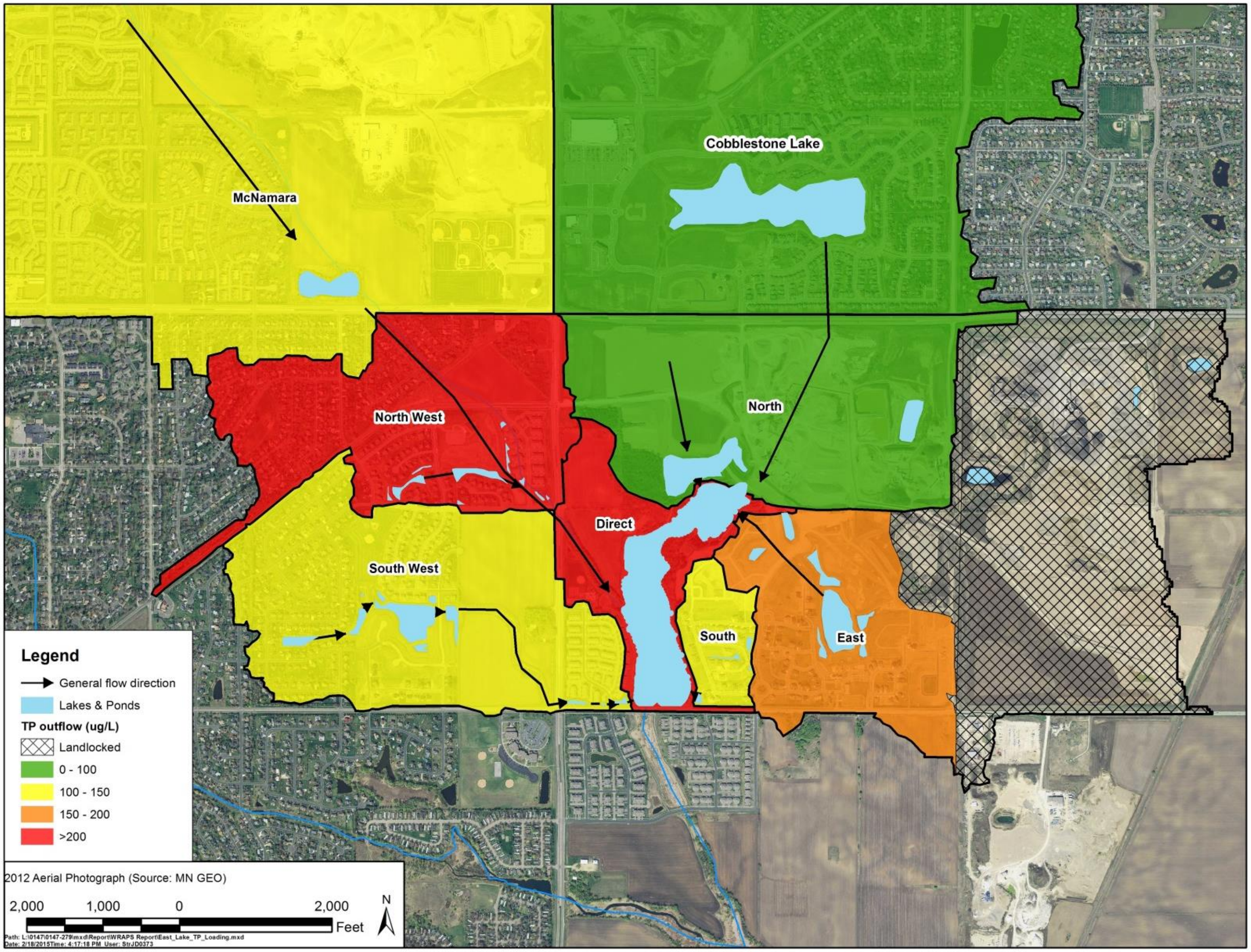


Figure 7. PONDNET Predicted Phosphorus Runoff Concentrations in the East Lake Watershed.

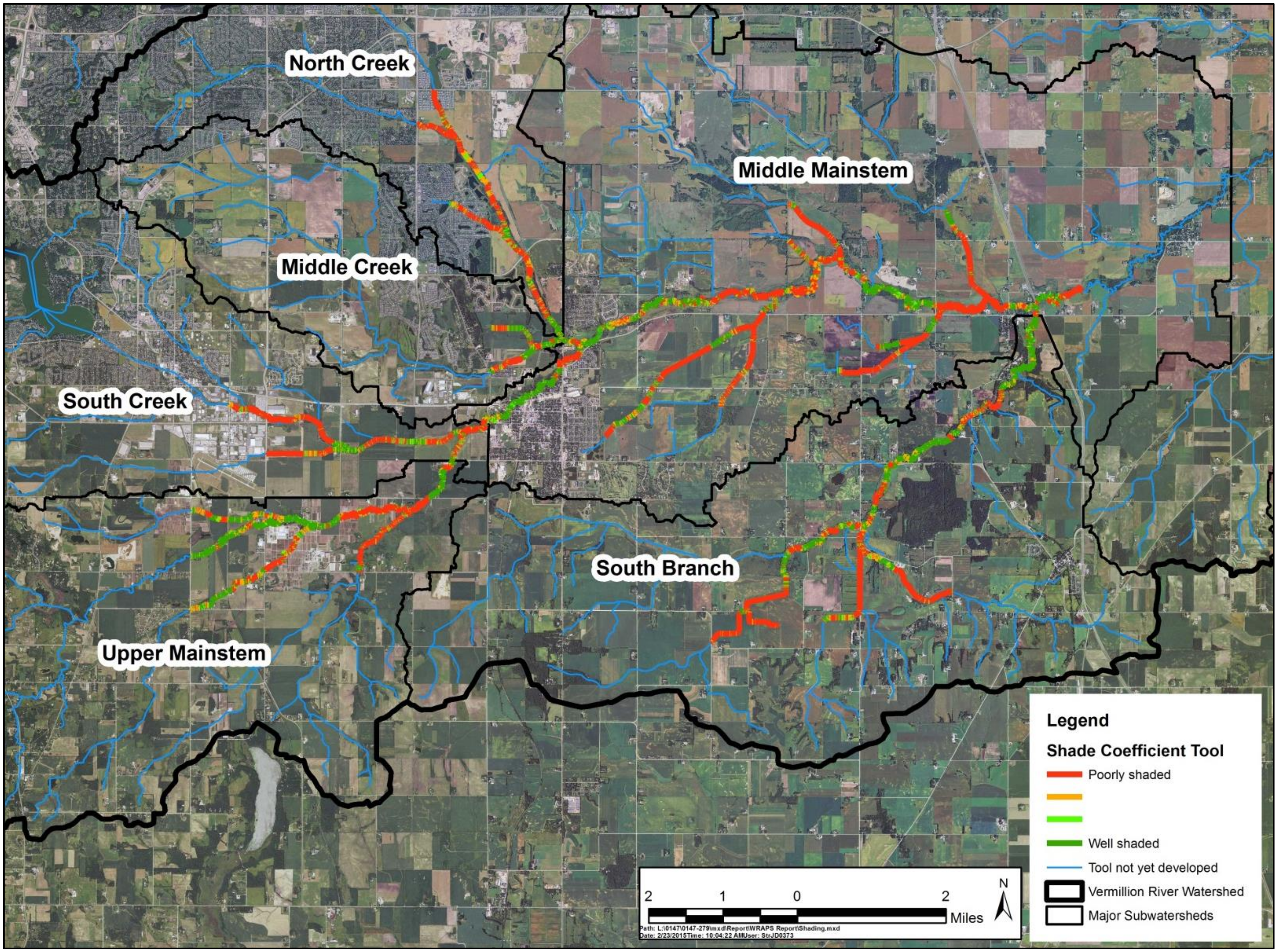


Figure 8. Shade Coefficient Analysis for Several Main stem and Tributary Reaches of the Vermillion River

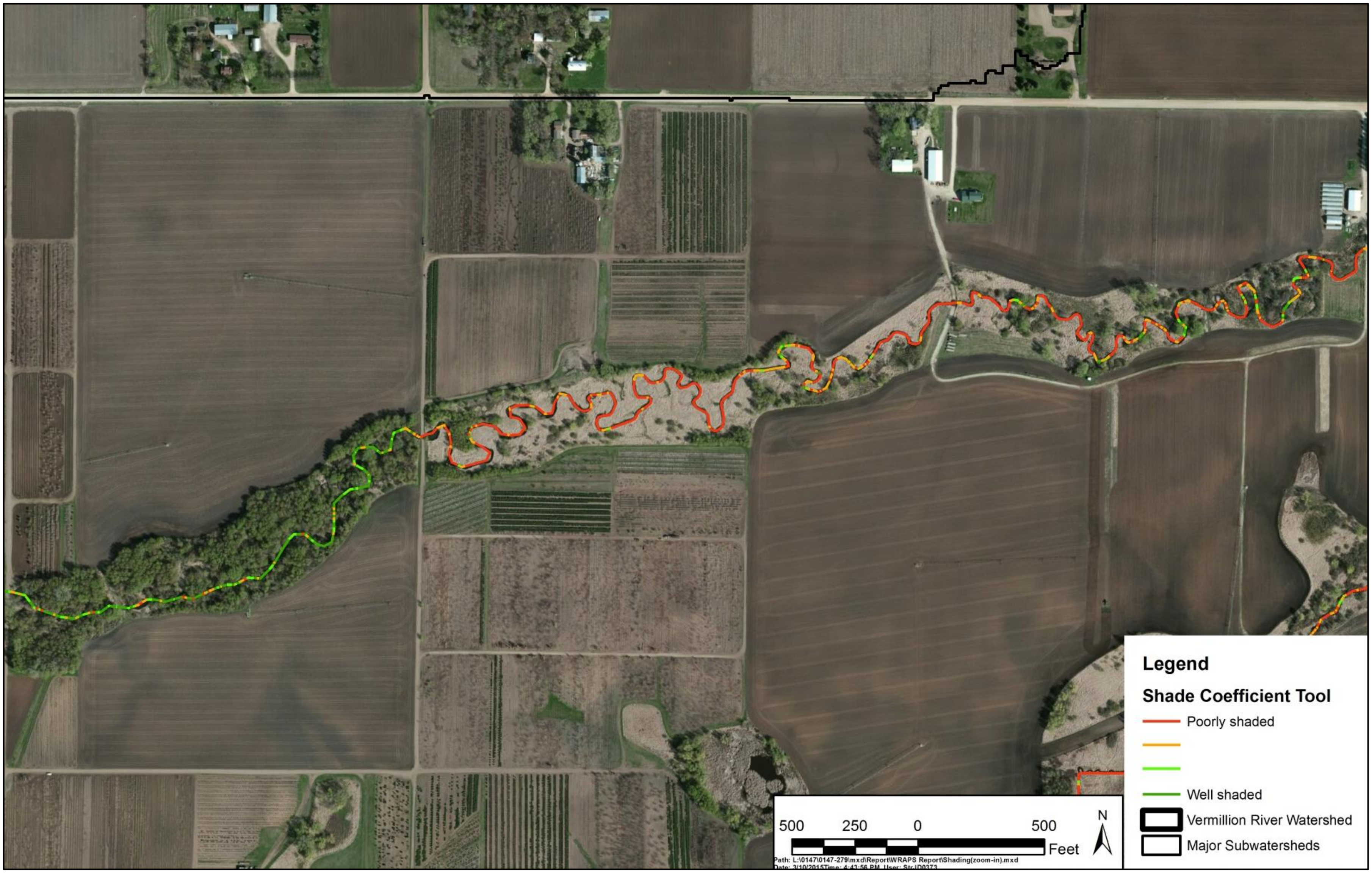


Figure 9. Closer Example of the Shade Coefficient Analysis (Reach -517 in the Upper Vermillion River Sub-watershed).

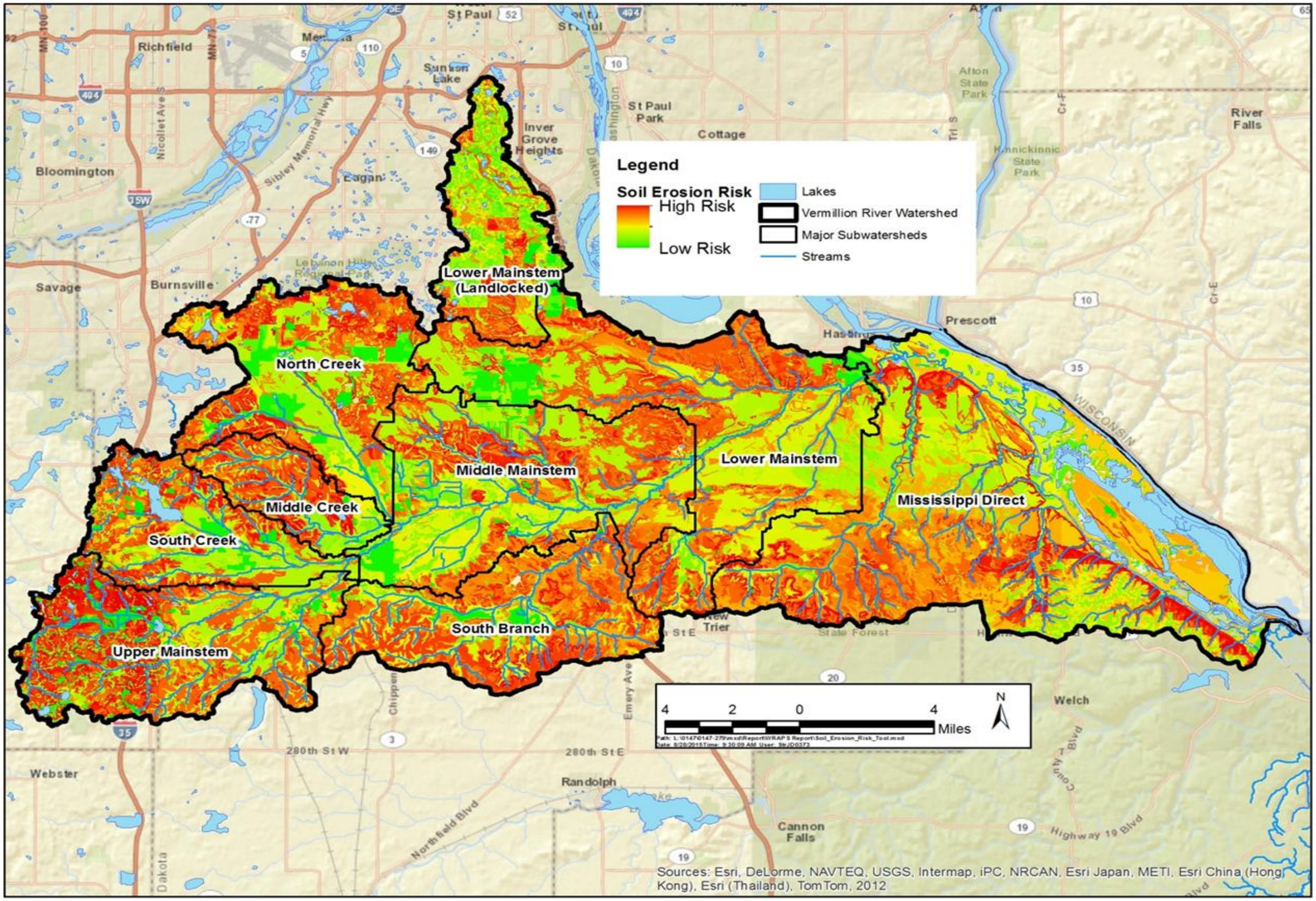


Figure 10. Soil Erosion Risk in the Vermillion River Watershed.

