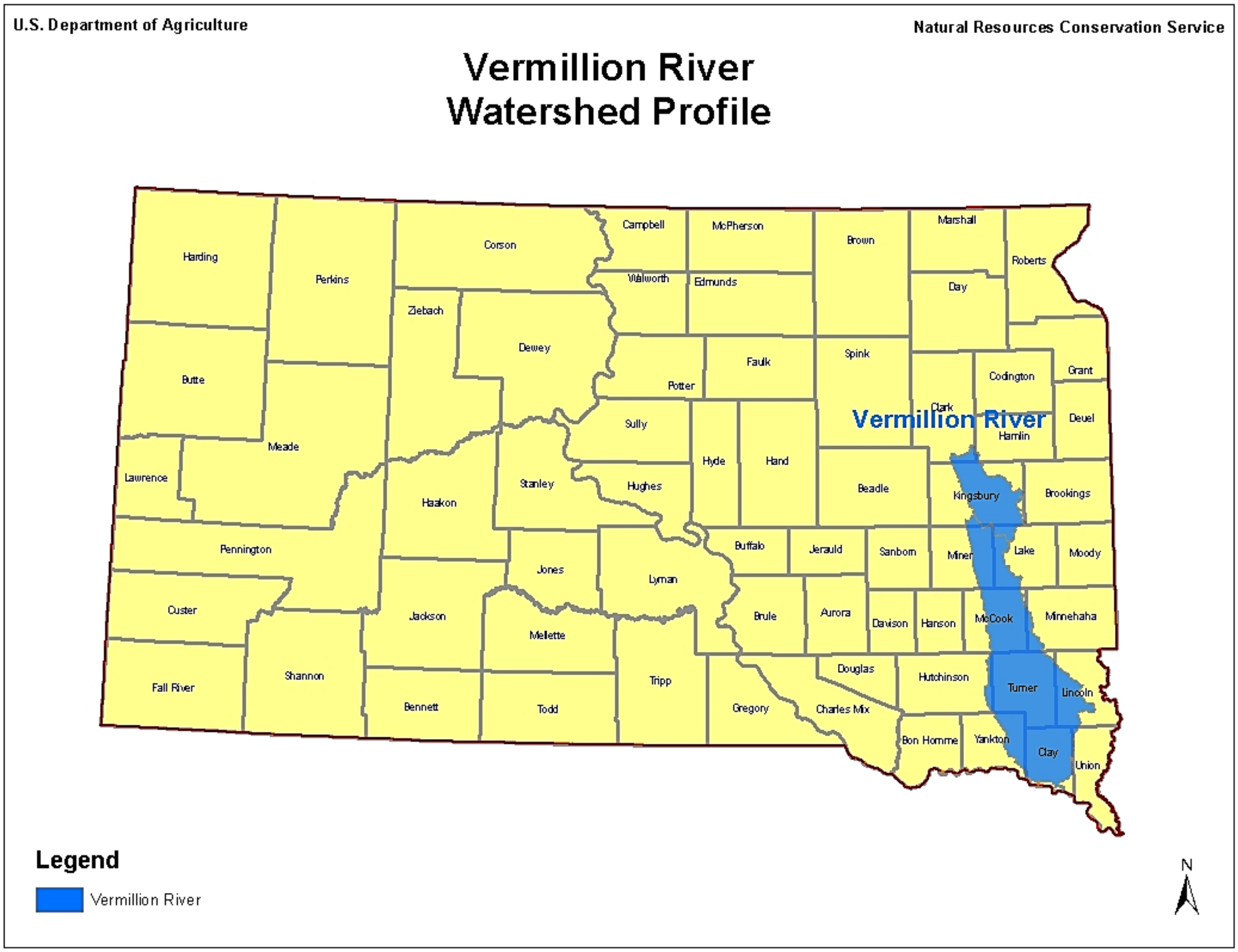

VERMILLION RIVER BASIN STRATEGIC PLAN

In Cooperation With:

South Dakota Conservation Districts

South Dakota Association of Conservation Districts

South Dakota Department of Environment and Natural Resources

USDA Natural Resources Conservation Service

Date: June 15, 2013

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TABLE OF CONTENTS

List of Figures

List of Tables

Executive Summary

The Vermillion River drains approximately 1.43 million acres in fourteen counties in southeastern South Dakota. The river has its beginnings as two separate streams, the East Fork and the West Fork of the Vermillion River. The headwaters of the East Fork begin just southwest of Oldham, while the West Fork begins approximately twelve miles south of De Smet. The East Fork and West Fork drain approximately 292,579 acres and 256,440 acres, respectively, and converge as the Vermillion River near the city of Parker. The river continues south toward Centerville emptying into the Missouri River near the city of Vermillion. The river basin is approximately 150 miles in length and varies in width from 12 miles in the north to 36 miles in the south, near Vermillion.

The overall gradient of the Vermillion River has an elevation drop of approximately four feet per mile. Poor natural drainage and reoccurring floods evoked a quick response to artificial drainage by early European settlers. Public-supported drainage projects were approved and completed within the first fifty years of settlement. Drainage ditches were constructed as early as 1886 through cooperative ventures of landowners in the Clay Creek drainage. These drainage efforts were continued with channelization projects and dikes to control the water and reduce the impact of flooding. There are now levees constructed along a 53-mile reach of the river from the city of Vermillion north to about three miles upstream of Long Creek. The above normal rainfall events from 1982 to the present renewed the interest in efforts to reduce flooding in the Vermilion River watershed.

The interest in the Vermillion River basin began with drainage projects designed to improve cropland conditions. As a result of these studies, water quality issues were also identified by the SDDENR resulting in the Vermillion River Basin Watershed Assessment that was initiated in 2004 and completed in 2007. The reported sources of water quality impairment from this assessment were fecal coliform bacteria, which exceeded the limits for limited contact recreation, and high Total Suspended Solids (TSS) concentrations present during high flow storm events.

The *2012 South Dakota-DENR Integrated Report for Surface Water Quality Assessment* for Vermillion River basin reported that dissolved oxygen (DO), Total Suspended Solids (TSS), high pH, Chlorophyll-*a*, temperature, *Escherichia coli*, and fecal coliform bacteria were the identified impairments listed within the watershed area. Point sources of pollutants were investigated for the six water bodies listed as 303(d) impaired in the 2012 SD DENR Integrated Report; East Lake Vermillion, Silver Lake, Long Creek, East Fork Vermillion River, West Fork Vermillion River, and the Vermillion River. The investigations did not identify any significant point discharges in the Vermillion River basin. The TMDL studies found that municipalities had either zero discharge NPDES permits, discharges that were NPDES permitted and controlled or the discharges were so minor and/or infrequent as to be negligible, and the remaining human

produced fecals not delivered to a municipal treatment facility had a minimal impact on total loading**.**

Non point sources of impairment were also investigated on designated water bodies in the Vermillion River Basin. Water bodies that met the 303(d) criteria for all their designated beneficial uses, per SD-DENR IR 2012, were Lake Henry, Swan Lake, Lake Thompson, Whitewood Lake, the Little Vermillion River, and segment R4 of the Vermillion River. The water bodies of Camp Creek and Long Creek were reported to have insufficient water quality data to ascertain whether they met the supporting criteria of all their designated beneficial uses. Water quality studies in the Vermillion River basin concluded that agricultural activities were the major nonpoint source of excessive nutrients to the watershed by sheet and rill erosion from the agricultural lands, manure from livestock feedlots, livestock defecating while wading in water bodies and while grazing on rangeland, and stream bed and bank erosion; other potential sources were minimal.

The Vermillion River Basin Watershed Assessment project developed into the current Vermillion River Basin Watershed Project (VRBWP), whose goal is to restore the beneficial uses of the Vermillion River through the implementation of Best Management Practices. There were two previous implementation projects in the watershed; the Turkey-Ridge Creek 319 Implementations Project sponsored by the Turner Conservation District from 2005-2009; and the Kingsbury Lakes 319 project sponsored by the Kingsbury Conservation District from 2005-2008. Both projects have been completed and their subwatersheds have been integrated into the VRBWP.

The McCook Conservation District is the current project sponsor and the lead agency responsible for the completion of the goals, objectives, and tasks of the VRBWP. The McCook Conservation District has entered into an agreement with other watershed Conservation Districts' to help advise the project sponsor, develop priorities, practice manuals, work plans, and strategies for the VRBWP. The goal of this strategic plan is to; identify the pollutant sources for the 303(d) listed water bodies; to find suitable Best Management Practices (BMP) that, when implemented, will result in the delisting of the 303(d) water bodies; and to identify practice and administrative costs and goals over a five year period. The Best Management Practices in this Strategic Plan have been selected based on the identified 303(d) pollutants and their success at achieving load reductions. The implementation of these BMPs should achieve delisting of the identified water bodies by eliminating or reducing the nutrient, sediment, and fecal coliform bacteria loadings to the Vermillion River from its watershed and tributaries.

1. INTRODUCTION

1.1 Project Background and Scope

The Vermillion River drains approximately 1.43 million acres in fourteen counties in southeastern South Dakota. The river has its beginnings as two separate streams; the East Fork and the West Fork of the Vermillion River. The headwaters of the East Fork begin just southwest of Oldham, at the outlet of Lake Thompson, and flow south to Montrose. The main stem of the East Fork is impounded south of Montrose, forming East Lake Vermillion and the basis of a State Park. It then continues south toward Parker; draining water from Kingsbury, Brookings, Clark, Miner, Lake, McCook, Minnehaha, and Turner Counties. The West Fork begins approximately twelve miles south of De Smet, flowing south toward the communities of Howard, Canova, Salem, Marion, and Parker; draining water from Kingsbury, Miner, McCook, and Turner Counties. The East Fork and West Fork drain approximately 292,579 acres and 256,440 acres, respectively, (SDDENR 2011) and converge as the Vermillion River near the city of Parker. The river continues south toward Centerville emptying into the Missouri River near the city of Vermillion.

The rivers watershed is approximately 150 miles in length and varies in width from 12 miles in the north to 36 miles in the south near Vermillion. See Figure 1-1 for the Vermillion River watershed area. Above-normal precipitation in the northern portion of the Vermillion River watershed from 1982 through 1987 caused substantial rises in lake levels in the Lake Thompson Chain-of-Lakes, (USGS, Benson et al. 1988) resulting in discharge from Lake Thompson to the East Fork of the Vermillion River. The Lake Thompson chain-of-lakes were previously thought to be a noncontributing portion of the Vermillion River watershed (USGS 1988). The other major tributaries to the Vermillion River include the perennial streams of Ash Creek, Clay Creek, Frog Creek, Little Vermillion River, Spirit Mound Creek, Turkey Ridge Creek, and the intermittent streams of Baptist Creek, Blind Creek, Camp Creek, Elce Creek, Hurley Creek, Long Creek, Saddlerock Creek, and Yankton-Clay Ditch.

The entire Vermillion River watershed is within two Hydrological Units (HU); the Vermillion River HU10170102 and the Lake Thompson HU 101701103. See Figure 1-1 for HU boundaries. The fourteen counties within this watershed are Brookings, Clark, Hamlin, Hutchinson, Kingsbury, Lake, Lincoln, Miner, McCook, Minnehaha, Turner, Yankton, Clay, and Union. Table 1-1 presents the area in square miles and percent of each county represented in the watershed. Two of these counties, Lincoln and Minnehaha, make up the Sioux Falls metropolitan area and have their economic focus on that urban area (Power et al. 1998). The remaining counties are nonmetropolitan and largely rural counties; however, all of the land draining into the Vermilion River has similar characteristic agricultural land uses. The counties of Brookings and Hamlin will not be detailed in the Strategic Plan because of their comparatively small portions of acres involved in the watershed.

Figure 1-1. Hydrological Units in the Vermillion River Watershed, South Dakota

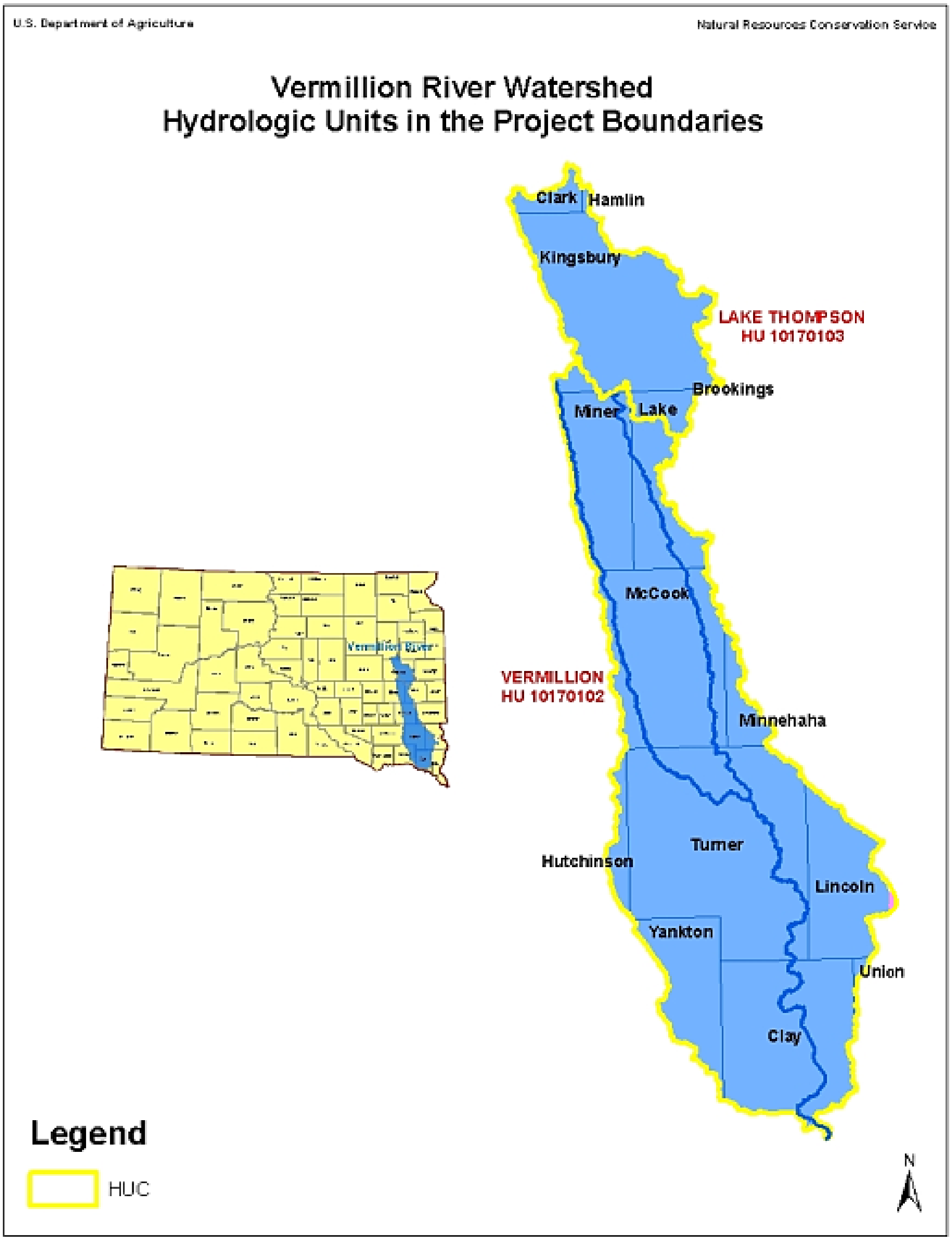


Table 1-1. Area of Counties Represented in the Vermillion River Watershed

Area of Counties in Watershed		
County	**Sq. Miles**	**Percent**
Turner	605	22.4
Kingsbury	428	15.9
McCook	389	14.4
Clay	358	13.3
Miner	212	7.9
Lincoln	211	7.8
Lake	182	6.8
Yankton	163	6.0
Minnehaha	52	1.9
Hutchinson	44	1.6
Clark	31	1.1
Union	15	0.6
Hamlin	4	0.2
Brookings	3	0.1
Totals	2,697	100

The climate of the Vermillion River watershed is classified as sub-humid continental. The highest mean temperature in the northern part for De Smet in July is 77.6 degrees Fahrenheit (^{o}F), while the lowest mean temperature in January is -2.7 ^{o}F; the average median temperature is 44.0 ^{o}F. The highest mean temperature at the south end for Vermillion in July is 80.9 ^{o}F, while the lowest mean in January is 4.9 ^{o}F; the average median temperature is 49.6 ^{o}F. The annual precipitation in De Smet and Vermillion is 23.84 and 25.36 inches, respectively. The weather data references are from the South Dakota State University, South Dakota Climate and Weather, Normal Statistics 1971-2000. Climate conditions are relatively uniform throughout the watershed, which experiences all of the conditions of the temperate continental climate classification; pronounced seasonality with long, cold winters, hot summers, mid-latitude cyclonic storms, and variable precipitation. Strong surface winds patterns across the watershed persist principally blowing from the north and northwest during the colder part of the year.

The Vermillion River watershed is largely rural in nature with the City of Vermillion having the largest population at 10,597 residents. The second largest city is Lennox with a population of 2,216 residents. There are approximately 40 incorporated and unincorporated cities and villages within the watershed. Table 1-2 lists the cities' with populations over 500 and the counties' populations in the watershed. A map of the cities and counties locations and watershed boundaries is shown in Figure 1-2.

Table 1-2. Population Statistics of the Vermillion River Watershed in SD

Population Statistics of the Vermillion River Basin. US Census Bureau 2010 Census					
Cities with Populations Over 500				Total County Populations	
City	County	Population		County	Population
Vermillion	10,597	Clay		Lincoln	45,177
Lennox	2,216	Lincoln		Union	14,155
Beresford	1,980	Union		Clay	13,902
Salem	1,425	McCook		Turner	8,357
DeSmet	1,260	Kingsbury		McCook	5,613
Howard	1,094	Miner		Kingsbury	5,159
Parker	1,087	Turner		Miner	2,389
Centerville	917	Turner			
Viborg	888	Turner			
Lake Preston	728	Kingsbury			
Marion	703	Turner			
Montrose	667	McCook			
Canistota	589	McCook			
Irene	508	Turner		Total	94,752

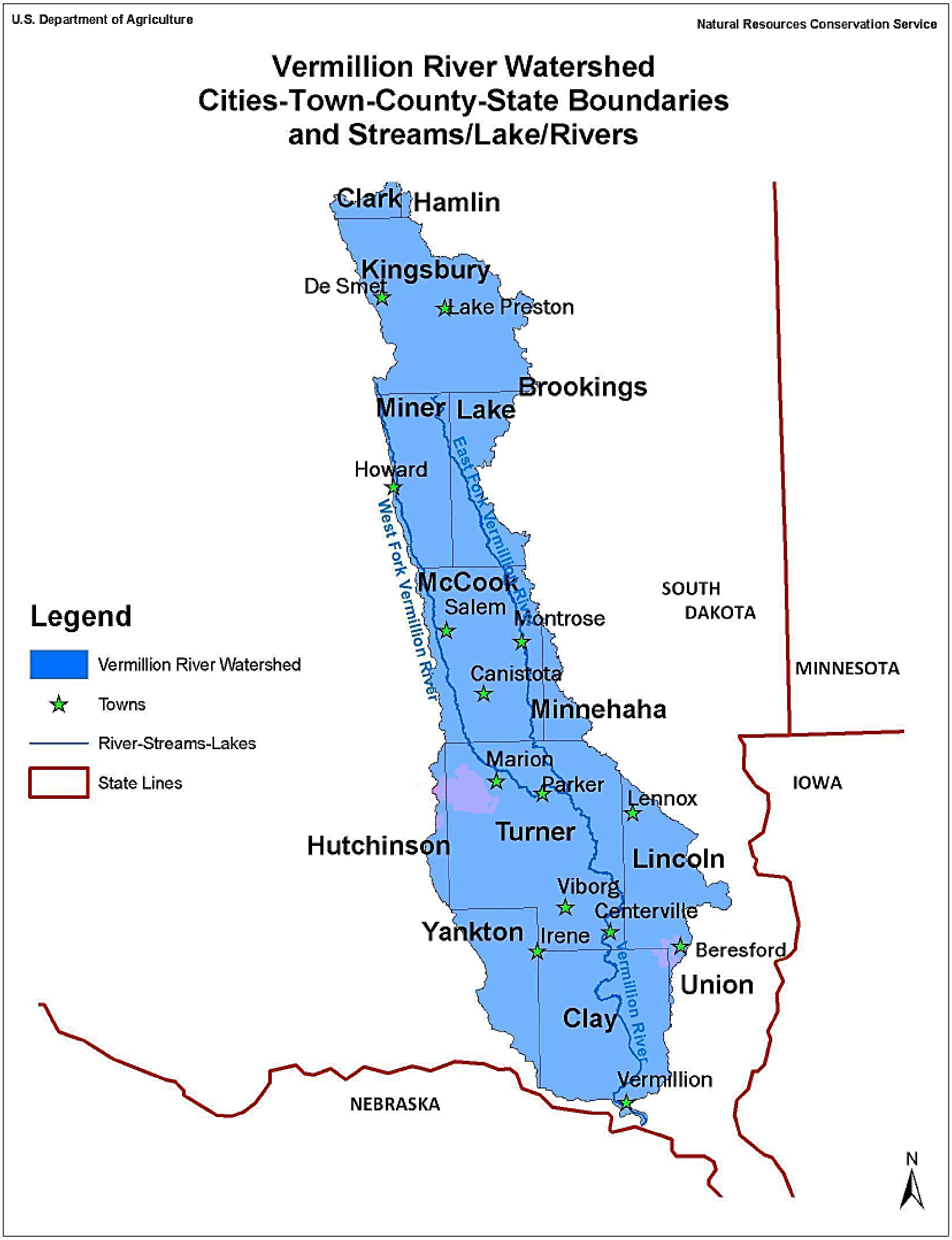
1.2 Vermillion River, Watershed History

The origin of the Vermillion River's name is uncertain, although on the Lewis and Clark expedition of 1804 they called the river the Redstone River (Schmulbach 1993) on their return trip. French trappers were the first Caucasians to settle at the river's mouth and the term "red" in the original Indian names was probably translated as "vermillion" by the trappers.

The Vermillion River drains approximately 2,234 square miles in southeastern South Dakota. It is one of the smaller tributaries that enter the middle Missouri River along its eastern bank. Most east bank tributaries of the Missouri River have small drainage basins and poorly developed surficial drainage of the Pleistocene glacial drift and till. The overall gradient of the Vermillion River has an elevation drop of approximately four feet per mile. This poor natural drainage and reoccurring floods evoked a quick response to artificial drainage by early European settlers. The Missouri River and the Vermillion River combined flood event in 1881 destroyed about seventy-five percent of the city of Vermillion. This resulted in Vermillion being relocated away from the Missouri River floodplain to its present site on the bluff overlooking the Missouri River.

As a consequence, public-supported drainage projects were approved and completed within the first fifty years of settlement. Drainage ditches were constructed as early as 1886 through cooperative ventures of landowners in the Clay Creek drainage (Power et al. 1998). These drainage efforts were continued with channelization projects and dikes to control the water and reduce the impact of flooding. Plans for dredging and ditching of the main stem Vermillion River

Figure 1-2. Cities, Counties, Water Bodies of the Vermillion River in South Dakota.



were approved by the Clay County commissioners in 1910 and completed by 1913. There are now levees constructed along a 53-mile reach of the river from the city of Vermillion north to about three miles upstream of Long Creek.

According to stream flow records maintained since 1944, flooding on the Vermillion River has occurred almost every year with a duration from one to three weeks. This relatively long flooding period is caused by a low stream gradient and the high storage potential of the valley. The two main periods of flooding in the annual hydrologic cycles are in early spring following snowmelt and in early summer, usually June; periods associated with heavy rainfall. Flood control efforts have not eliminated the problems of periodic flooding. Flood frequency and peak flood levels on the Vermillion River have actually increased during the twentieth century (Power et al. 1998) due to increased rainfall amounts in the early 1980's and 1990's.

Because of high precipitation events, Lake Thompson grew from a water body having a surface area of 9,000 acres to a lake of 20,000 acres, flooding many acres of agricultural lands in its growth. This excessive rainfall caused Lake Thompson to overflow its natural outlet and discharge water into the East Fork of the Vermillion River. Unlike most periodic flooding, the high water levels of Lake Thompson did not recede and the surface acres have remained fairly constant.

The above normal rainfall events from 1982 to the present renewed the interest in efforts to reduce flooding in the Vermilion River watershed. Proposals to control flooding are as follows:

- The Lake Thompson Watershed Project Plan in 1991 focused on restoration of wetlands, purchasing of uplands, and the public acquisition of flooded private lands. This also resulted in the creation of a state park on Lake Thompson.

- The Vermillion Basin Water Development District has worked for the construction of a large storage dam on the East Fork of the Vermillion River near the Turner-McCook county line. This project proposal did not show adequate cost-benefit ratios for construction.

- The U.S. Army Corps of Engineers completed a *Reconnaissance Report and Appendices Vermillion River Basin, South Dakota,* in 1992, which studied a variety of flood control measures to reduce damages. They did not find any of these measures to meet federal cost-benefit guidelines.

- Representatives from counties within the basin formed the Vermillion Basin Watershed Advisory Board in the early 1990's. They hired Victor Engineering to develop a flood mitigation plan which consisted of multiple smaller impoundments on the tributaries of the Vermillion River. This project did not develop due to lack of funding.

- A workshop sponsored by the Hazard Mitigation Division of the Federal Emergency Management Agency (FEMA) in 1992 brought together technical experts and local people to develop management strategies along the Vermillion River. This resulted in the publication *Multi-Objective Flood Mitigation Plan: Vermillion River Basin, South Dakota*.

- A report by Rex R. Johnson entitled *The Vermillion River: Managing the Watershed to Reduce Flooding* focused on wetland restoration and protection as a way of reducing the impacts of flooding in the Vermillion River basin. This report was published in 1997 by the Clay Conservation District as they searched for alternatives, other than drainage, to reducing flooding.

This focus on flood control and prevention eventually led to water quality assessment studies that identified the impairments of designated beneficial uses for its streams and lakes. The nonpoint source pollutants causing these impairments were nutrients from cropland fertilizers and manure from animal feedlots, bacteria from animal feedlots, and excessive sediments. Several projects developed to implement Best Management Practices (BMP) and address resource concerns were: (1) the Kingsbury Lakes Water Quality Implementation Project, sponsored by the Kingsbury Conservation District, ran from 2005-2008 in the Lake Thompson watershed; (2) the Turkey Ridge Creek project sponsored by the Turner Conservation District from 2005-2009; (3) the Swan Lake restoration sponsored by the Turner Conservation District from 1992-1998; and (4) the current main stem Vermillion River Basin Watershed Project initiated by the McCook Conservation District in 2003.

The project proposals were developed by the local Conservation District representatives with assistance from the Vermillion River Basin Water Development District; the South Dakota Association of Conservation Districts; the South Dakota Department of Environment and Natural Resources; the South Dakota Department of Agriculture; the Natural Resources Conservation Service; all meeting as a project advisory work group. Monies and in-kind match for these implementation projects came from the landowners; the Vermillion Basin Water Development District; the South Dakota Department of Environment and Natural Resources Consolidated Facilities Construction Fund and Consolidated Water Facilities Construction Fund; the South Dakota Game, Fish, and Parks Private Lands Program; the South Dakota Department of Agriculture Land and Water Conservation Grant Program; US Environmental Protection Agency 319 funds; the US Fish & Wildlife Service; the USDA Farm Service Agency; and the USDA Natural Resources Conservation Service.

