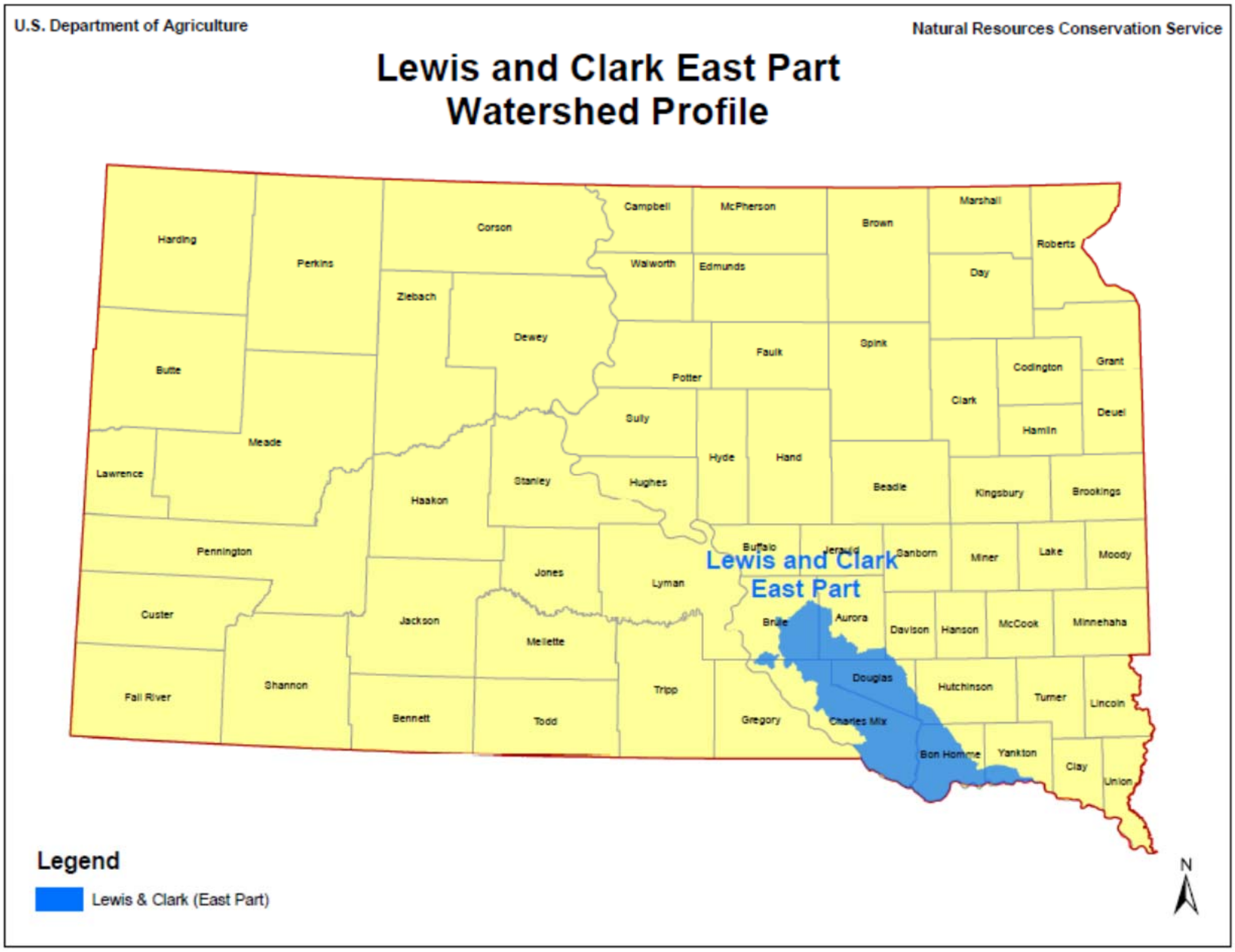


LEWIS & CLARK STRATEGIC PLAN

MISSOURI RIVER EAST

In Cooperation With:
Randall Resource Conservation & Development
Lower James Resource Conservation & Development
South Dakota Conservation Districts
South Dakota Association of Conservation Districts
South Dakota Department of Environment and Natural Resources
USDA Natural Resources Conservation Service
Date: December 2012

Prepared by:

LEBEDA CONSULTING, LLC
26175 – 456TH AVENUE
HUMBOLDT, SD 57035

TABLE OF CONTENTS

List of Figures

List of Tables

Executive Summary

The Missouri River watershed encompasses one-sixth of the contiguous United States flowing from the Rocky Mountains, through the Great Plains to the Central Lowlands, and joins the Mississippi River near St. Louis, Missouri. It drains 9,700 square miles of Canada and 513,300 square miles of the United States. The river travels 2,341 miles in this distance to its confluence with the Mississippi River, making it the longest river in the United States. In South Dakota the Missouri River enters the state in the north-central region, near Pollock, flowing south and southeast through the center of the state, forming a portion of the boundary with Nebraska, and leaves the state in the southeast corner near the town of Jefferson.

The early concerns of the Missouri River watershed were focused on flood control with the first flood control dam authorized by Franklin D. Roosevelt in 1933 and constructed near Fort Peck, Montana, in 1940. Congress then passed the Flood Control Act of 1944 that authorized the Pick-Sloan Missouri Basin Program; which was a comprehensive plan for the conservation, control, and use of water resources in the entire Missouri River Basin. The Pick-Sloan Plan called for the construction of five additional dams along the main stem of the Missouri River. Four large dams were constructed in South Dakota; the Fort Randall Dam, the Gavins Point Dam, the Oahe Dam, and the Big Bend Dam. The fifth dam was the Garrison Dam constructed in North Dakota.

Water quality issues became a concern when local citizens noticed the increasing amount of sediment loading in Lewis and Clark Lake, above the Gavins Point Dam, which threatened the storage capacity and lifespan of the Lewis and Clark Lake reservoir. The U.S. Army Corps of Engineers projected the reservoir to be at 50% of its design volume by the year 2045. Public meetings were held in 2002 with local organizations and citizens to address their concerns. This concern led the Lower James Resource Conservation and Development District, local Conservation Districts, and the SD Department of Environment and Natural Resources to administer a watershed assessment project in the years 2003 to 2005.

Although the original scope of the assessment was on sedimentation, modifications to the Lewis & Clark Watershed Improvement Project (LCWIP) were made to assess the presence of animal feeding operations and to establish Total Maximum Daily Loads (TMDL) for several smaller lakes, creeks, and rivers located in the watershed. Analysis revealed water quality issues of temperature, pH, dissolved oxygen, fecal coliform bacteria, total suspended solids, total phosphorous, and sedimentation. The assessment led to the two year Corsica Lake Watershed project where monies were used to implement Best Management Practices with landowners in the watershed. The watershed project was expanded in 2007 to include most of the Lewis and Clark Lake and Fort Randall Hydrological Units. During the year 2008 the Lake Andes watershed and the west river counties of Gregory, Tripp, and Todd Counties were added. In

2011 additional watersheds were incorporated into the LCWIP bringing the watershed to its current size of 2,465,500 acres. As of July 2011, $2,595,008 has been spent on the implementation of BMP's within the LCWIP area.

Because of the land use differences between the east and west sides of the Missouri River, this Strategic Plan concerns only the portion of the LCWIP whose watershed lies east of the Missouri River. Water quality studies in the LCWIP area evaluated both point and nonpoint pollution and determined that point pollution was not a major contributor to these 303(d) listings. Nonpoint sources of pollution, identified in the TMDL studies, were mainly agricultural in nature arising from animal feeding operations, the improper application of animal manures, over grazing of pastures, excessive grazing in the riparian zones, direct livestock access to water bodies, livestock trampling of stream banks and shorelines, excessive erosion on crop fields, and stream channel instability from culverts and bridges. Water quality studies in the LCWIP area resulted in information that led to the U.S. Environmental Agency 303(d) water quality impairment listing in the SD DENR Integrated Report of 2012 for Lake Andes, Dante Lake, Geddes Lake, and Emanuel Creek for Dissolved Oxygen, High pH, *Escherichia coli* and Fecal Coliform bacteria.