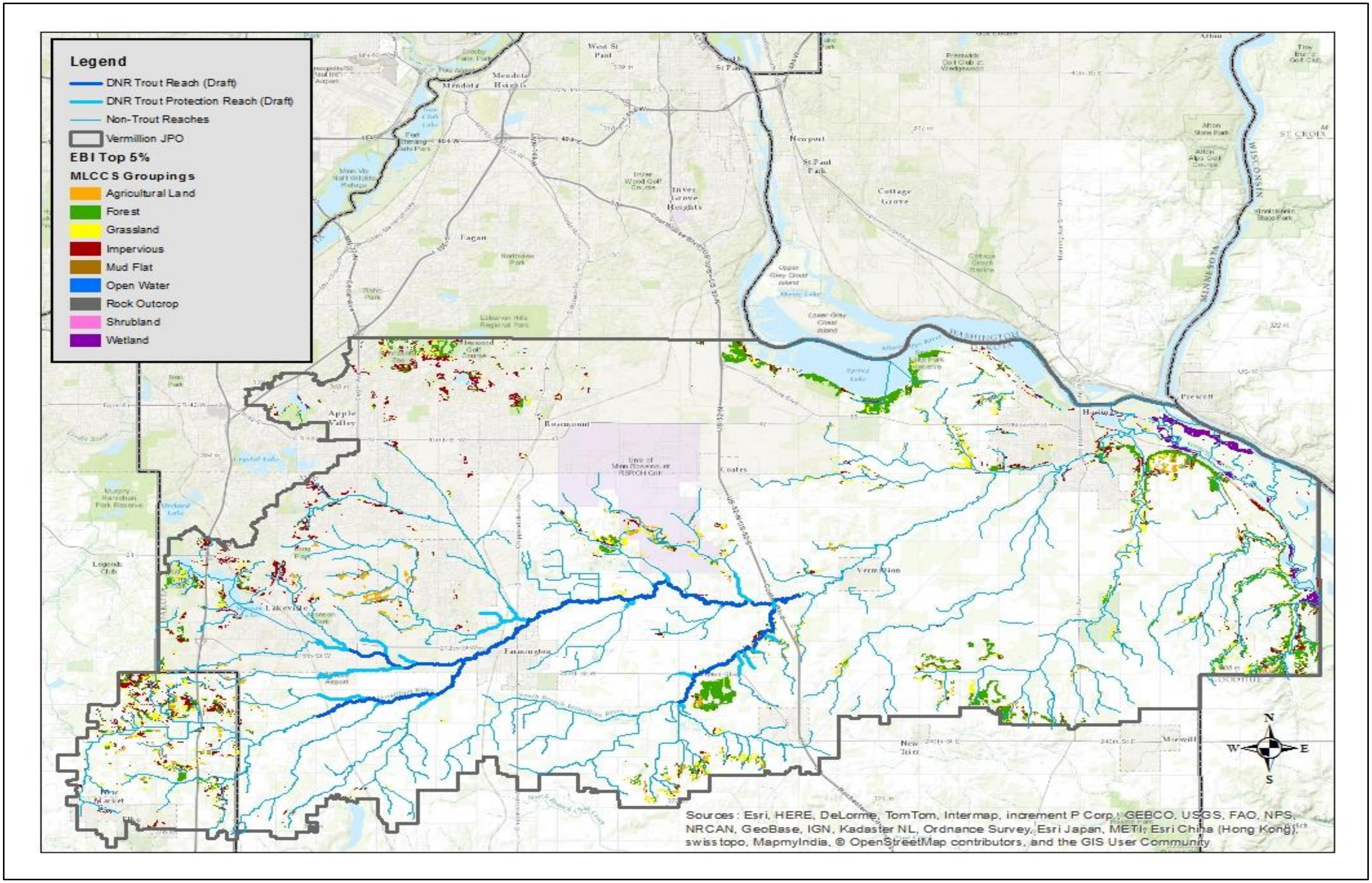


Figure 11. BWSR's Environmental Benefits Index (EBI) Tool Top 5% Priority Areas within the Vermillion River Watershed based on Soil Erosion Risk, Water Quality Risk, and Wildlife Habitat Quality. (This map is not an aggregate of all the other maps and information listed above.)

3.2 Civic Engagement

To date, civic engagement in the Vermillion River Watershed taken on numerous forms, but was developed primarily by a citizen stakeholder process. A committee termed the Watershed Engagement Team (WET) was selected from a pool of citizens who live, work, or play within the Vermillion River Watershed. The VRWJPO staff informed the WET of the existing water quality, demographics, land use, and other aspects important to understanding the watershed. Their role was to inform staff on activities the VRWJPO could implement to help improve the watershed while engaging citizens, messages that would capture the attention of those who could help improve the watershed, and networks that exist that could help in promoting messages and activities to further our watershed improvement efforts.

Of those activities, messages, and networks identified, the VRWJPO staff has participated in the following events, activities, or presentations on water quality, TMDLs, and strategies for improvement that have utilized identified activities, messages, and networks:

- Hastings Area Birding Festival
- Farmington's Earth Day and Arbor Day event
- Lakeville's Watershed Cleanup Day event
- Dakota County Parks Department's Earth Day Celebration and Cleanup event.
- Lake Alimagnet Association's spring meeting
- A follow up meeting on June 30, 2014, with the Lake Alimagnet Association's President
- Three open house meetings that staff termed, "Community Conversations," to identify, discuss, and prioritize the major issues for the VRWJPO
- A presentation to Dakota County Environmental Resources Department
- Dakota Soil and Water Conservation District 70th Anniversary
- Vermillion River Watershed Tour
- Grand Opening of Dakota County's Whitetail Woods Regional Park
- Presentation on WRAPS/TMDL for Lake Alimagnet to the Burnsville Parks and Natural Resources Commission
- Three follow up "Community Conversations" meetings ," to lay out major issues and objectives for the VRWJPO
- Dakota County Fair
- Alimagnet Park Wildflower Planting
- Dakota County Winter Maintenance (Sidewalk and Parking Lot) Workshop
- Long Lake Association meeting with Lake Association President
- Restoration Project in Doyle Kennefick Park in Elko New Market
- Dakota County Parks Department Park Naturalist's Programming
- Dakota County Library Staff Programming
- Development of a Stewardship Grant Program to promote activities identified to help with water quality improvement while civically engaging groups of individuals
- Presentation on WRAPS/TMDL to Castle Rock, Eureka, and Vermillion Townships

- Presentation on WRAPS/TMDL to the city of Farmington's City Council and Planning Commission

Future civic engagement activities planned or anticipated are:

- Presentations on WRAPS/TMDL to other communities, interest groups, or other networks within the watershed
- Utilization of other networks to disseminate information and messages regarding water quality
- Targeted stewardship events to help address pollutant loading within specific subwatersheds
- Blue Thumb raingarden, native garden, and shoreline stabilization workshops
- Pilot program to inform riparian landowner of water quality problem and allow for self-selection of BMPs to address the issue

Additionally, the Scott Clean Water Education Program (SCWEP) has conducted various events, activities, and trainings in 2014 that worked towards clean water goals. These events, activities, and trainings included, but were not limited to: Cover crop/soil health information and workshop, native prairie workshop, shoreline restoration workshop, raingarden workshops, promoting conservation practices for rural residential and hobby farm properties, tree planting program and information, promotion of environmentally friendly lawn care management, distribution of storm drain stenciling kit, and outreach to local government leaders on water resource issues.

3.3 Restoration & Protection Strategies

Specific strategies have been developed to restore the impaired waters within the watershed and for protecting waters within the watershed that are not impaired. The subwatershed-based implementation strategy tables that follow outline the strategies and actions that are capable of cumulatively achieving the needed pollution load reductions for point and non-point sources, as well as watershed and in-stream improvements to decrease stressors on biological communities throughout the watershed. The tables were developed by thoroughly reviewing the specific conditions affecting each of the waters and collecting input from the VRWJPO and watershed stakeholders. As this WRAPS Report includes waters that have been previously addressed by past TMDLs, specific implementation plans have already been developed for some of the water bodies. In these cases, links to the past work are provided in the table. Some of the practices in the restoration and protection strategies tables may be credited as progress toward achieving TMDL WLAs. MS4s and other permitted entities may contact the MPCA to discuss which practices may be credited.

A couple important resources to note within the Vermillion River Watershed are the Vermillion River Watershed Joint Powers Boards Watershed Plan and local rules and standards. The VRWJPO Local Watershed Plan is currently under development and will include the strategies laid out in this report for the next 10 years, as well as other priority issues and concerns. The VRWJPO also has Watershed Standards and Rules that govern many of the activities in the Vermillion Watershed. All of these actions will also help with the restoration and protection of the Vermillion River Watershed.

Here are links to the VRWJPO's Standards and Rules:

- Stream Classification & Buffer Standard and Map
  VRWJPO Watershed Rules

Additional Vermillion River Watershed Restoration and Protection Resources

Vermillion River Corridor Plan - VRWJPO

Vermillion River Watershed Thermal Trading Project -VRWJPO

Vermillion River Stream Cooling Demonstrations - VRWJPO

Vermillion River Corridor Handbook – Dakota County

Upper Vermillion River and South Branch Drained Wetland Inventory

Vermillion River Watershed Handbook - Minnesota Department of Natural Resources (DNR)

Vermillion River USGS Monitoring Station - USGS

North Creek Sub-watershed Strategies

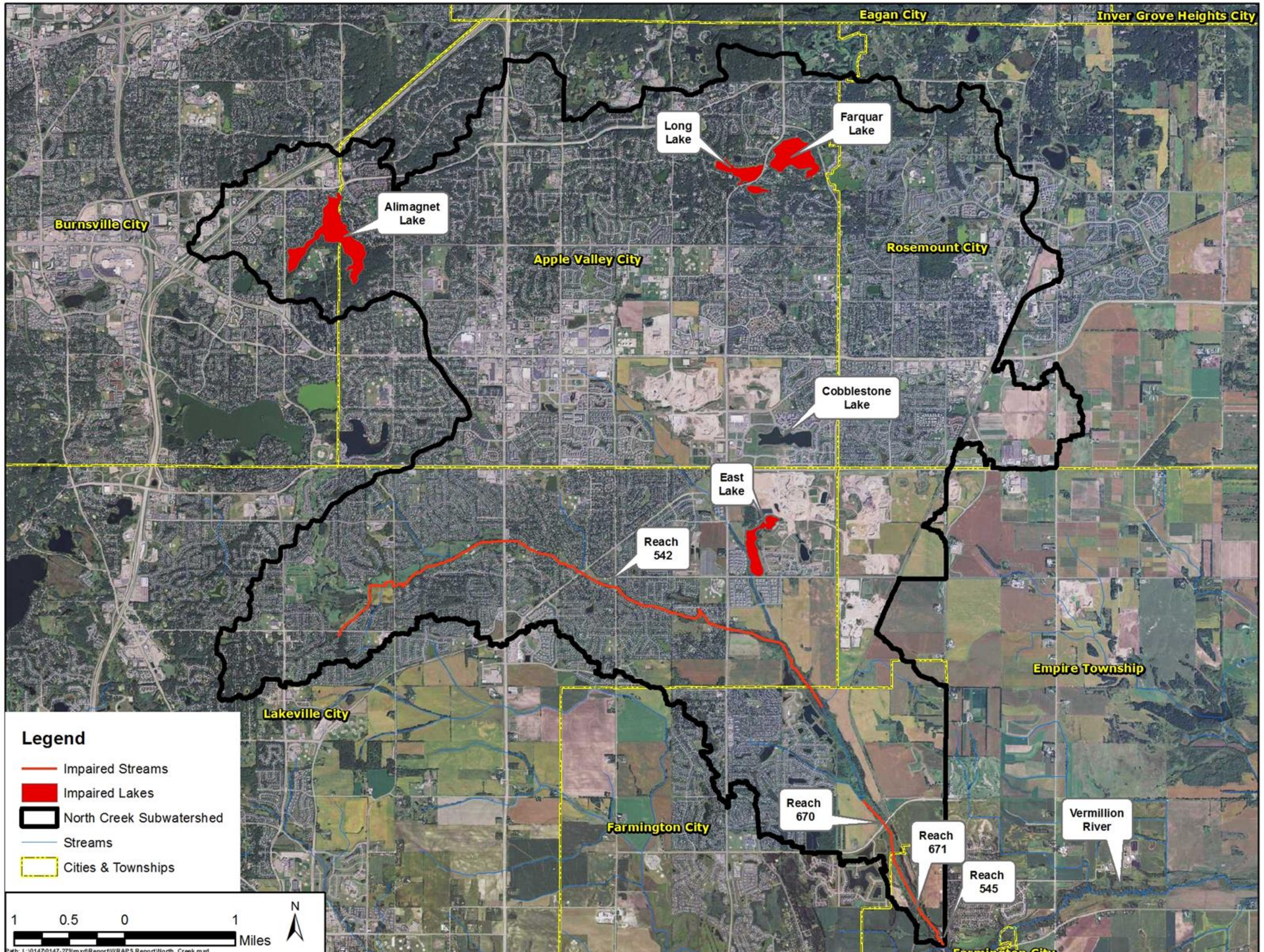


Table 10. North Creek Sub-watershed Restoration and Protection Strategies.

Key for shading: Red = Restoration Strategies; Green = Protection Strategies.

Key for Government Unit Responsibilities: P= Primary/Lead role; S = Secondary role; A = Assist as Needed.

Major Subwatershed	Waterbody and Location: Waterbody (ID)	Waterbody and Location: **Location** and Upstream Influence Counties; Cities and other MS4s	Parameter (incl. non-pollutant stressors)	Water Quality: TMDL Baseline Conditions	Water Quality: TMDL Goals / Targets and Estimated % Reduction	Strategies (see Table 18)	Strategy types and estimated scale of adoption needed to meet final water quality target	Interim 10-yr Milestones	Vermillion River JPO	Dakota County	Dakota County SWCD	MPCA	DNR	City of Burnsville	City of Apple Valley	City of Lakeville	City of Farmington	MNDOT	Lake Associations	Estimated Year to Achieve Water Quality Target
North Creek	Long Lake (19-0022)	Dakota Co.; Apple Valley	TP	508 lbs/yr	123 lbs/yr 76% reduction	Detailed strategies have been developed for Long Lake and Farquar Lake through the Long and Farquar Lakes Nutrient TMDL (2009) and Implementation Plan (2010). These documents are approved by the EPA and available through the MPCA website: http://www.pca.state.mn.us/index.php/water/water-types-and-programs/minnesotas-impaired-waters-and-tmdls/tmdl-projects/lower-mississippi-river-basin-tmdl/project-long-farquar-lakes-excess-nutrients.html														
	Farquar Lake (19-0023)	Dakota Co., Rosemount, Apple Valley		792 lbs/yr	263 lbs/yr 67% reduction															
	Alimagnet Lake (19-0021)	Dakota Co.; Burnsville, Apple Valley, MNDOT		386 lbs/yr	230 lbs/yr 43% reduction	Reduce in-water loading (TP)	Continue monitoring fish population, rough fish removals as needed	Monitor (once every 3 years)	A				**P**	S	S					2040
							Perform study to determine drawdown feasibility and potential benefits, as well as a feasibility study to determine internal chemical treatment options and benefits (internal load reduction goal is 106.7 lbs, or approximately 65% of the total load reduction needed for the lake)	Complete feasibility study (5 years) Implement findings (within 10 years)	A			A	A	**P**	**P**				S	
							Continue monitoring; develop vegetation management plan	Monitor (annually), complete vegetation mgt. plan (3 years)	A				S	**P**	**P**				S	
						Improve urban SW mgt. (TP)	Enhanced street sweeping program throughout watershed. Target direct watershed, areas near the lake, and DCIAs (estimated to achieve 5% of the TP load reduction)	Develop enhanced sweeping plan and implement (3 years)	A	**P**				**P**	**P**			**P**		
							Conduct subwatershed BMP retrofit assessment study. Implement 5-10 SW retrofit projects (estimated to achieve 15% of the TP load reduction)	Study to ID potential areas and develop plans (3 years), implement 5 BMPs (10 years)	**P**					S	S					
							Inspect and evaluate major ponds in watershed, pond improvements as necessary (sizing, dredging, iron enhanced sand filters) (estimated to achieve 15% of the TP load reduction)	Inspect and evaluate major ponds (3 years), 1-2 pond improvements (10 years)	A					**P**	**P**					
	East Lake (19-0349)	Dakota Co.; Eagan, Apple Valley, Empire Township, Rosemount, Lakeville, MNDOT		985 lbs/yr	605 lbs/yr 42% reduction	Improve urban SW mgt. (TP)	Monitor flow and WQ for NCL-57 and other ponds, assess results and potential improvements (estimated to achieve 20% of the TP load reduction)	Monitor (2 years), pond improvements (5 years)	A							**P**				
							Monitor McNamara pond WQ and flow changes from 2014 pond improvements (estimated reduction goal for McNamara Pond and Apple Valley is 210.7 pounds, or 51% of the total load reduction needed for the lake)	Monitor annually for 3 years	A						**P**					
							As development continues, Monitor WQ for major SW ponds in watershed to track efficiency of ponds	Monitor annually for 3 years							**P**	**P**				
							Conduct subwatershed BMP retrofit assessment study.	Study to ID potential areas and develop plans (2 years), implement 2-5 BMPs (10 years)	P		S				**P**	**P**				
						Reduce in-water loading (TP)	Monitor lake WQ to determine success of 2013 alum treatment (internal load reduction goal is 119.7 lbs, or approximately 29% of the total (estimated) load reduction needed for the lake)	Monitor annually	A							**P**				
							Monitor fish populations, rough fish removals as necessary, assess need for fish barriers	Monitor annually for 3 years, assess need for removal or barriers within 3 years	S				**P**			S				