1.3 Vermillion River Watershed Water Quality Studies

The Vermillion River watershed experienced extended periods of above normal rainfall from 1992-1998 that resulted in flooding during the spring and summer of 1993, 1995, and to some extent, in 1997, 1998, and 2001 (SDDENR-IR 2004). These high water conditions produced increased siltation and sedimentation to local water bodies. The water quality of the river below Lake Vermillion was reported as marginal for its designated beneficial uses, most often the result of elevated Total Suspended Solids (TSS). During the years 1991-1995 the warm water fishery beneficial use continued to be impacted by excessive TSS and represented the sole cause of nonsupport for the lower reaches of the main stem. A moderate impairment for secondary contact was noted in the upper and lower reaches of the river due to elevated fecal coliform numbers in the second half of the 1990's. During the SDDENR-IR reporting years 1998-2003, the lower reach from below Centerville to its confluence with the Missouri River was impaired due to high TSS and excessive fecal coliform bacteria. The river segment from the East Lake Vermillion tail-waters to Centerville fully supported its beneficial uses.

A watershed assessment of the Vermillion River was completed in 2007 and identified over 2,000 animal feeding areas in the basin. The sources of impairment for the water bodies determined by the assessment were:

- Fecal coliform bacteria exceeded the limits for limited contact recreation in the lower reaches of the Vermillion River. The high coliform level was projected to be associated with land application of manure, livestock feeding areas, and/or cattle pastured in riparian areas.
- Water quality data indicated that high TSS concentrations were present in the lower reaches of the river during high flow storm events. The sources of high TSS were thought to be associated with livestock grazing in the riparian zone, stream bank erosion, and soil erosion from uplands.

Eight lakes in the watershed have also been assessed; Lake Preston, Whitewood Lake, Swan Lake, Silver Lake, Lake Thompson, Lake Vermillion (also called East Vermillion Lake), Lake Marindahl, and Lake Henry (SDDENR-IR 2004). All these lakes were highly eutrophic (high Trophic State Index) in 2004 except for Marindahl, which was ranked as eutrophic. Algae, nutrient enrichment, and siltation were listed as the major causes of nonsupport. Siltation and sedimentation problems were particularly severe at Lake Vermillion owing to its large watershed comprised of mostly cropland. Lake Vermillion is currently impaired for the designated beneficial uses of immersion and limited contact recreation. Resident responses within the Vermillion River watershed have indicated that the local lakes were not meeting their swimmable uses due to excessive algal/macrophyte growth and deterioration of beaches by siltation (SDDENR-IR 2004). Eutrophication of the river has also been accelerated by the large number of feedlots and/or animal holding/management areas, erosion runoff from fertilized cropland, and stream bank erosion.

The water resource concerns along the Vermillion River had been initially focused on flood control measures. Further study of water bodies revealed issues with temperature, pH, dissolved oxygen, fecal coliform bacteria, total suspended solids, total phosphorous, and sedimentation. The South Dakota Department of Environment and Natural Resources Integrated Report (SDDENR-IR) 2012 listed sixteen water bodies within the Vermillion River watershed; three have approved Total Maximum Daily Loads (TMDL); six fully supported their designated uses; one had insufficient data; and six were impaired and need a TMDL. A short synopsis of each study within the Vermillion River watershed is as follows:

- Segment 2 of the East Fork Vermillion River was studied in the SDDENR 2012 document *Pathogen Total Maximum Daily Load (TMDL) for One Segment of the East Fork of the Vermillion River*. Livestock uses was a significant land use type within this watershed. The animal feeding operation (AFO) inventory conducted found 15 AFOs within 500 meters of the main stem. The operations were ranked by the Agricultural Nonpoint Source Computer Model (AGNPS). Thirteen exhibited an AGNPS rating of 50 or greater. The lake was 303 (d) listed in the 2012 DENR Integrated report for Chlorophyll-*a* and Temperature.

- The Vermillion River was evaluated in the SDDENR 2011 document *Total Suspended Solids Total Maximum Daily Load (TMDL) for Segment R8 of the Vermillion River in Clay, Hutchinson, Lincoln, Turner, Yankton, and Union Counties South Dakota*. The primary nonpoint sources of TSS included sheet and rill erosion from the agriculturally dominated landscape, and bed and bank erosion from the various tributaries as well as the Vermillion River main stem. The Vermillion River, Segment R8 from the Little Vermillion River to its mouth, was 303(d) listed in the 2012 DENR Integrated Report for *Escherichia coli*.

- The West Fork Vermillion River was studied in the SDDENR 2012 TMDL document *Fecal Coliform and Escherichia coli Bacteria Total Maximum Daily Load Evaluations for the West Fork of the Vermillion River, South Dakota*. The main source of fecal coliform and *E. coli* bacteria in the West Fork watershed was livestock from a combination of feedlots and grazing. Bacteria migration from feedlots and upland grazing occurred during major run-off events. Direct use of the stream by livestock was also the source of bacteria at low flows. The West Fork, segment R9, was 303 (d) listed in the 2012 DENR Integrated report for *Escherichia coli* and Fecal Coliform.

- The *Watershed Assessment, Final Report, Turkey Ridge Creek, Turner County, South Dakota* (SDDENR 2005) determined the sources of excessive sediment and nutrients, the period of time the creek exhibited the highest water quality, and the potential of a sediment retention basin for Swan Lake. The AGNPS feedlot analysis identified 129 feedlots within the watershed with 17 feedlots having an AGNPS rating of 60 or more on a scale of 0-100. The lower 26.1 miles required a 95.1% reduction in fecal coliform bacteria during high flow storm events. The study recommendations were to target animal feeding operations, grazing management, manure management on cropland, and install filter strips along riparian zones to reduce fecal coliform bacteria.

- A total maximum daily load evaluation was completed by SDDENR for Turkey Ridge Creek and published as the *Total Maximum Daily Load Evaluation (Fecal Coliform Bacteria) for Turkey Ridge Creek (HUC 10170102), Turner County, South Dakota*, in December 2006. The water quality data collected during the assessment indicated that the creek was not fully supporting the limited contact beneficial use due to fecal coliform bacteria. Sources of the bacteria were cattle on pasture, cattle in direct contact with streams, and animal feeding operations.

- The Swan Lake TMDL was established in the SDENR document *Swan Lake Watershed, Turner County South Dakota, January, 1999.* Sixty percent of the nutrient loading was coming from the spring thaw runoff from the Turkey Ridge Creek by improper operation of the control structures on the inlet channel. Recommendations were to control the source of incoming water. Swan Lake was not 303(d) listed in the 2012 SDDENR Integrated Report.

- The TMDL was established by SDDENR for Camp Creek in 2004 in the document *Total Maximum Daily Load for Ammonia in Camp Creek near Chancellor, South Dakota*. The previous TMDL was completed in 1999 for the Vermillion River. The beneficial uses of Camp Creek were upgraded in 2004 to include a warm water marginal fish life propagation water classification. The waste load allocations developed using Camp Creek were more stringent than the Vermillion River allocations and are presented in the TMDL. Camp Creek was listed as having insufficient data to make a 303 (d) determination in the 2012 DENR Integrated Report.

- The US Geological Survey Circular reported details on the Little Vermillion River in 1999, for one of the approximately 50 stations in the Hydrologic Benchmark Network (HBN), described in the four-volume U.S. Geological Survey Circular 1173: *Little Vermillion River near Salem, South Dakota (06478540).* The Little

Vermillion River was listed as fully supporting its designated used in the 2012 DENR Integrated Report.

- The West Fork of the Vermillion River had a TMDL established in the document *Total Maximum Daily Load for Ammonia in the West Fork Vermillion River Near Salem, South Dakota, South Dakota Department of Environment and Natural Resources, 2007*. Point source ammonia loads at critical low flow conditions were primarily due to discharges from the city of Salem's municipal wastewater treatment facility. A Surface Water Discharge permit for point source control was issued by the SDDENR. The West Fork was 303 (d) listed in the 2012 DENR Integrated report for *Escherichia coli* and Fecal Coliform; however, the main source of fecal coliform and *E. coli* bacteria was later identified (SDDENR TMDL 2012) as livestock from a combination of feedlots and grazing.

- The Lake Thompson chain-of-lakes are located in Kingsbury County in the northern portion of the Vermillion River basin. An implementation project was reported on in 2008 as the *Watershed Project Final Report; Lake Thompson, Lake Henry, lake Preston, Whitewood Lake; Kingsbury Lakes Water Quality Implementation Project*. The goal of the project was to reduce phosphorous loading to maintain the Trophic State Index (TSI) for Lake Thompson and Lake Henry at or near the regional criteria, TSI=65, and move the Lakes Preston and Whitewood TSI values closer to the regional criteria. Other water quality issues identified that were of concern were high pH, unionized ammonia and fecal coliform bacteria in excess of State standards, low dissolved oxygen in bottom samples, and beach closures at Lake Thompson. The project implemented Best Management Practices to improve and/or maintain water quality to support designated beneficial uses.

- Thomas M. Power and Ernie Niemi published *An Economic Evaluation of Flood Control Alternatives in the Vermillion River Basin, South Dakota,* in 1998. Their case study detailed the history of the Vermillion River basin and the economic consequences of flooding and wetland management in the basin. It entails an in-depth analysis of three active proposals to reduce flooding; a large retention dam on the main stem, numerous smaller retention dams on the tributaries, and reduced drainage of wetlands and wetland restoration.

- The Clay County Conservation District sponsored Rex R. Johnson to review past flood control projects on the Vermillion River and the potential of wetland restoration to reduce flooding in the 1997 report *The Vermillion River: Managing the Watershed to Reduce Flooding*. The report emphasizes that if the water in the

Vermillion River is to flow downstream at a natural rate, then the water must enter the river at a more natural rate using nonstructural flood control measures.

- The United States Army Corps of Engineers completed a *Reconnaissance Report and Appendices, Vermillion River Basin, South Dakota, Flood Control* study published in October of 1992. The reconnaissance study goal was to define the flooding problems and identify and evaluate alternative solutions. Potential solutions were the construction of dams, levees, diversion, or channel improvements, and non-structural measures.

- The Federal Emergency Management Agency (FEMA) and the National Park Service conducted a task force in 1994 to examine the problems on the Vermillion River in the *Multi-Objective Flood Mitigation Plan, Vermillion River Basin, South Dakota*. The flooding problems and potential solutions were investigated for a week by local citizens, private groups, local government, state government agencies, and federal agency officials. Recommendations were to establish state and local floodplain management programs and to implement Best Management Practices on agricultural and urban lands to reduce runoff and erosion.

- The effect of Best Management Practices (BMP) in the entire Missouri River Basin was studied by USDA- Natural Resources Conservation Service (NRCS) and reported on in the document *Assessment of the Effects of Conservation Practices on Cultivated Cropland in the Missouri River Basin*, June 2012. The primary focus of the study was on the 29 percent of the basin that is cultivated cropland. The study was designed to quantify the effects of conservation practices commonly used on cultivated cropland, evaluate the need for additional conservation treatment in the region on the basis of wind erosion and edge-of-field sediment and nutrient losses, and to estimate the potential gains that could be attained with additional conservation treatment. The study found the most cost effective and efficient way of reducing soil loss and nutrient loadings was to install Best Management Practices on the 18% of under-treated cropland identified as having inherent vulnerability and in need of High and Moderate levels of conservation treatment.

1.4 Goals of the Vermillion River Watershed Strategic Plan

The goal of the strategic plan for the Vermillion River watershed is to identify the pollutant sources for the 303(d) listed water bodies and to find suitable Best Management Practices (BMP) that, when implemented, will result in the delisting of the 303(d) water bodies. The implementation of the BMPs will eliminate or reduce the nutrient, sediment, and fecal coliform bacteria loadings to the Vermillion River from its watershed and tributaries. In addition to the

303(d) delisting, the implementation of this plan will allow the continued use of the water bodies for flood control, drinking water, livestock water, swimming, boating, recreation, irrigation, commerce, wildlife, and residential living.

2. CAUSES AND SOURCES OF IMPAIRMENTS

2.1 Geography

The majority of the Vermillion River watershed is located in the Level III Northern Glaciated Plains with a small portion at the southern end of the watershed in the Western Corn Belt Plains ecoregion. The Northern Glaciated Plains ecoregion was historically dominated by transitional grassland containing both tall grass and short grass prairie communities. Drift plains, large glacial lake basins, and shallow river valleys, with level to undulating surfaces and deep soils, provide the basis for crop agriculture. The young geologic age has left an immature drainage system and the ecoregion is dotted with substantial numbers of wetland depressions, ranging in size and permanence. This moderately high concentration of semi-permanent and seasonal wetlands is commonly referred to as Prairie Potholes. There are also sub-regional concentrations of glacial formed permanent lakes. Cropland, grassland, wetland, and surface water form the general mosaic of land covers within the Northern Glaciated Plains ecoregion.

The Western Corn Belt Plains ecoregion was once a tall grass prairie covered with little bluestem, big bluestem, Indiangrass, switchgrass, numerous forbs, and with small areas of bur oak and oak-hickory woodlands; the region has nearly all been converted to agricultural land. There are intermittent and perennial streams, many of which have been channelized, and a few natural lakes. The topography consists of nearly level to gently rolling glaciated till plains and hilly loess plains. Thick loess and glacial till cover the Mesozoic and Paleozoic shale, sandstone, and limestone. Mollisol soils are dominant with mesic soil temperatures and udic soil moisture. Over 75 percent of the Western Corn Belt Plains is now used for cropland agriculture and much of the remainder is in forage for livestock.

The Vermillion River watershed lies in the Central Feed Grains and Livestock Region and the Northern Great Plains Spring Wheat Region, Land Resource Regions M and F, respectively. The Major Land Resource Areas (MLRA) are part of a USDA classification system that defines land as a resource for farming, ranching, forestry, engineering, and other uses. The MLRA is a broad-based geographic area characterized by a uniform pattern of soils, elevation, topography, climate, water resources, potential natural vegetation, and land use. The large MRLA's are subdivided into smaller more homogeneous resource areas referred to a Common Resource Area's (CRA). The Vermillion River watershed includes the CRA's the Southern Dark Brown Glaciated Plains 55C in Region F; the Rolling Till Prairie 102A, the Till Plains 102B, and the Loess Uplands 102C in Region M. See Figure 2-1.

The major landforms in this MLRA are stagnation moraines, end moraines, glacial outwash terraces, and flood plains. The area is dominated by drift covered moraines. The stagnation moraines generally are nearly level to gently rolling and have many depressions and ill-defined drainage ways. The steeper slopes are on end moraines and on breaks adjacent to some of the larger tributaries. Small outwash areas are adjacent to the minor moraines. The dominant parent materials are silty drift, glacial till, glacial outwash, and alluvium.

2.2 Soils

The dominant soil order in this MLRA is Mollisols. The soils dominantly have a mesic soil temperature regime, an ustic soil moisture regime that borders on udic, and mixed or smectitic mineralogy. They generally are very deep, well drained to poorly drained, and clayey or loamy. Calciustolls (Ethan series) and Calciustepts (Betts series) formed in till on the steeper slopes on moraines. Calciaquolls formed in silty drift (Wakonda series) and glacial till (Davison series) in areas characterized by upward water movement. Haplustolls formed in lacustrine sediments (Huntimer series), silty drift (Wentworth and Trent series), silty drift over glacial till (Egan and Viborg series), or glacial till (Clarno series). They also formed in glaciofluvial deposits on outwash plains (Dempster, Graceville, Delmont, and Enet series). Argiaquolls (Chancellor series) formed in alluvium in wet drainage ways. The soils that formed in alluvium in depressions include Argialbolls (Tetonka series), Argiaquolls (Worthing series), and Endoaquolls (Baltic series). Soils that formed in stream alluvium include Haplustolls (Bon, Davis, and Roxbury series), Endoaquolls (Lamo, Clamo, and Salmo series), Calciaquolls (Arlo and Storla series), and Fluvaquents (Chaska series).

The predominant soil associations in the watershed area are shown on Figure 2-2. Official Soil Series Descriptions or a Series Extent Map can be retrieved using the following link; https://soilseries.sc.egov.usda.gov/osdname.asp**.** Soil survey data can be obtained by visiting the online Web Soil Survey at http://websoilsurvey.nrcs.usda.gov for official and current USDA soil information as viewable maps and tables.

The poorly drained soils developed on glacial till and loess east of the Missouri River tend to be clay rich with limited infiltration potential. More than 90 percent of runoff trapped in prairie potholes is typically lost to evapotranspiration (ET). Annual potential ET exceeds precipitation in most years, which explains why most prairie wetlands undergo a wet-dry cycle each year. The land surface is a nearly level to gently sloping, dissected glaciated plain.

Figure 2-1. Common Resource Areas of the Vermillion River Watershed

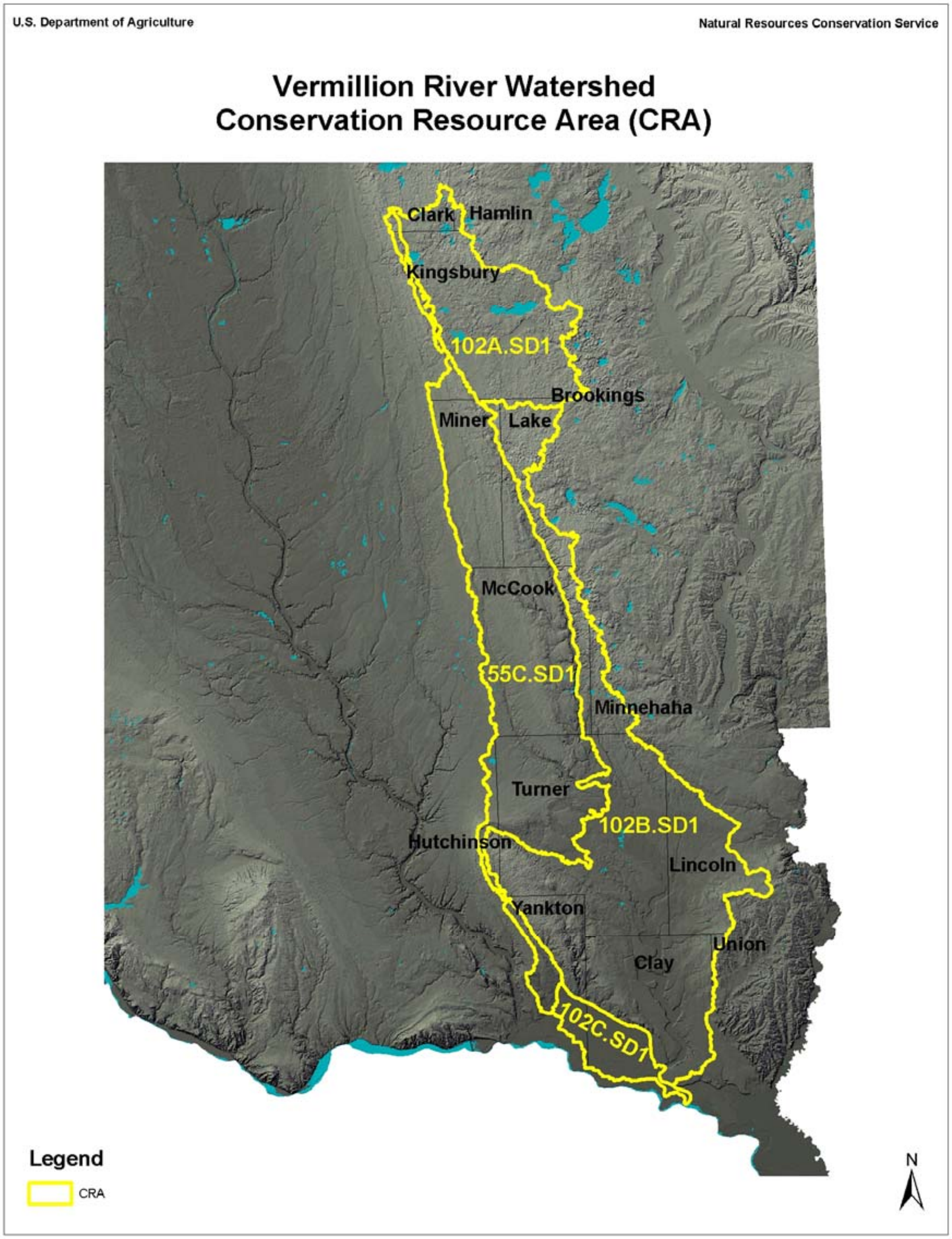
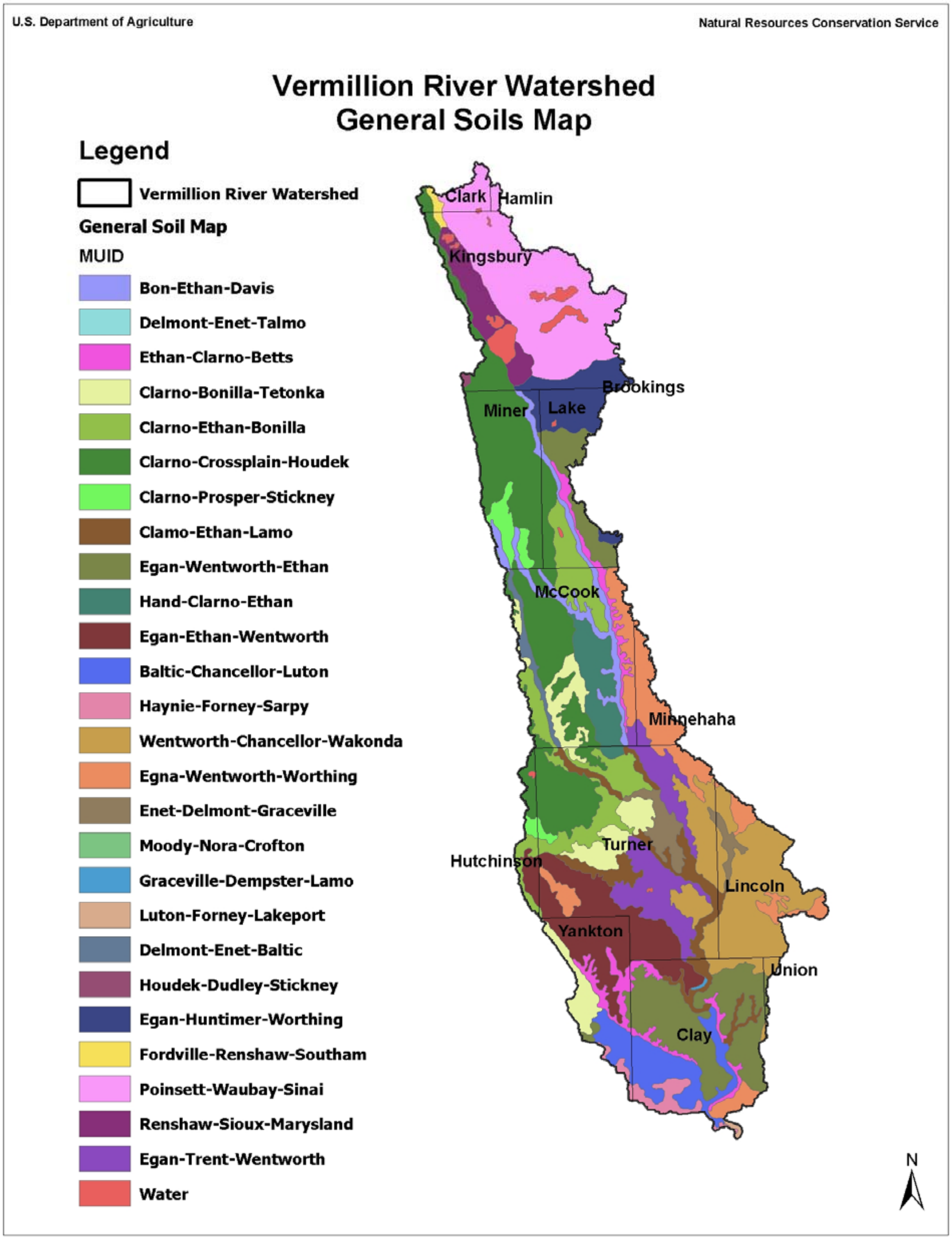


Figure 2-2. General Soils Map of the Vermillion River Watershed



2.3 Land Use

The Vermillion River watershed lies in the highly productive glaciated soils region in southeastern South Dakota. The land use of the watershed is estimated at about 68.6% cropland (NRCS 2012) with the production of row crops and hay land as the primary cropland uses. The principal crops are corn, soybeans, alfalfa, spring wheat, and oats. Grazing lands make up approximately 13.4% of the acres being used for livestock operations. Urban lands consist of about 5.8% of the watershed acres with Forest and Other uses comprising 4.0%. See Table 2-1 for the agricultural data for the counties within the watershed. Cropland and Rangeland productivity maps are presented in Figures 2-3 and 2-4, respectively. Wooded areas generally occur as narrow bands along streams and rivers or as shelterbelts around farmsteads. Recreational hunting and fishing are important land uses around the many water bodies within the watershed. Resource concerns were water erosion, soil wetness, wind erosion on lighter textured soils, maintenance of the content of organic matter and productivity of the soils, irrigation, and management of soil moisture. Conservation practices on cropland generally include systems of crop residue management, especially no-till or other conservation tillage systems that conserve moisture and contribute to soil quality. Other conservation practices include terraces, grassed waterways, and cropland nutrient management. Preserving the quality of surface water and ground water are also additional concerns in this region.

2.4 Water Resources

The total withdrawals of freshwater in the Central Feed Grains and Livestock Region average about 35,945 million gallons per day. This is one of six land resource regions in the United States that use more than 30,000 million gallons per day. About 87 percent is from surface water sources, and 13 percent is from ground water sources. The lower reaches of the large rivers in the southern part of the region have poor-quality water primarily because of sediment, nutrients, and pesticides from agricultural runoff.

Currently, four rural water systems provide water to the counties within the project area; Clark Rural Water System (RWS), Clay RWS, Kingbrook RWS, the South Lincoln RWS, and the TM Rural Water District. Regional water problems were identified in the southern part of the Vermillion River basin in the 1980's where shallow wells and aquifers were prone to contamination. New Federal drinking water standards, increased population growth, economic expansion, and insufficient water supplies resulted in efforts to meet the increasing water demand. These concerns led to the formation of the Lewis and Clark Rural Water System (LCRWS) in 1990 to provide clean and plentiful water to people for whom safe, reliable drinking water was never a reliable commodity.