To solve pollutant loading, Best Management Practices were selected that successfully reduced pollutants and, after implementation in the watershed, would result in the delisting of the impaired water bodies. The LCWIP also had Project Implementation Plans, Segments 1 and 2, to aid in this selection as many BMPs were evaluated by AGNPS and STEPL for load reductions. The BMPs identified were animal waste storage facilities, nutrient management plans, prescribed grazing systems, managed grazing on riparian areas, conservation tillage, conservation rotation and the use of conservation cover crops, grassed waterways, stream bank stabilization, wetland restoration, pond and sediment control basins, the conversion of cropland to grass land, grassed filter strips, terraces, and tree plantings. Local county field offices personnel were contacted to identify the BMPs and to give their best estimates of the total number and/or acres of BMPs necessary to meet complete resource protection. In most instances, the attainment of these BMP goals will require additional years beyond this five year Strategic Plan.

This Strategic Plan includes the estimates of costs of the actual BMPs and the administrative costs to implement the Lewis & Clark Watershed Implementation Project over a five year project period. Cost estimates were based on USDA-NRCS cost lists and BMP projects completed through the project implementation plans. The goal of this Strategic Plan is to evaluate all water quality studies, identify the impaired resource concerns, select BMPs that reduce pollutant loadings to water bodies, and complete a practice and administrative cost analysis and time shedule for installation of the BMPs.

1.0 INTRODUCTION

1.1 Project Background and Scope

This Strategic Plan is written for the portion of the Lewis & Clark Watershed Implementation Project (LCWIP) that lies on the east side of the main stem of the Missouri River in the south central and south east portions of the State of South Dakota. See Figure 1-1 for the LCWIP area**.** The east river portion of the LCWIP encompasses 1,350,000 acres and starts below Fort Randall Dam, near Pickstown, and ends near Yankton, downstream of the Gavin's Point Dam. The project area includes portions of the watersheds in Hydrological Unit's (HU) Fort Randall 10140101 and Lewis and Clark 10170101 that lie east of the Missouri River along the identified main stem of the Missouri River. See Figure 1-2 for HU boundaries. The counties within this watershed project are Aurora, Bon Homme, Brule, Charles Mix, Davison, Douglas, Hutchinson, and Yankton. Lewis and Clark Lake lies at the south end of the project area and forms the border between the States of South Dakota and Nebraska. Lewis and Clark Lake is a man-made reservoir on the Missouri River between Springfield and Yankton, South Dakota, created by the Gavin's Point Dam. The dam was constructed by the U.S Army Corps of Engineers (USACE) as one of a series of six flood control structures on the Missouri River. The lake, at its maximum normal operating pool elevation of 1,208 feet above mean sea level, has a pool length of 25 miles, a maximum depth of 45 feet, and a surface area of 31,400 acres.

The major drainages into the reservoir within the project area are Andes Creek, Emmanuel Creek, Choteau Creek, Platte Creek, Slaughter Creek, Snake Creek, and Snatch Creek. Outside of the project area, the watersheds of Ponca Creek, the Keya Paha River, and the Niobrara River (Nebraska) contribute 7.41 million additional acres to the Lewis and Clark Lake watershed. The Missouri River flows south through the central United States, out-letting into the Mississippi river near Saint Louis, Missouri. The drainage system continues south as the Mississippi River and enters the Gulf of Mexico near New Orleans, Louisiana.

The climate of the Lewis & Clark Project area is classified as Sub-humid Continental. The maximum mean temperature at Armour in July is 89.0 degrees Fahrenheit (^{o}F), while the minimum mean temperature in January is 8.2 ^{o}F; the average mean annual temperature is 48.8 ^{o}F. The maximum mean temperature at Yankton in July is 87.3 ^{o}F, while the minimum mean in January is 7.6 ^{o}F; the average mean annual temperature is 47.6 ^{o}F. The annual precipitation in Armour and Yankton is 23.72 and 25.09 inches, respectively. Climate conditions are relatively uniform throughout the watershed basin, 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 region experiences severe weather episodes such as tornadoes, hail storms, and blizzards in their respective seasons.

Figure 1-1. Lewis & Clark Watershed Implementation Project.

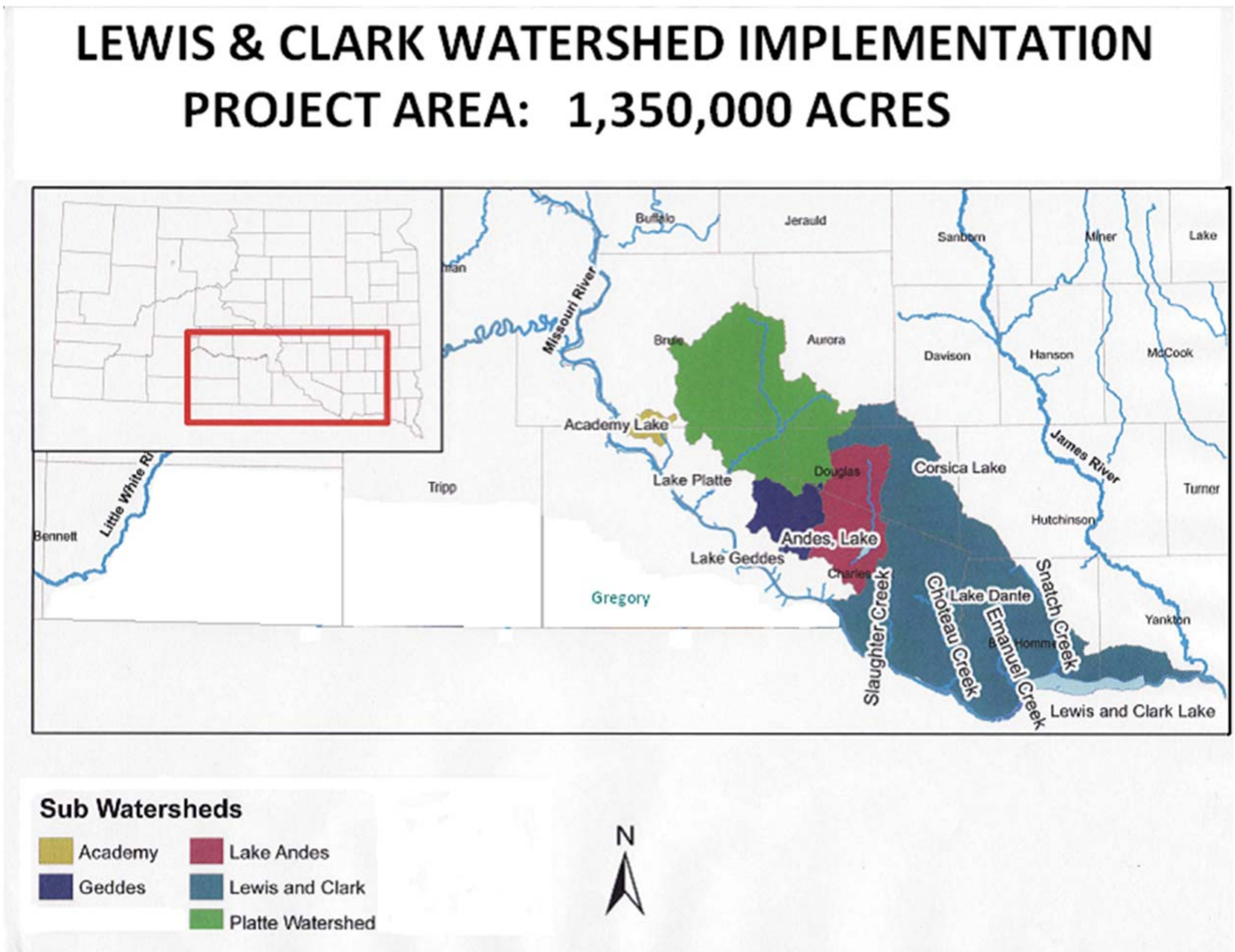
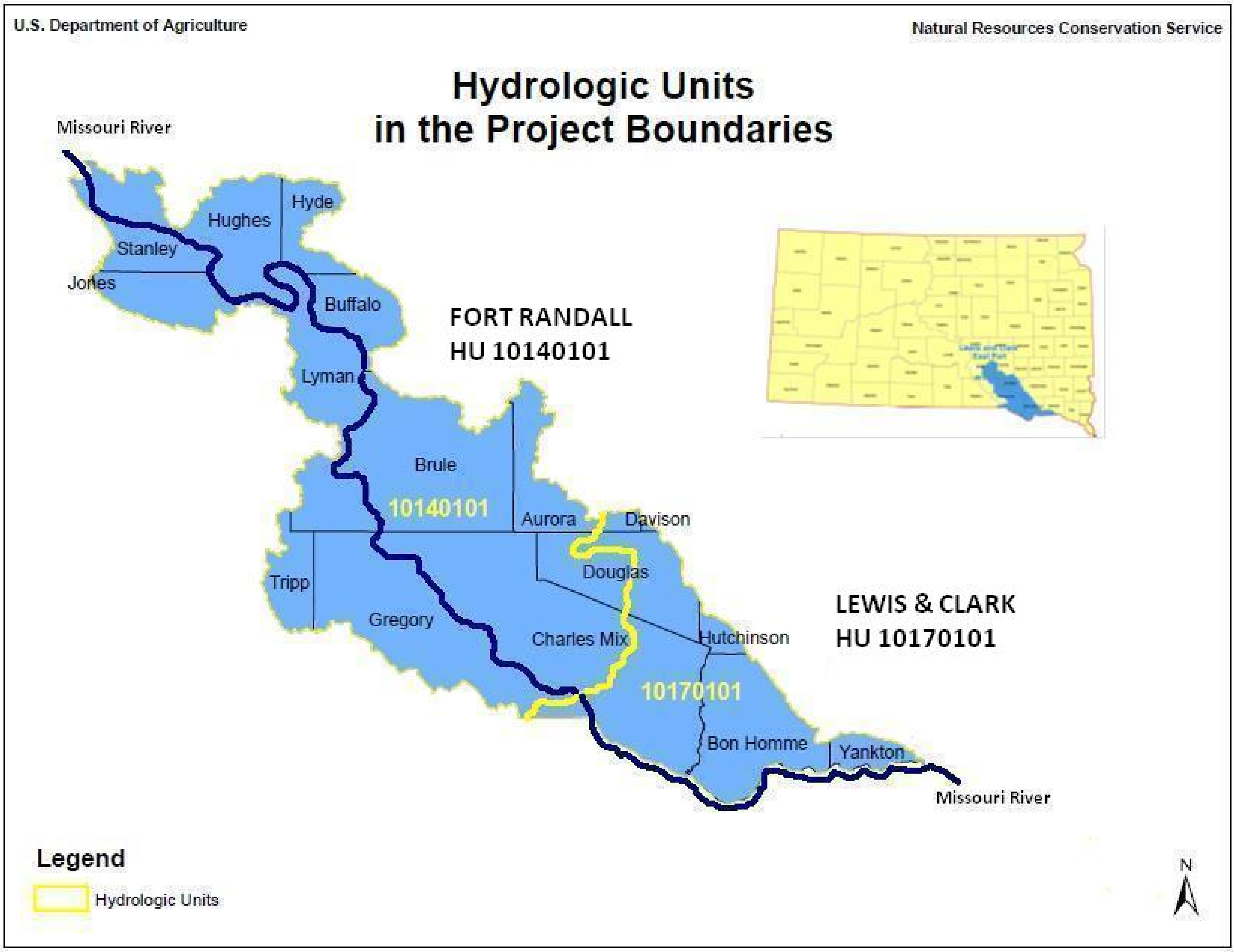