Major Subwatershed	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategies (see Table 18)	Strategy types and estimated scale of adoption needed to meet final water quality target	Interim 10-yr Milestones	Governmental Units with Primary Responsibility											Estimated Year to Achieve Water Quality Target
	Waterbody (ID)	**Location** and Upstream Influence Counties; Cities and other MS4s		TMDL Baseline Conditions	TMDL Goals / Targets and Estimated % Reduction				Vermillion River JPO	Dakota County	Dakota County SWCD	MPCA	DNR	City of Burnsville	City of Apple Valley	City of Lakeville	City of Farmington	MNDOT	Lake Associations	
							Continue monitoring, develop vegetation mgt. strategies as needed	Monitor annually	A							**P**				
							Perform study to determine drawdown feasibility and potential benefits	Complete feasibility study (5 years)	A				S			**P**				
	North Creek (542)	Dakota Co.; Empire Township, Farmington, Lakeville, MNDOT	*E. coli*	233-1,419 cfu/100mL	126 cfu/100mL 46% - 92% reduction	Improve urban SW mgt. (*E. coli*)	Assess presence of waterfowl (particularly geese) in stream corridor, monitor problem areas (VRWJPO), manage as necessary (DNR)	Complete assessment and work with DNR as needed (3 years)	**P**				**P**			A	A			
	North Creek (670)			78 – 272 cfu/100mL	126 cfu/100mL 0% - 51% reduction		Identify high bacteria loading tributaries and/or outfalls and install 1-5 biochar and/or iron filtration systems to reduce bacteria load, as well as TSS, and TP. Biochar filters have been shown to remove up to 96% of bacteria load	Complete monitoring and feasibility study (3 years), install 1-5 system (10 years)	**P**							S	S			
	North Creek (671)			96 – 304 cfu/100mL	126 cfu/100mL 0% - 56% reduction		Monitor 2-3 major SW ponds for in-pond *E. coli* concentrations. Manage in-pond bacteria sources as needed. Decrease *E. coli* loading to SW ponds through pet waste management initiatives.	Monitor ponds for 2 years (5 years)	**P**							A	A			
	North Creek (545)			129 – 330 cfu/100mL	126 cfu/100 mL 2% - 62% reduction	Improve riparian vegetation (*E. coli*, IBI, protection)	Increase riparian buffers and enforce buffer initiative on 100% of streams and tributaries. Target riparian buffers and plantings in urban areas upstream of Pilot Knob Rd	Buffers must be in place by 2017 for public waters, and 2018 for public drainage systems; additionally target 5 buffer improvement projects on public land (5 years) in watershed , 10 projects in 10 years throughout watershed	**P**							**P**	**P**			2040
	North Creek (671 & 545)	Dakota Co.; Empire Township, Farmington, Lakeville, MNDOT	Fish & Macro IBI	Stressors: DO, Turbidity/TSS, Habitat		Restore/enhance channel (IBI, DO, TSS)	Monitor re-constructed area in reach 670 downstream of 195th St for fish and DO	Monitor for 3 years (5 years)	**P**				**P**							
							Identify and implement sediment reduction and/or volume reduction BMPs within publicly owned lands.	Install 1-3 BMPs	**P**		**P**					**P**	**P**			
							Conduct subwatershed BMP retrofit assessment study. Implement 3-5 SW retrofit projects.	Study to ID potential areas and develop plans (2 years), implement 2-5 BMPs (10 years)	**P**	**P**						**P**				
							Connect re-constructed area in reach 670 upstream of 195th St	Connect within 3 years	**P**				**P**				**P**			
							Extend channel re-construction and re-meandering in reach 670 downstream of current re-constructed section	Develop plans and funding (5 years), complete construction (10 years)	**P**				**P**				S			
	North Creek (545)		DO	Varies depending on season, flow	>7 mg/L daily minimum		Extend channel re-construction and re-meandering upstream of current re-constructed section		**P**				**P**				S			
						Monitor (DO)	Conduct 2-3 early morning DO surveys to identify areas contributing to low DO	Complete 2-3 surveys (2 years)	**P**		**P**									
	All	All	All Conventional Parameters	--	--	Restore/enhance channel	Assess in-channel weirs/dams and backwater sections to determine if they are a source/sink of bacteria, other pollutants, and low DO	Complete monitoring/assessment (3 years), improvements or removals as necessary (10 years)	**P**		**P**		S			S	S			Ongoing
				--	--	Remove fish passage barriers	Target undersize culverts, private driveway crossings, farm road crossings and grade control structures identified in geomorphic assessment report (Inter-Fluve, 2012) for improvements or removals	Complete 1-2 projects (5 years), complete 2-5 projects (10 years)	**P**		A		S			S	S			

Major Subwatershed	Waterbody and Location: Waterbody (ID)	Waterbody and Location: **Location** and Upstream Influence Counties; Cities and other MS4s	Parameter (incl. non-pollutant stressors)	Water Quality: TMDL Baseline Conditions	Water Quality: TMDL Goals / Targets and Estimated % Reduction	Strategies (see Table 18)	Strategy types and estimated scale of adoption needed to meet final water quality target	Interim 10-yr Milestones	Vermillion River JPO	Dakota County	Dakota County SWCD	MPCA	DNR	City of Burnsville	City of Apple Valley	City of Lakeville	City of Farmington	MNDOT	Lake Associations	Estimated Year to Achieve Water Quality Target
				--	--	Improve urban SW mgt.	Provide Additional SW storage/retention near headwaters within publicly owned lands that does not further degrade existing natural resources.	Target 1-2 SW retention projects (5 years), 2-4 projects within 10 years	**P**		A					**P**				
				--	--		Implement BMP SW retrofits in older developments upstream of Pilot Knob Rd.	Assess and identify projects (3 years), implement 3-4 BMPs (10 years)	**P**		A					**P**				
				--	--	Improve education and outreach	Integrate N. Creek restoration projects with N. Creek Greenway Initiative to provide educational and recreational opportunities	Plan restoration projects and Greenway Initiative concurrently	**P**											
				--	--	Improve riparian vegetation	Promote buffer plantings with shade and habitat benefit. ID and target areas using shade coefficient study	Develop buffer guide & ed. materials for cities and counties	**P**		**P**									

Middle Creek Sub-watershed Strategies

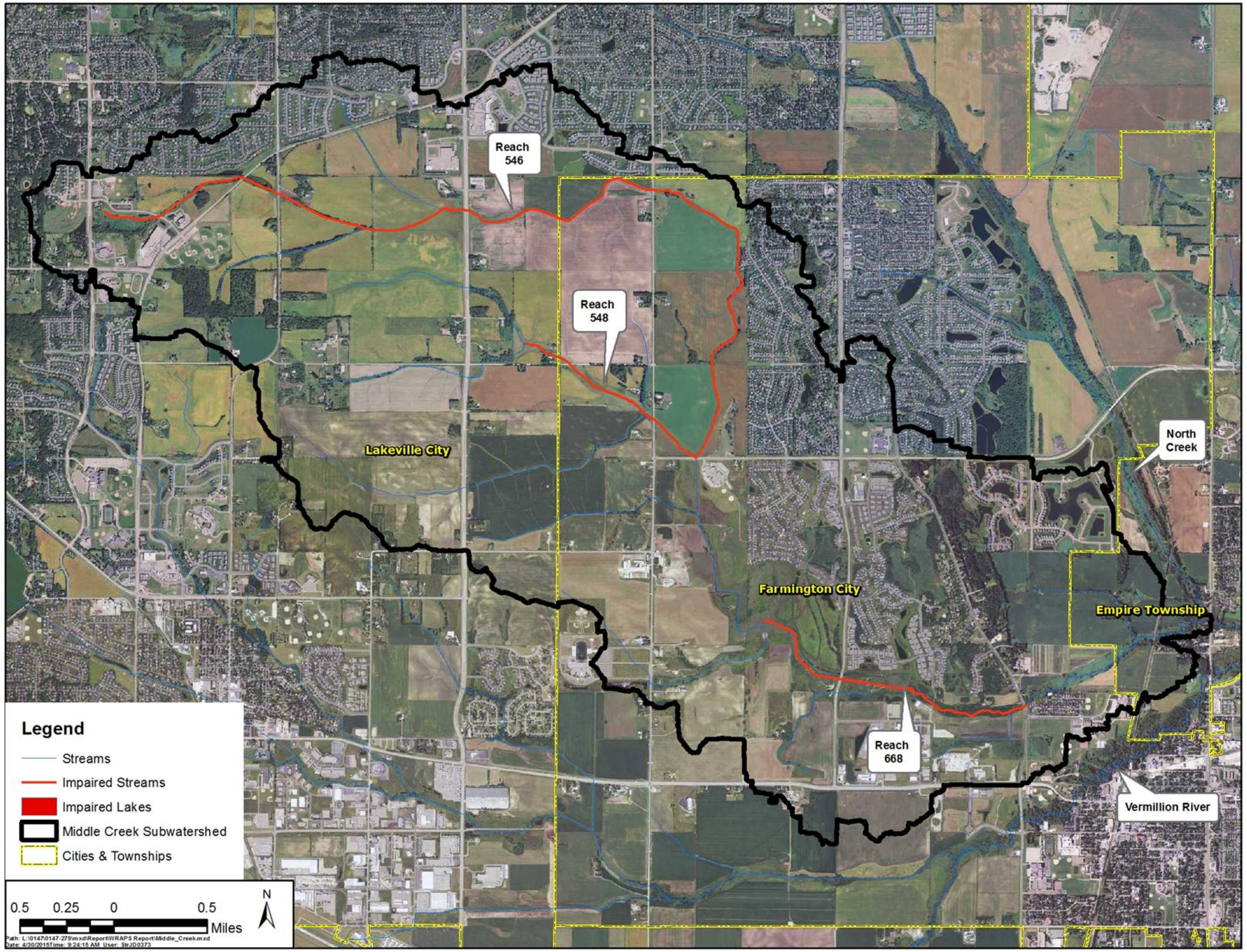


Table 11. Middle Creek Sub-watershed Restoration and Protection Strategies.

Key for shading: Red = Restoration Strategies; Green = Protection Strategies.

Key for Government Unit Responsibilities: P= Primary/Lead role; S = Secondary role; A = Assist as Needed.

	Waterbody and Location			Water Quality					Governmental Units with Primary Responsibility								
Major Subwatershed	Waterbody (ID)	**Location** and Upstream Influence Counties; Cities and other MS4s	Parameter (incl. non-pollutant stressors)	TMDL Baseline Conditions	TMDL Goals / Targets and Estimated % Reduction	Strategies (see Table 18)	Strategy types and estimated scale of adoption needed to meet final water quality target	Interim 10-yr Milestones	Vermillion River JPO	Dakota County SWCD	MPCA	DNR	City of Lakeville	City of Farmington	MNDOT	UMN Extension Services	Estimated Year to Achieve Water Quality Target
Middle Creek	Middle Creek (546)	Dakota Co.; Farmington, Lakeville	*E. coli*	550 – 2,162 cfu/100mL	126 cfu/100mL 77% - 94% reduction	Improve fertilizer and manure application mgt. (*E. coli*)	Promote/educate agronomic rates, chemical treatment of manure, and spreading in sensitive areas. Provide resources for soil nutrient testing. Hold 1-3 workshops to engage at least 50% of farmers and provide educational materials	Hold 1 workshop and work with 2-4 willing landowners	S	**P**						**P**	2040
						Improve upland/field surface runoff controls (*E. coli*, IBI)	Implement water and sediment control basins, grassed waterways, contour farming, cover crops, and conservation and reduced tillage BMPs on at least 50% of sensitive cropland areas identified using tools in section 3.1	Identify sensitive areas and potential BMP locations (3 years), Work with landowners and implement at least 2-3 BMPs (5 years), implement 3-5 BMPs (10 years)	S	**P**						**P**	
	Middle Creek (548)			202 – 778 cfu/100mL	126 cfu/100mL 38% - 84% reduction	Improve livestock mgt. (*E. coli*, IBI)	Establish livestock managed access control areas near streams, alternative watering sources and/or pastureland runoff controls/buffers on 100% of feedlots within 500 feet of streams/waterways. Target problem areas in reaches 546, 547 and tributaries identified in geomorphic assessment report.	Work with producers and implement at least 2-3 projects within 10 years.	S	**P**							
						Improve urban SW mgt. (*E. coli*)	Monitor 2-3 major SW ponds for in-pond *E. coli* concentrations. Manage in-pond bacteria sources as needed. Decrease *E. coli* loading to SW ponds through pet waste management initiatives.	Monitor ponds for at least 2 years (5 years)	**P**				A	A			
	Middle Creek (668)			187 – 876 cfu/100mL	126 cfu/100mL 33% - 86% reduction		Identify high bacteria loading tributaries and/or outfalls and install at least 1-5 biochar and/or iron filtration systems to reduce bacteria load, as well as TSS, and TP. Biochar filters have been shown to remove up to 96% of bacteria load	Complete feasibility study (3 years), install at least 1 system (5 years)	**P**				A	A			
						Improve riparian vegetation (*E. coli*, IBI, protection)	Increase riparian buffers and enforce buffer initiative on 100% of streams and tributaries. Target riparian buffers and plantings along main-stem and tributaries to reaches 546 and 548 upstream of 195th St	Buffers must be in place by 2017 for public waters, and 2018 for public drainage systems; additionally target 2-3 buffer improvement projects (5 years) throughout watershed, 3-5 projects in 10 years throughout watershed	S	**P**			**P**	**P**			
	Middle Creek (668)	Dakota Co.; Farmington, Lakeville	Fish & Macro IBI	Stressors: Turbidity/TSS, Habitat		Restore/enhance channel (IBI, DO, TSS)	Identify and implement sediment reduction and/or volume reduction BMPs within publicly owned lands.	Install 1-3 BMPs	**P**	P			P	P			
							Connect re-constructed area in reach 547 downstream of 195th St	Connect within 3 years	**P**			A					
							Extend channel re-construction and re-meandering, and/or restore in-channel wetland in reach 547 downstream of current re-constructed section	Develop plans and funding (5 years), complete construction (10 years)	**P**	A		S	A	A			
							Explore opportunities to extend channel re-construction and re-meandering into reaches 546, 548, and/or other areas upstream of current re-constructed section										

Major Subwatershed	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategies (see Table 18)	Strategy types and estimated scale of adoption needed to meet final water quality target	Interim 10-yr Milestones	Governmental Units with Primary Responsibility								Estimated Year to Achieve Water Quality Target
	Waterbody (ID)	**Location** and Upstream Influence Counties; Cities and other MS4s		TMDL Baseline Conditions	TMDL Goals / Targets and Estimated % Reduction				Vermillion River JPO	Dakota County SWCD	MPCA	DNR	City of Lakeville	City of Farmington	MNDOT	UMN Extension Services	
							Channel restoration to increase meandering, riffles and overall complexity in reach 669 downstream of Akin Rd (Site A15).		**P**			A					
	All	All	All Conventional	--	--	Monitor (DO)	Conduct 2-3 early morning DO surveys to identify areas contributing to low DO	Complete 2-3 surveys (2 years)	**P**	**P**							Ongoing
				--	--	Remove fish passage barriers	Target undersize culverts, private driveway crossings, farm road crossings and grade control structures identified in geomorphic assessment report (Inter-Fluve, 2012) for improvements or removals	Complete 1-2 projects (5 years), complete 2-5 projects (10 years)	**P**	A			S	S			
				--	--	Improve drainage management	Evaluate hydrology and WQ (DO) of large flow-through wetland complex in reach 668.	Monitor and evaluate (3 years), restorations/alterations as needed (10 years)	**P**	**P**		S					
				--	--		Explore wetland restoration opportunities in upper portions of watershed. Develop restorable wetlands inventory tool to identify potential wetland restoration locations	1-2 restorations/projects (10 years)	**P**	**P**		S					
				--	--		Dedicate some of headwater streams (upstream of 195th St) to SW retention/detention. Work with farmers, new developers on projects. Make small land purchases for SW basins and retention projects	Implement 2-3 retention projects (10 years)	**P**				**P**	**P**			
				--	--	Conservation easements	Work with willing landowners and target easements in priority areas	3-4 easements	**P**	**P**							
				--	--	Improve/protect urban SW mgt.	Work with land developers in headwater reaches to provide additional buffers, SW retention and green space near waterways beyond current Vermillion River JPO and DNR requirements	Ongoing	**P**				**P**	**P**			
				--	--	Improve riparian vegetation	Promote buffer plantings with shade and habitat benefit. ID and target areas using shade coefficient study	Develop buffer guide & ed. materials for cities and counties	**P**	**P**							
				--	--	(Nitrogen)	Use Drained Wetland Inventory Report (Dakota County SWCD, 2012) and/or other BMP siting tools (Table 9) to identify and target wetland restoration opportunities throughout watershed	Work with willing landowners to implement at least one restorations/projects (10 years)	**P**	**P**							