Table 2-1. Agricultural Data for Vermillion River Watershed Counties

Agricultural Data for Counties in the Vermillion River Basin							
	Clark	Clay	Hutchinson	Kingsbury	Lake	Lincoln	Data Year
Land Area Acres	613,127	263,450	520,341	536,592	360,491	370,009	2010
Number of Farms	577	484	723	551	514	855	2010
Total Cropland Acres	335,735	237,334	394,680	356,912	260,009	303,444	2010
Corn Acres	103,500	97,100	153,500	139,000	119,000	143,500	2010
Soybean Acres	131,000	93,500	151,000	137,000	112,000	130,000	2010
Small Grain Acres	34,100	0	13,300	4,900	600	900	2010
Hayland	35,000	14,000	39,500	34,000	38,500	10,500	2010
Pasture/Range Acres	18,054	4,589	110,967	19,936	14,567	21,753	2007
Cattle	74,000	15,100	94,600	85,000	38,500	36,500	2010
Swine	94,793	13,982	117,257	8,932	44,414	28,302	2007
Sheep	3,014	4,164	2,965	5,591	2,115	3,920	2007
	McCook	Miner	Minnehaha	Turner	Yankton	Union	Data Year
Land Area Acres	367,721	365,042	517,873	394,799	333,836	294,659	2010
Number of Farms	545	356	1,194	722	658	521	2010
Total Cropland Acres	289,157	201,746	326,402	308,316	249,268	251,355	2010
Corn Acres	120,500	80,900	168,500	143,500	93,000	123,500	2010
Soybean Acres	109,000	84,500	137,000	132,000	80,500	101,000	2010
Small Grain Acres	1,600	6,500	1,000	2,000	1,900	0	2010
Hayland	16,000	10,000	34,000	19,000	25,500	9,500	2010
Pasture/Range Acres	16,148	22,112	8,500	4,543	7,447	22,940	2007
Cattle	45,000	40,000	75,000	49,000	46,500	24,000	2010
Swine	61,228	13,335	61,333	61,412	17,981	48,985	2007
Sheep	4,115	3,953	5,583	13,145	2,848	1,420	2007
Data from USDA Agricultural Statistics Service							

Figure 2-3. Cropland Productivity in the Vermillion River Watershed

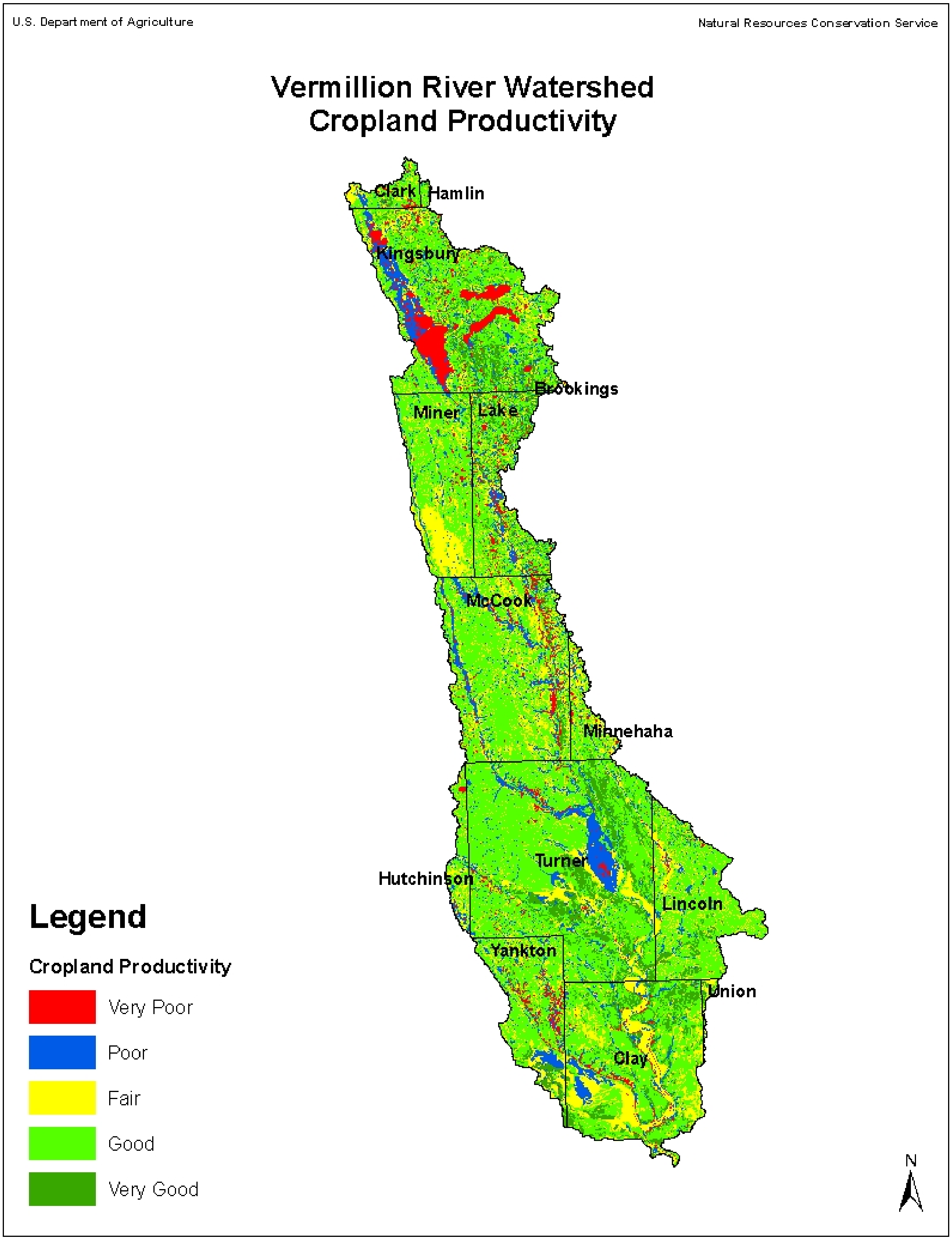
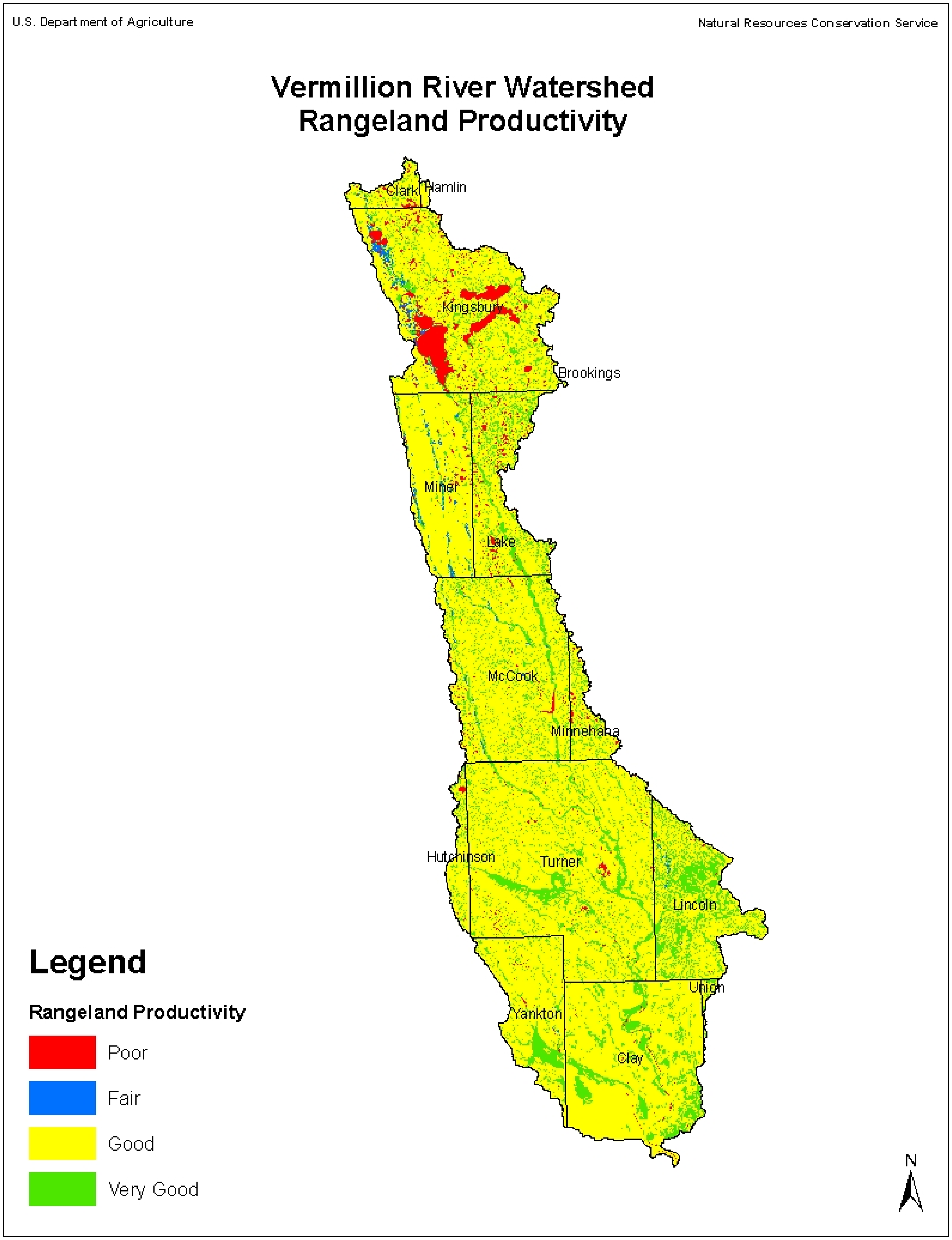


Figure 2-4. Rangeland Productivity in the Vermillion River Watershed



The LCRWS was organized to serve as a wholesale water system that would sell water to the participating 15 municipal and five rural water systems in southeast South Dakota, northwest Iowa, and southwest Minnesota. When the LCRWS is completed, it will pump drinking water from the Missouri River, through its members, to over 300,000 people in the tri-state area. The source of this water is from a series of wells drilled into an aquifer adjacent to the Missouri River near Vermillion. The water is treated and distributed through a network of pipelines, pump stations and storage reservoirs to service connections. Delivery of water will begin in 2013 to Beresford, Centerville, Lennox, Parker, and the Minnehaha Community Water Corporation. The Missouri River is an extremely valuable water resource with a low sodium hazard and a medium salinity hazard (USGS, Jorgensen 1971) making it suitable for domestic use, livestock use, and irrigation. The water from the Missouri River and these rural water systems is critical to the quality of life and economic development by providing a high-quality, reliable domestic water supply to people residing in the Vermillion River watershed.

2.5 Water Bodies Studies and Current Status

The interest in the Vermillion River watershed began with drainage projects designed to improve cropland conditions by reducing the effects of flooding along the Vermillion River. As water quality issues were identified by SDDENR, the Vermillion River Basin Watershed assessment was initiated at the request of local organization and citizens concerned with water quality problems related to pathogens, turbidity, and nutrients. The assessment was sponsored and undertaken by the Vermillion River Basin Water Development District (VRBWDD). The watershed assessment was completed in 2007. The McCook County Conservation District later agreed to take over the project after the Turkey Ridge Creek project, sponsored by the Turner County Conservation District, was combined into the Vermillion River Basin Watershed Project (VRBWP). A Project Implementation Plan (PIP) was developed to complete a comprehensive monitoring plan, identify critical regions in the watershed, and develop restoration alternatives.

Preliminary findings were reviewed at a project Advisory Committee meeting in September, 2010. The reported sources of impairment were; (1) fecal coliform bacteria exceeded the limits for limited contact recreation in the lower reaches of the Vermillion River. The high coliform level was projected to be associated with land application of manure, livestock feeding areas, and/or cattle pastured in riparian areas; (2) water quality data indicated that high Total Suspended Solids (TSS) concentrations are present in the lower reaches of the river during high flow storm events. The source of high TSS is thought to be associated with livestock grazing in the riparian zone, stream bank erosion, and soil erosion from uplands; and (3) data collected from reservoirs in the watershed will continue to be evaluated for Trophic State Indexes to identify sources of any impairment.

The *2012 South Dakota-DENR Integrated Report for Surface Water Quality Assessment* for Vermillion River basin reported that dissolved oxygen (DO), Total Suspended Solids (TSS), high pH, Chlorophyll-*a*, temperature, *Escherichia coli*, and fecal coliform bacteria were the identified impairments listed within the watershed area. The report of water bodies with designated beneficial uses, impairments, and causes of impairments is presented in Table 2-2. The 303(d) listed water bodies are summarized in Table 2-3. Figure 2-5 shows the locations of the reaches for the identified water bodies in the Vermilion River watershed.

2.6 Description of the Impairments for 303(d) Water Body Listings in the Vermillion River Basin

2.6.1 pH Levels

The pH of water has a strong effect on which fish, amphibians, invertebrates and plants can live in a community. The pH of water affects most chemical and biological processes in water and it is one of the most important environmental factors limiting the distribution of species in aquatic habitats. The pH is the measure of hydrogen ions or acidity in a water solution. The pH scale ranges from 0 (most acidic) to 14 (most basic). A pH of 7 is considered neutral. The pH scale is logarithmic and it changes by the power of ten; as a change of one whole number in the pH equals a tenfold change in the amount of acidity. Changes of two whole numbers indicate a 100-fold change in acidity. Naturally occurring pH levels typically fall between 6.5 and 9.0. The pH of a stream or lake is dependent on the water source and the kinds of rocks and soil that the water contacts. Certain dissolved minerals, such as calcium carbonate, can combine with the extra hydrogen or hydroxyl ions that alter the water's pH. When water percolates through these soils, these minerals dissolve and their buffering quality is passed along to the water. This buffering effect on the water does not allow the pH to change easily when acids or bases are added to the water.

High pH can also occur when plants use carbon dioxide (CO2) during photosynthesis to produce carbohydrates. Although highly soluble in water, most carbon dioxide in lakes is formed as an end product of respiration. When the rate of atmospheric CO2 diffusing into the water is less than the rate of photosynthesis, aquatic plants use dissolved carbonates as their source of carbon. As they produce carbon dioxide in water, it forms a series of compounds, including carbonic acid, bicarbonate, and carbonate. The process of photosynthesis also consumes protons which contribute to raising the pH. The resulting carbonate chemistry, along with the hydroxide (OH-) anion, contributes to the alkalinity and buffering capacity of water. This hydroxyl ion is responsible for the increase in lake water pH during photosynthesis. Alkalinity is a conservative parameter in that it does not change readily in well-buffered lakes. However, pH values may vary both temporally and spatially within a lake. During intense photosynthesis in the euphotic zone, carbon dioxide and its dissociation product, carbonic acid, can become less abundant. pH values may rise to as high as 9 with less of this acid. The combination of these effects can result in pH exceeding 10 in the late afternoon in lakes undergoing photosynthesis by phytoplankton. The pH standard set by South Dakota DENR 303(d) is a pH of 9.0.

Table 2-2. Vermillion River Watershed Water Bodies: Beneficial Uses, Listed as 303(d) Impaired, Source of Impairment, and Priority. (Data from "*The 2012 SD Integrated Report for Surface Water Quality Assessment*".)

WATERBODY AUID	LOCATION	MAP ID	BASIS	USE	SUPPORT	CAUSE	SOURCE	EPA CATEGORY	303(d) Priority
East Vermillion Lake	McCook	L1	DENR	Fish/Wildlife Prop, Rec, Stock	FULL			5	YES-2
SD-VM-L-E_Vermillion_01	County			Immersion Recreation	NON	Chlorophyll-a^	Unknown		
				Limited Contact Recreation	NON	Chlorophyll-a^			
				Warmwater Permanent Fish Life	NON	Chlorophyll-a^			
Lake Henry	Kingsbury	L2	DENR	Fish/Wildlife Prop, Rec, Stock	FULL			1	NO
SD-VM-L-Henry_01	County			Immersion Recreation	FULL				
				Limited Contact Recreation	FULL				
				Warmwater Marginal Fish Life	FULL				
Marindahl Lake	Yankton	L3	DENR	Fish/Wildlife Prop, Rec, Stock	FULL			2	No
SD-VM-L-Marindahl Lake_01	County			Immersion Recreation	NA				
				Limited Contact Recreation	NA				
				Warmwater Permanent Fish Life	NON				
Silver Lake	Hutchinson	L4	DENR	Fish/Wildlife Prop, Rec, Stock	FULL			5	Yes-2
SD-VM-L-Silver_01	County			Immersion Recreation	FULL				
				Limited Contact Recreation	FULL				
				Warmwater Marginal Fish Life	NON	pH High			
Swan Lake	Turner	L5	DENR	Fish/Wildlife Prop, Rec, Stock	FULL			1*	No
SD-VM-L-Swan_01	County			Immersion Recreation	FULL				
				Limited Contact Recreation	FULL				
				Warmwater Semipermanent Fish Life	FULL				
Lake Thompson	Kingsbury	L6	DENR	Fish/Wildlife Prop, Rec, Stock	FULL			1	No
SD-VM-L-Thompson_01	County			Immersion Recreation	FULL				
				Limited Contact Recreation	FULL				
				Warmwater Permanent Fish Life	FULL				

Category (1) All uses met, (2) Some uses met but insufficient data to determine support of other uses, (3) Insufficient data, (4a) Water impaired but has an approved TMDL, (5) Water impaired requires a TMDL. *Waterbody has an EPA approved TMDL. ^EPA added cause. D** TMDL development deferred to EPA.

Table 2-2: Continued

WATERBODY AUID	LOCATION	MAP ID	BASIS	USE	SUPPORT	CAUSE	SOURCE	EPA CATEGORY	303(d) Priority
Whitewood Lake	Kingsbury	L7	DENR	Fish/Wildlife Prop, Rec, Stock	FULL			1	No
SD-VM-L-Whitewood_01	County			Immersion Recreation	FULL				
				Limited Contact Recreation	FULL				
				Warmwater Marginal Fish Life	FULL				
Camp Creek	Vermillion River	R1	DENR	Fish/Wildlife Prop, Rec, Stock	INS			3	No
SD-VM-R-Camp_01	to			Irrigation Waters	INS				
	S6, T99N, R52W			Limited Contact Recreation	INS				
				Warmwater Marginal Fish Life	INS				
Little Vermillion River	Near Salem, SD	R2	DENR	Fish/Wildlife Prop, Rec, Stock	FULL			1	No
SD-VM-R-Little Vermillion			USGS	Irrigation Waters	FULL				
River_01_USGS									
Long Creek	Vermillion River	R3	DENR	Fish/Wildlife Prop, Rec, Stock	INS			5	Yes -1
SD-VM-R-Long_01	to			Irrigation Waters	INS	Escherichia coli	Livestock		
	Highway 44					Fecal Coliform			
				Limited Contact Recreation	INS-TH				
				Warmwater Semipermanent Fish Life	NON				
Vermillion River	Headwaters	R4	DENR	Fish/Wildlife Prop, Rec, Stock	FULL			1	No
SD-VM-R-Vermillion_01	to			Irrigation Waters	FULL				
	Turkey Ridge			Limited Contact Recreation	FULL				
	Creek			Warmwater Semipermanent Fish Life	FULL				
Vermillion River	Turkey Ridge	R5	DENR	Fish/Wildlife Prop, Rec, Stock	FULL			4A*	No
SD-VM-R-Vermillion_02	Creek		USGS	Irrigation Waters	FULL				
	to			Limited Contact Recreation	FULL				
	Baptist Creek			Warmwater Semipermanent Fish Life	NON	Total Suspended Solids			
						(TSS)			
Vermillion River	Baptist Creek	R6	DENR	Fish/Wildlife Prop, Rec, Stock	FULL			4A*	No
SD-VM-R-Vermillion_03	to		USGS	Irrigation Waters	FULL				
	Mouth			Limited Contact Recreation	FULL				
				Warmwater Permanent Fish Life	NON	TSS	Livestock		
							Crops		

Category (1) All uses met, (2) Some uses met but insufficient data to determine support of other uses, (3) Insufficient data, (4a) Water impaired but has an approved TMDL, (5) Water impaired requires a TMDL. *Waterbody has an EPA approved TMDL. ^EPA added cause. D** TMDL development deferred to EPA.

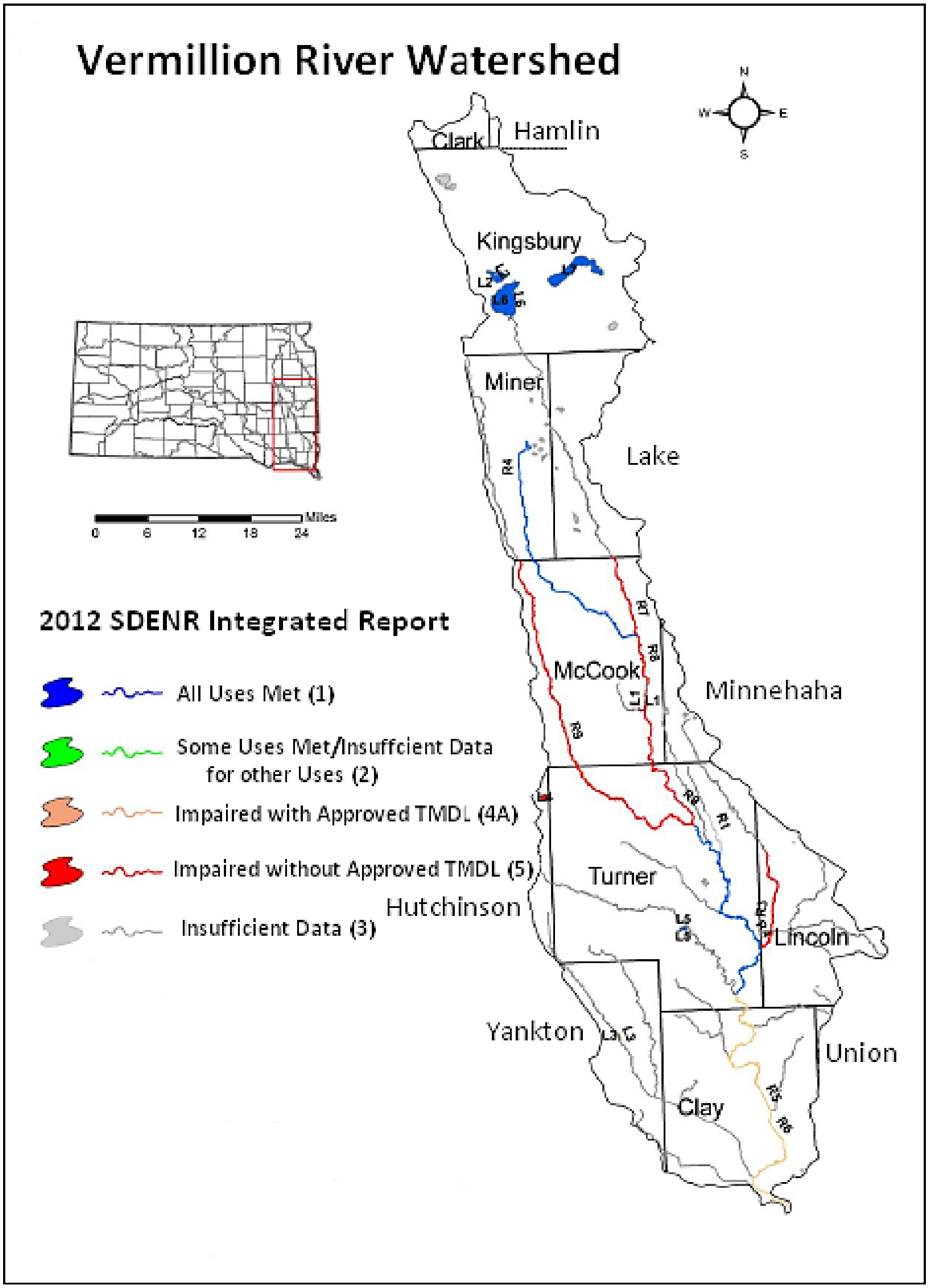
Table 2-2: Continued

WATERBODY AUID	LOCATION	MAP ID	BASIS	USE	SUPPORT	CAUSE	SOURCE	EPA CATEGORY	303(d) Priority
East Fork	McCook/Lake	R7	DENR	Fish/Wildlife Prop, Rec, Stock	FULL			5	Yes -1
Vermilion River	County to			Irrigation Waters	FULL				
SD-VM-R-Vermillion	Little Vermillion			Limited Contact Recreation	NON	Fecal Coliform			
East_Fork_01	River					Dissolved Oxygen			
				Warmwater Marginal Fish Life	FULL				
East Fork	Little Vermillion	R8	DENR	Fish/Wildlife Prop, Rec, Stock	FULL			5	Yes -1
Vermilion River	River to		USGS	Irrigation Waters	FULL				
SD-VM-R-Vermillion	Confluence with			Limited Contact Recreation	NON	Escherichia coli			
East_Fork_02	West Fork			Warmwater Marginal Fish Life	FULL				
West Fork	Vermillion River	R9	DENR	Fish/Wildlife Prop, Rec, Stock	FULL			5	Yes -1
Vermilion River	to		USGS	Irrigation Waters	FULL				
SD-VM-R-Vermillion	McCook/Miner			Limited Contact Recreation	INS-TH	Escherichia coli			
West_Fork_02_USGS	County Line					Fecal Coliform			
				Warmwater Marginal Fish Life	FULL				

Table 2-3. Summary of Vermillion River Watershed Water bodies Listed as 303(d) Impaired

Water Body Impaired	Beneficial Use Impaired	Listed Cause of Impairment
East Vermillion Lake - L1	Immersion Recreation	Chlorophyll-a
	Limited Contact Recreation	Chlorophyll-a
	Warmwater Permanent Fish Life	Chlorophyll-a
		Temperature
Silver Lake - L4	Warmwater Permanent Fish Life	High pH
Long Creek - R3	Limited Contact Recreation	Escherichia coli
		Fecal Coliform
Vermillion River - R5, R6	Warmwater Semipermanent Fish Life	Total Suspended Solids
East Fork Vermillion River - R7	Limited Contact Recreation	Fecal Coliform
		Dissolved Oxygen
East Fork Vermillion River - R8	Limited Contact Recreation	Escherichia coli
West Fork Vermillion River - R9	Limited Contact Recreation	Escherichia coli
		Fecal Coliform

Figure 2-5. 303(d) Listed Water Bodies in the Vermillion River Watershed



The most significant environmental impact of pH involves its synergistic effects, as the pH of a solution also influences the amount of substances like heavy metals that dissolve in it. This process is especially important in surface waters, as runoff from agricultural, domestic, and industrial areas may contain iron, aluminum, ammonia, mercury or other elements. Ammonia is relatively harmless to fish in water that is neutral or acidic; however, as the water becomes more basic and the pH increases, ammonia becomes increasingly toxic.

A change in the pH can alter the behavior of other chemicals in the water. These dissolved metals may also interfere with body functions. They can influence developing eggs and larvae which can lead to lower natural reproduction. Ultimately the population declines, the food chain collapses, and the community suffers. Developing eggs and larvae also have specific, narrower pH requirements. Perch can tolerate a pH of between 4.6 to 9.5 and remain relatively healthy. However, even at the high and low ends of this pH tolerance level fish become stressed. Aquatic invertebrates, with external skeletons or shells made of calcium, are extremely sensitive to pH below neutral. These organisms are important members of aquatic food chain.

2.6.2 Dissolved Oxygen

The amount of oxygen in water, Dissolved Oxygen (DO), is expressed as a concentration in milligrams per liter of water (mg/L) and can also be expressed as parts per million (ppm). Aquatic organisms use oxygen for metabolic processes and require concentrations above a certain level to survive and grow. Energy production is dependent on the availability of oxygen. When dissolved oxygen (DO) is less than 3 or 4 mg/L for warm water fish or 7 mg/L for cold-water fish, they are unable to extract sufficient oxygen from the water to support physiological functions. Their ability to catch prey is reduced, reproduction is negatively impacted, and a variety of other adverse physiological effects occur.