Figure 1-2. Lower Missouri River HUs in South Dakota

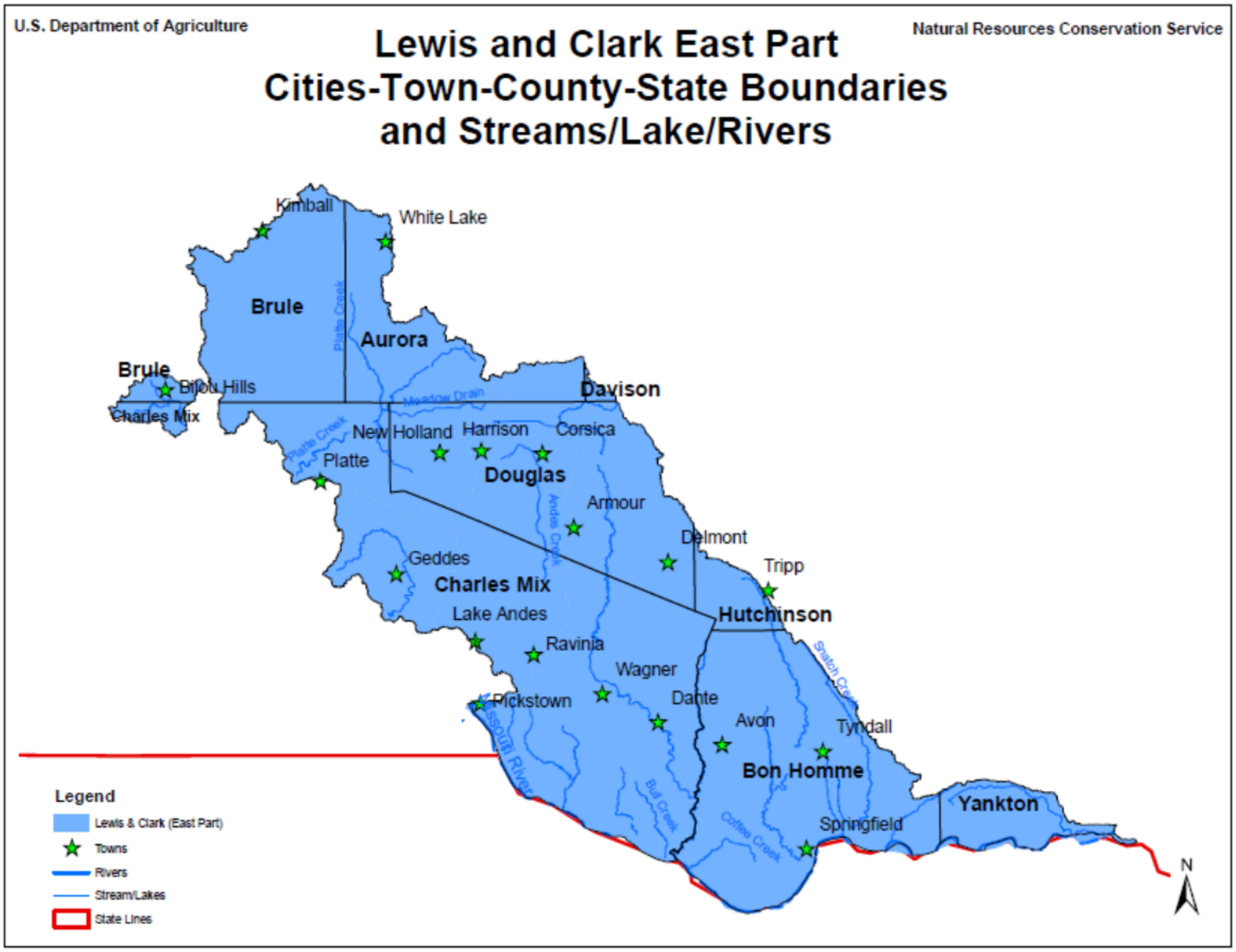


The LCWIP area is largely rural in nature with the City of Springfield having the largest population at 1,989 residents. The second largest city is Wagner with a population of 1,566 residents. There are approximately 23 incorporated and unincorporated cities and villages within the watershed. Table 1-1 lists the cities with populations over 500 and the Counties' populations in the watershed. A map of the cities and counties locations and State boundaries is shown in Figure 1-3.

Table 1-1. Population Statistics of the Lewis & Clark Project in SD

Population Statistics of the Lewis & Clark Project in SD. US Census Bureau 2010 Census					
Cities with Populations Over 500				Total County Populations	
City	County	Population		County	Population
Springfield	Bon Homme	1,989		Aurora	2,710
Wagner	Charles Mix	1,566		Bon Homme	7,070
Tyndall	Bon Homme	1,365		Brule	5,255
Platte	Charles Mix	1,230		Charles Mix	9,129
Lake Andes	Charles Mix	879		Davison	19,504
Kimball	Brule	703		Douglas	3,002
Armour	Douglas	699		Hutchinson	7,343
Tripp	Hutchinson	647		Yankton	22,438
Corsica	Douglas	592			
Avon	Bon Homme	590		Total	76,451

Figure 1-3. Cities, Counties, Water Bodies of the Lewis & Clark Watershed in South Dakota.