South Creek Sub-watershed Strategies

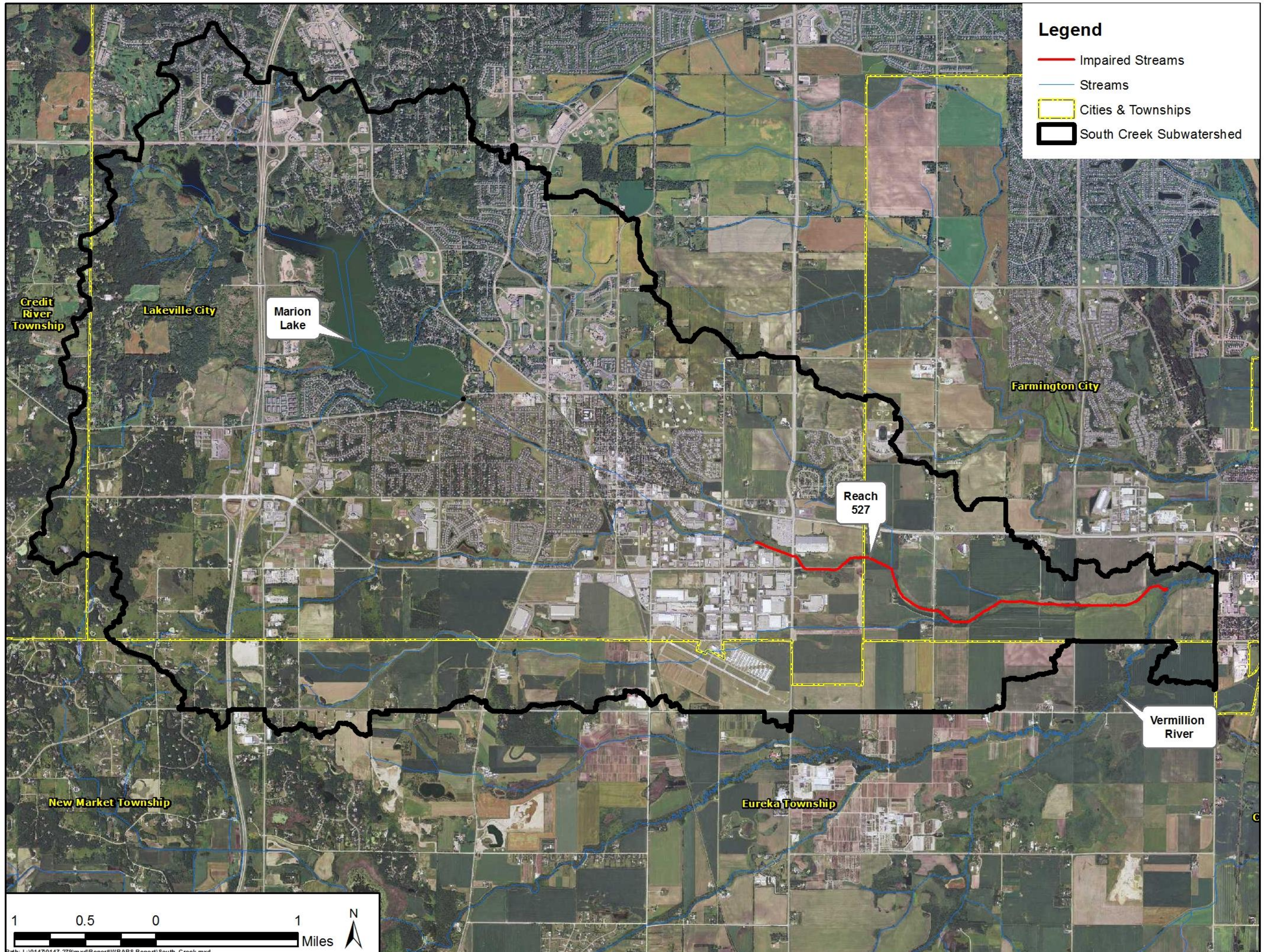


Table 12. South Creek Sub-watershed Restoration and Protection Strategies.
Key for shading: Red = Restoration Strategies; Green = Protection Strategies.
Key for Government Unit Responsibilities: P= Primary/Lead role; S = Secondary role; A = Assist as Needed.

Major Subwatershed	Waterbody and Location: Waterbody (ID)	Waterbody and Location: **Location** and Upstream Influence Counties; Cities and other MS4s	Parameter (incl. non-pollutant stressors)	Water Quality: TMDL Baseline Conditions	Water Quality: TMDL Goals / Targets and Estimated % Reduction	Strategies (see Table 18)	Strategy types and estimated scale of adoption needed to meet final water quality target	Interim 10-yr Milestones	Vermillion River JPO	Dakota County SWCD	Scott County SWCD	MPCA	DNR	City of Lakeville	City of Farmington	Dakota County	Scott County	Credit River Township	Other Townships	MNDOT	UMN Extension Service	Lake Associations	Estimated Year to Achieve Water Quality Target
South Creek	South Creek (527)	Dakota Co.; Farmington, Lakeville, New Market Township, Eureka Township	*E. coli*	57 - 295 cfu/100mL	126 cfu/100mL 0% – 77% reduction	Improve fertilizer and manure application mgt. (*E. coli*)	Promote/educate agronomic rates, chemical treatment of manure, and spreading in sensitive areas. Provide resources for soil nutrient testing. Hold 1-3 workshops to engage at least 50% of farmers and provide educational materials	Hold 1 workshop and work with 2-4 willing landowners	S	**P**	**P**			A	A		S		A			**P**	2040
						Improve upland/field surface runoff controls (*E. coli*, IBI)	Implement water and sediment control basins, grassed waterways, contour farming, cover crops, and conservation and reduced tillage BMPs on at least 50% of sensitive cropland areas identified using tools in section 3.1	Identify sensitive areas and potential BMP locations (3 years), work with landowners and implement at least 2-3 BMPs (5 years), implement 3-5 BMPs (10 years)	S	**P**	**P**			A	A		S		A				
						Improve urban SW mgt. (*E. coli*)	Educate and enforcement of proper pet waste management in urban areas	Provide signage, educational and disposal materials in city parks	S					**P**	**P**								
							Identify high bacteria loading tributaries and/or outfalls and install at least 1-5 biochar and/or iron filtration systems to reduce bacteria load, as well as TSS, and TP. Biochar filters have been shown to remove up to 96% of bacteria load	Complete feasibility study (3 years), install at least 1 system (5 years)	**P**					S	S								
						Improve riparian vegetation (*E. coli*, IBI, protection)	Increase riparian buffers and enforce buffer initiative on 100% of streams and tributaries. Target riparian buffers and plantings along main-stem and tributaries as described in Inter-fluve report (2010)	Buffers must be in place by 2017 for public waters, and 2018 for public drainage systems; additionally target 2-3 buffer improvement projects (5 years), 3-5 projects in 10 years	**P**	S			A	**P**	**P**	**P**	**P**						
	South Creek (527)	Dakota Co.; Farmington, Lakeville, New Market Township, Eureka Township	Fish & Macro IBI	Stressors: Temperature, DO, Turbidity/TSS, Habitat			Vegetation management in riparian areas to promote native vegetation and diversity	Target 2-3 vegetation management projects (10 years)	**P**	S				S	S								
						Restore/enhance channel (IBI, TSS, DO)	Explore opportunities for channel re-construction to increase meandering, riffles, large woody features, and overall complexity. Target continuously flowing reaches downstream of Cedar Ave	Develop plans and funding (5 years), complete 1 re-construction project (10 years) in watershed	**P**				S	**P**	**P**								
							Conduct targeted assessment of urban drainage areas to identify alternatives for improved management of the stormwater discharged directly to local water resources	Study to ID potential areas and develop plans (2 years), implement 1-2 BMPs (10 years)	**P**	**S**					**P**								
							Identify and implement sediment reduction and/or volume reduction BMPs within publicly owned lands.	Install 1-3 BMPs	**P**	P			P										
						Monitor (DO)	Conduct 2-3 early morning DO surveys to identify areas contributing to low DO	Complete 2-3 surveys (2 years)	**P**	**P**													
	Marion Lake (19-0026)	Dakota & Scott Co.; Lakeville, Credit River Township	Not impaired	Summer average TP typically 27-55 ug/L	Protect to maintain shallow lake state WQ standards: 60 ug/L TP	Improve urban SW mgt.	Explore iron-enhanced sand filters and other BMP retrofits throughout Marion Lake watershed	Identify and implement 2-3 projects	S	**P**	S			**P**		A	A	A				A	Ongoing
						Reduce/protect in-water loading	Vegetation management to reduce CLP, milfoil and/or other invasive species as well as shoreline management and buffers.	Manage as needed	S				**P**	S								A	
							Continue monitoring and assessing fish populations. Rough fish removals as necessary	Manage as needed					**P**	S								A	
	All	Dakota & Scott Co.; Lakeville, Farmington, Credit River Township,	All Conventional Pollutants	--	--	Improve urban SW mgt.	Conduct subwatershed BMP retrofit assessment study on Air-Lake Industrial Park and/or old downtown area (Lakeville). Identify and implement SW retrofit projects	Complete study (3 years), implement at least 2-3 BMPs (10 years)	**P**	**P**				**P**		A							

Major Subwatershed	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategies (see Table 18)	Strategy types and estimated scale of adoption needed to meet final water quality target	Interim 10-yr Milestones	Governmental Units with Primary Responsibility														Estimated Year to Achieve Water Quality Target
	Waterbody (ID)	**Location** and Upstream Influence Counties; Cities and other MS4s		TMDL Baseline Conditions	TMDL Goals / Targets and Estimated % Reduction				Vermillion River JPO	Dakota County SWCD	Scott County SWCD	MPCA	DNR	City of Lakeville	City of Farmington	Dakota County	Scott County	Credit River Township	Other Townships	MNDOT	UMN Extension Service	Lake Associations	
		New Market Township, Eureka Township		--	--		Explore urban BMP retrofit opportunities in residential areas of Lakeville downstream of Marion Lake.	Identify and implement 2-3 BMPs	**P**	**P**				**P**									
				--	--		Implement enhanced infiltration, retention and other BMP opportunities into plans for Hamburg Avenue re-construction in reaches 570 and 715	Vermillion JPO to work with city and developers during planning process	**P**	S				**P**									
				--	--	Improve drainage mgt.	Use restorable wetlands inventory tool to identify wetland restoration opportunities throughout watershed	1-2 restorations/projects	**P**	**P**													
				--	--	Improve riparian vegetation	Promote buffer plantings with shade and habitat benefit. ID and target areas using shade coefficient study	Develop buffer guide & ed. materials for cities and counties, incorporate into riparian habitat projects	**P**	S				S	S								
				--	--	Store and treat tile drainage waters (Nitrogen)	Use Drained Wetland Inventory Report (Dakota County SWCD, 2012) and/or other BMP siting tools (Table 9) to identify and target wetland restoration opportunities throughout watershed	Work with willing landowners to implement at least one restorations/projects (10 years)	**P**	**P**								A	A				

Upper Mainstem Vermillion River Sub-watershed Strategies

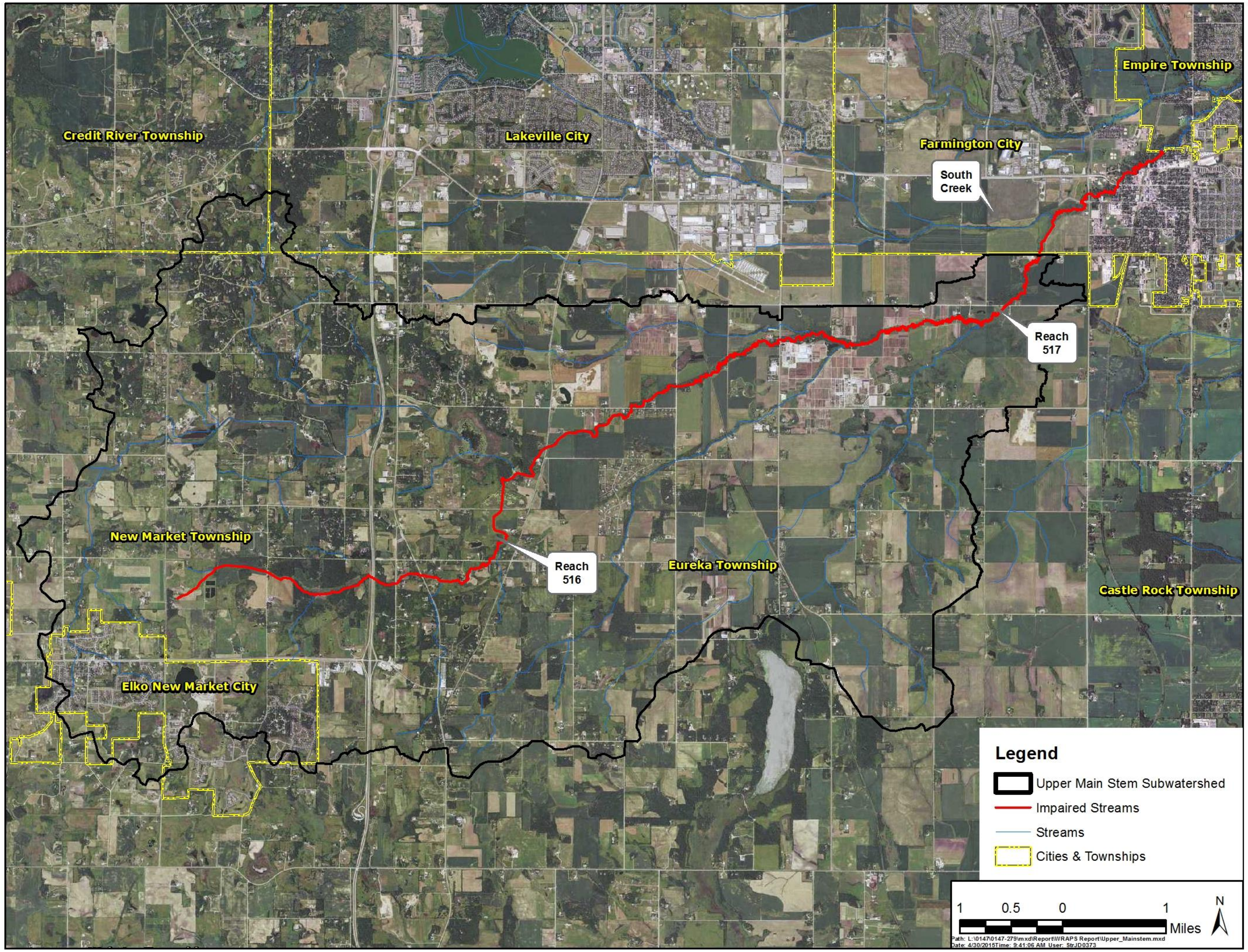


Table 13. Upper Mainstem Vermillion River Restoration and Protection Strategies.

Key for shading: Red = Restoration Strategies; Green = Protection Strategies.

Key for Government Unit Responsibilities: P= Primary/Lead role; S = Secondary role; A = Assist as Needed.