Hypoxia, the condition of low dissolved oxygen, is a significant problem for waters that receive a lot of runoff that contains nutrients like nitrogen, phosphorous, animal wastes, and other oxygen-demanding biological wastes. Excessive nutrients in aquatic systems stimulate algal growth, which in turn uses up the oxygen needed to maintain healthy fish and shellfish populations. Water bodies produce and consume oxygen, gaining oxygen from the atmosphere and from plants as a result of photosynthesis. DO levels in lakes are most likely to vary vertically in the water column as compared to running water that mixes and dissolves more oxygen because of its churning. Therefore, DO levels in rivers and streams changes more horizontally along the course of the waterway than vertically, as in lakes or reservoirs. This is especially true in smaller, shallower streams. The DO levels in and below riffle areas, waterfalls, or dam spillways are typically higher than those in pools and slower-moving stretches. Dams may pose an oxygen supply problem when they release waters from the bottom of their reservoirs into streams and rivers. Although the water on the bottom may be cooler than the warm water on top, it may also be low in oxygen when large amounts of organic matter has fallen to the bottom and is decomposed by bacteria.

Respiration by aquatic animals, decomposition, and various chemical reactions consume oxygen. Wastes from sewage treatment plants, animal feedlots, farmland, storm water from urban streets, and failing septic systems often contains organic materials that are decomposed by microorganisms that use oxygen in this process. The amount of oxygen consumed by these organisms in breaking down the waste is known as the biochemical oxygen demand (BOD). BOD directly affects the amount of dissolved oxygen in rivers and streams. The greater the BOD the more rapidly oxygen is depleted in the stream. This means less oxygen is available to higher forms of aquatic life. The consequences of high BOD are the same as those for low dissolved oxygen as aquatic organisms become stressed, suffocate, and die.

Aquatic life can have a hard time in stagnant water that has a lot of rotting, organic material in it, especially in summer. The concentration of dissolved oxygen is inversely related to water temperature, as cold water can hold more DO than warm water. During the summer months with hotter water, lower DO and high BOD conditions may become especially serious resulting in the death of many fish. The concentration of dissolved salts has a synergistic effect on DO levels and reduces the amount of oxygen held in water. The SDDENR standard for DO levels is a minimum of 5 Mg/L for a warm water fisheries beneficial use.

2.6.3 *Escherichia coli* and Fecal Coliform

Fecal coliform are bacteria that are found in the waste of warm-blooded animals. Common types of bacteria associated with livestock, wildlife, and human feces are *Escherichia coli*, Salmonella, and Streptococcus. These fecal indicators are microbes whose presence indicates that the water is contaminated with human or animal wastes. Fecal coliform, enterococci, and *E. coli* bacteria are not usually disease-causing agents themselves; however, high concentrations may suggest the presence of disease-causing organisms.

Of the coliforms, *E. coli* is generally the most sensitive to environmental stresses and rarely grows outside the human or animal gut. *E. coli* bacteria are normally excreted by the billions in animal wastes and their survival time in the environment generally lasts only four to twelve weeks. The inability of *E. coli* to grow in water, combined with its short survival time in water environments, means that the detection of *E. coli* in a water body is a good indicator that fecal contamination from sewage or animal waste recently entered the system. Thus, *E. coli* is used to indicate the probability of finding other pathogenic organisms in a stream. The pathogenic microbes in these wastes can cause short-term health effects, such as diarrhea, cramps, nausea, headaches, or other symptoms. They also pose a special health risk for infants, young children, some of the elderly, and people with severely compromised immune systems. Sources of fecal contamination to surface waters include wastewater treatment plants, on-site septic systems, domestic and wild animal manure, and storm runoff. The presence of elevated levels of fecal bacteria can also cause cloudy water, unpleasant odors, and an increased oxygen demand.

2.6.4 Temperature

Fish and most aquatic organisms are cold-blooded and are unable to control their internal body temperature except by behavior. Their metabolism increases two to three times per 18 degrees Fahrenheit (^{o}F) increase in water temperature. Water temperature can influence oxygen concentration, metabolism (body functions), reproduction and growth. Each species of aquatic organism has its own optimum water temperature. If the water temperature shifts too far from the optimum, the organism suffers. Cold-blooded animals cannot survive temperatures below 32 ^{o}F, and only rough fish can tolerate temperatures much warmer than about 97 ^{o}F. The water temperatures at which fish growth ceases are 82 ^{o}F for Northern pike, 90 ^{o}F for channel catfish, and 97 ^{o}F for carp. The Northern pike and channel catfish die when water temperatures exceed 86 ^{o}F and 95 ^{o}F, respectively. The South Dakota standard for water temperature for Warm water Permanent Fish Life is 80 ^{o}F.

Fish are not the only organisms requiring specific temperatures. Diatoms grow best at a temperature of 59-77 ^{o}F, green algae at 77-95 ^{o}F, and blue-green algae at 86-104 ^{o} F. While temperature changes can cause mortality, it can also cause sub-lethal effects by altering the physiology of aquatic organisms. Temperatures outside of an acceptable window affect the ability of aquatic organisms to grow, reproduce, escape predators, and compete for habitat. Warm water also makes some substances like heavy metals, phenol, xylene, and zinc more toxic for aquatic animals. When high water temperatures are combined with low dissolved oxygen levels, the toxicity is increased.

Water temperature is also influenced by the seasons, the amount of sunlight reaching the water, amount and speed of the water, the source of the water (springs or runoff) and the amount of material suspended in the water. The color of the water also affects its temperature as most heat warming for surface waters comes from the sun; so water bodies with dark-colored water or those with high turbidity absorb heat best. The depth of the water also influences the water temperature as deeper waters usually are colder than shallow waters simply because they require more time to warm up. Shallow waters open to wind currents also mix more thoroughly and temperatures are generally the same from surface to the bottom. This happens because the shallow waters are mixed by air currents which do not allow them to stratify into thermal layers and they therefore do not develop colder layers of water.

2.6.5 Total Suspended Solids (TSS)

Solids present in water are addressed separately as total solids, dissolved solids, suspended solids, and volatile suspended solids. The TSS are the sum of all forms of material including suspended and dissolved solids that will not pass through a filter. The TSS can include a wide variety of material, such as silt, decaying plant and animal matter, industrial wastes, and sewage. High concentrations of suspended solids can cause many problems for stream health and aquatic life by blocking light from reaching submerged vegetation. As the amount of light passing through the water is reduced, photosynthesis slows down. Reduced rates of photosynthesis causes less DO to be released into the water by plants. If light is completely blocked from bottom dwelling plants, the plants will stop producing oxygen and die. Bacteria uses up additional oxygen from the water as the plants decompose resulting in lower DO and can lead to fish kills. High TSS can also cause an increase in surface water temperature because the suspended particles absorb heat from sunlight. This can cause DO levels to fall even further as warmer waters hold less DO.

The decrease in water clarity caused by TSS can affect the ability of fish to see and catch food. Suspended sediment can also clog fish gills, reduce growth rates, decrease resistance to disease, and prevent egg and larval development. When suspended solids settle to the bottom of a waterbody, they can smother the eggs of fish and aquatic insects, as well as suffocate newly hatched insect larvae. Settling sediments can fill in spaces between rocks which could have been used by aquatic organisms. High TSS in a waterbody can mean high concentrations of bacteria, nutrients, pesticides, and metals in the water. These pollutants attach to sediment particles on the land, are carried into water bodies with storm events, and are then released from the sediment or travel farther downstream.

2.6.6 Chlorophyll-*a*

Chlorophyll-*a* is the primary photosynthetic pigment found in oxygen producing plants and blue-green algae. The measurement of Chlorophyll-*a* is an indirect indicator of the nutrient levels in a lake, the lake's productivity, and its state of eutrophication. Waters that have high chlorophyll-*a* conditions are typically high in nutrients, generally phosphorus and nitrogen. These two nutrients cause the algae to grow or bloom. High levels of nitrogen and phosphorus are indicators of pollution from man-made sources, such as animal wastes, septic system leakage, poorly functioning wastewater treatment plants, soil erosion, or fertilizer runoff. Chlorophyll-*a* measurement is utilized as an indirect indicator of these nutrient levels.

Nitrogen is difficult to limit in aquatic environments because of its highly soluble nature. Due to the many environmental sources of nitrogen (atmospheric, soil, fertilizer, and fecal matter), nitrogen is difficult to remove from a water system. Blue green algae can also convert nitrogen for their own growth making it even more difficult to control. For these reasons, the focus on nutrient reduction is usually on phosphorous instead of nitrogen.

Phosphorus is easier to control in the environment, making it the primary nutrient targeted for reduction when attempting to control lake eutrophication. The large algal blooms in studied lakes typically coincided with large phosphorus concentrations. Chlorophyll-*a* levels significantly increase due to algae blooms that occur during periods of higher water temperature. Levels may also increase due to the stratification of the water column (Rose Hill Lake/Sand Creek, DENR, 2002), which may cause anoxic conditions in the hypolimnion. The anoxia is accompanied by low pH values and results in the release of nutrients, particularly phosphorus, from the bottom sediments. This release of total nitrogen, total phosphorous and total dissolved phosphorous concentration can result in the algal blooms that persist throughout the summer.

When algae populations bloom and then die in response to changing environmental conditions, they deplete DO levels - a primary cause of most fish kills. Methods to eliminate the existing nutrients by artificial oxygenation of lake bottoms could result in fewer and less intense algal blooms. However, little data exists on circulators, oxygenators, and other types of equipment that eliminate stratification of the water column and the affect they will have on the frequency or intensity of nuisance algal blooms. The reduction of nutrient inputs, primarily phosphorous, into the Vermillion River basin water bodies would be the preferred method to prevent algal blooms, reduce Chlorophyll-*a* concentrations, and meet 303(d) impairment standards

Scientists from the U.S. Geological Survey (USGS 2010), studying the effects of harmful algal blooms on lake water quality, found that blooms of blue-green algae (cyanobacteria) in Midwestern lakes also produced mixtures of cyanotoxins and taste-and-odor causing compounds such as geosmin. Cyanotoxins can be toxic to mammals, including humans, causing allergic and/or respiratory issues, attacking the liver and kidneys, or affecting the nervous system. The findings of this study were significant because studies assessing toxicity and risk of cyanotoxin exposure have historically focused on only one class of toxins (microcystins). The World Health Organization has established the highest risk threshold for human exposure to cyanotoxins at >50 milligram per Liter (mg/L). It was recommended that lakes having a chlorophyll-*a* level within the moderate exposure range of 10-50 mg/L should be sampled for cyanobacteria and microcystin levels. After examining various thresholds and approaches, Region 8 of the U.S. EPA set a maximum threshold average of 30 mg/L during the growing season of May 1 to September 30 as the 303(d) listing criteria.

2.7 Defining the Sources of Impairments for 303(d) Listed Water Bodies

The general sources of impairment have been listed in the 2012 South Dakota Integrated Report for Surface Water Quality Assessment (SDDENR), see Table 2-3; however, further identification of the physical sources is required for the land application of Best Management Practices (BMPs) to be successful. The implementation of BMPs that address the impairments of the listed water bodies would more specifically solve the water quality issues. Investigations of both point and nonpoint sources were completed within portions of the Vermillion River watershed by SDDENR to identify the main sources of these impairments.

2.7.1 Point Sources of Impairment

Point sources of pollutants were investigated for the six water bodies listed as 303(d) impaired in the 2012 SD DENR Integrated Report; East Lake Vermillion (L1), Silver Lake (L4), Long Creek (R3), East Fork Vermillion River (R7, R8), West Fork Vermillion River (R9), and the Vermillion River (R5, R6).

Both Silver Lake and the East Fork Vermillion River watersheds have no point source pollutants of concern (SDDENR January 2012) since there were no communities in their watershed. East Lake Vermillion does have one National Pollutant Discharge Elimination System (NPDES) non-discharge permit upstream of the lake, from the City of Montrose. The only point discharge on Long Creek is the city of Lennox which has a National Pollutant Discharge Elimination System (NPDES) discharge permit. The discharge from the city of Lennox is required to meet the chronic water quality standards in their NPDES permit.

The West Fork Vermillion River has seven communities within the watershed with six potential point discharge NPDES permitted facilities; the cities of Canistota, Howard, Marion, Monroe, Parker, and Salem. All facilities discharge one to three times a year and generally outside of the recreation season, May 1- September 30, when the limited contact beneficial use does not apply (SDDENR April 2012). The normal operation of these systems resulted in only a small portion of the calculated daily amounts actually being discharged and all discharges are required to meet the chronic water quality threshold standards for the West Fork. The city of Monroe is a small facility that is permitted for no discharge.

The Vermillion River, from Baptist Creek to the mouth of the Vermillion River, has five NPDES permits located within its watershed; the cities of Gayville, Irene, Vermillion (two permits), and Volin. The Gayville Waste Water Treatment Facility (WWTF) is authorized to discharge its one-cell pond system, but only does so seasonally. The Irene WWTF is authorized to discharge its three-cell pond system, but only does so seasonally. The city of Volin has a small one-cell pond system that is not authorized to discharge. The City of Vermillion is subject to Phase II of the Municipal Separate Storm Sewer Systems (MS4) Program because it has a population in excess of 10,000. Thus, Vermillion is required to develop and implement a Storm Water Management Program (SWMP) to reduce the contamination of storm water runoff and prohibit illicit discharges. Vermillion's mechanical plant is covered by a general permit. All the NPDES facilities identified in these TMDLs have mechanisms in place that reduce fecal coliform and *E. coli* bacteria. The bacteria in the wastewater lagoons and ponds are only viable for short periods due to extended retention time and resultant exposure to the ultraviolet sun light. The wastewater data collected from the facilities finds that fecal coliform and *E. coli* bacteria contributions from NPDES permitted facilities are minor and not causing impairment.

The investigations did not identify any significant point discharges in the Vermillion River watershed. This conclusion has been supported by other TMDL watershed studies in South Dakota that evaluated potential point sources of loading. The TMDL studies found that municipalities had either (1) zero discharge NPDES permits, (2) discharges that were NPDES permitted and controlled or the discharges were so minor and/or infrequent as to be negligible, and (3) the remaining human produced fecals not delivered to a municipal treatment facility had a minimal impact on total loading**.**

2.7.2 Non Point Sources of Impairment

Non point sources of impairment have not been identified for all designated water bodies in the Vermillion River watershed either because the water body met all of its 303(d) designated beneficial uses or because of insufficient water quality data to make a determination. Water bodies that have met the 303(d) criteria of all their designated beneficial uses, per SD-DENR IR 2012, were Lake Henry, Swan Lake, Lake Thompson, Whitewood Lake, the Little Vermillion River, and segment R4 of the Vermillion River.

The water bodies of Camp Creek and Long Creek were reported in the 2012 SD-DENR IR to have insufficient water quality data to ascertain whether they met the supporting criteria of all their designated beneficial uses. These water bodies are not listed as having any priority under the 303(d) listing in this report. The future status of these water bodies' evaluations is unknown.

Water quality studies in the Vermillion River watershed have concluded that agricultural activities were the major nonpoint source of excessive nutrients to the watershed by sheet and rill erosion from the agricultural lands, manure from livestock feedlots, livestock defecating while wading in water bodies and defecating while grazing on rangeland, and stream bed and bank; other potential sources were minimal. The following pollutants, as identified by the SDDENR 2012 Integrated Report, are discussed by each listed 303(d) impairment for the described water bodies.

2.7.2.1 Chlorophyll-a: East Vermillion Lake, L1

East Lake Vermillion is listed 303(d) as Chlorophyll-*a* impaired for the support of Immersion Recreation, Limited Contact Recreation, and Warm Water Permanent Fish Life in the 2012 SDENR-IR. East Lake Vermillion is a 512 acre impoundment constructed in 1958 on the East Fork of the Vermillion River, approximately six miles east of the town of Canistota. East Vermillion Lake is owned and managed by the Parks and Wildlife Divisions of the South Dakota Department of Game, Fish and Parks. Together, the two State divisions own 1,826 acres which includes the surface area of the lake. The lake forms the basis of the Lake Vermillion Recreation Area which provides the recreational values of camping, boating, fishing, and swimming. The lake has a mean depth of 12.0 feet, a maximum depth of 23 feet, and a holding capacity of approximately 6,600 acre-feet of water. A low-level outlet gate can be opened for flood control and dam maintenance purposes. The 2001 National Land Cover Data set for the East Fork of the Vermillion River shows the watershed is comprised of 56.5% cropland and 32.3% grass/pasture land. Forest (farmstead woodlots), urban areas, and water make up the remainder of the watershed.

The water quality information in the TMDL (SDDENR 2012) for Segment R7 of the East Fork Vermillion River is pertinent to East Lake Vermillion, as this data was collected from the watershed that contributes to the Lake. Segment R7 runs from the McCook/Lake County line to the mouth of the Little Vermillion River near Montrose and was identified as R2 in the TMDL. The East Fork then continues to flow south for six miles where it enters the East Lake Vermillion reservoir.

During the Animal Feeding Operation (AFO) inventory conducted for the Vermillion River Basin Watershed Assessment; 15 AFOs were found within 500 meters of the main stem of the East Fork. All the AFOs were ranked by the Agricultural Nonpoint source Computer Model (AGNPS) and 13 exhibited an AGNPS rating of 50 or greater (SDDENR 2012). Table 2-4 shows the fecal coliform sources to be 90.3% from livestock manure.

Table 2-4. Fecal Coliform Allocations for the East Fork of the Vermillion River

Source	Percentage
Feedlots	75.5%
Livestock on Grass	14.8%
Wildlife	6.0%
Septic Tanks	3.7%

Nutrients from manure are a source of the phosphorous and nutrients that cause algal blooms and resultant high levels of Chlorophyll-*a*. Algal and macrophyte photosynthesis acts to increase a lake's pH, while respiration and the decomposition of organic matter will reduce the pH. The extent to which this occurs is affected by the lake's ability to buffer against changes in pH. The presence of a high alkalinity represents considerable buffering capacity and will reduce the effects of both photosynthesis and decay in producing large fluctuations in pH. It is likely that any reduction in algae would result in a reduction in pH to a point where the water quality pH criterion was met.

2.7.2.2   Temperature: East Vermillion Lake, L1

East Lake Vermillion is listed as 303(d) impaired for temperature for the support of Warm Water Permanent Fish Life in the 2012 DENR-IR. Even though the lake has a mean depth of 12.0 feet and a maximum depth of 23 feet, the upper end of the lake is very shallow and silt laden.   East

Vermillion Lake also has a northwest to southeast geographical orientation which is conducive to wind energy that can also break down a lake's vertical stratification. Wind energy transports phosphorus from bottom sediments and resuspends it into all water levels. The resuspension of sediments can also lead to an earlier warming of water temperatures above normal, as the suspended particles near the surface facilitate the absorption of heat from sunlight. This internal loading of phosphorus and early warming can accelerate an early growth of algae and aquatic plants and the resulting plant problems associated with human induced cultural eutrophication.

2.7.2.3 Dissolved Oxygen: East Fork Vermillion River, R7

The East Fork of the Vermillion River is listed as 303(d) impaired for Dissolved Oxygen (DO) for the support of both Limited Contact Recreation. The DO standard for the recreational uses serves as an indicator for those causes that can contribute to low DO levels. There are several potential sources of oxygen demand in a river system (MWPCA 2004):

- nitrogen oxygen demands derived by the nitrogen cycle (i.e. when ammonia is converted into nitrate/nitrate chemically binding the oxygen);
- sediment oxygen demand combining diffusion gradients with organic and/or chemical and mineral oxygen demands (i.e. when oxidized iron reenters an aerated water column it uses up oxygen as it reforms ferric compounds;
- bacterial uptake of dissolved oxygen in ground water;
- organic sources directly discharged to the water (e.g. BOD); and
- BOD from eutrophication caused by high levels of nutrients producing excess algae. When the algae dies and decays, it exerts an oxygen demand leading to low dissolved oxygen.

These last two sources exerted most of the BOD during low flow conditions in the lower Minnesota River. The Little Minnesota River/Big Stone Lake Phase I study (SDDENR 1983) determined that the most detrimental factors affecting water quality were nutrients and sedimentation runoff from agricultural practices on land in the watershed. High feedlot run-off and high algae biomass can result in low DO levels because of the high Biological Oxygen Demand (BOD) when organic matter decays. The result of low DO can be fish kills and undesirable recreational value.

The DO impairment, resulting from high BOD caused by excess phosphorus, especially manifests itself during low stream flow conditions. These high levels of available nutrients during low flows encourage intense algal blooms to occur during the warmer summer months. Under low stream flow conditions, streams become quiescent as a result of reduced flow. The slow-moving water provides sufficient residence time for algae to settle out, die, and decay; such that oxygen demand is greater than oxygen production. Decay of excessive levels of algae can cause severe oxygen depressions which results in reduced dissolved oxygen concentrations. The

SDDENR standard for DO levels is a minimum of 5 Mg/L for a warm water fisheries beneficial use.

2.7.2.4 *Escherichia coli* – Fecal Coliform. Long Creek, R3; East Fork Vermillion, R7& R8; West Fork Vermillion, R9.

Long Creek (R3), the East Fork Vermillion River (R7 & R8), and the West Fork Vermillion River (R9) are listed as 303(d) impaired for *Escherichia coli* and/or Fecal Coliform for the support of Limited Contact Recreation in the 2012 SDDENR-IR. Fecal coliform bacteria are usually not harmful, but they can indicate the presence of other harmful bacteria, viruses and/or parasites. Examples include the pathogenic strain of *E. coli* that is often linked to food borne illnesses, as well as giardia and cryptosporidium. Recreational contact, especially swimming, is not recommended when high concentrations of fecal coliform bacteria are present.

2.7.2.4.1 Segment R3, Long Creek

Segment R3 of Long Creek, from its mouth with the Vermillion River upstream to SD Highway #44, is listed as 303(d) impaired for *Escherichia coli* and Fecal Coliform in the SDDENR-IR 2012. Long Creek starts in the southwest corner of Minnehaha County, flowing southeast between Chancellor and Lennox, it continues south entering the Vermillion River four miles north of Centerville. The 2010 Environmental Protection Agency Waterbody Report for Long Creek lists the probable sources of impairment being agricultural in nature as Animal Feeding Operations (AFO) and Livestock Grazing.

2.7.2.4.2 Segments R7 - East Fork (SD VMR Vermillion East Fork 01)

Segment R7 as listed in the SDDENR 2012 IR was identified as segment R2 in the SDDENR 2012 TMDL. This segment is a 21.2 mile reach of the East Fork from the McCook/Lake County line to near Montrose, SD, approximately 6 miles upstream of East Lake Vermillion. There were no documented point sources within this subwatershed (SDDENR 2012).

Approximately 90% of the nonpoint sources of fecal coliform bacteria in the watershed came primarily from agricultural sources. Discharge in the East Fork of the Vermillion River displayed seasonal variation for the period of record with the highest stream flows typically occurred during spring. Fecal coliform concentrations also displayed seasonal variation relative to flow with most exceedances occurring in the low flow zones. The higher concentrations occurred at lower flows when livestock had direct access to the stream and used the water to cool off in during warmer temperatures of the summer. The high and low stream flow regimes were considered as critical conditions and have been targeted for the implementation of BMPs to achieve the TMDL.

Several types of BMPs have been considered in the development of a water quality management implementation plan for the impaired segments of the Vermillion River watershed. The results identified in the Load Duration analysis indicated significant reductions were required in the lower flow zones. Because of the rural area and the lack of point sources most of the implementation measures were recommended to focus on the following:

- Livestock access to streams should be reduced, and livestock should be provided sources of water away from streams.
- Unstable stream banks should be protected by enhancing the riparian vegetation that provides erosion control and filters runoff of pollutants into the stream.
- Filter strips should be installed along the stream bordering cropland and pastureland.
- Animal confinement facilities should implement proper animal waste management systems.

2.7.2.4.3 Segment R8 - East Fork Vermillion River (SD VMR- East Fork 02)

Segment R8 runs approximately 37.3 miles from the mouth of the Little Vermillion River, just north of Montrose, to the confluence of the East Vermillion River with the West Vermillion River near Parker. The R8 segment of the East Fork is listed 303(d) for *Escherichia coli* and impaired for the support of Limited Contact Recreation in the 2012 SDENR-IR.

The city of Montrose, SD, with a population of 667, is the only municipality located within the Segment R3 watershed. Their wastewater treatment facility (WWTF) is classified as a zero discharge facility resulting in a zero waste load allocation (WLA) for this segment.

Livestock uses were a significant land use within this watershed. Twenty-one (21) Animal Feeding Operations were identified within 500 meters of the stream bank. Each system was ranked by the Agricultural Nonpoint Source Computer Model (AGNPS) and 16 had a rating score of 50 or greater (Draft SDDENR 2012). Manure from livestock was a potential source of fecal coliform to the stream, as livestock contribute fecal coliform bacteria directly to the stream by defecating while wading in the water and defecating while grazing on rangelands. Bacteria laden manure gets washed off into the water bodies during precipitation events.

The fecal coliform TMDL was developed using a Load Duration Curve (LDC) measurement of stream flow in cubic feet per second. The East Fork of the Vermillion River had violations that occurred in the three lowest stream flow zones and at high stream flows (storm events). Bacterial load allocations were 90.3% for domestic livestock, 6.0% for wildlife, and 3.7% for human septic systems. The implementation measures recommended for use on nonpoint sources of pollutants were the same as those for segment R7 in the previous subsection.

2.7.2.4.4 Segment R9 - West Fork Vermillion River

The West Fork of the Vermillion River is 102.7 miles in length and drains approximately 251,010 total acres in southeastern South Dakota; only 177,413.4 acres was covered in the 2012 SDDENR TMDL. Only 64.6 miles of the entire 102.7 miles length is classified with the limited contact recreation beneficial use. The West Fork begins in northeast Miner County flowing southward toward Howard and then to its confluence with the East Fork near Parker; where together they form the main stem of the Vermillion River. Segment R9 of the West Fork Vermillion River is listed 303(d) for *Escherichia coli* and Fecal Coliform bacteria impaired for the support of Limited Contact Recreation in the 2012 SDENR-IR.

Livestock uses are a significant land use type within this watershed. During the Animal Feeding Operation (AFO) inventory 60 AFOs were found within 500 meters of the main stem of the West Fork Vermillion River. Each of the AFOs was ranked by the Agricultural Nonpoint Source Computer Model (AGNPS). Twenty-six of the AFOs exhibited an AGNPS rating of 50 or greater. The main source of fecal coliform and *E. coli* bacteria in the West Fork watershed was livestock from a combination of both feedlots and grazing. Bacteria migration from feedlots and upland grazing occurs during major run-off events that also produce significant amounts of sheet and rill erosion from animal feeding area. These excessive flows transport bacteria laden waste material throughout the West Fork of the Vermillion and impair the recreational beneficial use.