1.2 Lewis & Clark Project, Lower Missouri River, Watershed History

The Missouri River begins along the Continental Divide in the northern Rocky Mountains and flows generally southeasterly to join the Mississippi River near St. Louis, Missouri. The river drains approximately 9,700 square miles of Canada and 513,300 square miles or one-sixth of the contiguous United States. This river was forced into its present course in ancient geologic times along the west face of the Continental glacier. Its headwaters begin near Three Forks, Montana where the Madison River, the Jefferson River, and the Gallatin River join to form the Missouri River. From there it travels 2,341 miles to its confluence with the Mississippi River, making it the longest river in the United States. The basin topography varies from the 56,000 square mile Rocky Mountain area in the west, where many peaks exceed 14,000 feet in elevation; to the approximately 370,000 square mile fertile soils of the Great Plains area in the heartland of the basin; to the 90,000 square mile Central Lowlands area in the lower basin, where the elevation is

379 feet at its mouth near St. Louis, Missouri. Correspondingly, the stream slopes vary from about 200 feet per mile in the higher elevations of the mountains to about 0.9 foot per mile in the Great Plains and Central Lowlands. The Missouri River basin includes over 95 major tributary rivers and streams in its watershed.

In South Dakota, the Missouri River enters the State in the north-central region near Pollock and flows generally south. The river turns southeast near Pickstown, in south-central South Dakota, flowing in that direction and forming a common boundary with the state of Nebraska, until it leaves South Dakota at the southeast corner near Jefferson. As it flows through South Dakota, the Missouri River is fed by eight major tributary rivers and streams; the Grand, Moreau, Cheyenne, Bad, White, James, Vermillion, and Big Sioux Rivers'.

The Missouri River was a free flowing river until the first flood control dam was constructed at Fort Peck, Montana, which forms Fort Peck Lake. President Franklin D. Roosevelt authorized the Fort Peck project in 1933, during the Great Depression, and the dam was completed in 1940. Congressional passage of the Flood Control Act in 1944 authorized the Pick–Sloan Missouri Basin Program which was a general comprehensive plan for the conservation, control, and use of water resources in the entire Missouri River Basin. The Pick-Sloan Plan was a cooperative effort between the U.S. Army Corps and U.S. Bureau of Reclamation that called for the construction of five more dams along the main stem of the Missouri River.

Four large dams impound the Missouri River in South Dakota. The Fort Randall Dam, impounding Lake Francis Case near Pickstown, was the first dam completed in 1952. Gavins Point Dam, finished in 1955, forms Lewis and Clark Lake near Yankton and is the smallest impoundment on the main stem Missouri River. Oahe Dam, forming Lake Oahe near Pierre, is one of the largest rolled earthen dams in the world and was completed in 1958. The Big Bend Dam, finished in 1963, forms Lake Sharpe near Fort Thompson, was the last of the Missouri River impoundments to be finished. The sixth main stem dam built on the Missouri River was the Garrison Dam, in North Dakota, which forms Lake Sakakawea. In addition to the six main stem projects operated by the Corps, 65 tributary reservoirs operated by the Bureau of Reclamation and the Corps provide over 15 million acre-feet of flood control storage. The Bureau of Reclamation operates many additional reservoirs for irrigation and power production, which provide incidental flood control benefits. See Figure 1-4 for Missouri River Flood Control Reservoirs.

The five dams upstream of the Gavins Point dam and Lewis & Clark Lake project control 263,480 square miles of drainage system. The immediate Lewis and Clark Lake drainage area, controlled by the Gavins Point Dam, is approximately 16,000 square miles in size, and is operated to provide stabilized flows for navigation. The dam was constructed primarily as a reregulation dam for releases from Fort Randall Dam. Reregulated releases assist navigation on the lower Missouri River by supplying a steady flow of water. Although navigation on the

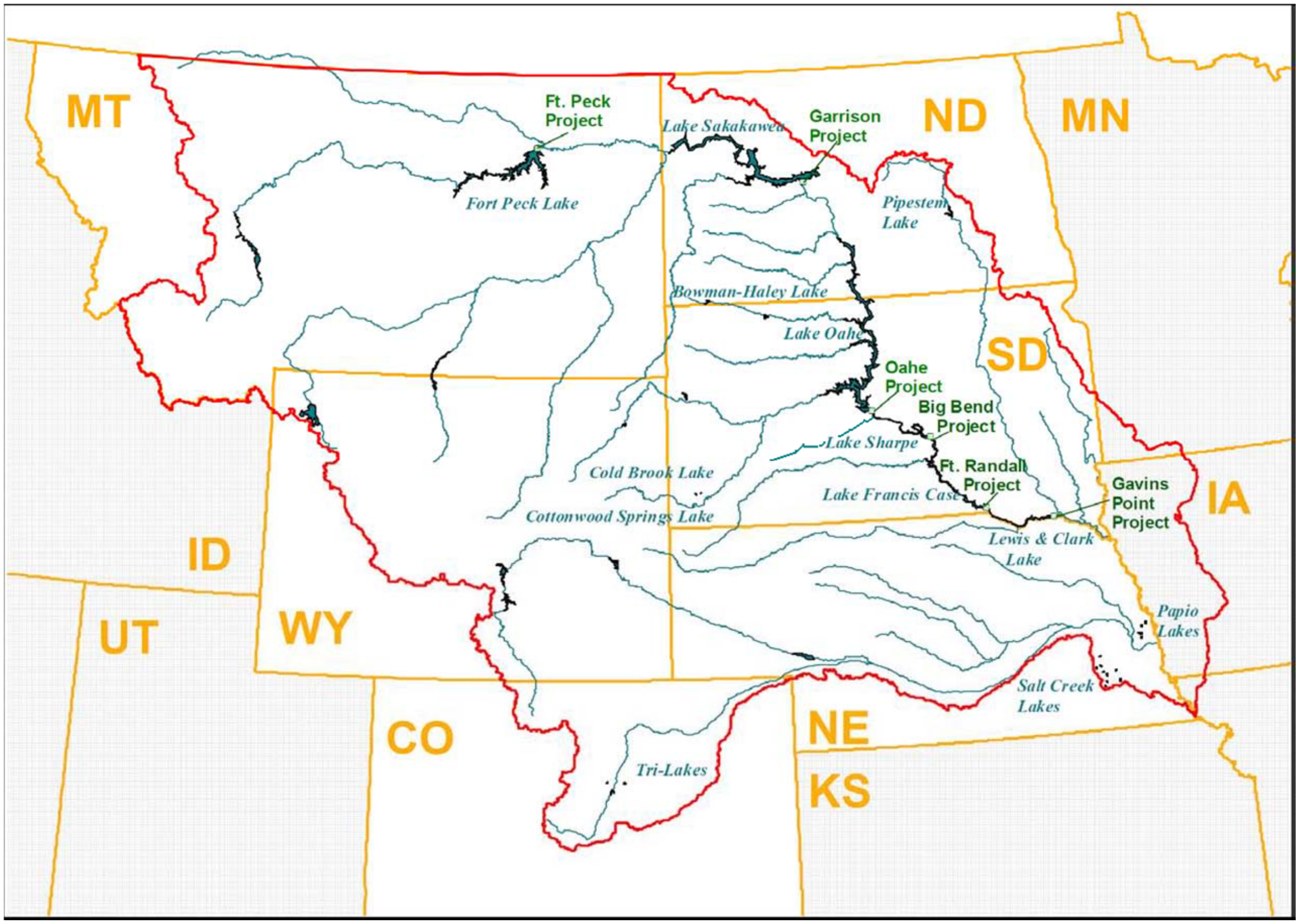
Missouri River originally passed through South Dakota, there is no commercial navigation through this reach of the river today. Commercial navigation on the Missouri River is largely confined to the river at and downstream from Sioux City, Iowa.

The reservoir system on the Missouri River was designed for the multipurpose uses of hydroelectric power, flood control, navigation, municipal water, irrigation, fish and wildlife habitat, and recreation. However, the main mission of the dams is flood control and all the other authorized purposes and functions are subordinate to the flood control mission of the project. The Gavins Point Dam project provides 59,000 acre-feet of exclusive flood control storage. Flood control projects in the entire Missouri River basin are estimated to have prevented over $26.0 billion in flood damages in the period 1938-2002 indexed to 1997 dollars; during which the Gavins Point project is credited with preventing $322 million in damages. Three generators generate 754 million kilowatt-hours of electrical energy at Gavins Point each year. Hydroelectric power generated at this project is used by industries, farms, municipalities, and homes in the Pick-Sloan Missouri Basin marketing area.

Two semi-natural segments of the regulated free-flowing Missouri River remain in South Dakota; a 45-mile stretch below Fort Randall Dam that flows into Lewis and Clark Lake, and a second 58 miles stretch below Gavins Point Dam, that flows into the channelized portion of the Missouri River near Sioux City, Iowa. These river sections received protection under the Wild and Scenic Rivers Act in 1991 and 1978, respectively.