Major Subwatershed	Waterbody and Location: Waterbody (ID)	Waterbody and Location: **Location** and Upstream Influence Counties; Cities and other MS4s	Parameter (incl. non-pollutant stressors)	Water Quality: TMDL Baseline Conditions	Water Quality: TMDL Goals / Targets and Estimated % Reduction	Strategies (see Table 18)	Strategy types and estimated scale of adoption needed to meet final water quality target	Interim 10-yr Milestones	Vermillion River JPO	Dakota County SWCD	Scott County SWCD	MPCA	DNR	City of Lakeville	City of Farmington	City of Elko New Market	Dakota County	Scott County	Credit River Township	Other Townships	MNDOT	UMN Extension Service	Estimated Year to Achieve Water Quality Target
Upper Mainstem	Vermillion River (516)	Scott & Dakota Co.; Credit River Twp., Elko New Market, Lakeville, Elko and New Market Twps.	*E. coli*	133 – 623 cfu/100mL	126 cfu/100mL 5% - 80% reduction	Improve fertilizer and manure application mgt. (*E. coli*)	Promote/educate agronomic rates, chemical treatment of manure, and spreading in sensitive areas. Provide resources for soil nutrient testing. Hold 1-3 workshops to engage at least 50% of farmers and provide educational materials	Hold 1 workshop and work with 2-4 willing landowners	S	**P**	**P**					A			A	A		**P**	2040
						Improve livestock mgt. (*E. coli*, IBI)	Establish livestock managed access control areas near streams, alternative watering sources and/or pastureland runoff controls/buffers on 100% of feedlots within 500 feet of streams/waterways. Target upper portion of subwatershed – feedlots near reach 516 and tributaries to reach 517	Implement 2-4 projects within 10 years.	S	**P**	**P**							S	A	A			
						Improve urban SW mgt. (*E. coli*)	Educate and enforcement of proper pet waste management in urban areas	Provide signage, educational and disposal materials in public areas	S							**P**							
						Improve riparian vegetation (*E. coli*, IBI, DO, TSS, protection)	Increase riparian buffers and enforce buffer intiative on 100% of streams and tributaries. Target riparian buffers in township areas along tributaries and ditches	Buffers must be in place by 2017 for public waters, and 2018 for public drainage systems; additionally target 2-5 buffer improvement projects (10 years)	**P**	S	S		A			**P**	**P**	**P**	A	A			
	Vermillion River (517)	Scott & Dakota Co.; Credit River Twp., Elko New Market, Farmington, Lakeville	*E. coli*	187 – 452 cfu/100mL	126 cfu/100mL 32% - 72% reduction		Clear downfalls and target tree thinning to improve velocity and reaeration by 60% to increase DO in reach 517 between Flagstaff Ave and Highview Ave.	Develop vegetation management plan (3 years), 20% of reach tree thinning complete (10 years)	**P**				S							A			
			DO	Varies depending on season and flow condition	>7 mg/L daily minimum		Promote buffer plantings with shade benefit to decrease water temperature and increase DO. Target low shade area in reach 517 between Flagstaff Ave and 225th St to improve shading from 5% (current) to 50% shading throughout reach.	Contact willing landowners and develop plans (5 years); veg. plantings for 1,000 ft of reach (10 years)	**P**	S										A		A	
			Turbidity/ TSS	7 – 20 mg/L (TSS)	<10 mg/L (TSS) 0% - 50% reduction	Improve upland/field surface runoff controls (*E. coli*, TSS, IBI)	Implement water and sediment control basins, grassed waterways, contour farming, cover crops, and conservation and reduced tillage BMPs on at least 50% of sensitive cropland areas identified using tools in section 3.1	Identify sensitive areas and potential BMP locations (3 years), Work with landowners and implement at least 2-3 BMPs (5 years), implement 3-5 BMPs (10 years)	S	**P**	**P**			A	A			A	A	A		A	
							Conduct subwatershed BMP assessment study for TSS reduction projects for the areas draining to reach 517.	Install 3-5 TSS reduction projects.	S	P					S					A			
			Fish & Macro IBI	Stressors: Turbidity/TSS, DO		Restore/enhance channel (DO, TSS, IBI)	Identify and implement sediment reduction and/or volume reduction BMPs within publicly owned or managed lands.	Install 1-3 BMPs	**P**	P					P								
							Conduct targeted assessment of urban drainage areas to identify alternatives for improved management of the stormwater discharged directly to local water resources	Study to ID potential areas and develop plans (2 years), implement 1-2 BMPs (10 years)	**P**	**S**					P								
							Streambank stabilization to decrease bank erosion. Target the top 20% problem areas identified in reach 517 during TMDL survey once tree thinning and downfalls are addressed	10% of major bank problem areas re-stabilized within 10 years	**P**	S			S							A			
	Rice Lake (70-0001)	Dakota & Scott Co.; Eureka Twp. and Elko and New Market Twps.	Not assessed	Not assessed	Protect waterfowl habitat, recreation, and WQ standards: 60 ug/L TP	Reduce/protect in-water loading	Monitor/protect riparian and submerged vegetation.	Develop monitoring plan and protection plan/strategies	S	S	S	**P**	**P**										Ongoing
							Monitor/protect fish populations and passage, determine presence of carp																

Major Subwatershed	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategies (see Table 18)	Strategy types and estimated scale of adoption needed to meet final water quality target	Interim 10-yr Milestones	Governmental Units with Primary Responsibility														Estimated Year to Achieve Water Quality Target
	Waterbody (ID)	**Location** and Upstream Influence Counties; Cities and other MS4s		TMDL Baseline Conditions	TMDL Goals / Targets and Estimated % Reduction				Vermillion River JPO	Dakota County SWCD	Scott County SWCD	MPCA	DNR	City of Lakeville	City of Farmington	City of Elko New Market	Dakota County	Scott County	Credit River Township	Other Townships	MNDOT	UMN Extension Service	
	All	Scott & Dakota Co.; Lakeville, Farmington, Elko New Market, Credit River Township, Elko and New Market Twps., Eureka Twp.	All Conventional Pollutants	--	--	Improve drainage mgt.	Use Drained Wetland Inventory Report (Dakota County SWCD, 2012) to identify and target wetland restoration opportunities throughout watershed	Work with willing landowners to implement 2-3 restorations/projects (10 years)	**P**	**P**										A			
				--	--	Remove fish passage barriers	Target undersize culverts, private driveway crossings, farm road crossings and grade control structures for improvements or removals	Complete 1-2 projects (5 years), complete 2-5 projects (10 years)	**P**	S	S		**P**	S	S					A			
				--	--	Improve riparian vegetation	Promote buffer plantings with shade and habitat benefit. ID and target areas using shade coefficient study	Develop buffer guide & ed. materials for cities and counties, incorporate into riparian habitat projects	**P**	S				S	S								
				--	--	Monitor (flow)	Increase flow monitoring in reaches 516 and 517 to help groundwater appropriations and identify losing reaches/sections	Establish new flow station and monitor for 5 years	**P**	S	S		**P**										
				--	--	Store and treat tile drainage waters ()	Use Drained Wetland Inventory Report (Dakota County SWCD, 2012) and/or other BMP siting tools (Table 9) to identify and target wetland restoration opportunities throughout watershed	Work with willing landowners to implement at least one restorations/projects (10 years)	**P**	**P**									A	A			

South Branch of the Vermillion River Sub-watershed Strategies

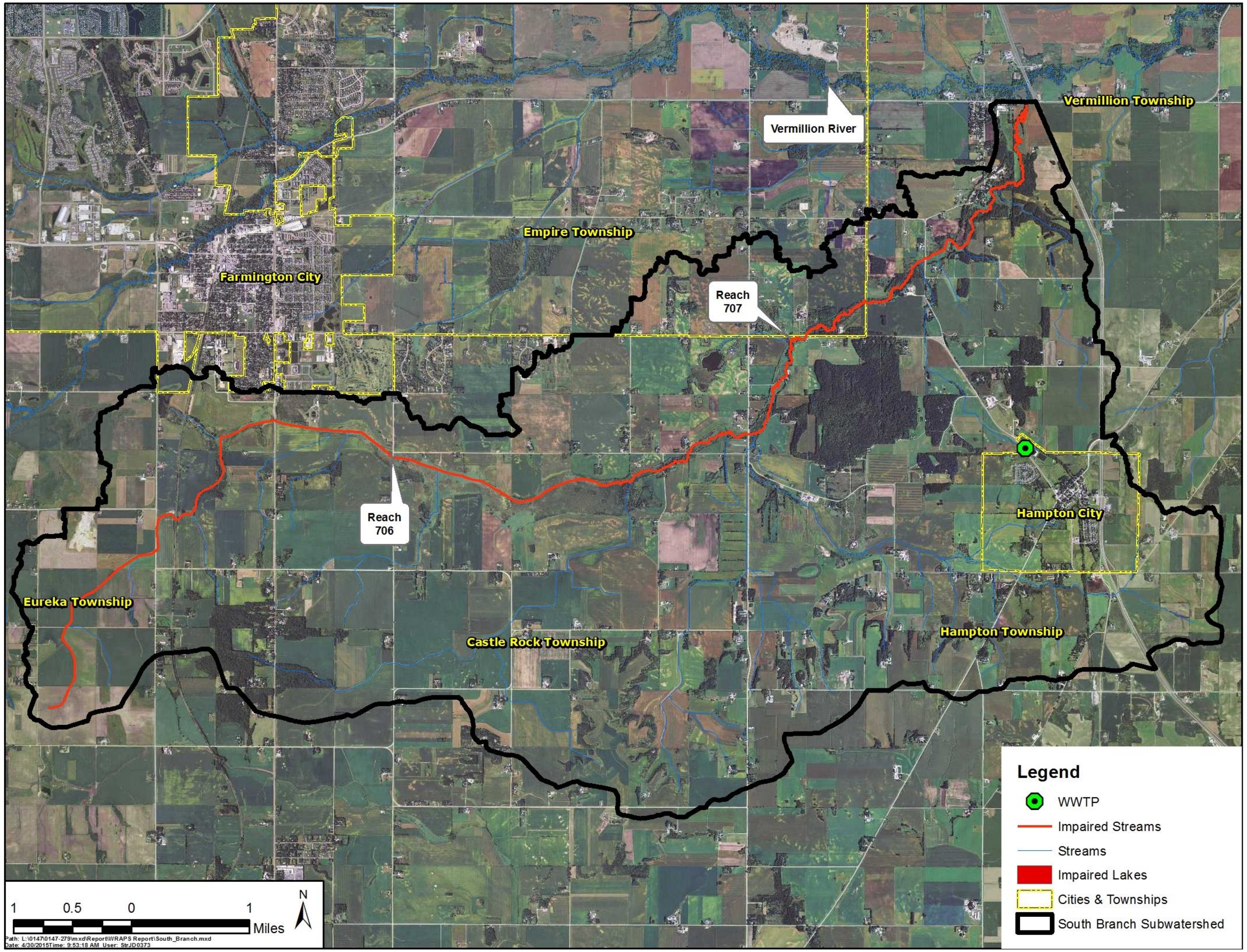


Table 14. South Branch of the Vermillion River Restoration and Protection Strategies.
Key for shading: Red = Restoration Strategies; Green = Protection Strategies.
Key for Government Unit Responsibilities: P= Primary/Lead role; S = Secondary role; A = Assist as Needed.

Major Subwatershed	Waterbody and Location: Waterbody (ID)	Waterbody and Location: **Location** and Upstream Influence Counties; Cities and other MS4s	Parameter (incl. non-pollutant stressors)	Water Quality: TMDL Baseline Conditions	Water Quality: TMDL Goals / Targets and Estimated % Reduction	Strategies (see Table 18)	Strategy types and estimated scale of adoption needed to meet final water quality target	Interim 10-yr Milestones	Vermillion River JPO	Dakota County SWCD	MPCA	DNR	City of Farmington	Empire Township	Other Townships	Dakota County	UMN Extension Service	Estimated Year to Achieve Water Quality Target
South Branch Vermillion	South Branch (706)	Dakota Co.; Farmington, Eureka Twp., Castle Rock Twp.	*E. coli*	174 - 249 cfu/100mL	126 cfu/100mL 28% – 49% reduction	Improve fertilizer and manure application mgt. (*E. coli*)	Promote/educate agronomic rates, chemical treatment of manure, and spreading in sensitive areas. Provide resources for soil nutrient testing. Hold 1-3 workshops to engage at least 50% of farmers and provide educational materials	Hold 1 workshop and work with 3-5 willing landowners	S	**P**			A		A		**P**	2040
	South Branch (707)	Dakota Co.; Farmington, Empire Twp., Castle Rock Twp., Eureka Twp., City of Hampton, Hampton Twp.	*E. coli*	165 – 279 cfu/100mL	126 cfu/100mL 24% - 55% reduction	Improve livestock mgt. (*E. coli*, IBI)	Establish livestock managed access control areas near streams, alternative watering sources and/or pastureland runoff controls/buffers on 100% of feedlots within 500 feet of streams/waterways. Target areas along reach 707 and downstream end of reach 706 near Blaine Ave	Implement 1-3 projects within 10 years.	S	**P**			A	A	A			
			Fish & Macro IBI	Stressors: Turbidity/TSS, Habitat		Improve riparian vegetation (*E. coli*, IBI, protection)	Increase riparian buffers and enforce buffer initiative on 100% of streams and tributaries. Target areas near main-stem headwaters of reach 706 headwaters upstream of Denmark Ave. All ditch and tributary channels throughout watershed should also be targeted for increased buffers and/or grassed waterways	Buffers must be in place by 2017 for public waters, and 2018 for public drainage systems; additionally target 3-4 buffer improvement projects (5 years), 4-8 projects in 10 years	**P**	S		A		A	A	**P**		
	All	Dakota Co.; Farmington, Empire Twp., Castle Rock Twp., Eureka Twp., City of Hampton, Hampton Twp.	Nitrate	Very high throughout watershed	45% load reduction per Nutrient Reduction Strategy (MPCA et al, 2014)	Increase fertilizer and manure efficiency	Continue to work with landowners to utilize University of MN recommendations for the economic optimal nitrogen rate. Rates may vary with level of adoption of vegetative cover BMPs	Hold 1-2 workshops to develop understanding of commercial fertilizer rates for every operation. Manure management plans for every operation in watershed.	S	S				A	A	**P**	**P**	Ongoing
						Store and treat tile drainage waters (Nitrogen)	Use Drained Wetland Inventory Report (Dakota County SWCD, 2012) and/or other BMP siting tools (Table 9) to identify and target wetland restoration opportunities throughout watershed	Work with willing landowners to implement 2-4 restorations/projects (10 years)	**P**	**P**				A	A			
							Monitor and survey to determine potential locations for installing in-stream, or edge of field woodchip bioreactors – contact willing landowners	Identify potential BMP locations (3 years), work with landowners and install at least one system in watershed (10 years)	**P**	S				A	A	S		
						Increase vegetative cover/root duration	Establish program to provide information to farmers to encourage planting of crops and vegetation that maximize vegetative cover and capturing of soil nitrate by roots during spring-fall. Use NBMP tool to determine level of adoption needed throughout watershed	Create and distribute educational materials for farmers (3 years), develop test plots and cover crop demonstrations (6 years), cover crops established on 10% of rotations that include early-off crops	S	**P**				A	A	S	**P**	
			All Conventional Pollutants	--	--	Conservation easements	Work with willing landowners and target easements in priority areas	3-4 easements	S	S				A	A	**P**		
						Restore/enhance channel	Explore restoration opportunities to increase sinuosity, meanders, riffles, and large woody debris to provide channel complexity	1-2 channel restoration projects	**P**	A		**P**		A	A			
						Monitor	Monitor to determine spatial variability of nitrate and E. coli throughout watershed to determine spatial variability and role of large in-channel wetland complexes in WQ (source or sink)	1-2 longitudinal WQ profiles (3 years)	**P**	S								