Direct use of the stream by livestock was found to be the source of bacteria at low flows. Evidence of this was available in the load duration curves which indicated that elevated counts of Fecal Coliform and *E. coli* occurred throughout low flow regimes. Beef cattle and hogs were found to contribute the most significant amount of bacteria to the West Fork of the Vermillion River. Table 2-5 lists the sources and their percentages of contributions. Recommendations were that emphasis should be placed on reducing bacteria inputs from livestock sources (feedlots and grazing) to bring the recreational use of the classified segment of the West Fork of the Vermillion River into compliance.

Table 2-5. Fecal and *E. coli* Source Allocations for the West Fork

Source	Percentage
Feedlots	77.0%
Livestock on Grass	8.5%
Wildlife	2.2%
Septic Tanks	5.6%

2.7.2.5 Total Suspended Solids (TSS). West Fork Vermillion River, Segments R5 & R6

Segments R5 and R6 of the Vermillion River are listed 303(d) for Total Suspended Solids (TSS) for the support of Warmwater Seimpermanent Fish Life in the 2012 SDENR-IR. These combined segments run from the mouth of Turkey Ridge Creek, near Centerville, to the mouth of the Baptist Creek (R5), and then to the mouth of the Vermillion River as it enters the Missouri River (R6). The land use statistics are as follows: 62% row crops, 21.5% grassland/hayland, 6.5% herbaceous, 6% open space, 3% water/wetland/woods, 1% urban. There is a relatively limited urbanized area in the lower portion of the drainage area, and therefore impact from this land use is expected to be localized to the source.

A TMDL for Total Suspended Solids (SDDENR April 2011) was established for the 21 mile segment R6 of the Vermillion River, from the mouth of Baptist Creek to the mouth of the Vermillion River, as it joins the Missouri River, approximately four miles south of the city of Vermillion. Major tributaries to this segment include Yankton Clay Ditch, Clay Creek Ditch, Spirit Mound Creek, and Baptist Creek. This segment has a history of exceedance of the SD total suspended solids (TSS) water quality criterion. Initially listed in the 1998 SDDENR-IR due to warmwater semipermanent beneficial use impairment, this segment has consistently been listed in Integrated Reports for 2002, 2004, 2006, 2008 and 2010 for this same impairment. Other studies have cited the increased sediment loads and flooding problems in the Vermillion River (USACE 1992**).** The Vermillion River has had a long history of flooding problems. Multiple flood control studies and mitigation plans have been completed on the Vermillion River. Like most rivers in the glaciated prairie pothole region, the Vermillion River is flood prone. Because of wetland drainage, stream and river channelization, and an emphasis on cultivated crops, the watershed river equilibrium has been upset. Water now enters the river at a faster rate making the downstream flooding worse. The increased water velocity and sediment load has resulted in stream impairments in the main stem of the Vermillion River (Johnson 1997; USACE 1992; FEMA 1994).

The results of the rapid geomorphic assessments (RGAs) were collected from channel crossings throughout the river basin. The RGA was used to assess the current channel adjustment processes occurring in a reach and to determine the stage of channel evolution that best describes the set of current and historic adjustment processes. There are six stages identified in Simon's channel evolution model (Simon 1989):

Stage I: The waterway is a stable, undisturbed natural channel.
Stage II: The channel is disturbed by some drastic change such as cultivation of grassland, forest clearing, urbanization, dam construction, or channel dredging.
Stage III: Instability sets in with scouring of the bed.
Stage IV: Destructive bank erosion and channel widening occur by collapse of bank sections.
Stage V: The banks continue to cave into the stream, widening the channel. The stream also begins to aggrade, or fill in, with sediment from eroding channel sections upstream.
Stage VI: Aggradation continues to fill the channel, re-equilibrium occurs, and bank erosion ceases. Riparian vegetation once again becomes established.

The Vermillion Basin is almost exclusively in Stages III and IV (SDDENR 2011) as reflected in the mean TSS concentrations, Figure 2-6. There is a significant increase in sediment in the lower reaches of the Vermillion River. Land use changes such as increased grassland conversion to cropland and channelization have led to increased sediment concentrations. The nonpoint sources of sediments were identified by a review of available information, communication with local Natural Resources Conservation Service (NRCS) representatives, water quality and discharge data, FLUX loadings, Annualized-AGNPS modeling results, Rapid Geomorphic Assessments (RGAs), literature values, and load duration curves.

The results of the FLUX loadings estimated that over 40% of the total suspended solids load originated from bank erosion in the two higher flow zones. The primary nonpoint sources of TSS the Vermillion River watershed included: (1) sheet and rill erosion from the agriculturally dominated landscape, and (2) bed and bank erosion from the various tributaries as well as the Vermillion River main stem. TSS concentrations were highest in the basin during severe thunderstorms in the spring and summer months. These high-intensity rainstorm events, when combined with the peak in tillage for agricultural crops, produced significant amounts of sheet and rill erosion. These excessive flows and changing channel dynamics also increased the bed and bank erosion along the tributaries and main stem of the river. Annualized AGNPS analysis suggested that multiple drainages provide increased water and sediment loadings. An assessment of the effect of tiling on peak flows and bank erosion was recommended for the tributaries draining into these three segments of the Vermillion River. Implementation of BMPs targeted to the critical conditions should reduce the sediment loading in the river.

2.7.2.6 High pH - Silver Lake, L4

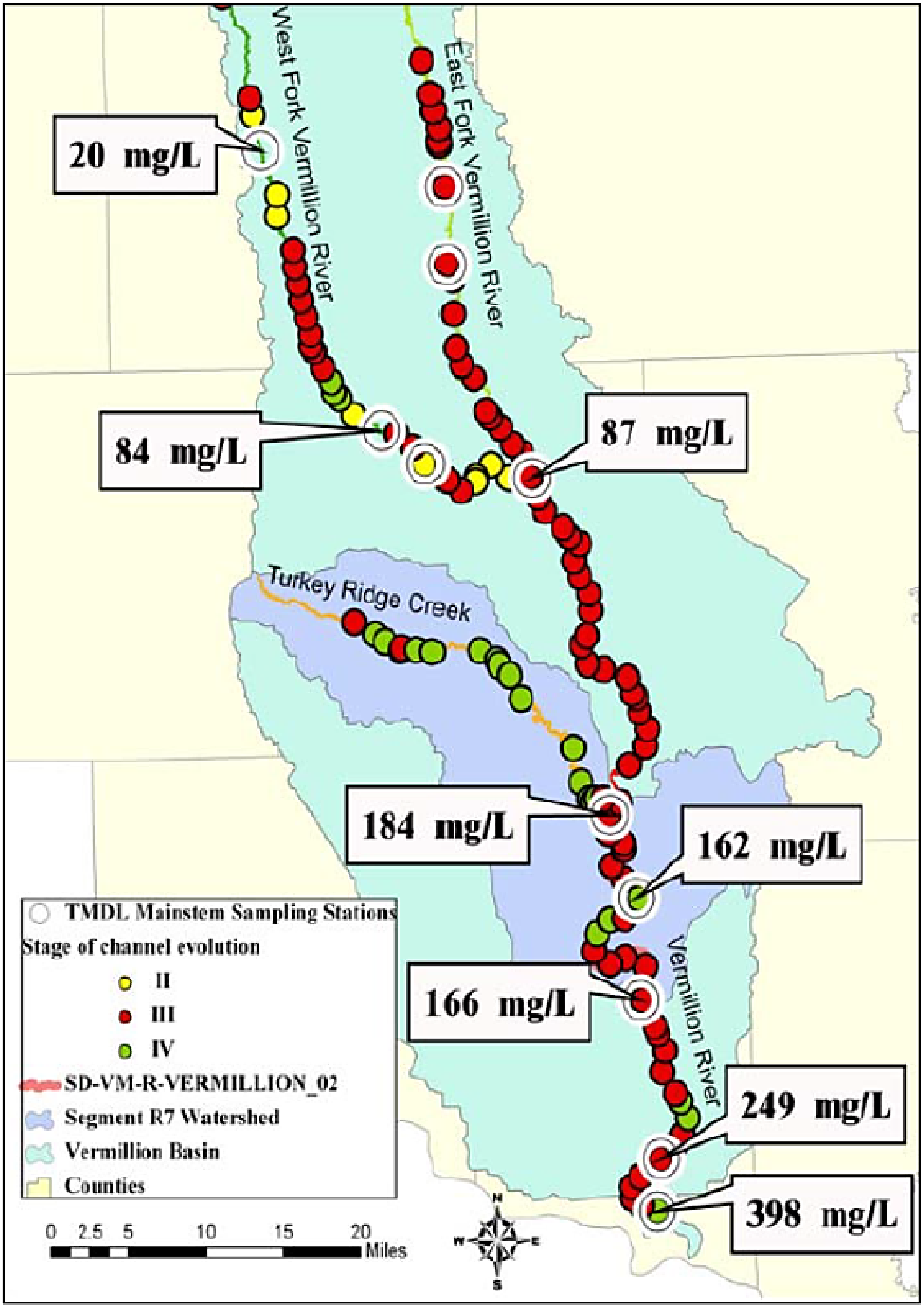
Silver Lake is listed 303(d) for High pH impaired for the support of Warmwater Permanent fish Life in the 2012 SDENR-IR. The lake is located seven miles north of Freeman in Hutchinson County. It has 393 surface acres with a 16,701 acre watershed. The mean depth is 3.5 feet with a maximum depth of 7 feet. The lake is listed in the State of South Dakota as meandered public waters with the fishery managed by the SD-Game, Fish, & Parks. Silver Lake has shore fishing access and a boat ramp on the east side of the lake, however, the remainder of the shoreline is privately owned. The 2011 South Dakota Statewide Fisheries Survey reported common cattail (*Typha* spp.), sago pondweed (*Potamageton pectinatus)*, and bulrush (*Scirpus* spp.) were abundant throughout the lake.

The beneficial use of Warm Water Marginal Fish Life requires that the pH values in the lake remain between the values of 6.5 and 9.0. Algal and macrophyte photosynthesis acts to increase a lake's pH, while respiration and the decomposition of organic matter will reduce the pH. It was assumed that the algae influences pH even though the relationship between growing-season chlorophyll-*a* versus pH was weak (Geddes Lake, SDDENR 2007). A composite algae sample taken on Geddes Lake indicated very high algae concentrations of mostly blue-green algae and diatoms. High pH levels and low DO readings were most likely directly related. The very high concentration of blue-green algae and diatoms were the assumed cause of the high pH levels as the photosynthesis from algae and macrophytes acts to increase the pH of water. It is likely that any reduction in algae would result in a reduction in pH to a point where the water quality pH criterion was met.

Similarly, Punished Woman Lake in Codington County was listed 303(d) as High pH impaired for the support of Warm Water Semi-Permanent Fish Life in the 2012 SDENR-IR. Recreational uses of fishing, swimming, and boating were reduced because excess sediment had caused a loss of water depth, an increase of nutrients, and an increase of aquatic macrophytes (SDDENR 1991). A sediment survey found approximately 2.7 million cubic yards of soft sediment in the lake. The removal of 15.5% of this sediment had a dramatic effect on beneficial uses as lake water clarity improved and suspended solids were reduced. Deepening large parts of the lake also reduced the exposure of phosphorous-rich bottom sediments to wind and wave action, thereby reducing inorganic water turbidity; which was formerly a major detriment to water clarity in Punished Woman's Lake.

Silver Lake will need further investigation of the sediment depth prior to making any management recommendations on dredging. Suggested BMP's to improve water quality are conservation tillage, contour farming, contour strip-cropping, crop rotation, terraces, grassed waterways, animal waste management systems, and range and pasture management.

Figure 2-6. Channel Evolution Stages of Vermillion River



3. NONPOINT SOURCE MANAGEMENT MEASURES

The management measures needed to address the causes and sources of pollution impairments are strongly interrelated. The nonpoint impairments have been identified as agricultural activities linked to livestock feeding operations, nutrients from livestock manure, direct use of water bodies by livestock, and soil erosion from both adjacent cropland and pasture. Practice effectiveness will overlap in many instances and these nonpoint measures will result in load reductions that affect several sources. Load reduction predictions from other studies are presented in Table 3-1(Evan et al. 2003/2008). The Nonpoint Source Measures will be described and referenced to Best Management Practices (BMPs) as defined by the Natural Resources Conservation Service (NRCS), USDA; however, any related NRCS practices may be added to supplement these identified BMPs.

Table 3-1. Estimated BMP Reduction Efficiencies by Pollutant Type

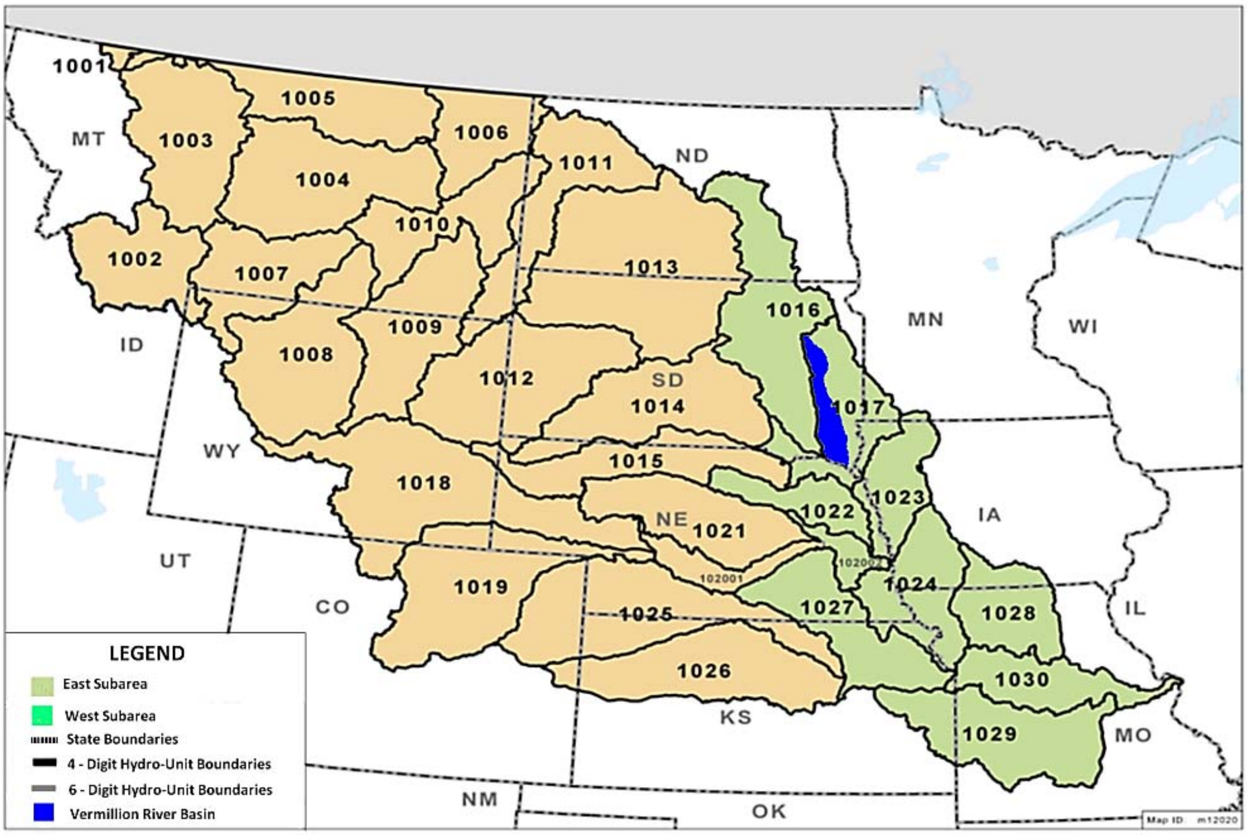
BMP SYSTEM/TYPE	NRCS PRACTICE	NITROGEN	PHOSPHOROUS	SEDIMENT	FECAL
Crop Residue Manage	329 & 345	50%	38%	64%	-
Vegetated Buffer	390	54%	52%	58%	70%
Grazing Land Manage	528	43%	34%	13%	-
Streambank Protect	580	65%	78%	76%	-
Nutrient Manage Plan	590	70%	28%	-	-
Grassed Waterways	428	54%	52%	58%	-
Constructed Ponds/Wetlands	378 & 657	88%	53%	51%	71%
Waste Storage Facility	313	75%	75%	-	75%

A thorough evaluation of the effects of conservation practices on cultivated cropland from 2003 to 2006 in the Missouri River Basin was completed by USDA-NRCS in 2012 via the Conservation Effects Assessment Project (CEAP). See Figure 3-1 for the watersheds covered in the study. The goals of CEAP were to estimate conservation benefits, to establish the scientific understanding of the effects and benefits of conservation practices at the watershed scale, and to provide research and assessment on how to best use conservation practices in managing agricultural landscapes to protect and enhance environmental quality. The studied subregion included in the Vermillion River Basin is the Missouri-Big Sioux-Lewis-Clark Lake (code 1017) with approximately 68.6 percent of its watershed in cultivated cropland and 21.6 in permanent grass.

The CEAP study used the computer model HUMUS/SWAT to evaluate conservation practices in use on cultivated cropland. The model estimated that conservation practices reduced sediment, nutrient, and atrazine loads delivered to rivers and streams from cultivated cropland sources per year, on average, by 54 percent for nitrogen, 60 percent for phosphorus, 76 percent for sediment, and 36 percent for atrazine.

A Field-Level Cropland Model called APEX, used to simulate the effects of conservation practices at the field level, showed that adoption of additional erosion control and nutrient management practices on the 15.3 million under-treated acres would further reduce field losses in the region by; 37 percent for sediment loss due to water erosion, 24 percent for nitrogen lost with surface runoff, 12 percent for nitrogen loss in subsurface flows, 20 percent for phosphorus lost to surface water (sediment-attached and soluble), and 22 percent for wind erosion.

Figure 3-1. Subregions Studied in the Missouri River Basin, CEAP, NRCS 2012



3.1 Animal Waste Management System. NRCS Practice Code 313, Waste Storage Facility

A Waste Storage Facility is part of an Animal Waste Management Systems (AWMS) and is designed for the full containment of animal wastes by the proper handling, storage, and utilization of wastes generated from animal confinement operations. The waste storage facility should reduce any discharge of animal wastes into the waters of the State. Therefore, the potential nutrient reduction in loading should be significant. Wastes would only be applied, through a Nutrient Management Plan (NMP), when growing crops can use the accompanying nutrients and soil and weather conditions are appropriate.

Over 2,000 Animal Feeding Operations (AFO) were identified in the 2010 Vermillion River Segment 2 Summary. Each of these will be evaluated and assigned a priority ranking, using the AGNPS Feedlot Rating Model. The AFOs with a rating above 50 will be subject to further evaluation and the higher rated ones may be targeted for the installation of an Animal Waste Management System (AWMS) to reduce fecal coliform impacts to the Vermillion River. During the Turkey Ridge Creek Assessment (DENR 2005) 129 AFOs were identified and 35% had an AGNPS rating of over 50. Similarly, the Lake Thompson Watershed Final Report (Strom 2008) identified 33% of the 84 AFO's in its watershed to have a rating of over 50. If this same percentage of priority operations holds true for the entire Vermillion River basin assessment, as many as 650 AFO's may rank over fifty and require an AWMS.

The Vermillion River and Lake Thompson projects constructed 18 AWMS's and had an average system nitrogen reduction of 12,806 pounds per year, a phosphorous reduction of 2,469 pounds per year, and a sediment reduction (Vermillion River only) of 267 tons per year. Other South Dakota studies identified below have found that AWMS's were very effective in eliminating nutrient loading as the source of the nutrients are contained in a closed system.

3.2 Nutrient Management System. NRCS Practice Code 590

A Nutrient Management Plan (NMP) is a required component of the AWMS. The purpose of an NMP is to utilize manure or organic byproducts as a plant nutrient source and minimize agricultural nonpoint source pollution of surface and ground water resources. A nutrient budget is developed for nitrogen, phosphorus, and potassium that considers all potential sources of nutrients including, but not limited to, animal manure and organic by-products, waste water, commercial fertilizer, crop residues, legume credits, and irrigation water. This should result in reduced nutrient loading from manure spread on fields as estimated in Table 3-1 of 70% for nitrogen and 28% for phosphorous.

The assessment of conservation practices for the entire Missouri River Basin (NRCS 2012) found the second highest percentage of cropped acres with manure applied for all subregions was the Missouri-Big Sioux-Lewis-Clark Lake (code 1017), as it had manure applied to 16 percent of its total cropland acres. The Vermillion River Basin Watershed Project (VRBWP) summary sheet reported that the high fecal coliform levels were associated with the land application of manure. This may include both excess application rates and not incorporating manure applied in areas subject to high runoff rates.

3.3 Prescribed Grazing – Riparian Areas. NRCS Practice Code 528

Prescribed Grazing may be applied on all lands where grazing and/or browsing animals are managed. Removal of herbage by the grazing animals will be in accordance with production limitations, plant sensitivities and management goals. Frequency of defoliations and season of grazing is based on the rate of growth and physiological condition of the plants. Duration and intensity of grazing is based on desired plant health and expected productivity of the forage species to meet management objectives. In all cases enough vegetation is left to prevent accelerated soil erosion. Proper grazing management would include practices such as (1) utilizing stocking rates to better manage grass height, (2) grazing riparian pastures timely when ground conditions are not conducive (wet) to excessive bank and shoreline damage, and (2) rotational use of pastures to allow periods of grass rest and recovery.

SDDENR watershed studies within the Vermillion River Basin that have identified livestock grazing as an additional source of nutrients, sediment, and fecal bacteria were the East Fork Vermillion River (SDDENR 2012), West Fork Vermillion River (SDDENR 2012), Vermilion River Watershed (SDDENR 2010), the Turkey Ridge Creek Watershed (SDDENR 2005), and Lake Thompson Watershed (Strom 2008).

The Turkey Ridge Creek (Ward 2010) reported load reductions of 3.52 pounds of nitrogen/acre/year, 0.91 pounds of phosphorous/acre/year, and 0.61 tons of soil/acre/year on 662 acres of grazing land management. The Lake Thompson study (Strom 2008) reported load reductions of 8.63 pounds of nitrogen/acre/year, 1.57 pounds of phosphorous/acre/year, and 0.93 tons of soil/acre/year on 1,337 acres of grazing land management. Rotational grazing and exclusion of livestock from critical riparian areas (steep slopes adjacent to the lake and stream) also provides benefits that are difficult to simulate in modeling.

The application of prescribed grazing basin wide would manipulate the intensity, frequency, duration, and season of grazing to: (1) improve water infiltration, (2) maintain or improve riparian and upland area vegetation, (3) protect stream banks from erosion, and (4) manage for deposition of fecal material away from water bodies. Management of livestock should include prescribed grazing, constructing fences or other barriers to control concentrated livestock access to riparian areas, livestock crossing structures, and alternative water supply. Other alternatives include seasonal access or rotational grazing to reduce the intensity and duration of access to riparian zones and uplands. Grazing along shorelines could be restricted by fencing the stream corridors off and keeping cattle out of the stream channel area. Since livestock may have direct contact with water bodies during hotter weather, grazing should be limited to cooler and less erosive periods of the year. Conservation Reserve Program (CRP) vegetative buffer strips could also be enrolled to protect streams and stream banks. Current CRP buffer practices allow up to 120 feet of perennial herbaceous vegetation to be protected from grazing adjacent to intermittent streams to benefit water quality. Other practices along riparian areas would be Stream Bank Restoration and Riparian Forest Buffers.

3.4 Residue & Tillage Management on Cropland. NRCS Practice Code 329

Residue and Tillage Management BMPs applies to all cropland and includes both no-till and tillage methods commonly referred to as mulch tillage; where the soil surface is disturbed by tillage operations. Mulch tillage includes vertical tillage, chiseling, disking, and also includes tillage/planting systems with relatively minimal soil disturbance. No Till or Strip Till applies to limiting the soil disturbing activities to only those necessary to place nutrients, condition residue, and plant crops. Surface residue is left evenly distributed and no full width tillage is implemented.

The NRCS CEAP study (2012) found some acres required additional conservation treatment on only one of the five resource concerns, while other acres required additional treatment for two or more resource concerns. The five resource concerns evaluated for the Missouri River Basin were; (1) sediment loss due to water erosion, (2) nitrogen loss with surface runoff (nitrogen attached to sediment and in solution), (3) nitrogen loss in subsurface flows, (4) phosphorus lost to surface water (phosphorus attached to sediment and in solution, including soluble phosphorus in subsurface lateral flow pathways), and (5) wind erosion.

After accounting for the acres that need treatment for multiple resource concerns, the evaluation of treatment needs for the Missouri River Basin determined the following:

- 1 percent of cropped acres (1.1 million acres) have a ‘High Level’ of need for additional conservation treatment,
- 17 percent of cropped acres (14.2 million acres) have a ‘Moderate Level’ of need for additional conservation treatment, and
- 82 percent of cropped acres (68.3 million acres) have a ‘Low Level’ of need for additional treatment and were considered to be adequately treated.

Land acres that required treatment for two or more resource concerns were considered ‘Under-Treated’; these acres were the high and moderate levels that needed additional conservation treatments. The Missouri-Big Sioux-Lewis/Clark Lake subregion (code 1017) had 5.2 percent of its subregion acres listed as under-treated. The delivery rates of nitrogen, phosphorous, and sediment per acre in this subregion was 6.52 lbs/ac/year, 0.38 lbs/ac/year, and 0.11 ton/ac/year, respectively. The Missouri River basin-wide averages were 5.82 N lbs/ac/year, 0.38 P lbs/ac/year, and 0.17 Sediment t/ac/year, respectively.

Eighty-two percent of the cropped acres in the Missouri River Basin that had a ‘low level’ of conservation treatment need were considered to be ‘adequately treated’. This is in part due to the relatively lower vulnerability potential for most cropped acres in this region as compared to other regions of the United States. Additional conservation treatment for these acres with a ‘low’ need for treatment is expected to provide small per-acre reductions in erosion and nutrient losses; requiring a large number of acres to be treated in order to have a significant impact at the subregional and regional levels. The emphasis in the NRCS-CEAP study was to identify and target the lands that needed Moderate and High Levels of conservation treatment needs and concentrate work efforts on these priority areas.

3.5 Streambank & Channel Stabilization. NRCS Practice Code 580

Stream bank stabilization is a treatment used to stabilize and protect banks of streams and shoreline of lakes or reservoirs. The purpose is to prevent the loss of land or damage to land use or facilities adjacent to the banks of streams or lakes. Stabilization efforts also reduce the offsite or downstream effects of sediment deposition resulting from bank erosion. The treatment of severely eroded banks usually involves back-sloping with heavy earth moving equipment to a stable grade. The area is then protected with a geotextile fabric and covered with stone rip-rap according USDA-NRCS standards. This practice is quite costly and is typically used as a last resort to stabilize a bank and protect valuable facilities adjacent to the bank.

The primary nonpoint sources of TSS (SDDENR 2011) for all three segments of the Vermillion River watershed include: (1) sheet and rill erosion from the agriculturally dominated landscape, and (2) bed and bank erosion from the various tributaries as well as the Vermillion River main stem. The results of the FLUX loadings estimated that over 40% of the total suspended solids load originates from bank erosion in the higher flow zones.