The initial water concerns on the Missouri River were with flood control and activities and started with the construction of the Fort Peck Dam as early as 1933. However, water quality concerns on Lewis and Clark Lake did not begin until around 2002. Public meetings were held to address the concerns of local organizations and citizens who were worried about the amount of sediment loading in Lewis and Clark Lake and the reduction in the storage capacity and lifespan of the reservoir behind the Gavins Point Dam. Lewis and Clark Lake was threatened by sedimentation to the level that its life span was estimated by the Corps of Engineers to be 75 to 135 years. The LCWIP Segment 1 was started from the results of these efforts. The Randall Resource Conservation & Development District (RC&D) administered a watershed assessment project from 2003 to 2005 with the help of Lower James RC&D, local Conservation Districts, and the South Dakota Department of Environment and Natural Resources.

Figure 1-4. USACE Flood Control Reservoirs along the Missouri River



The original scope of the project was intended to identify areas and causes of sediment to the reservoir and begin developing remediation strategies to reduce the amount of sediment entering the impoundment. Although all six of the Missouri River Reservoirs in the Upper Missouri River Basin are experiencing storage losses due to sediment, the three smallest reservoirs (Lewis and Clark Lake, Lake Francis Case, and Lake Sharpe), located in the lower part of the basin, have been far more significantly impacted than the other reservoirs. As of 2009, Lewis and Clark Lake has had a storage loss of almost 30 percent. Using the USACE supplied sediment data, Lewis and Clark Lake, is projected to be at 50% of its design volume by the year 2045. The South Dakota Department of Environment and Natural Resources (DENR) made an informal agreement with the Nebraska Department of Environmental Quality (NEDEQ) to share data collected in the watershed project and discuss mitigation activities upon completion of the assessment. Additional concerns were discovered during the first year of the LCWIP assessment, and as a consequence, the monitoring strategy was modified to assess the presence of large numbers of animal feeding operations and establish Total Maximum Daily Loads (TMDL) for several smaller lakes, creeks, and rivers located within the drainage.

These efforts resulted in a two year 56,300 acre Corsica Lake Watershed project that was initiated with $300,000 of U.S. Environmental Protection Agency (USEPA) monies. The goal of the LCWIP was to restore the beneficial uses of the Lewis and Clark Lake watersheds through the installation of Best Management Practices (BMPs) that target sources of sediment, nutrients, and fecal coliform bacteria. A final Total Maximum Daily Load (TMDL) report for Corsica Lake was drafted to install BMPs designed to reduce loading of these pollutants. Local cash and in-kind match came from the Conservation Districts and landowners and project monies were combined with the United States Department of Agriculture (USDA) Conservation Reserve Program (CRP) and Environmental Quality Improvement Program (EQIP) for the best use. With the help of the South Dakota Partnership (DENR, Douglas County Conservation District, SD Association of Conservation Districts, NRCS and others) this project became very successful surpassing assigned practice acreage and goals. To select, update, and prioritize BMPs best fitted to solve resource concerns, the Randall RC&D has held annual Steering Committee meetings comprised of personnel from the Conservation Districts, SDDENR, Lewis & Clark Watershed Improvement Project, NRCS field office, and tribal liaisons.

The watershed project was expanded in 2007 from 56,300 acres to 747,000 acres so it now included most the of the Lewis and Clark Lake and Fort Randall HU watersheds. The EPA Section 319 implementation grant award was increased by $514,800 in 2007 to cover the costs of this expansion. In 2008 the 95,000 acre contiguous Lake Andes watershed was added as well as the west river counties of Gregory, Tripp and Todd. The project work area now included eight east river counties, three west river counties and eleven Conservation Districts for a total watershed area of 1.9 million acres. The LCWIP Segment 3 proposal of 2011 added the four watersheds of Lake Andes, Geddes, Academy, and Platte Lake to bring the total project area acreage to 2,465,000 acres. The water bodies studied under the Lewis and Clark Project study as of 2011 were Lake Andes, Choteau Creek, Corsica Lake, Emanuel Creek, Slaughter Creek, and Lewis and Clark Lake. The LCWIP Segment 2 PIP Final Report (Knippling 2012) showed total project expenditures of $2,595,008 as of July 31, 2011. This Strategic Plan document, however, includes only that portion of the LCWIP located east of the Missouri River.

1.3 Lewis & Cark Watershed Water Quality Studies

Water quality resources were not studied intensively in the LCWIP area until more recent times. The water resource concerns along the Missouri River had been initially focused on flood control and sources of irrigation water. Further analysis has revealed water quality issues of 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 reported that of the identified fourteen water bodies within the LCWIP area only five have approved Total Maximum Daily Loads (TMDL). The remaining water bodies either had no available data or insufficient data to make a TMDL determination. A short synopsis of each study within the LCWIP is as follows:

- The Dante Lake and its watershed were identified in the 2006 *Phase I Watershed Assessment and Total Maximum Daily Load (TMDL) Final Report, Dante Lake, Charles Mix County, South Dakota*. Data collected was evaluated using computer models AnnAGNPS, BATHTUB, and FLUX. A long-term trend in declining water quality was found as a result of nutrients, sediment, and aquatic weed and algal growth. The lake was 303 (d) listed in the 2012 DENR Integrated report for Dissolved Oxygen.

- Corsica Lake was reviewed in the February 2005 *Phase I Watershed Assessment and TMDL Final Report Corsica Lake, Douglas County, South Dakota.* The lake had been listed in the 2008 SDDENR Integrated Report for trophic state index (TSI), Dissolved Oxygen (DO) and High pH. Best Management Practices were implemented in 2005 through Lewis & Clark Watershed Implementation Project and Corsica Lake was delisted in 2010 and not listed in 2012.

- Lake Andes was studied in the report *Dissolved Oxygen Total Maximum Daily Load (TMDL) Lake Andes, Charles Mix County, South Dakota*. February 2010. Nonpoint sources of pollution identified were agricultural runoff from cropland and livestock feeding operations. The lake was 303 (d) listed in the 2012 DENR Integrated report for Dissolved Oxygen.

- The Lake Geddes *Phase I Watershed Assessment and TMDL Final Report Geddes Lake Charles Mix County, South Dakota,* was completed in March, 2007. The purpose of this assessment was to determine the sources of impairment to Geddes Lake and its tributaries. Pease Creek is the primary tributary to Geddes Lake and drains a mix of grazing lands, some cropland, and has numerous winter feeding areas for livestock present in the watershed. The stream carried sediment and nutrient loads that degraded water quality in the lake and cause increased eutrophication. The lake was 303 (d) listed in the 2012 DENR Integrated report for Dissolved Oxygen and High pH.

- The U.S. Geological Survey reported on the *Water and Sediment Quality of Lake Andes and Choteau Creek Basins from 1983 to 2000*. One of the objectives of the Lake Andes/Choteau Creek water quality monitoring program was to describe the water and bottom sediment quality of the Lake Andes and Choteau Creek Basins. This baseline data would help evaluate any water-quality changes that might occur in the basins if a proposed Bureau of Reclamation Irrigation Demonstration Project was constructed.

- Choteau Creek was evaluated in the *Total Suspended Solids Total Maximum Daily Load Evaluation for Choteau Creek, Bon Homme and Charles Mix Counties, South Dakota South Dakota Department of Environment and Natural Resources, February, 2010.* The AnnAGNPS model suggested that a disproportionate percentage of the total suspended solid load originated from the Dry Choteau Creek drainage. The creek was not listed as 303 (d) impaired in the 2012 DENR Integrated Report.

- Dry Choteau Creek had a TMDL established in the document *Total Maximum Daily Load for Ammonia in Dry Choteau Creek near Avon, South Dakota, South Dakota Department of Environment and Natural Resources, 2004.* Point source ammonia loads were identified at critical low flow conditions, primarily due to discharges from the City of Avon's municipal wastewater treatment facility. Both thirty-day average and daily maximum loads were developed to ensure the surface water quality standards for ammonia are maintained. The creek was not listed as 303 (d) impaired in the 2012 DENR Integrated Report.

- Emanuel Creek was assessed in two separate documents in 2009; the *Total Suspended Solids (TSS) Total Maximum Daily Load Evaluation For Emanuel Creek, Bon Homme County, South Dakota* and the *Fecal Coliform Total Maximum Daily Load Evaluation For Emanuel Creek, Bon Homme County, South Dakota.* The TMDL document identified the major contributors of fecal coliform as feedlots, livestock on grass, and wildlife. The TMDL for the TSS identified most of the sediment as a result of bank failure and sheet and rill erosion on cropland. The primary cause of bank failures was the use of the riparian areas by livestock. The creek was listed as 303 (d) impaired for fecal coliform bacteria in the 2012 DENR Integrated Report.