Middle Mainstem of the Vermillion River Sub-watershed Strategies

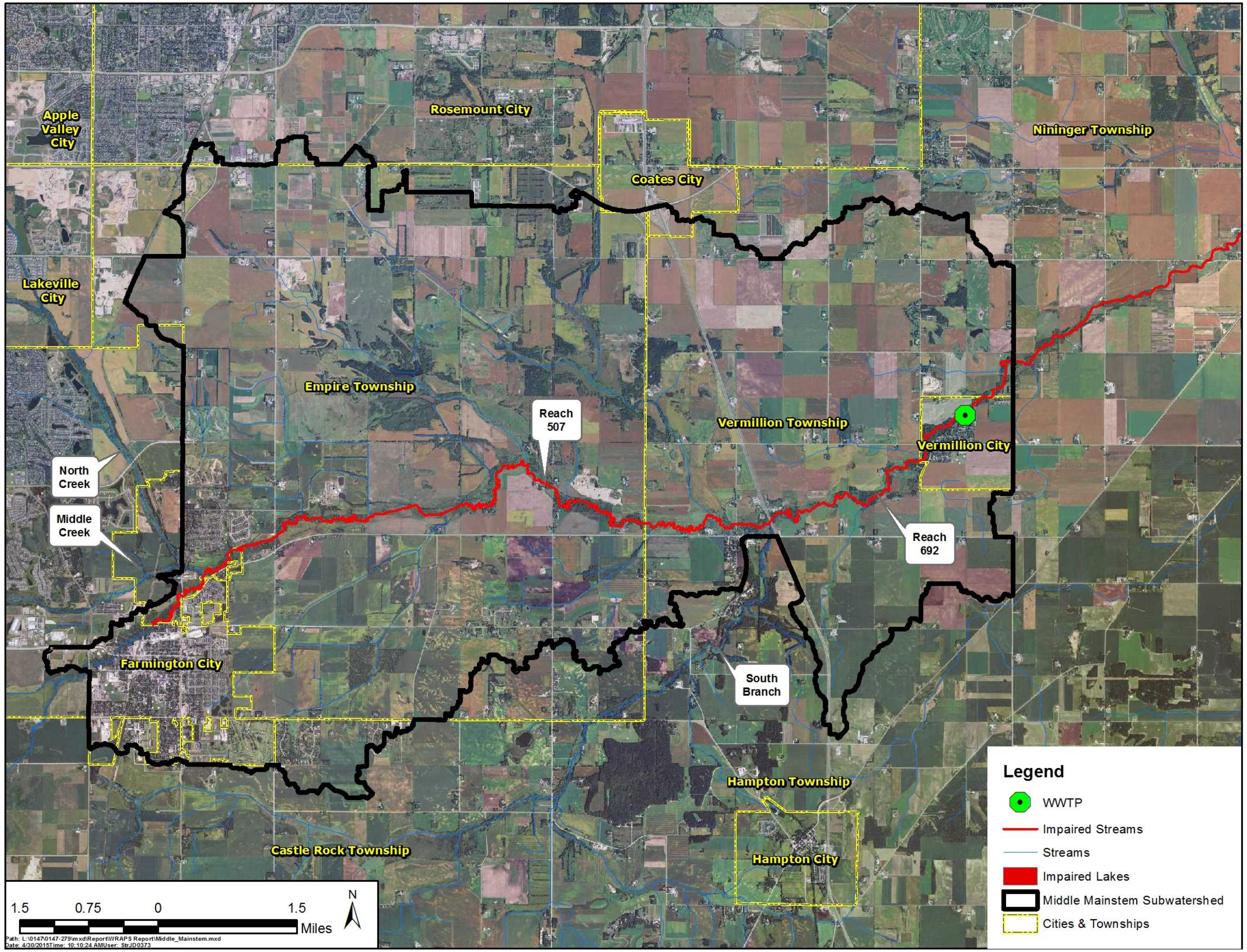


Table 15. Middle Mainstem of the Vermillion River Sub-watershed Restoration and Protection Strategies.
Key for shading: Red = Restoration Strategies; Green = Protection Strategies.
Key for Government Unit Responsibilities: P= Primary/Lead role; S = Secondary role; A = Assist as Needed.

Major Subwatershed	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategies (see Table 18)	Strategy types and estimated scale of adoption needed to meet final water quality target	Interim 10-yr Milestones	Governmental Units with Primary Responsibility										Estimated Year to Achieve Water Quality Target
	Waterbody (ID)	**Location** and Upstream Influence Counties; Cities and other MS4s		TMDL Baseline Conditions	TMDL Goals / Targets and Estimated % Reduction				Vermillion River JPO	Dakota County SWCD	MPCA	DNR	City of Farmington	City of Vermillion	Empire Township	Other Townships	Dakota County	UMN Extension Service	
Middle Main Stem	Vermillion River (507)	Dakota Co.; Empire Twp., Vermillion Twp., City of Farmington, City of Vermillion	Fish & Macro IBI	Stressors: Turbidity/TSS, Habitat		Improve upland/field surface runoff controls (TSS, IBI)	Implement water and sediment control basins, grassed waterways, contour farming, cover crops, and conservation and reduced tillage BMPs on at least 50% of sensitive cropland areas identified using tools in section 3.1. Use Soil Erosion Risk tool or USLE model or other tool to identify sensitive areas and high erosion areas.	Identify sensitive areas and potential BMP locations (3 years), Work with landowners and implement at least 3-5 BMPs (10 years)	S	P					A	A			2040
						Restore/enhance channel (TSS, IBI)	Identify and implement sediment reduction and/or volume reduction BMPs within publicly owned or managed lands.	Install 1-3 BMPs	P	P			P						
							Conduct targeted assessment of urban drainage areas to identify alternatives for improved management of the stormwater discharged directly to local water resources	Study to ID potential areas and develop plans (2 years), implement 1-2 BMPs (10 years)	P	S			P						
						Improve riparian vegetation (IBI)	Increase riparian buffers and enforce buffer initiative on 100% of streams and tributaries. Also target non-DNR protected tributaries, ditches and waterways in township areas to implement and enhance buffers.	Buffers must be in place by 2017 for public waters, and 2018 for public drainage systems; additionally target 1-3 buffer improvement projects (5 years), 3-5 projects in 10 years	P	S		A	P	A	A	A	P		
							Vegetation management in riparian areas to reduce reed canary grass and promote native vegetation and diversity. Target areas identified in Inter-Fluve reports (2010, 2012).	Target 2-3 vegetation management projects (10 years)	P	S		P	S	S	S	S			
	All	Dakota Co.; Empire Twp., Vermillion Twp., City of Farmington, City of Vermillion	All Conventional Pollutants	--	--	Restore/enhance channel	Continue to explore restoration opportunities to increase sinuosity, meanders, riffles, and large woody debris to provide channel complexity. Target areas and projects identified in Inter-Fluve reports (2010, 2012).	1-2 channel restoration projects	P			P			A	A			Ongoing
						Improve fertilizer and manure application mgt.	Promote/educate agronomic rates, chemical addition of manure, and spreading in sensitive areas. Provide resources for soil nutrient testing. Hold 1-3 workshops and provide educational materials	Hold 1 workshop and work with 2-4 willing landowners	S	P			A	A	A	A		P	
						Improve livestock mgt.	Establish livestock managed access control areas near streams, alternative watering sources and/or pastureland runoff controls/buffers.	Implement 1-2 projects within 10 years.	S	P					A	A			
						Improve urban SW mgt.	Study to determine SW pond temperature and effect on downstream receiving waters. Target SW ponds in Farmington and Empire Twp near mainstem of Vermillion River.	Complete feasibility study (5 years), further action as needed	P	S			A		A				
				--	--	Store and treat tile drainage waters (Nitrogen)	Use Drained Wetland Inventory Report (Dakota County SWCD, 2012) and/or other BMP siting tools (Table 9) to identify and target wetland restoration opportunities throughout watershed	Work with willing landowners to implement at least one restorations/projects (10 years)	P	P					A	A			

Lower Mainstem of the Vermillion River Sub-watershed Strategies

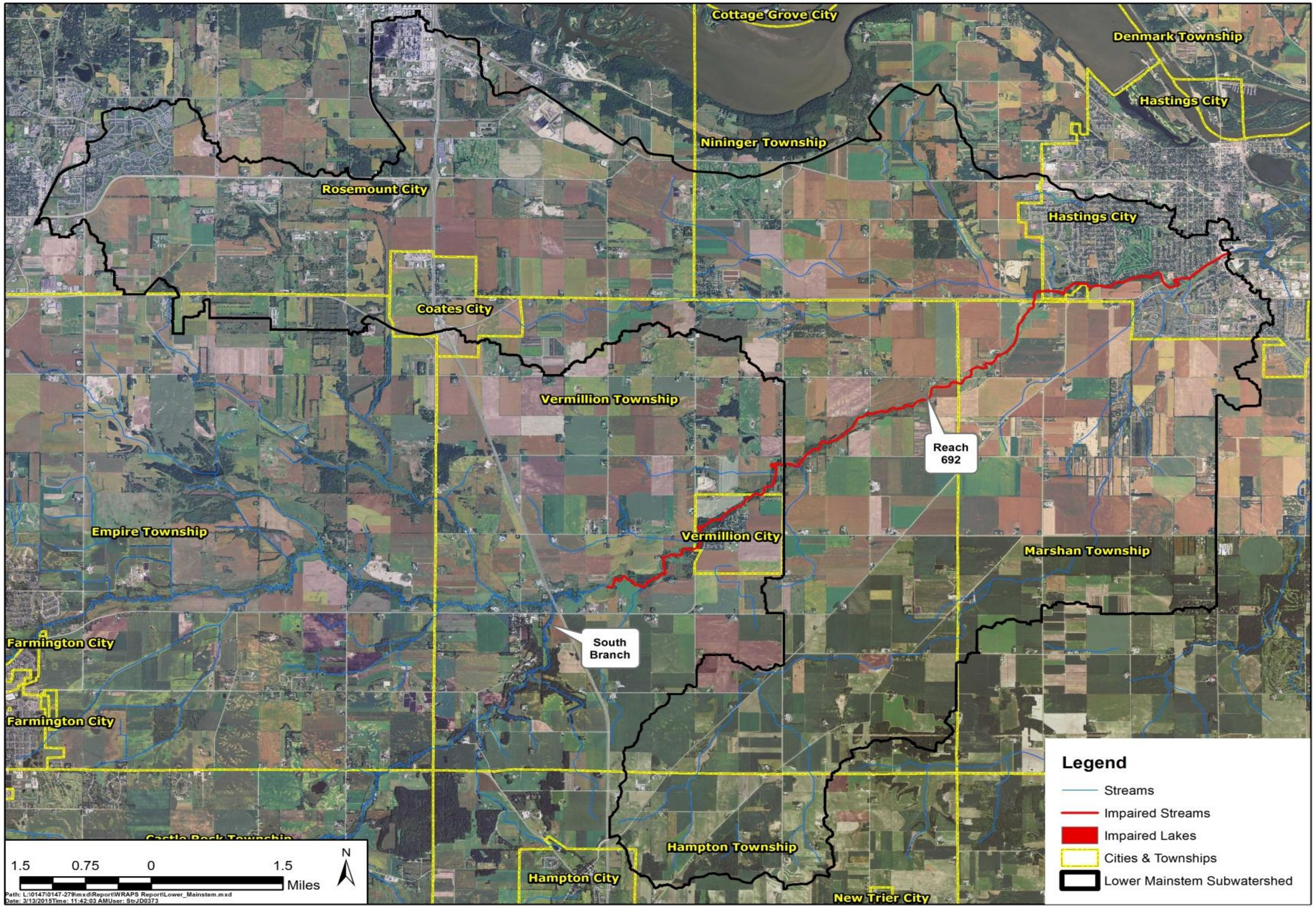


Table 16. Lower Mainstem of the Vermillion River Sub-watershed Restoration and Protection Strategies.

Key for shading: Red = Restoration Strategies; Green = Protection Strategies.

Key for Government Unit Responsibilities: P= Primary/Lead role; S = Secondary role; A = Assist as Needed.

Major Subwatershed	Waterbody and Location: Waterbody (ID)	Waterbody and Location: **Location** and Upstream Influence Counties; Cities and other MS4s	Parameter (incl. non-pollutant stressors)	Water Quality: TMDL Baseline Conditions	Water Quality: TMDL Goals / Targets and Estimated % Reduction	Strategies (see Table 18)	Strategy types and estimated scale of adoption needed to meet final water quality target	Interim 10-yr Milestones	Vermillion River JPO	Dakota County SWCD	MPCA	DNR	City of Hastings	City of Rosemount	Townships	Dakota County	UMN Extension Service	Estimated Year to Achieve Water Quality Target
Lower Main Stem	Vermillion River (692)	Dakota Co.; Rosemount, Hastings; Vermillion Twp., Marshan Twp., Nininger Twp.	Fish & Macro IBI	Stressors: Turbidity/TSS, Habitat		Restore/enhance channel (IBI, TSS)	Streambank stabilization to decrease bank erosion. Target top 20% of problem areas identified in Inter-Fluve geomorphic assessments	1-2 bank stabilization projects within 10 years	**P**	S		**P**	A		A			2040
						Improve riparian vegetation (IBI)	Increase riparian buffers by 100% and enforce buffer initiative on all streams and tributaries. Target mainstem areas between Hogan Ave and 160th St E. Also target non-DNR protected tributaries, ditches and waterways in township areas to implement and enhance buffers.	Buffers must be in place by 2017 for public waters, and 2018 for public drainage systems; additionally target 1-3 buffer improvement projects (5 years), 3-5 projects in 10 years	**P**	S		A	A		A	**P**		
							Vegetation management in riparian areas to reduce reed canary grass and promote native vegetation and diversity.	Target 2-3 vegetation management projects (10 years)	**P**	S			S		S			
						Improve upland/field surface runoff controls (TSS, IBI)	Implement water and sediment control basins, grassed waterways, contour farming, cover crops, and conservation and reduced tillage BMPs on at least 50% of sensitive cropland areas identified using tools in section 3.1. Utilize USLE model or other tool to identify and target high potential areas of upland erosion.	Identify sensitive areas and potential BMP locations (3 years), Work with landowners and implement at least 3-5 BMPs (10 years)	S	**P**				A	A			
							Conduct targeted assessment of urban drainage areas to identify alternatives for improved management of the stormwater discharged directly to local water resources	Study to ID potential areas and develop plans (2 years), implement 1-2 BMPs (10 years)	P	**S**			P					
						Restore/enhance channel (TSS, IBI)	Identify and implement sediment reduction and/or volume reduction BMPs within publicly owned or managed lands.	Install 1-3 BMPs	P	**P**			P					
	All	Dakota Co.; Rosemount, Hastings; Vermillion Twp., Marshan Twp., Nininger Twp.	All Conventional Pollutants	--	--	Improve livestock mgt.	Establish livestock managed access control areas near streams, alternative watering sources and/or pastureland runoff controls/buffers. Target problem areas near mainstem and tributary channels with livestock operations near streams/waterways	Implement 1-2 projects within 10 years.	S	**P**					A			Ongoing
						Improve fertilizer and manure application mgt.	Promote/educate agronomic rates, chemical addition of manure, and spreading in sensitive areas. Provide resources for soil nutrient testing. Hold 1-3 workshops and provide educational materials	Hold 1 workshop and work with 2-4 willing landowners	S	**P**			A	A	A		**P**	
						Improve urban SW mgt.	Explore biofiltration and other urban BMP retrofit opportunities in residential areas of Hastings draining to Vermillion River.	Identify and implement 2-3 BMPs	**P**	**P**			**P**					
				--	--	Store and treat tile drainage waters (Nitrogen)	Use Drained Wetland Inventory Report (Dakota County SWCD, 2012) and/or other BMP siting tools (Table 9) to identify and target wetland restoration opportunities throughout watershed	Work with willing landowners to implement at least one restorations/projects (10 years)	**P**	**P**					A			

Mississippi River Direct Sub-watershed Strategies

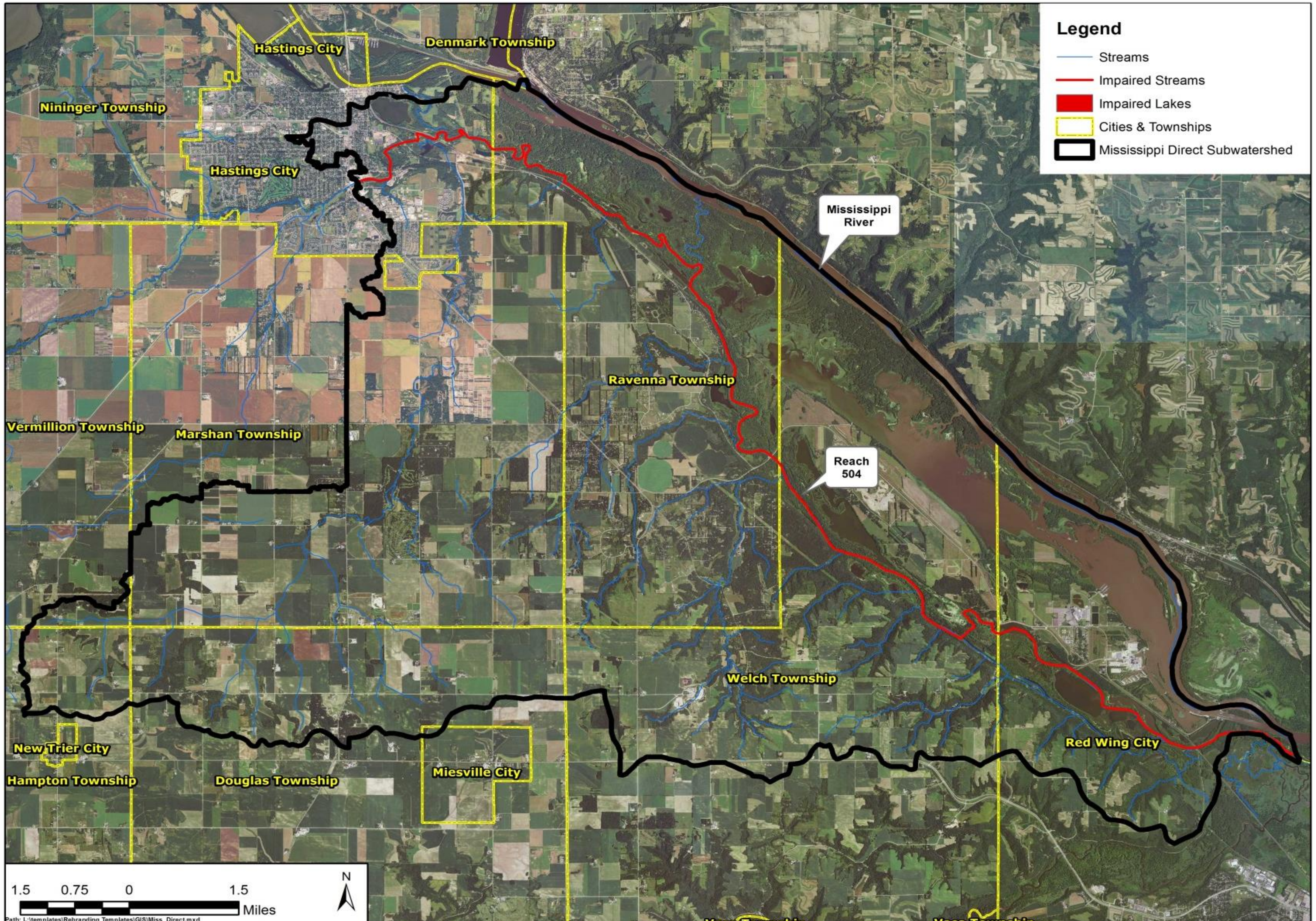


Table 17. Mississippi River Direct Sub-watershed Restoration and Protection Strategies.
Key for shading: Red = Restoration Strategies; Green = Protection Strategies.
Key for Government Unit Responsibilities: P= Primary/Lead role; S = Secondary role; A = Assist as Needed.