The suspected cause of bank failure was linked to livestock use of the riparian areas and the loss of riparian vegetation from cattle grazing. Properly functioning riparian areas can significantly reduce nonpoint source pollution by intercepting surface runoff, filtering and storing sediment and associated pollutants, and stabilizing banks. Stream bank stability is directly related to the species composition of the riparian vegetation and the distribution and density of these species (Sheffield 1997). Proposed BMPs to address riparian area degradation in this study included livestock use exclusion, stream bank stabilization and protection, and reseeding or manual planting of native plant species.

3.6 Grassed Waterways. NRCS Practice Code 412

Grassed waterways are shaped or graded channels that are established with suitable vegetation to carry surface water at a non-erosive velocity to a stable outlet. They are used to control gully erosion formed in fields where added water conveyance capacity and vegetative protection are needed to control erosion resulting from concentrated runoff. AnnAGNPS (Yuan et al. 2006) estimated that ephemeral gully erosion accounted for approximately 85% of the total landscape erosion in that watershed, while sheet and rill erosion amounted to the remaining 15%. The simulation of ephemeral gullies for delivery of sediments and associated nutrients is an important process captured in AnnAGNPS; which is not an element of many other watershed models and highlights the importance of grassed waterways and buffer strips in load reductions. The

PRediCT model, Evans et al. (2008), estimates a 54% reduction in nitrogen, a 52 % reduction in phosphorous, and a 58% reduction in sediment by installing grassed waterways.

Kringen, in the James River watershed (2010), reported nitrogen load reductions of 124.3 pounds/acre/year; phosphorous by 32.6 pounds/acres/year; and sediment by 16.7 tons/acre/year. Kringen's estimates will be used to determine load reductions for the Vermillion River because of similarity of drainage basins. Gullies are some of the more serious forms of erosion on slight to moderate slopes where contour farming and terraces are not practical. Grassed waterways need to be implemented basin wide in the identified critical cells in conjunction with conservation tillage and no-till.

3.7 Wetland Restoration, Pond Construction, Water & Sediment Control Basins, and Structures for Water Control. NRCS Practice Codes 657, 378, 638, 587, Respectively

Concave slopes, often occupied by wetlands, serve as sediment traps on the landscape and act as a filter for adjacent aquatic systems (NDSU 2006). Excessive deposition in wetland landscapes, where erosion has been accelerated substantially, has reduced the wetlands capabilities to store sediments. The problem of sedimentation is then passed downstream, eventually impacting aquatic systems such as lakes and streams. Wetlands have evolved to transform the soluble and adsorbed chemical load delivered in surface runoff into nontoxic forms that allow diverse biotic conditions to flourish. When wetlands are removed from the landscape, soluble and adsorbed chemicals are delivered directly to aquatic systems. Streams, rivers and lakes have not evolved the capacity to withstand increased chemical inputs, particularly at the rates delivered due to accelerated erosion. The result is hyper-eutrophic conditions and chemical toxicity that reduces the biotic diversity and value of aquatic water resources.

Nitrogen levels in Northern Prairie Pothole Region (NPPR) wetlands, lakes and tributaries have been observed to vary seasonally. Generally the highest concentrations of nitrites and nitrates are found during spring runoff from agricultural activities. These concentrations subside substantially by biological activity as temperatures increase later in the spring and summer. Total nitrogen concentrations in NPPR lakes are lowest in the fall, increase in the winter, remain the same or decrease in the spring, and increase in the summer. The periods of highest total nitrogen concentrations are the summer and winter. In the summer, the predominant form of nitrogen is organic due to flourishing populations of aquatic organisms. In the winter, the predominant form of nitrogen is ammonia. This is because decomposition of organic material only proceeds through the ammonification step of mineralization due to the reduced environment. By the end of winter, toxic levels of ammonia may become a water quality problem, particularly in smaller lakes.

Phosphorus is distinctly less mobile in the environment, compared with nitrogen. An important aspect of phosphorus control is related to the release of PO4 -3 from lake sediments, known as internal nutrient loading. Anoxic or low redox potentials in lake or wetland sediments will contribute to environmental conditions that maintain soluble PO4 -3 in the water at relatively high levels. The oxidation state of iron in iron oxides is reduced when the redox potential is lowered. Under these conditions PO4-3 is not readily adsorbed to iron oxide surfaces and is released to solution. Mineralization also continues to release PO4 -3 from organic matter. Therefore, aquatic systems that have accumulated a significant layer of eroded sediment likely will not see much reduction in PO4 -3 concentrations for extended periods after the implementation of management practices.

The Corsica Lake TMDL (2005) used AnnAGNPS management scenarios to simulate the removal of the 880 acres of impoundments 10 acres or larger in size (including small dams and wetland areas) throughout the watershed. Removal of these impoundments increased sediment loading by 8%, nitrogen by 1%, and phosphorus loading by 4%. While these reductions are fairly insignificant, it is important to note that the majority of these wetlands and impoundments were located upstream of the most critical areas in the watershed and that wetland restoration or small dam repair and maintenance downstream of critical areas may result in greater reductions than were represented in this simulation.

Load reductions for sediment and phosphorus were also documented in both restored wetlands with vegetated buffers and constructed ponds during the Little Minnesota River (Jensen 2007) project. Total sediment and phosphorous reductions on 51 multi-purposed ponds with 5,846 acres of watershed were reported as 91,579 tons and 174,000 lbs for their expected lifespan, respectively. For this reason, wetland restoration, pond construction, water and sediment control structures, and structures for water control will be part of the Vermillion River basins strategic plan. The purpose for these practices is to create multi-purpose ponds in the watershed to trap sediment, phosphorous, nitrogen, benefit wildlife, and serve as an alternative water source for grazing management systems.

3.8 Conversion of Cropland to Forage and Biomass Plantings. NRCS Practice Code 512

The ANNAGPS model (Yuan et al. 2006) estimated a suspended sediment loading reduction of 54% with a conversion of 10% of the highest eroding cropland to grassland. A 60% reduction was achieved for a combined management scenario involving conservation tillage, conversion of crop to grassland, and improved nutrient management. One scenario, which converted 25% of the highest eroding cropland in the watershed to grassland, reduced the sediment loads at the watershed outlet by 80 percent. Converting the highest eroding cropland cells to grassland was more efficient in sediment reductions than converting the highest eroding cropland cells from reduced tillage to no tillage practice (Yuan et al. 2006). The data clearly implies the importance of utilizing AGNPS programs that identifying critical cells throughout the Vermillion River basin and evaluating them before BMP’s are installed.

Kringen (2010) reported the savings of 4.01 pounds/acre/year of nitrogen, 1.23 pounds/acre/year of phosphorous, and 0.72 tons/acre/year of sediment converting cropland to grass through Conservation Reserve Programs (CRP). Kringen's estimates will be used to determine load reductions for the Vermillion River because of similarity of drainage basins. An alternative to conservation residue management within critical watershed cells would be the conversion of cropland to vegetative species suited to pasture, hayland, or biomass production. This would be a conversion without retiring the land from production completely, as with the Conservation Reserve Program. The benefits would be to reduce erosion and improve soil and water quality, while increasing forage production or energy production and improving livestock nutrition.

3.9 Conservation Crop Rotation and Conservation Cover Crops. NRCS Practice Codes 328 & 340

3.9.1 Conservation Crop Rotation (328)

A Conservation Crop Rotation that meets NRCS practice standards is the growing of crops in a planned sequence on the same field with at least one-third of the planned crop rotation, on a time basis, planted to annual crops. A planned crop rotation must consist of a minimum of two "crop types." Crop types in South Dakota are defined as follows; warm-season grasses (WSGs), examples; corn, sorghum, millet, warm season perennial grasses; cool-season grasses (CSGs), examples; winter and spring wheat, barley, oats, cool-season perennial grasses; warm-season broadleaf (WSB), examples; soybean, sunflower, dry beans, potatoes, alfalfa, and other warm season perennial broadleaf crop; and cool-season broadleaf (CSB), examples; field pea, flax, canola, mustard.

This practice consists of growing different crops in a planned rotation to manage nutrient and pesticide inputs, enhance soil quality, or reduce soil erosion. Including hay or a close grown crop in rotations with row crops can have a pronounced effect on long-term average field losses of sediment and nutrients, as well as enhancement of soil quality.

In the Missouri River Basin study (USDA 2012) crop rotations that meet NRCS criteria occurred on about 88 percent of the cropped acres. The Vermillion River Basin Watershed Project (VRBWP) would require an additional resource-conserving crop in the producer's rotation that reduces soil erosion, improves soil fertility and tilth, interrupts pest cycles, and reduces depletion of soil moisture or otherwise reduces the need for irrigation. A resource-conserving crop is one of the following; perennial grass; legume grown for use as forage, seed for planting, or green manure; legume-grass mixture; or a small grain grown in combination with a grass or legume green manure crop whether inter-seeded or planted in rotation.

Nutrient and sediment loading from cropland runoff has been identified in the Vermillion River Basin area as contributing to water quality degradation in the following SDDENR water quality reports; Turkey Ridge Creek 2005, Lake Thompson 2008, West Fork Vermillion 2012, East Fork Vermillion 2012, and Vermillion River 2011.

3.9.2 Conservation Cover Crop (340)

A conservation cover crop includes grasses, legumes, and forbs for seasonal cover that are planted on lands requiring vegetative cover for natural resource protection. A cover crop is also considered a crop in the rotation and does meet the standard for a Conservation Crop Rotation (328). Generally, the cover crop may be planted late in another crops growing season or soon after harvest for over wintering protection. A cover crop can provide multiple conservation benefits several being (1) to reduce erosion from wind and water, (2) to capture and recycle or redistribute nutrients in the soil profile thus preventing leaching, and (3) encourage the deposition of sediment to reduce sediment delivery to water bodies.

Studies (Hargrove 1991) have shown that cover crops are very effective at reducing soil erosion and the runoff from precipitation events. Conventional tillage on a soybean field had a soil loss of 3.34 tons/acre/year; the incorporation of a cover crop into the rotation reduced the soil loss to 0.75 tons/acre/year. Utilizing both a no-till system and a cover crop further reduced the soil erosion loss to 0.04 tons per acre. Soil loss reductions were more pronounced when a cover crop was used with conventional tillage systems. The winter cover crop treatment produced results similar to a meadow rotation treatment. Use of the cover crop reduced average annual runoff from 31% - 65% and accompanying soil losses from 42% - 92%. Conservation cover crop treatment use will provide both soil erosion benefits and the reduction of water runoff that carries the fertilizers and pesticides.

The two most important functions of cover crops (NRCS 2012) from a water quality perspective are (1) to provide soil surface cover and reduce soil erosion and (2) to utilize and convert excess nutrients remaining in the soil from the preceding crop into plant biomass, thereby reducing nutrient leaching and minimizing the amount of soluble nutrients in runoff during the non-crop growing season. In the Missouri River Basin, cover crops were not commonly used as a conservation practice, as less than one percent of the acres met the criteria for cover crop use in the basin.

3.10 Windbreak/Shelterbelt Establishment. NRCS Practice Code 380

The objectives of Windbreak/Shelterbelt Establishment are to reduce soil erosion from wind; provide shelter for structures, animals, and people; enhance wildlife habitat; improve air quality by reducing and intercepting air borne particulate matter, chemicals and odors; improve irrigation efficiency; increase carbon storage in biomass and soils; and reduce energy use.

During a comprehensive conservation planning process, the conservation resource needs of the land and producer are evaluated and addressed. The windbreak/shelterbelt practice also protects the land that is planted to trees and/or shrub species in that it requires the establishment of permanent woody vegetation with minimal use or only periodic management. Strom reported (2008) on converting 25.1 acres of cropland to trees in Kingsbury county that obtained load reductions on nitrogen of 9.2 lbs/ac/year; 3.17 lbs of phosphorous/ac/year; and 2.37 tons/ac/year of sediment.

3.11 Nutrient Management Plan - Cropland. NRCS Practice Code 590

This Nutrient Management Practice is intended for cropland acres where animal manures are not used on cropland fields. The use of animal manures may be impractical because of the distances involved in hauling manure to all crop fields, the lack of the quantities of manure needed to meet the needs of all fields, or the lack of livestock production, and thus the lack of available manure. Nutrient management utilizes farm practices that permit efficient crop production while controlling non-point source water pollutants. A nutrient management plan is a written, site-specific plan that addresses these issues. The plan must be tailored to specific soils and crop production systems. The goal of the plan is to minimize detrimental environmental effects, primarily on water quality, while optimizing farm profits. Nutrient losses will occur with the plan but will be controlled to an environmentally acceptable level. Nutrient management programs emphasize how proper planning and implementation will improve water quality and enhance farm profitability through reduced input costs. These plans incorporate soil test results, manure test results, yield goals and estimates of residual nitrogen (N) to generate field-by-field recommendations.

The efficient use of nutrients in agricultural production systems has important environmental implications. Crops are not efficient at removing fertilizer and manure nitrogen from the soil during the growing cycle. Unused or residual nitrogen is vulnerable to leaching prior to the start of the next cropping year especially during the fall and winter months if precipitation occurs when fields lay dormant. The potential exists for accelerated nutrient loss when essential nutrient amounts exceed crop uptake needs. Nutrient reactions and pathways in the soil-water system are complex. Nutrient flow to surface water and groundwater vary from nutrient to nutrient as do the threats to water quality. Potential surface water impacts include sedimentation, eutrophication, and overall water quality degradation. Evans et al. (2003/2008) estimated nutrient management plans efficiencies at 70% reduction for nitrogen and 28% reduction for phosphorous.

Although nutrient management practices were widely used on cropped acres in the Missouri river basin (NRCS 2012); few producers met the management criteria for application rate, timing of application, and method of application. Only 24 percent of the cropped acres met all three criteria for both nitrogen and phosphorous applications. The importance for the promotion of nutrient management plans on cropland is obvious and will be used as a BMP in the Vermillion River Basin Watershed Project.

3.12 Terraces - NRCS Practice Code 600

A terrace is an earth embankment, or a combination of a ridge and channel, constructed across the field slope usually on the contour. The terrace is generally applied as part of a resource management system to reduce erosion by reducing slope length, thus soil erosion, and retaining runoff for moisture conservation. The length of a hill's slope is reduced by constructing the terraces perpendicular to the slope. Both soil erosion and channel erosion are reduced further because the terraces force the field to be farmed on the contour between the terraces (Foster 1983). Although terraces are generally constructed on the contour, channel grades are sometimes increased to facilitate water storage for terraces with tile outlets in an effort to keep terraces parallel to each other to facilitate farming. Contouring farming alone is very effective in reducing soil erosion by approximately 50% (Czapar 2005), but it does have limits of application. Generally, as slope increases, the maximum slope length decreases, and when erosion is most severe, such as slopes exceeding 9%, much of the effectiveness of contouring is lost. Thus, terraces are needed for controlling slope length, managing water flow, and reducing soil erosion on the more erodible steeper and longer field slopes.

Terraces have a negligible effect on crop yields, but a major effect on sediment delivery (Czapar, etal. 2005). Estimated annual soil and nutrient losses under various erosion control practices in a Central Iowa climate, showed conventional tilled non-terraced soils with soil losses at 7.8 tons/acre/year compared to terracing with 2.3 tons/acre/year (averaged over ten soils, a 73 foot long slope of 9%, and a 300 foot long slope of 5%). Terraces in an Iowa corn/small grain rotation reduced soil loss from 7.6 kilogram/square-meter to 2.7 kilograms/square-meter (Foster 1983). Soil losses in these two examples were reduced 70.5% and 65.5%, respectively, by the installation of a terrace system.

Terraces may discharge their water through surface channels or by infiltration in a pond area through underground drain lines. Terraces that drain by surface channels are designed to have no erosion in the terrace channels. Terraces that drain through underground outlets are very effective at reducing sediment delivery of eroded material. It is estimated that about 95% of material eroded between terraces was deposited in pond areas around the underground intakes (Czapar, etal. 2005). However, terraces drained by tile outlets may deliver more nitrogen than fields that are not tiled. Total nitrogen yields in the Corn Belt region varied greatly, but were typically less than 10 lbs/acre/year in non-tiled drained watersheds and greater than 20 lbs/acre/year in tile-drained watersheds. Terraces may be used in the Vermillion River basin on steeper and longer field slopes when other BMP's do not bring soil losses down to acceptable levels or as needed to control rill and gully erosion.

3.13 Filter Strips - Non CRP

Areas adjacent to streams were evaluated in section 3.3 as riparian areas. Grassed filter strips can also be installed adjacent to other water bodies (wetland, ponds) or serve as filters for smaller animal waste facilities or tile outlets. A non CRP option would allow the haying or grazing of the filter strips without severe use restrictions and still provide resource protection. Haying would not impose much reduction in the conservation effects of grass cover, but grazing might and would need to be managed. Management of livestock may be needed allowing only seasonal access, rotational grazing, and/or time limitations, to reduce intensity and duration of grazing. Load reductions on grazed or hayed buffer strips were reported by Knippling (2012) at the rates of 4.83 lbs/acre of nitrogen, 1.35 lbs/acre of phosphorous, and 0.69 tons/acre for sediment. These lower rates will be used for the non-CRP filter strips.

3.14 Brush Management – NRCS Practice Code 314

One of the most striking land cover changes on rangelands worldwide over the past 150 years has been the proliferation of trees and shrubs at the expense of perennial grasses (Archer et al. 2011). Brush encroachment has long been considered one of the major management problems confronting managers of rangeland as a dense stand of brush usually minimizes grass cover (Welch 2000). The reduced grass cover results in increased soil erosion, inefficient use of rainfall with increased runoff, and loss of livestock production. Brush Management, NRCS conservation practice code 314, is the management or removal of invasive and noxious woody (nonherbaceous or succulent) plants to create the desired plant community consistent with the ecological site. The practice is designed to restore or release desired vegetative cover to protect soils, control erosion, reduce sediment, improve water quality, or enhance stream flow, and improve forage accessibility, quality, and quantity for livestock and wildlife. Brush includes woody half-shrubs, shrubs, and trees that invade areas on which they are not part of the natural plant community or that occur in amounts significantly in excess of that natural to the site.

A study by Zhang et al. (2012) found that dramatic increases in runoff and soil loss were attributed to the increase in the frequency and intensity of extreme events for plant communities in three scenarios, since there was no significant increase in mean annual precipitation. The projected mean annual runoff and soil loss approximately doubled and predicted erosion from shrub communities increased more than for other plant communities under the three scenarios. Greater increases of soil loss indicated that soil erosion was more sensitive to changes in storm patterns than runoff. A predicted future of increasing runoff and soil erosion appeared to accelerate the transitions of grassland to shrub lands or to more eroded states than what already had been occurring on the study area over the past century. The prediction of more soil erosion on shrub lands in the future (Westoby et al. 1989) could mean significant shifts from shrubs to the eroded state. This may imply that it may be difficult to restore historical plant communities over time frames relevant to ecosystem management. The option of woody plant control and removal through brush management is a technique that could be considered to reduce soil erosion on rangelands.

Brush management in the project area generally applies to the following species: Eastern Red cedar (*Juniperus virginiana*) and Rocky Mountain juniper (*Juniperus scopulorum*). It is designed to achieve the desired plant community based on species composition, structure, density, and canopy (or foliar) cover or height. Brush management is applied in a manner to achieve the desired control of the target woody species and protection of desired species. This can be accomplished by mechanical, chemical, or biological methods either alone or in combination. However, this practice should be completed in conjunction with a planned prescribed grazing management system, NRCS practice code 528.

4. LOAD REDUCTIONS

4.1 Animal Waste Storage Facilities

The Vermillion River Basin Watershed Assessment (2008) identified over 2,000 animal feeding operations. Based on the percentages of AFO's analyzed by AnnAGNPS in other studies, as many as 650 feedlots may be determined to be priority operations requiring the construction of an animal waste management system. Since that assessment, approximately 19 feedlots have had Animal Waste Storage Facilities (AWSF) constructed under implementation projects. The average estimated Animal Units (AU) per AWSF was 864, with a yearly construction rate of 5 AWSF's per year. At this construction rate it will take additional years to complete the needed AWSF's. Load reductions used were those calculated from AWMS's installed in the Vermillion River watershed that averaged reductions of 9,618 pounds of nitrogen and 2,122 pounds of phosphorous per system. Refer to Table 4-1 for projected load reductions and yearly applications.

Table 4-1. Estimated N, P, and Sediment Load Reductions Per AWSF System

Estimated Nitrogen (N), Phosphorous (P), Sediment (Sed) Load Reductions (LR) Associated with Animal Waste Storage Facilities (AWSF) (# = Pounds, T = Tons)						
Year	No. Goal	% Goal	N #/System	Total N #/Syst	P #/System	Total P #/Syst
1	5	0.8	15,810	79,050	3,489	17,445
2	5	0.8	15,810	79,050	3,489	17,445
3	5	0.8	15,810	79,050	3,489	17,445
4	5	0.8	15,810	79,050	3,489	17,445
5	5	0.8	15,810	79,050	3,489	17,445
Subtotal	25	4.0		395,250		87,225
6-10	25	4.0	15,810	395,250	3,489	87,225
11-15	25	4.0	15,810	395,250	3,489	87,225
15-Plus	575	88.0	15,810	9,090,750	3,489	2,006,175
Total	650	100.0		10,276,500		2,267,850

Nutrient reduction estimates from STEPL: Spreadsheet Tool for the Estimation of Pollutant Load. Vermillion River

4.2 Nutrient Management System Load Reductions for Animal Wastes

The NMPs for animal wastes are designed to manage the manure from the Animal Waste Storage Facilities. The NMPs need approximately one acre of land per animal unit to safely spread the manure over time. The manure is spread on approximately 10 percent of these acres annually to meet crop nutrient needs. An average of five facilities constructed each year with 864 animal units each would require approximately 4,320 acres in the NMPs; however, only about 432 acres (10%) would receive the manure each year. Load reductions used will be those of Kringen (2010), in the James River watershed, where he calculated 9.8 pounds of nitrogen/acre/year and 0.6 pounds of phosphorous/acre/year for an applied NMP. See Table 4-2 for the estimated nitrogen and phosphorous load reductions associated with NMPs.

Table 4-2. Estimated N and P Load Reductions by NMP System

Estimated Nitrogen (N) and Phosphorous (P) Load Reductions (LR) for Nutrient Management Plans Associated with Animal Waste Storage Facilities (AWSF)						
Year	# Goal	% Goal	N #/YR	Total N #/YR	P #/YR	Total P #/YR
1	5	0.8	4,234	21,170	259	1,295
2	5	0.8	4,234	21,170	259	1,295
3	5	0.8	4,234	21,170	259	1,295
4	5	0.8	4,234	21,170	259	1,295
5	5	0.8	4,234	21,170	259	1,295
Subtotal	25	4.0		105,850		6,475
6-10	25	4.0	4,234	105,850	259	6,475
11-15	25	4.0	4,234	105,850	259	6,475
15-Plus	575	88.0	4,234	2,434,550	259	148,925
Total	650	100.0		2,752,100		168,350

Nutrient reduction estimates from STEPL: Spreadsheet Tool for the Estimation of Pollutant Load. Kringen 2010

4.3 Prescribed Grazing Systems

4.3.1 Upland Prescribed Grazing Systems

The field offices in the Vermillion River basin were contacted for the number of acres of grazing lands that need a grazing management system for each county. The estimated need was for 70,000 acres of prescribed grazing systems to be planned and implemented. The estimated yearly average implementation rate was 5,500 acres per year. At the end of this five year Strategic Plan only 27,500 acres (29.5%) would be implemented. Additional years of planning to meet the projected grazing plan goals would be needed. Load reductions are presented in Table 4-3-1 using nitrogen load reduction estimates as documented in the Vermillion River watershed of 1.64 pounds of nitrogen/acre/year, 0.78 pounds of phosphorous/acre/year, and 1.00 ton of sediment/acre/year. Prescribed grazing systems are figured on 300 acres per system, with a rural water hook-up, two tanks, water pipeline footage of 2,000 feet, and 5,000 feet of fencing per system.

Table 4-3-1. Estimated N, P, and Sediment Load Reductions for Prescribed Grazing on Pasture and Rangeland in the Vermillion Watershed

Estimated Nitrogen (N), Phosphorous (P), and Sediment (Sed) Load Reductions (LR) for Prescribed Grazing								
Year	Acres	% Goal	N #/Ac/Yr	Total #N/Yr	P #/Ac/Yr	Total #P/Yr	Sed T/Ac/Yr	Total T/Yr
1	5,500	5.9	2.88	15,840	1.31	7,205	1.55	8,525.0
2	5,500	5.9	2.88	15,840	1.31	7,205	1.55	8,525.0
3	5,500	5.9	2.88	15,840	1.31	7,205	1.55	8,525.0
4	5,500	5.9	2.88	15,840	1.31	7,205	1.55	8,525.0
5	5,500	5.9	2.88	15,840	1.31	7,205	1.55	8,525.0
Subtotal	27,500	29.5		79,200		36,025		42,625.0
6-10	27,500	29.5	2.88	79,200	1.31	36,025	1.55	42,625.0
11-Plus	37,500	41.0	2.88	108,000	1.31	49,125	1.55	58,125.0
TOTAL	92,500	100.0		266,400		121,175		143,375.0

Nutrient and Sediment reduction estimates from STEPL: Spreadsheet Tool for the Estimation of Pollutant Load. Vermillion River

4.3.2 Riparian Area Grazing Management

Riparian area grazing management systems were estimated to be needed on 9,265 acres throughout the Vermillion Basin by field offices to reduce nutrient and sediment transport to water bodies. At a rate of 60 acres per year implementation, additional years would be needed to resolve resource problems which would require additional years to achieve. Load reductions were calculated from filter strips installed in the Vermillion River Basin project. A grazing management plan can be as simple as fencing off the riparian zones to schedule grazing periods during cooler and less erosive periods. The Continuous CRP can also be used to provide landowners an incentive to establish buffer strips along streams to improve the water quality. This program will assist landowners with exclusion of livestock from the riparian areas through planning and installation of grazing systems that utilize 10-15 year land use agreements**.** Table 4-3-2 presents the load reductions for nitrogen, phosphorous, and sediment for riparian management in the Vermillion River basin during the first five years of the Strategic Plan. Load reductions were obtained from the calculations of riparian area grazing BMP's in the Vermillion River project.

Table 4-3-2. Riparian Area Management Program and Conservation Reserve Program Load Reductions

Riparian Area Management Load Reductions of Nitrogen, Phosphorous, and Sediment								
Year	Acres Planned	% Goal	N Reduction Lbs/Ac	Total N Reduction Lbs/Year	P Reduction Lbs/Ac	Total P Reduction Lbs/Year	Sediment Reduction Tons/Ac	Total Sediment Tons/Year
1	60	0.7	4.88	292.8	1.56	93.6	1.08	64.8
2	60	0.7	4.88	292.8	1.56	93.6	1.08	64.8
3	60	0.7	4.88	292.8	1.56	93.6	1.08	64.8
4	60	0.7	4.88	292.8	1.56	93.6	1.08	64.8
5	60	0.7	4.88	292.8	1.56	93.6	1.08	64.8
Subtotal	300	3.5		1,464.0		468.0		324.0
6-10	300	3.5	4.88	1,464.0	1.56	468.0	1.08	324.0
11 Plus	8,665	93.0	4.88	42,285.2	1.56	13,517.4	1.08	9,358.2
TOTAL	9,265	100.0		45,213.2		14,453.4		10,006.2

Nutrient and Sediment reduction estimates from STEPL: Spreadsheet Tool for the Estimation of Pollutant Load. Vermillion River

4.4 Residue & Tillage Management on Cropland

Field Offices estimated 535,000 acres of conservation tillage would be needed to solve resource concerns. At the rate of 25,500 acres per year, additional years would be necessary to achieve this targeted goal. The sediment, nitrogen, and phosphorous load delivery rates vary per watershed depending on soil erodibility, tillage practices, rotations, steepness of the slope, and slope length. The Vermillion River projects reported a load reduction using conservation tillage on cropland of 4.34 pounds of nitrogen, 1.30 pounds of phosphorus, and 0.90 tons of soil saved per acre. These load reduction values are presented in Table 4-4.