- The Lewis & Clark Basin was studied in the *Phase I Watershed Assessment and TMDL Final Report Lewis and Clark Basin, Nebraska and South Dakota*, April 2011. The main purpose of this assessment was to locate the source of sediments entering Lewis and Clark Lake and determine the feasibility of reducing the amount of sediment and nutrients entering the reservoir through best management practices. An additional goal of the project included the development of TMDLs for all impaired water bodies located within the drainage.

- Sedimentation in Lewis & Clark Lake was reported on by the U.S. Army Corps of Engineers in the *Gavin's Point Dam/Lewis and Clark Lake Master Plan, Missouri River, Nebraska and South Dakota*, dated December 2004. This updated Master Plan guides the use and development of the natural and manmade resources of the project as it was authorized for flood control, navigation, hydropower, fish and wildlife, recreation, irrigation, municipal and industrial water supply, and other purposes. The main stem of the Missouri River is not listed as 303(d) impaired in the 2012 SDDENR Integrated Report.

- 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.

1.4 Goals of the Lewis & Clark Watershed Strategic Plan

The goal of the strategic plan for the Lewis & Clark Watershed Implementation Project in the State of South Dakota 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 Missouri 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.

2.0 CAUSES AND SOURCES OF IMPAIRMENTS

2.1 Geography

The Lewis & Clark project watershed is in the Level III Northern Glaciated Plains and the Northwestern Glaciated Plains ecoregions. The Northwestern Glaciated Plains ecoregion is a transitional region between the generally more level, moister, more agricultural Northern Glaciated Plains to the east and the generally more irregular, drier, Northwestern Great Plains to the west and southwest. The western and southwestern boundary roughly coincides with the limits of continental glaciation. Within the Northern Glaciated Plains ecoregion is a moderately high concentration of semi-permanent and seasonal wetlands, commonly referred to a Prairie Potholes.

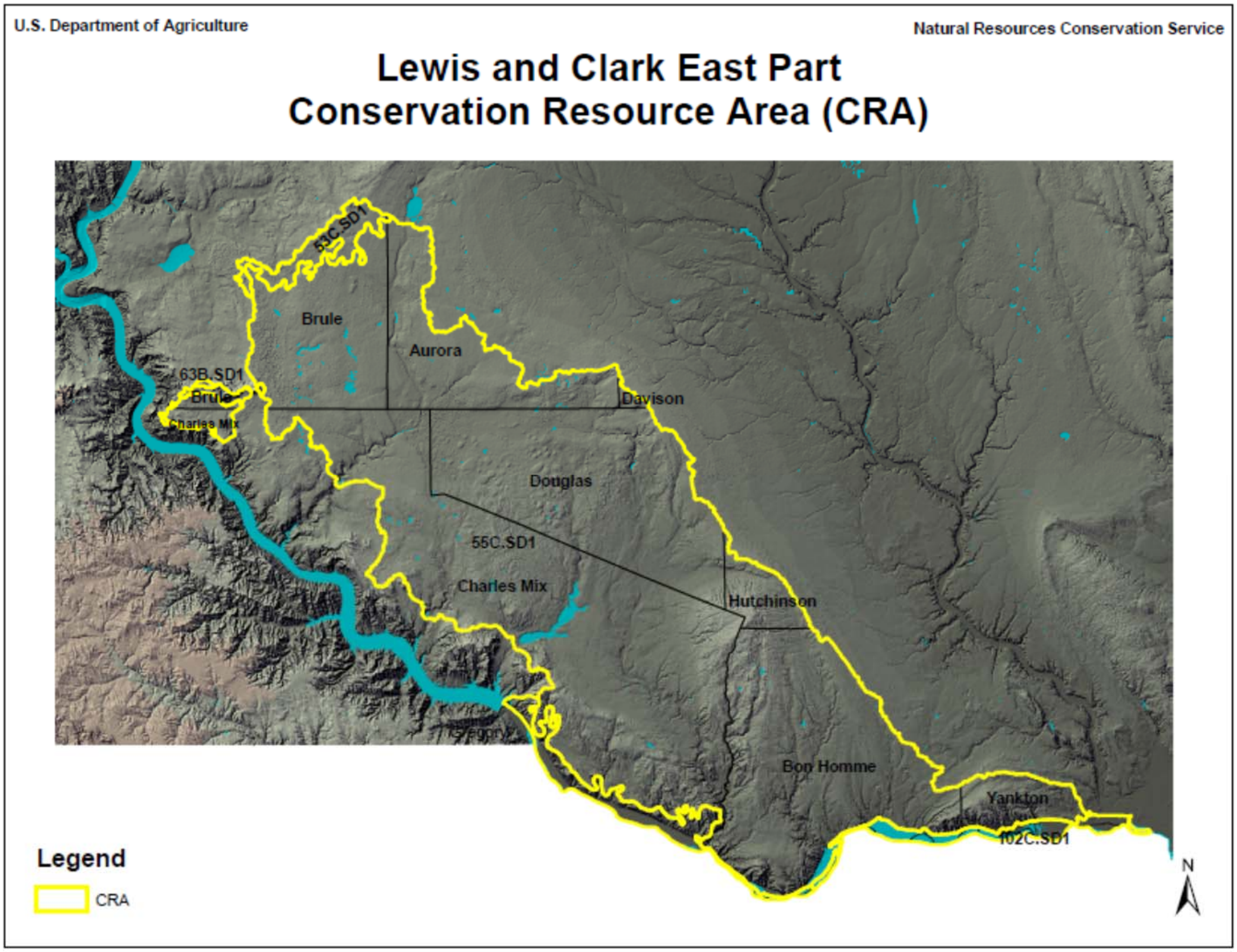
The project area is located in the Great Plains physiographic province on the west and in the Central Lowland province on the east. This area reflects the actions of several periods of glaciation. During the Pleistocene Epoch, movement of ice sheets southward over the relatively soft bedrock formations of the project area caused the accumulation of a heterogeneous mixture of rock materials within the ice mass. Glacial activity eroded and reworked the pre-glacial shale underlying the ice mass, as much of the fine-grained material within the till was derived from the Pierre Shale. When the ice mass melted and receded northward, a mantle of relatively unconsolidated sediments called glacial drift was left where the ice had been. The glaciated area was covered by at least one and perhaps several ice advances. Most of the glaciated areas are gently rolling, undulating plains, and relief is moderate. Drainages in the glaciated areas are generally poorly defined because of the rolling topography. Although there are few rivers, there is an abundance of lakes, ponds, and sloughs

The Missouri River Valley divides the province into two sections; the Western Young Drift section to the north and the Dissected Till Plains section to the south. The Western Young Drift section is characterized by young glacial plains, moraines, lakes, and lacustrine plains. This physiography reflects immature erosional development on the relatively young Wisconsin glacial drift. The Missouri River is the approximate limit of advance for the Wisconsin glacial ice sheet. The Dissected Till Plains section to the south of the river is characterized by sub-mature to mature dissected till plains. This nearly flat plain has been formed by erosion of the relatively older Kansan glacial drift. A mantle of loess measuring several feet overlies the till, and relief varies from 100 to 300 feet. The Missouri River Valley in the project area generally ranges from 1 to 3 miles in width. The valley alluvium consists principally of sands with some silt, clay, or gravel, ranging in geologic age from the Nebraskan to recent.

The majority of the LCWIP area for this strategic plan lies in the Northern Great Plains Spring Wheat Region, Land Resource Region F; with small portions in the Western Great Plains Range and Irrigated Region G and the Central Feed Grains and Livestock Region M. 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 Southern Black Glaciated Plains, area 55C, comprises the major CRA within the LCWIP area. Small portions of other CRA's also included in the project boundaries are; area 53C the Southern Dark Brown Glaciated Plains; area 63B the Southern Rolling Pierre Shale; and area 102C the Loess Uplands. See Figure 2-1.

The dominant land forms in this MLRA area are nearly level to undulating glacial till plains interrupted by steeper slopes adjacent to streams and moraines. Minor moraines are scattered throughout the MLRA and stagnation moraines are dominant with small areas of outwash adjacent to the minor moraines. The Missouri River flows in a trench cut by glacial melt water from the adjacent western MLRA. A high terrace scarp separates the valley floor along the Missouri River from the surrounding land. The transitional area between the uplands and the valley floors of the Missouri River is deeply eroded to and referred to as the "Missouri Breaks".