	Waterbody and Location			Water Quality				Governmental Units with Primary Responsibility											
Major Subwatershed	Waterbody (ID)	**Location** and Upstream Influence Counties; Cities and other MS4s	Parameter (incl. non-pollutant stressors)	TMDL Baseline Conditions	TMDL Goals / Targets and Estimated % Reduction	Strategies (see Table 18)	Strategy types and estimated scale of adoption needed to meet final water quality target	Interim 10-yr Milestones	Vermillion River JPO	Dakota County SWCD	Goodhue County SWCD	MPCA	DNR	City of Hastings	City of Rosemount	Townships	Dakota County	Goodhue County	UMN Extension Service	Estimated Year to Achieve Water Quality Target
Mississippi Direct	Vermillion River (504)	Dakota & Goodhue Co.; Hastings; Marshan Twp., Douglas Twp., Welch Twp., Ravenna Twp.	Turbidity/TSS	Mode 0: 12,117 kg/day Mode 1: 234,993 kg/day	TSS Target of 25 mg/L Mode 0: 7,793 kg/day (36% reduction) Mode 1:70,321 kg/day (70% reduction)	Detailed strategies have been developed for Reach 504 through the Lower Vermillion River Watershed Turbidity TMDL (2009) and Restoration Plan (2011). These documents are approved by the EPA and available through the MPCA website: http://www.pca.state.mn.us/index.php/water/water-types-and-programs/minnesotas-impaired-waters-and-tmdls/tmdl-projects/lower-mississippi-river-basin-tmdl/project-vermillion-river-turbidity.html														
	All	Dakota & Goodhue Co.; Hastings; Marshan Twp., Douglas Twp., Welch Twp., Ravenna Twp.	All Conventional Pollutants	--	--	Reduce bank/bluff/ravine erosion	Repair and protect road crossings, culverts, private driveways and other infrastructure impacted by erosion caused by high slopes and water velocities. Target problem locations in Etter Creek and Ravenna Coulees identified in geomorphic assessment study (Inter-fluve, 2011)	Complete 2-4 high priority projects identified for Etter Creek and Ravenna Coulees	**S**	**S**	**P**		A			A	A	A		Ongoing
							Work with willing land owners to implement bank stabilization projects. Target knickpoints and other problem areas identified in geomorphic assessment study (Inter-fluve, 2011)	Complete 1-2 stabilization projects	**S**	**S**	**P**		A			A		A		
						Improve drainage management	Work with willing land owners to reduce amount of water entering small streams/tributaries during high flow events by implementing retention basins, conversion of land to native vegetation, and altered farming practices to promote infiltration. Target upper portions of the Etter Creek and Ravenna Coulee watersheds identified in geomorphic assessment (Inter-fluve, 2011)	Work with 1-2 land owners to identify and implement projects	**S**	**S**	P					A		A		
						Improve upland/field surface runoff controls (TSS)	Implement water and sediment control basins, grassed waterways, contour buffer strips, stripcroping, terraces, contour farming, cover crops, and conservation and reduced tillage BMPs. Develop model or other tool to identify and target high potential areas of upland erosion.	Identify targeted areas (3 years), at least 2-4 BMPs (10 years)	S	**P**	**P**					A		S		
						Improve riparian vegetation (IBI)	Increase riparian buffers and enforce buffer initiative on all streams and tributaries. Also target non-DNR protected tributaries, ditches and waterways in township areas to implement and enhance buffers.	Buffers must be in place by 2017 for public waters, and 2018 for public drainage systems; additionally target 1-2 buffer improvement projects (5 years), at least 2-4 projects in 10 years	**P**	S	S		A			A	**P**	**P**		
						Improve urban SW mgt.	Explore biofiltration and other urban BMP retrofit opportunities in residential areas of Hastings draining to Vermillion River.	Identify and implement 2-3 BMPs	**P**		**P**			**P**						
						Conservation easements	Work with willing landowners and target easements in priority areas	1-2 easements	S	S	S					A	**P**	**P**		

Vermillion River Watershed (All)

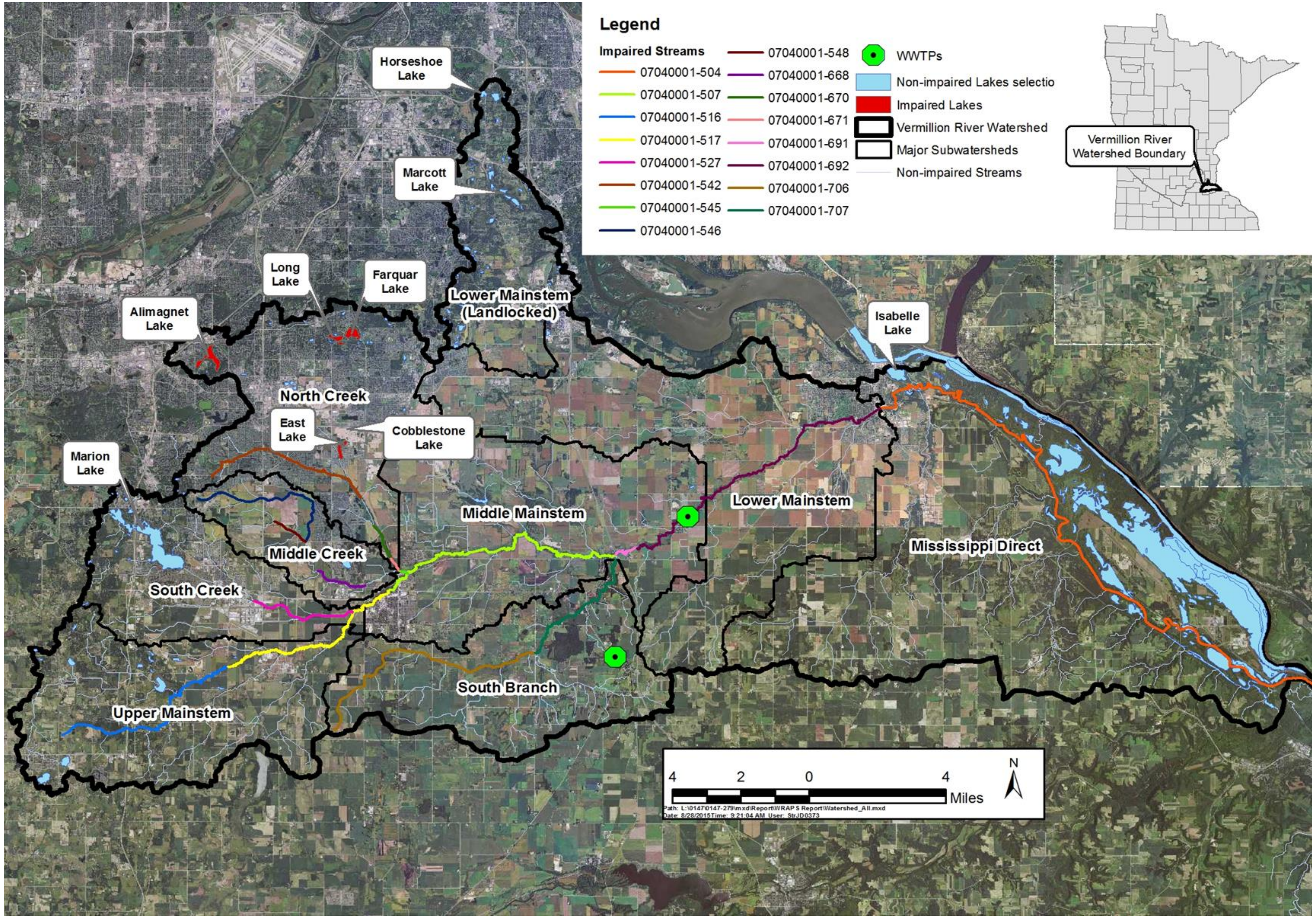


Table 18. Vermillion River Watershed-wide Restoration and Protection Strategies.
Key for shading: Red = Restoration Strategies; Green = Protection Strategies; White = All
Key for Government Unit Responsibilities: P= Primary/Lead role; S = Secondary role; A = Assist as Needed.

Major Subwatershed	Waterbody and Location: Waterbody (ID)	Waterbody and Location: **Location** and Upstream Influence Counties; Cities and other MS4s	Parameter (incl. non-pollutant stressors)	Water Quality: TMDL Baseline Conditions	Water Quality: TMDL Goals / Targets and Estimated % Reduction	Strategies (see Table 18)	Strategy types and estimated scale of adoption needed to meet final water quality target	Interim 10-yr Milestones	Vermillion River JPO	Dakota County SWCD	Goodhue County SWCD	MPCA	DNR	Cities	Townships	Dakota County	Goodhue County	Scott County	UMN Extension Service	NRCS	Estimated Year to Achieve Water Quality Target
All	All		Parameters cited in permit	-	-	Wastewater facilities -- compliance with NPDES permits						**P**									-
			Parameters cited in permit	-	-	Construction and Industrial Stormwater permittees -- compliance with general permits						**P**									-
			Parameters citied in Permit	-	-	Manage Stormwater	See MPCA Stormwater Manual: http://stormwater.pca.state.mn.us/index.php/Main_Page					**P**									-
			Groundwater Usage			Efficient Irrigation	Develop an educational campaign for both Agricultural and Urban landuses that promotes efficient water usage.	Ongoing	**P**	S			S	S		S					-
						Water Reuse	Promote the reuse of stormwater on green space where possible.	Ongoing													
			Chloride			Road Salt Management	Promote and adopt the strategies laid out in the Chloride Management Plan. http://www.pca.state.mn.us/r0pgb86	Ongoing	**S**			**A**		**P**	**P**	**P**		**P**	A		-
			Habitat			Improve riparian vegetation (IBI)	Increase riparian buffers and enforce buffer initiative on all streams and tributaries. Also target non-DNR protected tributaries, ditches and waterways in township areas to implement and enhance buffers.	Buffers must be in place by 2017 for public waters, and 2018 for public drainage systems; additionally target 1-2 buffer improvement projects (5 years), 2-4 projects in 10 years	**P**	S	S		A		A	**P**	**P**	**P**			
						Remove fish passage barriers	Target undersize culverts, private driveway crossings, farm road crossings and grade control structures identified in geomorphic assessment report (Inter-Fluve, 2012) for improvements or removals	Ongoing	**P**	**S**			P	A	A	S	S				Ongoing
			All Conventional Pollutants All Conventional Pollutants	--	--	Reduce bank/bluff/ravine erosion	Work with willing land owners to implement bank stabilization projects. Target knickpoints and other problem areas identified in geomorphic assessment study (Inter-fluve, 2011)	Complete 1-2 stabilization projects	**S**	**S**	**P**		A		A		A				Ongoing
				--	--	Improve upland/field surface runoff controls (TSS)	Implement water and sediment control basins, grassed waterways, contour buffer strips, stripcroping, terraces, contour farming, cover crops, and conservation and reduced tillage BMPs. Develop USLE model or other tool to identify and target high potential areas of upland erosion.	Identify targeted areas (3 years), 2-4 BMPs (10 years)	S	**P**	**P**				A		S				Ongoing
						Improve urban SW mgt.	Explore biofiltration and other urban BMP retrofit opportunities in residential areas of Hastings draining to Vermillion River.	Identify and implement 2-3 BMPs	**P**		**P**			**P**							
						Conservation easements	Work with willing landowners and target easements in priority areas	1-2 easements	S	S	S				A	**P**	**P**	**P**			
	All		Phosphorus and Sediment	Downstream impairments: Mississippi River, Lake Pepin, Gulf of Mexico	45% Phosphorus load reduction per NRS (which would meet Pepin goal too); some	Reductions will be achieved as strategies and actions identified in the sub-watersheds are implemented.		Phosphorus and sediment loads continue to decrease; examine in 2025 (first NRS milestone) Subwatersheds with the lowest treatment percentage, increased to >20% treated (end goal of 40%)													2035

Major Subwatershed	Waterbody and Location: Waterbody (ID)	Waterbody and Location: **Location** and Upstream Influence Counties; Cities and other MS4s	Parameter (incl. non-pollutant stressors)	Water Quality: TMDL Baseline Conditions	Water Quality: TMDL Goals / Targets and Estimated % Reduction	Strategies (see Table 18)	Strategy types and estimated scale of adoption needed to meet final water quality target	Interim 10-yr Milestones	Governmental Units with Primary Responsibility: Vermillion River JPO	Dakota County SWCD	Goodhue County SWCD	MPCA	DNR	Cities	Townships	Dakota County	Goodhue County	Scott County	UMN Extension Service	NRCS	Estimated Year to Achieve Water Quality Target
Strategies to Address Downstream Goals				TP Annual Loads (kg): 2010 – 15,835 2011 – 19,152 2012 – 13,020 2013 – 21,725 TSS Annual Loads (kg) 2010 – 2,192,521 2011 – 3,122,380 2012 – 2,347,173 2013 – 4,928,436	progress already documented 20% TSS load reduction per South Metro Mississippi TMDL Restoration																
	All	All	Nitrogen	No local nitrogen-driven impairments; Downstream impairments: Gulf of Mexico NOx Annual Loads (kg) 2012 – 327,825 2013 – 387,073	45% Reduction per NRS	Nutrient Reduction Strategy (NRS)	Saturation effort in upland segments of each subwatershed with focus provided by local partners. See Appendix A for Nitrogen BMP tool scenarios.	Decreased N loads by 2025 (first NRS milestone); observed change in nitrate trend at Vermillion River below HWY 61.	**P**	**P**	**P**			A	A				**A**	**P**	2045
						Increase fertilizer and manure efficiency	Continue to work with landowners to utilize University of MN recommendations for the economic optimal nitrogen rate. Rates may vary with level of adoption of vegetative cover BMPs		S	S				A	A	**P**	**P**	**P**	S	**P**	
						Store and treat tile drainage waters	Use Drained Wetland Inventory Report (Dakota County SWCD, 2012) to identify and target wetland restoration opportunities throughout watershed		**P**	**P**				A	A				**P**		
							Monitor and survey to determine potential locations for installing in-stream, or edge of field woodchip bioreactors – contact willing landowners		**P**	S				A	A	S			**P**		
						Increase vegetative cover/root duration	Establish program to provide information to farmers to encourage planting of crops and vegetation that maximize vegetative cover and capturing of soil nitrate by roots during spring-fall.		S	**P**				A	A	S	**P**	S	S	**P**	
						Improve Stormwater Management	Provide educational materials to residents regarding appropriate lawn care, fertilizer use, and agricultural runoff management		**P**	**A**	A			S		A	**A**	A	A		

Table 19. Additional Restoration and Protection Strategies to Consider, Organized by Parameter of Concern.