Table 4-4. Estimated Nitrogen, Phosphorous, and Sediment Load Reductions for Cropland Conservation Tillage on Cropland Acres

Estimated Nitrogen (N), Phosphorous (P), and Sediment (S) Load Reductions (LR) for Cropland Conservation Tillage								
Year	Acres	% Goal	N #/Ac/Yr	Total #/Yr	P #/Ac/Yr	Total #/Yr	Sed T/Ac/Yr	Total T/Yr
1	25,500	4.8	3.49	88,995	0.98	24,990	0.64	16,320.0
2	25,500	4.8	3.49	88,995	0.98	24,990	0.64	16,320.0
3	25,500	4.8	3.49	88,995	0.98	24,990	0.64	16,320.0
4	25,500	4.8	3.49	88,995	0.98	24,990	0.64	16,320.0
5	25,500	4.8	3.49	88,995	0.98	24,990	0.64	16,320.0
Subtotal	127,500	24.0		444,975		124,950		81,600.0
6-10	127,500	24.0	3.49	444,975	0.98	124,950	0.64	81,600.0
11-15	127,500	24.0	3.49	444,975	0.98	124,950	0.64	81,600.0
16-20	127,500	24.0	3.49	444,975	0.98	124,950	0.64	81,600.0
21-25	25,000	4.0	3.49	87,250	0.98	24,500	0.64	16,000.0
TOTAL	535,000	100.0		1,867,150		524,300		342,400.0

Nutrient and Sediment reduction estimates from STEPL: Spreadsheet Tool for the Estimation of Pollutant Load. Vermillion River

4.5 Streambank Stabilization

The planned stream bank stabilization footages needed in the Vermillion River watershed were estimated by field office staff as 234,000 linear feet (LF). Stream bank stabilizations would be a new practice and an estimate of 1,000 LF installed per year would be made. This would require additional years to achieve. Table 4-5 presents load reductions for nitrogen as calculated using STEPL from stream bank restoration installed along the Big Sioux River (Strom 2010).

Table 4-5. Stream Bank Stabilization Load Reductions by Linear Feet

Stream Bank Stabilization and Load Reductions								
Year	Linear Feet (LF)	% Total	N Reduction	Total N Reduction	P Reduction	Total P Reduction	Sediment Reduction	Total Sediment
	Planned	Goal	Lbs/LF	Lbs	Lbs/LF	Lbs	Tons/LF	Tons
1	1,000	0.04	2.60	2,600	1.0	1,000	1.83	1,830
2	1,000	0.04	2.60	2,600	1.0	1,000	1.83	1,830
3	1,000	0.04	2.60	2,600	1.0	1,000	1.83	1,830
4	1,000	0.04	2.60	2,600	1.0	1,000	1.83	1,830
5	1,000	0.04	2.60	2,600	1.0	1,000	1.83	1,830
Subtotal	5,000	2.0	2.60	13,000	1.0	5,000	1.83	9,150
6-10	5,000	2.0	2.60	13,000	1.0	5,000	1.83	9,150
11 Plus	224,000	96.0	2.60	582,400	1.0	224,000	1.83	409,920
TOTAL	234,000	100.0		608,400		234,000		428,220

Nitrogen, Phosphorous, and Sediment Load Reduction estimates from STEPL: Strom 2010

4.6 Grassed Waterways

The constructed linear feet (LF) of grassed waterways estimated by field offices for full treatment of gullies is 253,000 feet. At 13,500 LF per year 67,500 LF will be completed in the five years of the Strategic Plan; which is 26.5% of the needed estimate. More years will be needed to complete the necessary linear feet of grassed waterways to control gully erosion. Nitrogen, phosphorous, and sediment load reduction estimates used were the waterway calculations used by Kringen (2010) for the James River basin as no data was available for he Vermillion River. This data is presented in Table 4-6.

Table 4-6. Grassed Waterway Load Reductions for N, P, and Sediment

Grassed Waterway Load Reductions for Nitrogen, Phosphorous, Sediment								
	Linear Feet		N	Total N	P	Total P	Sediment	Total
Year	(LF)	% Goal	Reduction	Reduction	Reduction	Reduction	Reduction	Sediment
	Planned		Lbs/LF	Lbs/Year	Lbs/LF	Lbs/Year	Tons/LF	Tons/Year
1	13,500	5.3	0.16	2,160	0.04	540	0.02	270
2	13,500	5.3	0.16	2,160	0.04	540	0.02	270
3	13,500	5.3	0.16	2,160	0.04	540	0.02	270
4	13,500	5.3	0.16	2,160	0.04	540	0.02	270
5	13,500	5.3	0.16	2,160	0.04	540	0.02	270
Subtotal	67,500	26.5		10,800		2,700		1,350
6-10	67,500	26.5	0.16	10,800	0.04	2,700	0.02	1,350
11-15	67,500	26.5	0.16	10,800	0.04	2,700	0.02	1,350
16-20	50,500	20.5	0.16	8,080	0.04	2,020	0.02	1,010
Total	253,000	100.0		40,480		10,120		5,060

N, P, and Sediment reduction estimates from STEPL: Spreadsheet Tool for the Estimation of Pollutant Load . Kringen 2010

4.7 Wetland Restoration, Pond, and Basin Construction

Planned restoration numbers of wetlands, pond construction, and water and sediment control basin numbers were estimated by field office personnel to be 1,030 to meet estimated load reductions. An average of thirty-nine basins are restored or constructed each year. At the end of the Strategic Plan, approximately 19% of the basin construction estimates will be completed. More years will be needed to meet the estimates of the FO personnel. See Table 4-7.

Water and sediment control basins are typically an 'open basin' and are drained with a tile outlet to control the water flow. This is unlike the closed systems of a wetland restoration or pond load reductions. However, the water and sediment basins should result in similar control of the sediment delivery and sediment attached phosphorous. The average size of the restored wetlands in the Vermillion River basin was 8.3 acres. Calculated load reductions in the Vermillion basin for wetland restorations were 4.06 lbs/ac/year of nitrogen, 1.29 lbs/ac/year of phosphorous, and 0.86 ton/ac/year for sediment per restored wetland.

Table 4-7. Wetland Restoration, Pond, Basin Construction Load Reductions

Wetland Restoration and Pond Construction Load Reductions									
Year	No. Ponds Wetlands Planned	% Goal	Wetland Acres Restored	N Reduction Lbs/Wet Ac Year	Total Lbs N Reduction Year	P Reduction Lbs/Wet Ac Year	Total Lbs P Reduction Year	Sed Reduct Tons/ Wet Ac Year	Total Tons Sed/Reduct Year
1	39	3.8	325	4.06	1,319	1.30	422.33	0.86	279.39
2	39	3.8	325	4.06	1,319	1.30	422.33	0.86	279.39
3	39	3.8	325	4.06	1,319	1.30	422.33	0.86	279.39
4	39	3.8	325	4.06	1,319	1.30	422.33	0.86	279.39
5	39	3.8	325	4.06	1,319	1.30	422.33	0.86	279.39
Subtotal	195	19.0	1,624		6,594.86		2,111.66		1,396.94
6-10	195	19.0	1,624	4.06	6,594.86	1.30	2,111.66	0.86	1,396.94
11-15	195	19.0	1,624	4.06	6,594.86	1.30	2,111.66	0.86	1,396.94
16-30	445	43.0	3,707	4.06	15,049.81	1.30	4,818.91	0.86	3,187.89
Total	1,030	100.0	8,579.9		34,834.39		11,153.87		7,378.71

Nutrient and Sediment reduction estimates from STEPL: Spreadsheet Tool for the Estimation of Pollutant Load. Vermillion River

4.8 Conversion of Cropland to Forage and Biomass Plantings

The conversion of the highest eroding cropland to vegetative species suited to pasture, hayland, or biomass production was estimated by field office staff to be 61,990 acres for the Vermillion River watershed. Six hundred and forty-five acres were estimated to be completed each year. At the end of the five year plan only 5% of this estimate would be completed requiring additional years to meet the goal. The calculated load reductions of nitrogen, phosphorous and sediment were those reported in the Vermillion River basin. Nitrogen load reductions were 3.31 pounds/acre, and phosphorous reductions were 1.09 pounds/acres, and Sediment load reductions were 0.75 tons/acre. This data is presented in Table 4-8.

Table 4-8. Estimated N, P, and Sediment Load Reductions for Cropland Conversion to Perennial Vegetation

Estimated Nitrogen (N), Phosphorous (P), and Sediment (Sed) Load Reductions (LR) for Cropland Conversion to Perennial Vegetation								
Year	Acres	% Goal	N #/Ac/Yr	Total #N/Yr	P #/Ac/Yr	Total #P/Yr	Sed T/Ac/Yr	Total T/Yr
1	645	1.0	5.38	3,470	1.77	1,142	1.23	793.35
2	645	1.0	5.38	3,470	1.77	1,142	1.23	793.35
3	645	1.0	5.38	3,470	1.77	1,142	1.23	793.35
4	645	1.0	5.38	3,470	1.77	1,142	1.23	793.35
5	645	1.0	5.38	3,470	1.77	1,142	1.23	793.35
Subtotal	3,225	5.0		17,351		5,708		3,966.75
6-10	3,225	5.0	5.38	17,351	1.77	5,708	1.23	3,966.75
11-Plus	55,440	90.0	5.38	298,267	1.77	98,129	1.23	68,191.20
Total	61,890	100.0		332,968		109,545		76,124.70

Nutrient and Sediment reduction estimates from STEPL: Spreadsheet Tool for the Estimation of Pollutant Load. Vermillion River

4.9 Conservation Crop Rotation and Conservation Cover Crop on Cropland Acres

The need of Conservation Crop Rotations and/or Cover Crops on cropland acres was estimated by field office staff to be 700,000 acres for the Vermilion River basin; at 40,000 acres installed each year, this goal will only be achieved through additional project implementation years. The effectiveness in using cover crops to reduce soil erosion and rainfall runoff was demonstrated by Hargrove (1991). However, the sediment and nutrient delivery on cropland acres has not been analyzed in the Vermillion River basin. The watershed study of Clear Lake (SDDENR 1999) reported the sediment transport and deliverability throughout the watershed indicated that for an average year, approximately 3,084 tons (0.121 tons/acre) of sediment enter the lake. The AGNPs data indicated that the Clear Lake sub watersheds had a total nitrogen (soluble+sediment bound) deliverability rate of 22.1 lbs./acre/yr., and a total phosphorus (soluble+sediment bound) deliverability rate of 5.2 lbs./acre/yr. to the lake. The results also indicated that runoff from fertilized cropland was a significant source of water soluble nutrients to Clear Lake.

Hargrove (1991) found the use of cover crops reduced average annual runoff from 31% - 65%. Applying his data to the Clear Lake study; nitrogen and phosphorous could be reduced conservatively by 31%. Applying this estimate to the Clear Lake data; 22.1 lbs. nitrogen/acre/year could be reduced by 31% or 6.85 lbs./ac/year and 5.2 lbs. of phosphorous/acre/year could be reduced by 31% or 1.6 lb./ac/year.

The analysis of the sediment transport and deliverability throughout the watershed to Clear Lake indicated that for an average year, approximately 3,084 tons (0.121 tons/acre) of sediment entered the lake. Hargrove's report found soil losses to be reduced from 42% - 92%; again a conservative application to the Clear Lake study would be a 42% reduction in soil loss and resultant 42% in sediment load delivery. The load reduction is estimated at 0.121 tons/acre/year multiplied by 42% reduction equals a load reduction of 0.05 ton/acre/year. These load reductions from the use of a cover crop are applied in Table 4-9. The winter cover crop treatment produced results similar to a meadow rotation treatment (Hargrove 1991); therefore the load reductions reported in Table 4-9 may be higher if a crop rotation that incorporates meadow or hayland is included.

Table 4-9. Estimated Nitrogen (N), Phosphorous (P), and Sediment (S) Load Reductions (LR) for Crop Rotations and Cover Crops on Cropland

Estimated Nitrogen (N), Phosphorous (P), and Sediment (S) Load Reductions (LR) for Conservation Crop Rotation and Cover Crops on Cropland								
Year	Acres	% Goal	N #/Ac/Yr	Total #/YR	P #/Ac/YR	Total #YR	Sed T/Ac/YR	Total T/YR
1	40,000	5.7	6.85	274,000	1.61	64,400	0.05	2,000
2	40,000	5.7	6.85	274,000	1.61	64,400	0.05	2,000
3	40,000	5.7	6.85	274,000	1.61	64,400	0.05	2,000
4	40,000	5.7	6.85	274,000	1.61	64,400	0.05	2,000
5	40,000	5.7	6.85	274,000	1.61	64,400	0.05	2,000
Subtotal	200,000	28.5		1,370,000		322,000		10,000
6-10	200,000	28.5	6.85	1,370,000	1.61	322,000	0.05	10,000
11- Plus	300,000	43.0	6.85	2,055,000	1.61	483,000	0.05	15,000
Totals	700,000	100.0		4,795,000		1,127,000		35,000

Projected Estimates from Hargrove 1991 and TMDL Clear Lake AGNPS SDDENR 1999

4.10 Windbreak/Shelterbelt Establishment

Windbreak or Shelterbelt Establishment typically consists of trees and/or shrub plantings designed to solve a conservation resource concern. Field offices estimated the need for 2,265 acres of trees to address resource concerns in the VRWBP. At the rate of 168 acres annually, only 37% of this goal will be reached in five years. Strom (2008) reported load reductions gained by converting cropland to trees within the Lake Thompson watershed averaged a nitrogen load reduction at 9.20 pounds/acre/year, phosphorus at 3.17 pounds/acre/year, and sediment at 2.37 tons/acre/year. Estimated load reductions are presented in Table 4-10.

Table 4-10. Nitrogen, Phosphorous, and Sediment Load Reductions on Tree Plantings

Estimated Nitrogen (N), Phosphorous (P), and Sediment (Sed) Load Reductions (LR) for Cropland Conversion to Tree Plantings								
Year	Acres	% Goal	N #/Ac/Yr	Total #N/Yr	P #/Ac/Yr	Total #P/Yr	Sed T/Ac/Yr	Total T/Yr
1	168	7.4	3.65	613.2	2.52	423.36	0.87	146.16
2	168	7.4	3.65	613.2	2.52	423.36	0.87	146.16
3	168	7.4	3.65	613.2	2.52	423.36	0.87	146.16
4	168	7.4	3.65	613.2	2.52	423.36	0.87	146.16
5	168	7.4	3.65	613.2	2.52	423.36	0.87	146.16
Subtotal	840	37.0		3,066.0		2,116.80		730.80
6-10	840	37.0	3.65	3,066.0	2.52	2,116.80	0.87	730.80
11-15	585	26.0	3.65	2,135.3	2.52	1,474.20	0.87	508.95
TOTAL	2,265	100.0		8,267.3		5,707.80		1,970.55

Nutrient and Sediment load reduction estimates from STEPL: Spreadsheet Tool for the Estimation of Pollutant Load v. 4.0. Strom 2008

4.11 Nutrient Management Plan - Cropland

This nutrient management practice is intended for cropland acres where animal manures are not used on cropland fields and the fields are fertilized with commercial fertilizers. The field offices estimated a total need of 660,000 acres of nutrient management plans on cropland where manure is not applied in the VRBWP. With approximately 9,750 NMP acres targeted annually, it will require additional years of project implementation to meet their goal. A nutrient management plan (NMP) will be developed for nitrogen, phosphorus, and potassium that considers all potential sources of nutrients including commercial fertilizer, crop residues, and legume credits. The NMP would also require that NRCS practice standards be met for Conservation Tillage. Load reductions for NMPs were computed from the remaining load deliveries after the implementation of conservation tillage, calculated with STEPL, and multiplied by Evans (2003/2008) estimated load reduction percentages of nitrogen (70%) and phosphorus (28%). These estimated load reductions attributed solely to the NMP are presented in Table 4-11.

Table 4-11. Nitrogen and Phosphorous Load Reductions on Nutrient Management Plans on Non-Manure Applied Cropland

Estimated Nitrogen (N) and Phosphorous (P) Load Reductions (LR) for Nutrient Management Plans Associated Non-Manured Cropland						
Year	Acres	% Goal	N #/AC/YR	Total N #/YR	P #/YR/AC	Total P #/YR
1	9,750	1.5	1.04	10,140	0.10	975
2	9,750	1.5	1.04	10,140	0.10	975
3	9,750	1.5	1.04	10,140	0.10	975
4	9,750	1.5	1.04	10,140	0.10	975
5	9,750	1.5	1.04	10,140	0.10	975
Subtotal	48,750	7.5		50,700		4,875
6-10	48,750	7.5	1.04	50,700	0.10	4,875
11-Plus	562,500	85.0	1.04	585,000	0.10	56,250
Total	660,000	100.0		686,400		66,000

Nutrient reduction estimates from STEPL Vermillion River and Evans Estimate % of Load Reductions

4.12 Terraces

Erosion concerns on cropland can be addressed with tillage and crop rotations, however, terraces may be needed on steeper slopes. Field Offices estimated a need of 102,000 LF of terrace construction to address these steeper slopes in the VRBWP; completing 3,200 LF per year would require additional years to complete their goal. Soil loss calculations projected before and after terrace construction were based on average soil losses computed in the VRBWP. The average soil loss of steeper field slopes that would need terracing was estimated at 9.0 tons/acre/year without terraces as compared to 2.0 tons/acre/year after terraces application.

The soil load reductions were more easily calculated using soil erosion estimators. However, calculating load reductions of nitrogen and phosphorous is more complicated. The dominant path for nitrate loss is leaching and nitrate concentrations in runoff are usually low compared to subsurface (tile) drainage waters. The impacts of increased losses of dissolved phosphorus and decreased losses of particulate phosphorus due to the widespread adoption of conservation tillage systems make estimates less certain. In some settings, dissolved inorganic phosphorus is likely to be more biologically available than sediment bound phosphorus. In other settings, dissolved phosphorus may become sediment bound and relatively unavailable. Sediment bound phosphorus can also become released in anaerobic environments, and thus become more biologically available for phytoplankton. Load reductions for nitrogen and phosphorous were based on load reductions losses with associated soil. Czapar reported loss reductions of nitrogen from 32.8 lbs/acre/year to 7.4 lbs/acre/year, a savings of 25.4 lbs/acre/year (77.4%) and phosphorous from 12.7 lbs/acre/year to 2.9 lbs/acre/year, a savings of 9.8 lbs/acre/year (77.2%). These load reductions using a 77% load reduction for both nitrogen and phosphorous are presented in Table 4-12. The acres of cropland protected are on-site field conditions and based on terrace length times an estimated 180 feet of protected cropping area.

Table 4-12. Terrace Load Reductions for N, P, and Sediment

Terrace Load Reductions for Nitrogen, Phosphorous, and Sediment									
Year	Linear Feet Planned	Acres Protected	% Goal	N Reduction Lbs/Acre	Total N Reduction Lbs/Year	P Reduction Lbs/Acre	Total P Reduction Lbs/Year	Sediment Reduction Tons/Acre	Total Sediment Tons/Year
1	3,200	13.0	3.1	25.4	330.2	9.8	127.4	5.0	65.0
2	3,200	13.0	3.1	25.4	330.2	9.8	127.4	5.0	65.0
3	3,200	13.0	3.1	25.4	330.2	9.8	127.4	5.0	65.0
4	3,200	13.0	3.1	25.4	330.2	9.8	127.4	5.0	65.0
5	3,200	13.0	3.1	25.4	330.2	9.8	127.4	5.0	65.0
Subtotal	16,000	65.0	15.5		1,651.0		637.0		325.0
6-10	16,000	65.0	15.5	25.4	1,651.0	9.8	637.0	5.0	325.0
11-Plus	70,000	287.0	69.0	25.4	7,289.8	9.8	2,812.6	5.0	1,435.0
Total	102,000	417.0	100.0		10,591.8		4,086.6		2,085.0

4.13 Filter Strips - Non-CRP

The need for Non-CRP filter strips was estimated by Field Offices to be 26,450 acres within the VBWP. Installing 150 acres annually would require additional years to meet the estimated goal. It is unknown whether the non-CRP filter strips will be harvested for hay or grazed, therefore the load reduction calculations will be based on the more severe land use of grazing. The load reduction for nitrogen, phosphorous, and sediment for grassed filter strips were calculated from

2,841 acres of rotational grazing installed as reported in the VRBWP. The load reduction estimates are presented in Table 4-13.

Table 4-13. N, P, and Sediment Load Reduction of Non-CRP Filter Strips

Estimated Nitrogen (N), Phosphorous (P), and Sediment (S) Load Reductions (LR) for Non CRP Filter Strips								
Year	Acres	% Goal	N #/Ac/Yr	Total #N/Yr	P #/Ac/Yr	Total #P/Yr	Sed T/Ac/Yr	Total T/Yr
1	150	0.6	2.88	432	1.31	197	1.55	233
2	150	0.6	2.88	432	1.31	197	1.55	233
3	150	0.6	2.88	432	1.31	197	1.55	233
4	150	0.6	2.88	432	1.31	197	1.55	233
5	150	0.6	2.88	432	1.31	197	1.55	233
SubTotal	750	3.0		2,160		983		1,163
6-10	750	3.0	2.88	2,160	1.31	983	1.55	1,163
11-Plus	24,950	94.0	2.88	71,856	1.31	32,685	1.55	38,673
TOTAL	26,450	100.0		76,176		34,650		40,998

Nutrient and Sediment reduction estimates from STEPL: Spreadsheet Tool for the Estimation of Pollutant Load. Vermillion River

4.14 Brush Management

Zhang et al. (2012) evaluated the climate change impacts on soil erosion and surface runoff in southeastern Arizona with the Rangeland Hydrology and Erosion Model (RHEM). Data from the 1970 -1999 conditions was compared to future conditions in 2050s and 2090s. The results suggested no changes in annual precipitation across the region under the three scenarios, but projected annual runoff and soil loss increased significantly, ranging from 78.7% - 91.7% and from 127.3% - 157.1%, respectively, relative to the baseline years 1970-1999**.** The baseline annual mean runoff was 0.09 inches/year with the projected future scenarios annual mean runoff of 0.21 inches. Estimated reduction in annual runoff is the difference of these two figures; 0.12 inches/year. Zhang's average annual soil loss rates were 0.09 ton/acre/year during 1970 to 1999 and 0.23 ton/acre/year for all the combinations in future scenarios. Soil loss estimates used in Table 4-14 were 0.23 ton/acre/year minus 0.09 ton/acre/year, which equaled a reduction or savings of 0.14 ton/acre/year.

Table 4-14. Mean Annual Runoff/ Sediment Load Reductions for Brush Management

Mean Annual Runoff Depth and Mean Annual Sediment Loading Reductions for Brush Management						
Year	Acres Planned	% Goal	Reduction Runoff Depth Inches	Total Runoff Reduction Inches/Year	Sediment Reduction Tons/Acre	Total Sediment Tons/Year
1	50	3.1	0.12	6.0	0.14	7.0
2	50	3.1	0.12	6.0	0.14	7.0
3	50	3.1	0.12	6.0	0.14	7.0
4	50	3.1	0.12	6.0	0.14	7.0
5	50	3.1	0.12	6.0	0.14	7.0
Subtotal	250	15.5		30.0		35.0
6-10	250	15.5	0.12	30.0	0.14	35.0
11-Plus	1,100	69.0	0.12	132.0	0.14	154.0
Total	1,600	100.0		192.0		224.0

5. TECHNICAL AND FINANCIAL ASSISTANCE NEEDED

The McCook Conservation District will be the lead sponsor and administratively responsible for the project implementation. A project coordinator will manage all water quality project activities among the watershed counties and cooperate with all the local, state, and federal conservation personnel. The counties supporting the project will appoint members to serve on a steering committee. The Conservation District Managers and NRCS District Conservationists will assist the project coordinator with cost-share reimbursement, file maintenance, and other financial transactions. Technical expertise from these offices will be necessary to implement the BMPs in each local county. This expertise has been and will continue to be provided through existing partnerships with the local Conservation Districts; Vermillion River proposed Resource Conservation & Development, Pheasants Forever; East Dakota Water Development District; SD Grassland Coalition; the SD Association of Conservation Districts; SD Game, Fish & Parks Technical Assistance Programs; USDA-FSA, Conservation Reserve and Continuous Conservation Reserve Programs (CRP and CCRP); USDI-FWS, Annual appropriation for SD habitat projects; and USDI-EPA Clean Water Act Section 319 Implementation Project grants. Additional funding sources for the implementation of the BMPs will be solicited from other programs such as; the USDA-NRCS Environmental Quality Incentive Program and Wetland Reserve Program; USDA-FSA Conservation Reserve Program and Conservation Reserve Enhancement Program; SD GF&P Wildlife Partnership Program and Wetland and Grassland Habitat Program; and USDI-FWS Grassland and Wetland Easement Programs and Private Land Programs; SDDENR; SD Department of Agriculture (SDDOA); SD Extension Service; US

Environmental Protection Agency; US Fish and Wildlife Service; USDA Farm Service Agency (FSA); and USDA Natural Resources Conservation Service.

The sources of funds accessed for financial assistance during the Turkey Ridge Creek, Lake Thompson Chain-of-Lakes, and the Vermillion River implementations projects included: SDDOA, SD Soil and Water Conservation Grant awarded through the SD Conservation Commission; SD GF&P, State Acres for Wildlife Enhancement (SAFE); SD DENR, Consolidated Water Facilities Construction Fund Program; USDA-NRCS, Environmental Quality Incentive (EQIP), Wildlife Habitat Incentive (WHIP), and Farm Bill Implementation

The Vermillion River watershed basin land use is fairly homogenous and the impairment problems have been consistently identified as agricultural in nature for both cropland and animal uses. The financial extrapolations have been conservative with the BMP goals estimated by the local county field offices. This Five Year Strategic Plan is intended to describe and detail the funding needed for the proposed BMP's and the administrative costs needed to implement them. The estimated costs are based on the 2012 NRCS cost share docket and actual costs from similar local projects. Tables 5-1 through 5-5 summarize the costs of the BMP and associated practice components per each year. Table 5-6 presents an annual summary of both BMPs and administrative costs which includes personnel, office equipment and supplies for the project years.