Figure 2-1. Common Resource Areas of the LCWIP

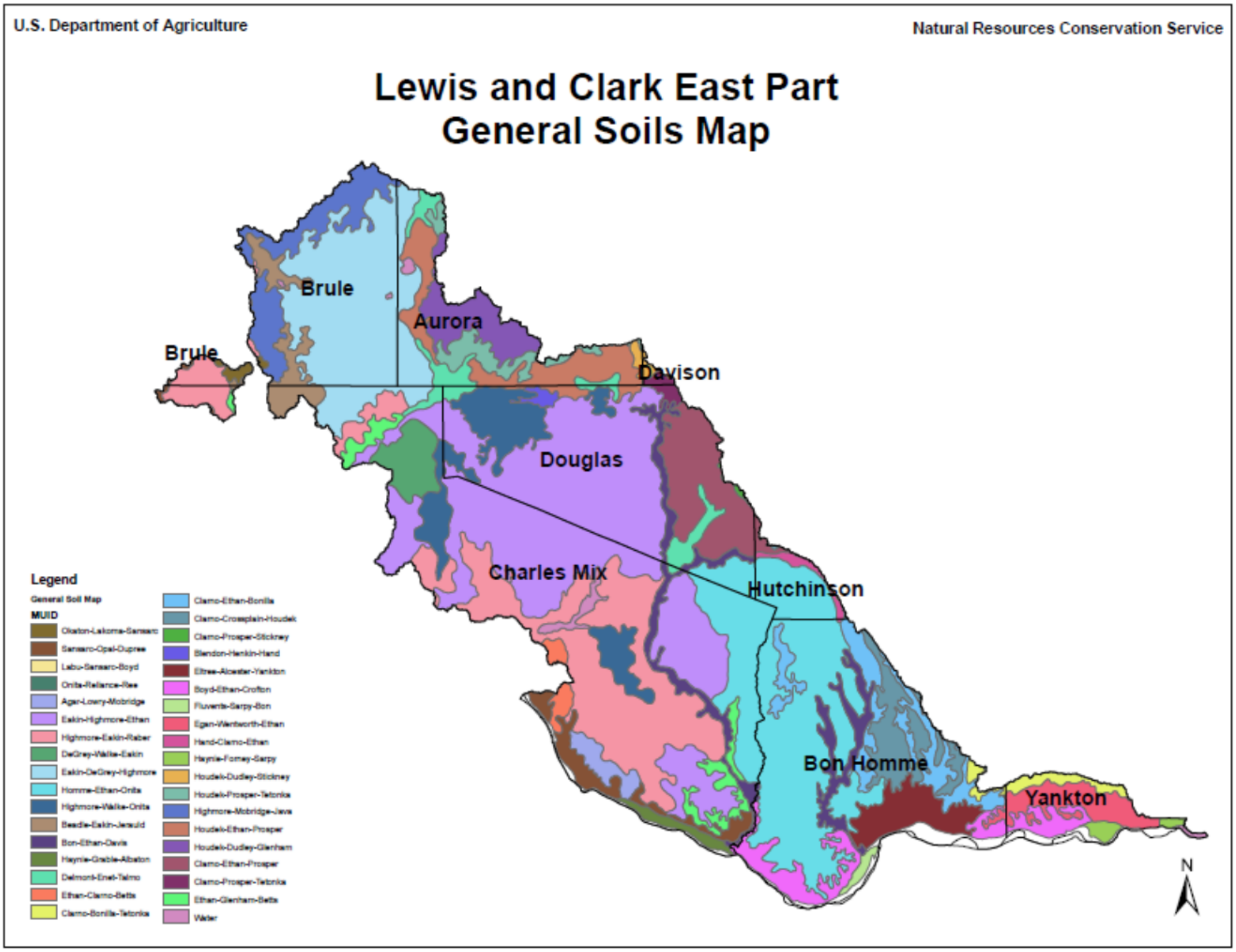


2.2 Soils

The dominant soil order in this MLRA is Mollisols. The soils in the area dominantly have a mesic soil temperature regime, an ustic soil moisture regime, and mixed or smectitic mineralogy. They generally are very deep, well drained to very poorly drained, and clayey or loamy. Calciustolls (Ethan series) and Calciustepts (Betts series) formed in till on moraines and the steeper slopes. Natrustolls (Dudley, Stickney, and Jerauld series) formed in till on till plains. Haplustolls formed in till on till plains (Bonilla and Clarno series), in glaciofluvial deposits on outwash plains (Hand, Delmont, and Enet series), and in sandy eolian material (Forestburg series). Argiustolls formed in till (Beadle, Houdek, and Prosper series), silty drift (Highmore series), and a silty mantle over till (Eakin series) on till plain and hills and in alluvium (Onita series) on fans and foot slopes and in swales. Agriabolls (Tetonka series), Agriaquolls (Worthing series), and Natraquolls (Hoven series) formed in alluvium in depressions on till plains. 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. The major soil resource concerns are water erosion, wetness, and maintenance of the content of organic matter and productivity of the soils. Wind erosion is a hazard in some of the northern parts of the region where the lighter textured soils occur. The soils and climate favor agriculture.

Figure 2-2 General Soils Map of the LCWIP



2.3 Land Use

The Missouri River dramatically divides the land uses in this MLRA. The area of the LCWIP east of the Missouri River is in the glaciated soils region. The land use of the LCWIP is estimated at about 76.8% 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. The major resource concern during the early phases of the project in 2003 was the sedimentation of Lewis & Clark Lake. As the project progressed and water quality data was analyzed, the Project Implementation Plan (PIP) was drafted to address the identified loadings of nutrients, sediment, and coliform bacteria. Resource concerns were wind erosion, water erosion, maintenance of the content of organic matter and productivity of the soils, irrigation, soil wetness, 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.

Table 2-1. Agricultural Data LCWIP Watershed Counties

Agricultural Data for Counties in Lewis & Clark Watershed									
	Aurora	Bon Homme	Brule	Charles Mix	Davison	Douglas	Hutchinson	Yankton	Data Year
Land Area Acres	453,268	360,606	524,190	702,900	278,690	277,515	520,341	333,836	2010
Number of Farms	379	563	370	693	406	363	723	658	2010
Total Cropland Acres	228,775	219,754	287,619	403,374	214,888	157,298	394,680	249,268	2010
Corn Acres	75,300	96,300	73,300	132,500	65,700	68,100	153,500	93,000	2010
Soybean Acres	66,000	93,500	69,000	135,500	66,500	71,000	151,000	80,500	2010
Small Grain Acres	15,600	9,000	28,900	44,000	9,700	15,200	13,300	1,900	2010
Hayland	42,000	37,000	64,500	91,000	20,000	24,000	39,500	25,500	2010
Pasture/Range Acres	126,647	86,714	234,851	263,605	73,113	65,257	110,967	66,243	2007
Cattle	46,500	62,000	80,000	140,600	49,600	51,600	94,600	62,600	2010
Swine	19,927	23,142	30,225	74,260	45,832	87,172	117,257	17,981	2007
Sheep	4,106	1,997	5,765	13,205	4,015	2,775	2,965	2,848	2007