Parameter (incl. non-pollutant stressors)	Strategy Key	
	Description	Example BMPs/actions
TSS	Improve upland/field surface runoff controls: Soil and water conservation practices that reduce soil erosion and field runoff, or otherwise minimize sediment from leaving farmland	Cover crops
		Water and sediment basins, terraces
		Rotations including perennials
		Conservation cover easements
		Grassed waterways
		Strategies to reduce flow- some of flow reduction strategies should be targeted to ravine subwatersheds
		Residue management - conservation tillage
		Forage and biomass planting
		Open tile inlet controls - riser pipes, french drains
		Contour farming
		Wetland restoration
		Stripcropping
	Protect/stabilize banks/bluffs: Reduce collapse of bluffs and erosion of streambank by reducing peak river flows and using vegetation to stabilize these areas.	Strategies for altered hydrology (reducing peak flow)
		Streambank stabilization
		Riparian forest buffer
		Livestock exclusion - controlled stream crossings
	Stabilize ravines: Reducing erosion of ravines by dispersing and infiltrating field runoff and increasing vegetative cover near ravines. Also, may include earthwork/regrading and revegetation of ravine.	Field edge buffers, borders, windbreaks and/or filter strips
		Contour farming and contour buffer strips
		Diversions
		Water and sediment control basin
		Terrace
		Conservation crop rotation
		Cover crop
		Residue management - conservation tillage
	Improve forestry management	Proper Water Crossings and road construction
		Forest Roads - Cross-Drainage
		Maintaining and aligning active Forest Roads
		Closure of Inactive Roads & Post-Harvest
		Location & Sizing of Landings
		Riparian Management Zone Widths and/or filter strips
	Improve urban stormwater management [to reduce sediment and flow]	See MPCA Stormwater Manual: http://stormwater.pca.state.mn.us/index.php/Main_Page

Parameter (incl. non-pollutant stressors)	Strategy Key	
	Description	Example BMPs/actions
Nitrogen (TN) or Nitrate	Increase fertilizer and manure efficiency: Adding fertilizer and manure additions at rates and ways that maximize crop uptake while minimizing leaching losses to waters	Nitrogen rates at Maximum Return to Nitrogen (U of MN rec's)
		Timing of application closer to crop use (spring or split applications)
		Nitrification inhibitors
		Manure application based on nutrient testing, calibrated equipment, recommended rates, etc.
	Store and treat tile drainage waters: Managing tile drainage waters so that nitrate can be denitrified or so that water volumes and loads from tile drains are reduced	Saturated buffers
		Restored or constructed wetlands
		Controlled drainage
		Woodchip bioreactors
		Two-stage ditch
	Increase vegetative cover/root duration: Planting crops and vegetation that maximize vegetative cover and capturing of soil nitrate by roots during the spring, summer and fall.	Conservation cover (easements/buffers of native grass & trees, pollinator habitat)
		Perennials grown on marginal lands and riparian lands
		Cover crops
		Rotations that include perennials
Phosphorus (TP)	Improve upland/field surface runoff controls: Soil and water conservation practices that reduce soil erosion and field runoff, or otherwise minimize sediment from leaving farmland	Strategies to reduce sediment from fields (see above - upland field surface runoff)
		Constructed or restored wetlands
		Pasture management
		Restored wetlands
	Reduce bank/bluff/ravine erosion	Strategies to reduce TSS from banks/bluffs/ravines (see above for sediment)
	Increase vegetative cover/root duration: Planting crops and vegetation that maximize vegetative cover and minimize erosion and soil losses to waters, especially during the spring and fall.	Conservation cover (easements/buffers of native grass & trees, pollinator habitat)
		Perennials grown on marginal lands and riparian lands
		Cover crops
		Rotations that include perennials
	Preventing feedlot runoff: Using manure storage, water diversions, reduced lot sizes and vegetative filter strips to reduce open lot phosphorus losses	Open lot runoff management to meet 7020 rules
		Manure storage in ways that prevent runoff
	Improve fertilizer and manure application management: Applying phosphorus fertilizer and manure onto soils where it is most needed using techniques which limit exposure of phosphorus to rainfall and runoff.	Soil P testing and applying nutrients on fields needing phosphorus
		Incorporating/injecting nutrients below the soil
		Manure application meeting all 7020 rule setback requirements

Parameter (incl. non-pollutant stressors)	Strategy Key	
	Description	Example BMPs/actions
	Address failing septic systems: Fixing septic systems so that on-site sewage is not released to surface waters. Includes straight pipes.	Sewering around lakes
		Eliminating straight pipes, surface seepages
	Reduce in-water loading: Minimizing the internal release of phosphorus within lakes	Rough fish management
		Curly-leaf pondweed management
		Alum treatment
		Lake drawdown
		Hypolimnetic withdrawal
	Improve forestry management	See forest strategies for sediment control
	Reduce Industrial/Municipal wastewater TP	Municipal and industrial treatment of wastewater P
		Upgrades/expansion. Address inflow/infiltration.
	Treat tile drainage waters: Treating tile drainage waters to reduce phosphorus entering water by running water through a medium which captures phosphorus	Bioreactor
	Improve urban stormwater management	See MPCA Stormwater Manual: http://stormwater.pca.state.mn.us/index.php/Main_Page
E. coli	Reducing livestock bacteria in surface runoff: Preventing manure from entering streams by keeping it in storage or below the soil surface and by limiting access of animals to waters.	Strategies to reduce field TSS (applied to manured fields, see above)
		Improved field manure (nutrient) management
		Adhere/increase application setbacks
		Improve feedlot runoff control
		Animal mortality facility
		Manure spreading setbacks and incorporation near wells and sinkholes
		Rotational grazing and livestock exclusion (pasture management)
	Reduce urban bacteria: Limiting exposure of pet or waterfowl waste to rainfall	Pet waste management
		Filter strips and buffers
		See MPCA Stormwater Manual: http://stormwater.pca.state.mn.us/index.php/Main_Page
	Address failing septic systems: Fixing septic systems so that on-site sewage is not released to surface waters. Includes straight pipes.	Replace failing septic (SSTS) systems
		Maintain septic (SSTS) systems
		Reduce straight pipe (untreated) residential discharges

Parameter (incl. non-pollutant stressors)	Strategy Key	
	Description	Example BMPs/actions
	Reduce Industrial/Municipal wastewater bacteria	Reduce WWTP untreated (emergency) releases
Dissolved Oxygen	Reduce phosphorus	See strategies above for reducing phosphorus
	Increase river flow during low flow years	See strategies above for altered hydrology
	In-channel restoration: Actions to address altered portions of streams.	
Chloride	Manage and minimize salt use.	Promote and adopt the strategies laid out in the Chloride Management Plan: https://www.pca.state.mn.us/sites/default/files/wq-iw11-06ff.pdf

4. Monitoring Plan

Water quality sampling in the VRWJPO is conducted as part of the annual comprehensive monitoring program. The VRWJPO has monitored stream flow and quality, precipitation and other hydrologic parameters annually beginning in the early 2000's. Lake water quality sampling is typically conducted or coordinated by the local cities. The VRWJPO also began conducting annual fish and macroinvertebrate sampling in 2009, and plans to continue annual surveys. Since the mid-2000s, the VRWJPO has actively coordinated with other agencies to collect additional monitoring data.

The VRWJPO's monitoring program:

- Tracks long term water quality trends
- Quantifies pollutant loading and yields
- Performs detailed investigation of specific pollutant issues to pinpoint sources
- Tracks attainment of water quality standards
- Determines biotic health of stream reaches
- Tracks efficacy of VRWJPO projects
- Provides model calibration datasets

The program is a joint collaboration between the VRWJPO, Dakota and Scott County SWCDs, MCES, USGS, Dakota County, Scott County, the MPCA, and the DNR. In 2014, the VRWJPO monitored eight sites on the Vermillion River and tributaries for water quantity and quality, with another site monitored in cooperation with MCES. The VRWJPO, in cooperation with the DNR and Dakota SWCD, monitored 14 sites on stream reaches throughout the watershed for fish and macroinvertebrates. Lake water quality sampling is conducted or coordinated by each of their respective cities in cooperation with the MCES. Program data includes a calculation of annual runoff, flow, pollutant loads and yields, and precipitation. These data are published annually in the Vermillion River Watershed Monitoring Report (posted on-line: http://www.vermillionriverwatershed.org, and search "Monitoring Stations").

Progress toward meeting TMDL goals will be measured by regularly monitoring water quality and tracking total BMPs completed. Water quality monitoring will be accomplished through the comprehensive monitoring program. It is anticipated that member cities and permitted MS4s will perform monitoring in the watershed or evaluation via other methods as applicable to the partitioned WLA and associated correlation to each NPDES permit.

Additional Vermillion River Watershed Monitoring Efforts and Information

Vermillion River Watershed Monitoring Reports (2006-2013)

Vermillion River Watershed Fish Sampling (2009 – 2013)

Vermillion River Watershed BiomonitoringBio-monitoring Geomorphic Assessment Report (2009-2012)

Vermillion River JPO Volunteer Monitoring Programs

Geomorphic Assessment Study Reports

Metropolitan Council Stream Monitoring & Assessment Reports (Vermillion River)

Vermillion River USGS Monitoring Station - USGS

5. References and Further Information

Bonestroo, Rosene, Anderlik and Associates. 2007. Long and Farquar Lakes Nutrient TMDL. http://www.pca.state.mn.us/index.php/view-document.html?gid=7975

Chapman, K., B. Olsen, H. Kieng, and B. Nerbonne, 2008. Groundwater Environment and Temperature in the Vermillion River Watershed. Report prepared for the Vermillion River Watershed Joint Powers Organization, Apple Valley, MN.

Dakota County SWCD. 2013. Vermillion River Monitoring Network 2013 Annual Report. http://www.vermillionriverwatershed.org/attachments/057_2013%20Vermillion%20River%20Water%20Quality%20Monitoring%20Report.pdf

Interfluve. 2009. South Creek Subwatershed Fluvial Geomorphic Assessment Report. <http://www.vermillionriverwatershed.org/index.php?option=com_content&view=article&id=61:plans-studies-and-documents&catid=39:tools&Itemid=90.

Interfluve. 2011. Fluvial Geomorphic Assessment of North Creek and Middle Creek, Dakota County, MN: Final Report. http://www.vermillionriverwatershed.org/index.php?option=com_content&view=article&id=61:plans-studies-and-documents&catid=39:tools&Itemid=90>

Interfluve. 2012. Empire Drainages Geomorphic Assessment, Dakota County, MN: Final Report. <http://www.vermillionriverwatershed.org/index.php?option=com_content&view=article&id=61:plans-studies-and-documents&catid=39:tools&Itemid=90>

Minnesota Department of Agriculture, 2013. Minnesota Nitrogen Fertilizer Management Plan. http://www.mda.state.mn.us/chemicals/fertilizers/nutrient-mgmt/nitrogenplan/~/media/Files/chemicals/nfmp/2013nfmpdraft.ashx

Minnesota Pollution Control Agency (MPCA), 2006. Revised Regional Total Maximum Daily Load Evaluation of Fecal Coliform Bacteria Impairments in the Lower Mississippi River Basin in Minnesota. http://www.pca.state.mn.us/index.php/view-document.html?gid=8006

Minnesota Pollution Control Agency (MPCA), 2012. Vermillion River Watershed Monitoring and Assessment Report. http://www.pca.state.mn.us/index.php/view-document.html?gid=18751

Minnesota Pollution Control Agency (MPCA), 2015. Vermillion River Watershed Draft TMDL Report (In progress).

Tetra Tech, 2009. Lower Vermillion River Watershed Turbidity TMDL. http://www.pca.state.mn.us/index.php/view-document.html?gid=8216

Vermillion River Watershed Joint Powers Organization (VRWJPO). 2008. Watershed Management Plan. http://www.vermillionriverwatershed.org/attachments/061_VRW_FinalPlanDocumentAmended2008.pdf

Wenck Associates. 2013. Stressor Identification Report for the Vermillion River Watershed Restoration and Protection Strategies. http://www.pca.state.mn.us/index.php/view-document.html?gid=20202

6. Appendix A Nitrogen BMP Spreadsheet Scenarios

These scenarios were discussed and designed by MPCA staff and local partners as part of the Wells Creek Watershed, which is part of the Mississippi River – Lake Pepin Major Watershed Project. While not part of the Vermillion Project, the development involved the same groups involved in the Major Watershed. They describe estimated scales of adoption that correspond to ~16% and 27% reductions in nitrogen loading from the MRLP watershed.

Watershed: Mississippi River - Lake Pepin — 32 — 0.137 million acres in watershed or state

		% suitable	% adoption	% treated	% treated, combined	acres treated (000), combined
7	Corn acres receiving target N rate, no inhibitor or timing shift	49.49%	70%	34.64%	33.58%	45.89
8	Fall N target rate acres receiving N inhibitor	8.69%		0.00%	0.00%	0.00
9	Fall N applications switched to spring, % of fall-app. acres	8.69%		0.00%	0.00%	0.00
10	Fall N switch to split spring/sidedressing, % of fall acres	8.69%		0.00%	0.00%	0.00
11	Restored wetlands	7.98%	0%	0.00%	0.00%	0.00
12	Tile line bioreactors	7.02%	0%	0.00%	0.00%	0.00
13	Controlled drainage	7.02%	0%	0.00%	0.00%	0.00
14	Saturated buffers	7.02%	0%	0.00%	0.00%	0.00
15	Riparian buffers	2.25%	100%	2.25%	2.25%	3.08
16	Cereal rye cover crop after corn grain, before soybeans	28.12%	5%	1.41%	1.37%	1.87
17	Short season crops planted to a rye cover crop	7.41%	50%	3.71%	3.65%	4.99
18	Perennial crop % of corn & soy area — marginal only	17.67%	0%	0.00%	0.00%	0.00

19 Weather scenario: Average weather - all of preplant N is available — of preplant — Load default data

20 For wet spring scenario 2, fertilizer & manure N lost — 30%

21 The rate of sidedressed N is increased to offset the lost preplant N.

22 N load reduction with these adoption rates: 16.7% of cultivated ag land source load — More results===>

23 Treatment cost before fertilizer cost savings & corn yield impacts — $0.83 million/year

24 N fertilizer cost savings & corn yield impacts — -$1.00

25 Net BMP treatment cost — -$0.18 million/year

Watershed: Mississippi River - Lake Pepin — 32 — 0.137 million acres in watershed or state

		% suitable	% adoption	% treated	% treated, combined	acres treated (000), combined
7	Corn acres receiving target N rate, no inhibitor or timing shift	49.49%	100%	49.49%	46.45%	63.49
8	Fall N target rate acres receiving N inhibitor	8.69%	0%	0.00%	0.00%	0.00
9	Fall N applications switched to spring, % of fall-app. acres	8.69%	0%	0.00%	0.00%	0.00
10	Fall N switch to split spring/sidedressing, % of fall acres	8.69%	100%	8.69%	8.34%	11.40
11	Restored wetlands	7.98%	0%	0.00%	0.00%	0.00
12	Tile line bioreactors	7.02%	0%	0.00%	0.00%	0.00
13	Controlled drainage	7.02%	0%	0.00%	0.00%	0.00
14	Saturated buffers	7.02%	1%	0.07%	0.07%	0.10
15	Riparian buffers	4.50%	100%	4.50%	4.50%	6.16
16	Cereal rye cover crop after corn grain, before soybeans	28.12%	20%	5.62%	5.33%	7.28
17	Short season crops planted to a rye cover crop	7.41%	100%	6.94%	6.72%	9.18
18	Perennial crop % of corn & soy area — marginal only	17.67%	0%	0.00%	0.00%	0.00

19 Weather scenario: Average weather - all of preplant N is available — of preplant — Load default data

20 For wet spring scenario 2, fertilizer & manure N lost — 30%

21 Sidedressing is done after the rains. The average-year rate of sidedressed N is applied.

22 N load reduction with these adoption rates: 27.0% of cultivated ag land source load — More results===>

23 Treatment cost before fertilizer cost savings & corn yield impacts — $1.76 million/year

24 N fertilizer cost savings & corn yield impacts — -$1.25

25 Net BMP treatment cost — $0.51 million/year