Table 5-1. Technical and Financial Resources Needed					Year 1			
Year	BMP - Animal Waste management System				BMP - Prescribed Grazing			
1	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Engineer Design	$ 20,000	5	$ 100,000	Grazing System, EA	$ -	19	$ -
	AWSF	$200,000	5	$ 1,000,000	Rural Water, EA	$ 2,500	19	$ 47,500
	Const Mgmt	$ 18,750	5	$ 93,750	Pipeline, LF	$ 5	38,000	$ 190,000
	NMP	$ 2,500	5	$ 12,500	Tanks, EA	$ 1,500	38	$ 57,000
	Cultural Study	$ 500	5	$ 2,500	Fencing, LF	$ 1	95,000	$ 95,000
				$ 1,208,750				$ 389,500
Year	BMP - Riparian Areas				BMP - Bank Stabilization			
1	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Grazing AC	$ -	60	$ -	Rock, Fabric/LF	$ 110	1,000	$ 110,000
	Fencing LF	$ 1	7,500	$ 7,500				$ -
				$ 7,500				$ 110,000
Year	BMP - Residue & Tillage Manage				BMP - Grassed Waterways			
1	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Cost Incentive/AC	$ 10	25,500	$ 255,000	Dirt Work, Seed/ LF	$ 2.20	13,500	$ 29,700
				$ 255,000				$ 29,700
Year	BMP - Wetlands, Ponds, Sed Basins				BMP - Cropland Conversion to Forage Plantings			
1	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Dirt Work/Seed EA	$ 2,800	39	$ 109,200	Tillage/Seeding AC	$ 46	645	$ 29,670
				$ 109,200				$ 29,670
Year	BMP - Rotation/Cover Crop on Cropland				BMP - Nutrient Manage Plan, Non AWMS			
1	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Cost Incentive/AC	$ 38	40,000	$ 1,520,000	Cost Incentive/AC	$ 3.58	9,750	$ 34,905
				$ 1,520,000				$ 34,905
Year	BMP - Windbreak/Shelterbelt				BMP - Terraces			
1	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Cost Incentive/AC	$400	168	$ 67,200	Dirt Work/LF	$ 3.50	3,200	$ 11,200
				$ 67,200				$ 11,200
Year	BMP - Filter Strips, Non-CRP				Brush Management			
1	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Cost Incentive/AC	$ 46	150	$ 6,900	Cost Incentive/AC	$ 300	50	$ 15,000
				$ 6,900				$ 15,000
					TOTAL BMP COSTS			$ 3,794,525

Table 5-2. Technical and Financial Resources Needed					Year 2			
Year	BMP - Animal Waste management System				BMP - Prescribed Grazing			
2	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Engineer Design	$ 20,000	5	$ 100,000	Grazing System, EA	$ -	19	$ -
	AWSF	$200,000	5	$ 1,000,000	Rural Water, EA	$ 2,500	19	$ 47,500
	Const Mgmt	$ 18,750	5	$ 93,750	Pipeline, LF	$ 5	38,000	$ 190,000
	NMP	$ 2,500	5	$ 12,500	Tanks, EA	$ 1,500	38	$ 57,000
	Cultural Study	$ 500	5	$ 2,500	Fencing, LF	$ 1	95,000	$ 95,000
				$ 1,208,750				$ 389,500
Year	BMP - Riparian Areas				BMP - Bank Stabilization			
2	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Grazing AC	$ -	60	$ -	Rock, Fabric/LF	$ 110	1,000	$ 110,000
	Fencing LF	$ 1	7,500	$ 7,500				$ -
				$ 7,500				$ 110,000
Year	BMP - Residue & Tillage Manage				BMP - Grassed Waterways			
2	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Cost Incentive/AC	$ 10	25,500	$ 255,000	Dirt Work, Seed/ LF	$ 2.20	13,500	$ 29,700
				$ 255,000				$ 29,700
Year	BMP - Wetlands, Ponds, Sed Basins				BMP - Cropland Conversion to Forage Plantings			
2	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Dirt Work/Seed EA	$ 2,800	39	$ 109,200	Tillage/Seeding AC	$ 46	645	$ 29,670
				$ 109,200				$ 29,670
Year	BMP - Rotation/Cover Crop on Cropland				BMP - Nutrient Manage Plan, Non AWMS			
2	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Cost Incentive/AC	$ 38	40,000	$ 1,520,000	Cost Incentive/AC	$ 3.58	9,750	$ 34,905
				$ 1,520,000				$ 34,905
Year	BMP - Windbreak/Shelterbelt				BMP - Terraces			
2	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Cost Incentive/AC	$400	168	$ 67,200	Dirt Work/LF	$ 3.50	3,200	$ 11,200
				$ 67,200				$ 11,200
Year	BMP - Filter Strips, Non-CRP				Brush Management			
2	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Cost Incentive/AC	$ 46	150	$ 6,900	Cost Incentive/AC	$ 300	50	$ 15,000
				$ 6,900				$ 15,000
					TOTAL BMP COSTS			$ 3,794,525

Table 5-3. Technical and Financial Resources Needed					Year 3			
Year	BMP - Animal Waste management System				BMP - Prescribed Grazing			
3	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Engineer Design	$ 20,000	5	$ 100,000	Grazing System, EA	$ -	19	$ -
	AWSF	$200,000	5	$ 1,000,000	Rural Water, EA	$ 2,500	19	$ 47,500
	Const Mgmt	$ 18,750	5	$ 93,750	Pipeline, LF	$ 5	38,000	$ 190,000
	NMP	$ 2,500	5	$ 12,500	Tanks, EA	$ 1,500	38	$ 57,000
	Cultural Study	$ 500	5	$ 2,500	Fencing, LF	$ 1	95,000	$ 95,000
				$ 1,208,750				$ 389,500
Year	BMP - Riparian Areas				BMP - Bank Stabilization			
3	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Grazing AC	$ -	60	$ -	Rock, Fabric/LF	$ 110	1,000	$ 110,000
	Fencing LF	$ 1	7,500	$ 7,500				$ -
				$ 7,500				$ 110,000
Year	BMP - Residue & Tillage Manage				BMP - Grassed Waterways			
3	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Cost Incentive/AC	$ 10	25,500	$ 255,000	Dirt Work, Seed/ LF	$ 2.20	13,500	$ 29,700
				$ 255,000				$ 29,700
Year	BMP - Wetlands, Ponds, Sed Basins				BMP - Cropland Conversion to Forage Plantings			
3	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Dirt Work/Seed EA	$ 2,800	39	$ 109,200	Tillage/Seeding AC	$ 46	645	$ 29,670
				$ 109,200				$ 29,670
Year	BMP - Rotation/Cover Crop on Cropland				BMP - Nutrient Manage Plan, Non AWMS			
3	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Cost Incentive/AC	$ 38	40,000	$ 1,520,000	Cost Incentive/AC	$ 3.58	9,750	$ 34,905
				$ 1,520,000				$ 34,905
Year	BMP - Windbreak/Shelterbelt				BMP - Terraces			
3	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Cost Incentive/AC	$400	168	$ 67,200	Dirt Work/LF	$ 3.50	3,200	$ 11,200
				$ 67,200				$ 11,200
Year	BMP - Filter Strips, Non-CRP				Brush Management			
3	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Cost Incentive/AC	$ 46	150	$ 6,900	Cost Incentive/AC	$ 300	50	$ 15,000
				$ 6,900				$ 15,000
					TOTAL BMP COSTS			$ 3,794,525

Table 5-4. Technical and Financial Resources Needed					Year 4			
Year	BMP - Animal Waste management System				BMP - Prescribed Grazing			
4	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Engineer Design	$ 20,000	5	$ 100,000	Grazing System, EA	$ -	19	$ -
	AWSF	$200,000	5	$ 1,000,000	Drilled Wells, EA	$ 2,500	19	$ 47,500
	Const Mgmt	$ 18,750	5	$ 93,750	Pipeline, LF	$ 5	38,000	$ 190,000
	NMP	$ 2,500	5	$ 12,500	Tanks, EA	$ 1,500	38	$ 57,000
	Cultural Study	$ 500	5	$ 2,500	Fencing, LF	$ 1	95,000	$ 95,000
				$ 1,208,750				$ 389,500
Year	BMP - Riparian Areas				BMP - Bank Stabilization			
4	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Grazing AC	$ -	60	$ -	Rock, Fabric/LF	$ 110	1,000	$ 110,000
	Fencing LF	$ 1	7,500	$ 7,500				$ -
				$ 7,500				$ 110,000
Year	BMP - Residue & Tillage Manage				BMP - Grassed Waterways			
4	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Cost Incentive/AC	$ 10	25,500	$ 255,000	Dirt Work, Seed/ LF	$ 2.20	13,500	$ 29,700
				$ 255,000				$ 29,700
Year	BMP - Wetlands, Ponds, Sed Basins				BMP - Cropland Conversion to Forage Plantings			
4	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Dirt Work/Seed EA	$ 2,800	39	$ 109,200	Tillage/Seeding AC	$ 46	645	$ 29,670
				$ 109,200				$ 29,670
Year	BMP - Rotation/Cover Crop on Cropland				BMP - Nutrient Manage Plan, Non AWMS			
4	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Cost Incentive/AC	$ 38	40,000	$ 1,520,000	Cost Incentive/AC	$ 3.58	9,750	$ 34,905
				$ 1,520,000				$ 34,905
Year	BMP - Windbreak/Shelterbelt				BMP - Terraces			
4	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Cost Incentive/AC	$400	168	$ 67,200	Dirt Work/LF	$ 3.50	3,200	$ 11,200
				$ 67,200				$ 11,200
Year	BMP - Filter Strips, Non-CRP				Brush Management			
4	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Cost Incentive/AC	$ 46	150	$ 6,900	Cost Incentive/AC	$ 300	50	$ 15,000
				$ 6,900				$ 15,000
					TOTAL BMP COSTS			$ 3,794,525

Table 5-5. Technical and Financial Resources Needed					Year 5			
Year	BMP - Animal Waste management System				BMP - Prescribed Grazing			
5	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Engineer Design	$ 20,000	5	$ 100,000	Grazing System, EA	$ -	19	$ -
	AWSF	$200,000	5	$ 1,000,000	Rural Water, EA	$ 2,500	19	$ 47,500
	Const Mgmt	$ 18,750	5	$ 93,750	Pipeline, LF	$ 5	38,000	$ 190,000
	NMP	$ 2,500	5	$ 12,500	Tanks, EA	$ 1,500	38	$ 57,000
	Cultural Study	$ 500	5	$ 2,500	Fencing, LF	$ 1	95,000	$ 95,000
				$ 1,208,750				$ 389,500
Year	BMP - Riparian Areas				BMP - Bank Stabilization			
5	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Grazing AC	$ -	60	$ -	Rock, Fabric/LF	$ 110	1,000	$ 110,000
	Fencing LF	$ 1	7,500	$ 7,500				$ -
				$ 7,500				$ 110,000
Year	BMP - Residue & Tillage Manage				BMP - Grassed Waterways			
5	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Cost Incentive/AC	$ 10	25,500	$ 255,000	Dirt Work, Seed/ LF	$ 2.20	13,500	$ 29,700
				$ 255,000				$ 29,700
Year	BMP - Wetlands, Ponds, Sed Basins				BMP - Cropland Conversion to Forage Plantings			
5	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Dirt Work/Seed EA	$ 2,800	39	$ 109,200	Tillage/Seeding AC	$ 46	645	$ 29,670
				$ 109,200				$ 29,670
Year	BMP - Rotation/Cover Crop on Cropland				BMP - Nutrient Manage Plan, Non AWMS			
5	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Cost Incentive/AC	$ 38	40,000	$ 1,520,000	Cost Incentive/AC	$ 3.58	9,750	$ 34,905
				$ 1,520,000				$ 34,905
Year	BMP - Windbreak/Shelterbelt				BMP - Terraces			
5	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Cost Incentive/AC	$400	168	$ 67,200	Dirt Work/LF	$ 3.50	3,200	$ 11,200
				$ 67,200				$ 11,200
Year	BMP - Filter Strips, Non-CRP				Brush Management			
5	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Cost Incentive/AC	$ 46	150	$ 6,900	Cost Incentive/AC	$ 300	50	$ 15,000
				$ 6,900				$ 15,000
					TOTAL BMP COSTS			$ 3,794,525

TABLE 5-6. SUMMARY OF 5 YEAR COSTS - VERMILLION RIVER BASIN						
BMP IMPLEMENTATION COSTS	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	TASK TOTAL
Animal Waste Manage System	$1,208,750	$1,208,750	$1,208,750	$1,208,750	$1,208,750	$6,043,750
Prescribed Grazing	$389,500	$389,500	$389,500	$389,500	$389,500	$1,947,500
Riparian Area	$7,500	$7,500	$7,500	$7,500	$7,500	$37,500
Bank Stabilization	$110,000	$110,000	$110,000	$110,000	$110,000	$550,000
Residue & Tillage Manage	$255,000	$255,000	$255,000	$255,000	$255,000	$1,275,000
Grassed Waterways	$29,700	$29,700	$29,700	$29,700	$29,700	$148,500
Wetland/Pond/Basin Restoration	$109,200	$109,200	$109,200	$109,200	$109,200	$546,000
Cropland Conversion to Grass	$29,670	$29,670	$29,670	$29,670	$29,670	$148,350
Conservation Cover Crop & Rotation	$1,520,000	$1,520,000	$1,520,000	$1,520,000	$1,520,000	$7,600,000
Nutrient Manage Plan, Non AWMS	$34,905	$34,905	$34,905	$34,905	$34,905	$174,525
Windbreak/Shelterbelt	$67,200	$67,200	$67,200	$67,200	$67,200	$336,000
Terraces	$11,200	$11,200	$11,200	$11,200	$11,200	$56,000
Filter Strips Non-CRP	$6,900	$6,900	$6,900	$6,900	$6,900	$34,500
Brush Management	$15,000	$15,000	$15,000	$15,000	$15,000	$75,000
BMP SUB TOTAL COSTS	$3,794,525	$3,794,525	$3,794,525	$3,794,525	$3,794,525	$18,972,625
PERSONNEL SUPPORT						
Project Coordinator	$60,000	$61,800	$63,700	$65,600	$67,600	$318,700
Admin. Assistant	$40,000	$41,200	$42,400	$43,700	$45,000	$212,300
OPERATIONS						
Vehicle, Fuel, Travel, Insurance	$12,000	$13,300	$14,700	$16,000	$17,300	$73,300
ADMINISTRATION						
Computer, Supplies, Telephone,	$8,700	$9,300	$10,000	$10,700	$11,300	$50,000
RC&D Office, Postage						
PERS/ADMIN SUB TOTAL COSTS	$120,700	$125,600	$130,800	$136,000	$141,200	$654,300
YEARLY TOTALS	$3,915,225	$3,920,125	$3,925,325	$3,930,525	$3,935,725	$19,626,925

6. PUBLIC OUTREACH

The Vermillion River Basin Watershed Assessment project was initiated in 2004 at the request of local organizations and citizens that expressed concerns about the water quality problems in the Vermillion River. The main water quality concerns were related to pathogens, turbidity, and nutrients. The watershed assessment was completed in 2007. The preliminary results were presented to the project partners and stakeholders and identified the high coliform levels with the land application of manure, livestock feeding area, and/or cattle pastured in riparian zones. The sources of high total suspended solids were livestock grazing in the riparian zone, stream bank erosion, and soil erosion from uplands. This assessment developed into the Vermillion River Basin Watershed Project (VRBWP) whose goal was to restore the beneficial uses of the Vermillion River through the implementation of Best Management Practices in the watershed that target sources of fecal coliform bacteria and suspended solids. The project initiated the installation of BMPs to achieve full support of all designated beneficial uses of the river.

There were two similar activities in the watershed; the Turkey-Ridge Creek 319 Implementations Project sponsored by the Turner Conservation District from 2005-2009; and the Kingsbury Lakes 319 project sponsored by the Kingsbury Conservation District from 2005-2008. Both projects have been completed and their subwatersheds have been integrated into the VRBWP.

The McCook Conservation District is currently the project sponsor and will be responsible for the completion of the goals, objectives, and tasks of the VRBWP. The McCook Conservation District will enter into agreements with other watershed Conservation Districts' and form a steering committee. This steering committee will advise the project sponsor, develop priorities, practice manuals, work plans, and strategies for the project. They will meet at least two times each year to provide input for project management and coordination of resources to the McCook Conservation District. The USDA NRCS offices are usually co-located with the local Conservation District and staff from these offices will be utilized to disseminate the information to producers. Updates and achievements will be emailed to these field offices on a quarterly basis by the project coordinator.

Other local, state and federal agencies, and organizations providing technical and financial assistance are; the Vermillion River Basin WDD, Lower James Resource and Conservation Development (RC&D), the Vermillion Watershed RC&D applicant area, SD Game, Fish, & Parks, SD Department Environmental Natural Resources, SD Department of Agriculture, SD Association of Conservation Districts, SD State University Extension Service, USDA Natural Resources Conservation Service, USDA Farm Service Agency, and the US Fish & Wildlife Service. Segments I and II of the VRBWP have utilized monies from participant local match, State funding, EPA 319, and USDA EQIP.

Public involvement is encouraged through their participations in Local Work Groups (LWG). These LWGs are sponsored by each of the fourteen counties Soil and Water Conservation Districts' in the VRBWP. The LWGs meet annually gathering input on critical resource concerns and BMP solutions within each county. The LWGs then come together on a watershed basis to share their priorities and recommendations on the needs of the watershed. Other outreach activities will be through notice in WEB sites, conservation district newsletters, information presentations, and newspaper and radio advertisements.

7. IMPLEMENTATION SCHEDULE

The implementation of this project will be through voluntary programs with producers and landowners in a fourteen county watershed area and will be coordinated by the project coordinator. The implementation of the conservation Best Management Practices will be targeted at the agricultural sector. The unique delivery systems of the South Dakota Conservation Districts to this sector will be utilized to implement the voluntary tasks scheduled. The County Conservation Districts have an office located in each county that does business with the landowners and agricultural producers. The BMPs will be implemented with funding as available from local funding sources, South Dakota Conservation Commission funds, South Dakota Consolidated Funds, the USDA programs, and EPA 319 funds. The implementation schedule for BMPs, project outreach, task assignments, and project reports is detailed semi-annually in Table 7-1.

Table 7-1: Implementation & Task Assignment			Year 1		Year 2		Year 3		Year 4		Year 5	
Objectives, Tasks, Products	Group	Quantity	Jan - Jun	Jul-Dec	Jan - Jun	Jul - Dec	Jan - Jun	Jul - Dec	Jan - Jun	Jul - Dec	Jan - Jun	Jul - Dec
OBJECTIVE 1: BMP IMPLEMENTATION												
Task 1: Animal Waste Manage Systems (#)												
Product 1: Animal Waste Manage Systems	1,2,3											
Engineering Studies		25		5		5		5		5		5
Animal Waste Storage Facilities		25		5		5		5		5		5
Construction Management		25		5		5		5		5		5
Nutrient Management Plan		25		5		5		5		5		5
Cultural Resource Study		25		5	3	5	3	3	2	2	2	0
Task 2: Grassland Management	1,2,4											
Product 2: Prescribed Grazing Systems (Ac)		27,500		5,500		5,500		5,500		5,500		5,500
Product 3: Riparian Areas (Ac)		300		60		60		60		60		60
Product 4: Brush Management (Ac)		250		50	25	25	25	25	25	25	25	25
Task 3: Streambank Stabilization	2,4											
Product 5: Streambank Stabilization (LF)		5,000		1,000	0	1,000	0	1,000	0	1,000	0	1,000
Task 4: Cropland Management	1,2,4											
Product 6: Residue & Tillage Manage (Ac)		127,500		25,500	10,000	15,500	10,000	15,500	10,000	15,500	10,000	15,500
Product 7: Grassed Waterways (LF)		67,500		13,500		13,500		13,500		13,500		13,500
Product 8: Wetland & Pond Construct (No)		195		39	10	29	10	29	10	29	10	29
Product 9: Conversion of Crop to Grass (Ac)		3,225		645		645		645		645		645
Product 10: Conservation Rotation/Cover Crop (Ac)		200,000		40,000		40,000		40,000		40,000		40,000
Product 11: Cropland NMP (Ac)		48,750	3,000	6,750	3,000	6,750	3,000	6,750	3,000	6,750	3,000	6,750
Product 12: Windbreak/Shelterbelt (Ac)		840		168		168		168		168		168
Product 13: Terraces (LF)		16,000		3,200	1,000	2,200	1,000	2,200	1,000	2,200	1,000	2,200
Product 14: Filter Strips, Non-CRP (Ac)		750		150		150		150		150		150
OBJECTIVE 2: INFORMATION OUTREACH												
Task 5: Information Distribution												
Product 15: Articles, Newsletter, Radio, WEB	1,2,3,4											
CD Newsletters		10	1	1	1	1	1	1	1	1	1	1
Newspaper Articles		5	1		1		1		1		1	
Radio Spots		5		1		1		1		1		1
OBJECTIVE 3: PROJECT REPORTS												
Task 6: Semi-annual, Annual, Final												
Product 16: Reports	1,2											
Semi-Annual		5	1		1		1		1		1	
Annual		5		1		1		1		1		1
Final		1										1

8. SHORT-TERM CRITERIA AND MILESTONES FOR BMP IMPLEMENTATION AND PROGRESS

The implementation schedule will be used as a comparative measurement to determine progress of the Strategic Plan. The BMPs in this Strategic Plan have been selected based on the identified 303(d) pollutants and their success at achieving load reductions. These BMPs have been documented by previous research as reducing fecal coliform bacteria, *Escherichia coli*, nutrients, Chlorophyll-*a*, pH, TSS, and dissolved oxygen. Although this method of measuring progress is not the same as testing water quality, it is assumed that the successful implementation of the practices will have a positive impact on water quality of the Vermillion River watershed. The short-term progress of the project will be measured annually in the last quarter of each project year. The project coordinator will be responsible for tabulating the number of BMPs installed, the number of acres treated, and the public outreach campaign efforts made in each county as identified in Table 8-1. This information will be published in an annual report sent to all cooperating agencies and made available to residents of the watershed. The project steering committee will examine the achievements to determine if adequate progress has been made by the current BMP implementations. If they determine that adequate progress has not been made, they can adjust the implementation projects in order to achieve the five year BMP goals.

Table 8-1. Short-term Criteria & Milestones				Year 2		Year 3		Year 4		Year 5
BMP or Activity	Quantity	Year 1	Year 2	Subtotal	Year 3	Subtotal	Year 4	Subtotal	Year 5	Subtotal
Engineering Studies - AWMS	25 No.	5	5	10	5	15	5	20	5	25
Animal Waste Storage Facilities	25 No.	5	5	10	5	15	5	20	5	25
Construction Management - AWMS	25 No.	5	5	10	5	15	5	20	5	25
Nutrient Management Plan	25 No.	5	5	10	5	15	5	20	5	25
Cultural Resource Study - AWMS	25 No.	5	6	11	7	18	5	23	2	25
Prescribed Grazing Systems	27,500 Ac.	5,500	5,500	11,000	5,500	16,500	5,500	22,000	5,500	27,500
Riparian Areas	300 Ac.	60	60	120	60	180	60	240	60	300
Brush Management	250 Ac.	50	50	100	50	150	50	200	50	250
Streambank Stabilization	5,000 LF	1,000	1,000	2,000	1,000	3,000	1,000	4,000	1,000	5,000
Residue & Tillage Manage	127,500 Ac.	25,500	25,500	51,000	25,500	76,500	25,500	102,000	25,500	127,500
Grassed Waterways	67,500 LF	13,500	13,500	27,000	13,500	40,500	13,500	54,000	13,500	67,500
Wetland/Pond/Basin Construction	195 No.	39	39	78	39	117	39	156	39	195
Conversion of Crop to Grass	3,225 Ac.	645	645	1,290	645	1,935	645	2,580	645	3,225
Conservation Cover & Crop Rotation	200,000 Ac.	40,000	40,000	80,000	40,000	120,000	40,000	160,000	40,000	200,000
Nutrient Management Plan Crop	48,750 Ac	9,750	9,750	19,500	9,750	29,250	9,750	39,000	9,750	48,750
Windbreak/Shelterbelt	840 Ac.	168	168	336	168	504	168	672	168	840
Terraces	16,000 LF	3,200	3,200	6,400	3,200	9,600	3,200	12,800	3,200	16,000
Filter Strips Non-CRP	750 Ac.	150	150	300	150	450	150	600	150	750
CD Newsletters	10	2	2	4	2	6	2	8	2	10
Newspaper Articles	5	1	1	2	1	3	1	4	1	5
Radio Spots	5	1	1	2	1	3	1	4	1	5
Semi-Annual Reports	5	1	1	2	1	3	1	4	1	5
Annual Reports	5	1	1	2	1	3	1	4	1	5
Final	1	0	0	0	0	0	0	0	1	1

9. MONITORING AND EVALUATION PLAN

The McCook Conservation District, with technical support from DENR, will develop a project-specific sampling and analysis plan for this project, using existing state standard operating procedures. The McCook Conservation District will monitor project progress based on project milestones and include progress in a semi-annual project report. Progress to meet milestones will include a financial accounting of funds and the source of funds expended on each milestone or project task.

Monitoring and evaluation efforts will include analyzing water quality changes from BMP installation compared to water quality changes since the most recent watershed assessments on selected sites. The completion of the TMDL studies cited in Section 1.2 of this document has also provided a solid baseline of water quality data to use as BMPs are installed. The AGNPS can be used to identify specific feeding operations or cropland practices where the BMPs should be implemented and the models can again be used to quantify the changes in load reductions.

The effectiveness of BMPs installed relative to the improvement in water quality will be evaluated using the appropriate tools and models available. The McCook Conservation District will receive technical assistance and training on which models to use and how to use them from SD DENR. The AnnAGNPS, STEPL, GIS, and RUSLE2 models will be used to evaluate the effectiveness of BMP installation as follows; feedlot assessments before and after installation of the waste storage facilities, AnnAGNPS; sheet, rill, and gully erosion formulas for soil loss and transport, RULSE2; reductions in fecal coliform bacteria, sediment and nutrient loading by establishing buffers and riparian vegetation, STEPL and AnnAGNPS; changes in loadings will be evaluated with AnnAGNPS, STEPL, and RUSLE2 models.

The McCook Conservation District will also be responsible for collecting, storing, and managing data collected during implementation of this project. South Dakota DENR will provide technical assistance and guidance to help the Conservation District set-up the appropriate record systems and computer software for project data collected. Data collected will be forwarded to South Dakota DENR for entry into the STORET database.

The SDDENR also maintains five ambient water quality monitoring (WQM) sites within the watershed. Three stations are located on the Vermillion River. Two sites are in Clay County; WQM-4 near Wakonda from Turkey Ridge Creek to Baptist Creek; and WQM-5 near Vermillion from Baptist Creek to the mouth. One site is in Turner County; WQM-61 west of Chancellor, from the headwaters to Turkey Ridge Creek. The East Fork of the Vermillion River has two sites; WQM-150 north of Montrose, from the McCook/Lake County line to Little Vermillion River; and WQM-154 near East Lake Vermillion, from the Little Vermillion River to mouth . The data from these five water quality monitoring stations can also be used by the project director to make comparisons of installed practices. This data can be collected from

DENR on an annual basis as BMPs are installed and results evaluated. All water sampling, testing, and test result evaluations for water quality changes will be completed with technical assistance from DENR. They will also assist to develop a sampling and analysis plan, train project staff, and help in data storage and evaluation. Sampling will be completed according to the "Standard Operating Procedures for Field Samplers, Volumes I & II, Tributary and In-Lake Sampling Techniques", SD DENR, 2005.

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