Data from USDA Agricultural Statistics Service

Figure 2-3. Cropland Productivity in the Lewis & Clark Project Watershed

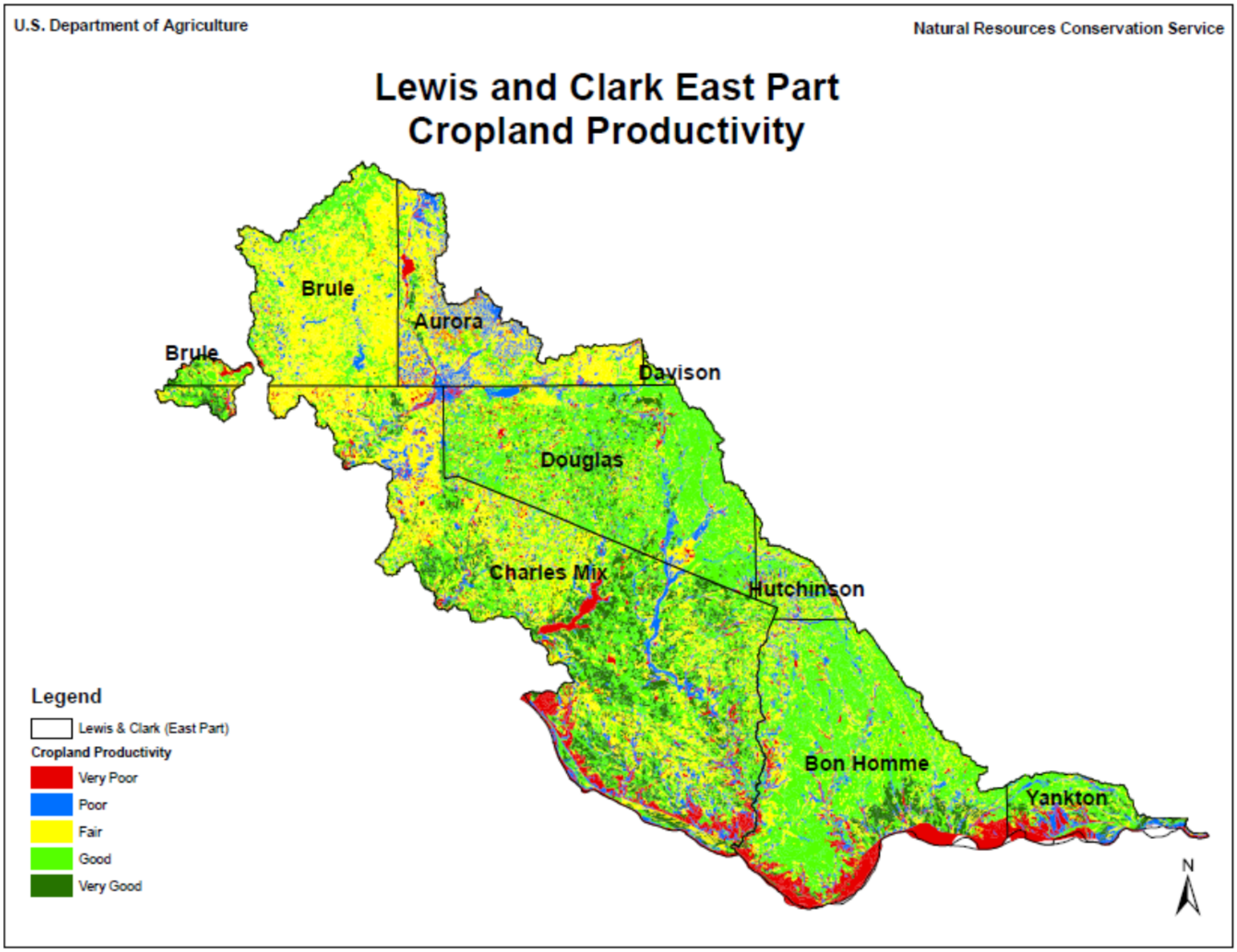
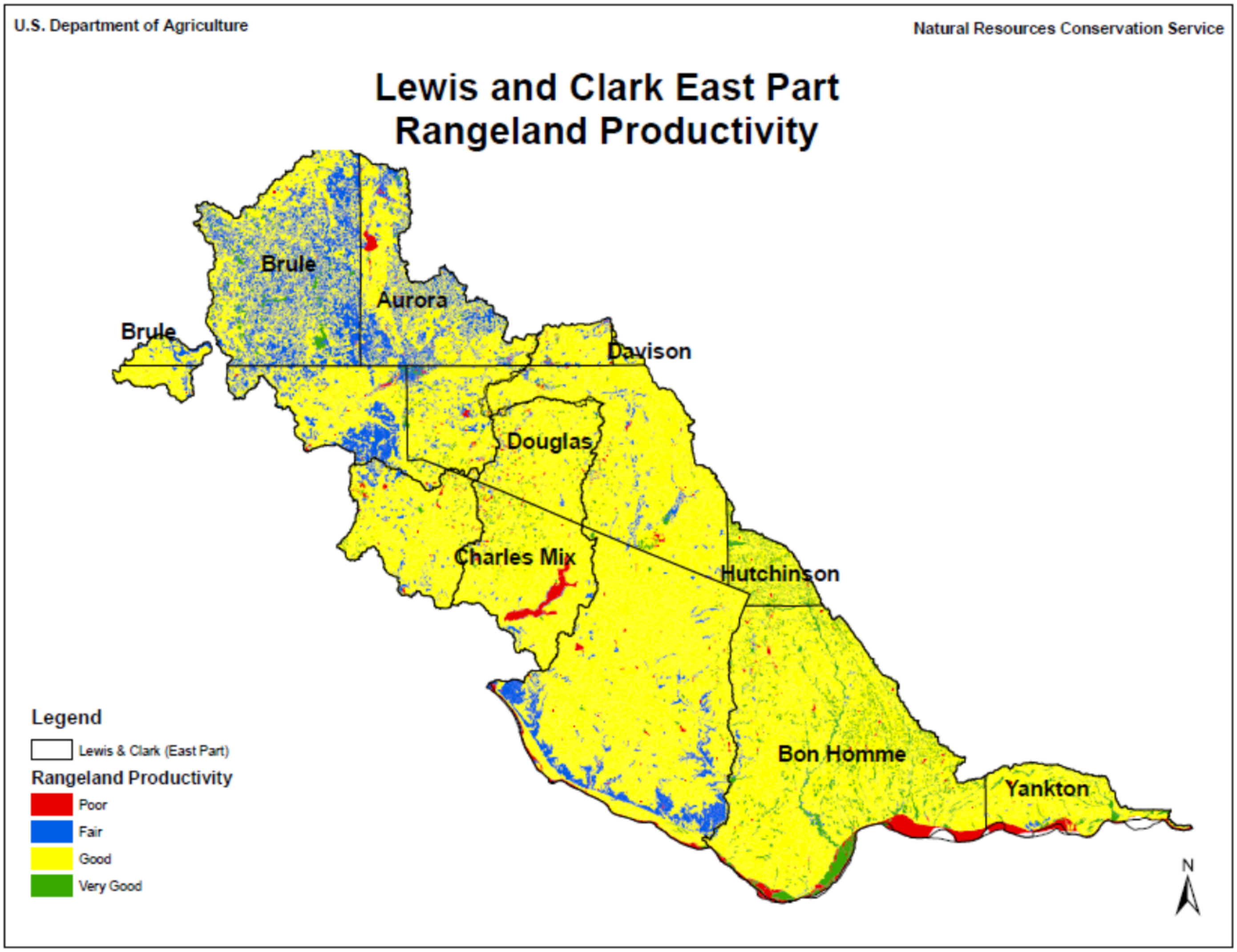


Figure 2-4. Rangeland Productivity in the LCWIP Watershed



2.4 Water Resources

Freshwater is a critical resource of this MLRA Region and the total withdrawal of freshwater averages 90 million gallons per day. About 71 percent of this is from ground water sources and 29 percent from surface water sources. Of this amount, the public water supply uses 5.6% of the surface water and 6.9% of the groundwater. In most years precipitation is inadequate for maximum crop production. Irrigation is a common agricultural practice in the area with 74.4 % of the water withdrawal used for irrigation; 21.5% of this percentage comes from surface water and 52.9% from ground water. Perennial streams are few and widely spaced and not adequate for irrigation; hence the importance of area reservoirs.

The major groundwater sources in this area are from unconsolidated glacial till aquifers which are generally shallow and less than 1,000 feet in depth and bedrock aquifers that lie below the bedrock under the glacial till. The six major glacial till aquifers are the Choteau, Corsica, Geddes, Greenwood, Tower, and Delmont. Water in these unconsolidated deposits range from fresh water containing less than 1,000 milligrams per liter of total solids to slightly saline. The water is generally very hard and contains water of sodium-sulfate or calcium-sulfate types. These shallow till aquifers are low in sodium and high in salinity and generally are not suited for irrigation. The Choteau aquifer is the most widely used of the aquifers in the unconsolidated deposits supplying water to irrigation wells, public-supply wells, livestock, and domestic wells.

Approximately, 80 percent of all domestic, livestock, and public water-supply wells produce water from the bedrock aquifers. There are three major bedrock aquifers, the Dakota, Codell, and Niobrara. The Niobrara and Codell aquifers contain soft to moderately hard water of a sodium-bicarbonate-sulfate type that is slightly saline. The Dakota aquifer contains very hard water averaging 990 milligrams total solids per liter of water of a calcium-sulfate type that is slightly saline. The Codell is the major source of bedrock aquifer water and the Dakota formation is second.

The implementation of guidelines and restrictions proposed in the U.S. Environmental Protection Agency (EPA) *Safe Drinking Water Act* (SDWA) is making water quality issues increasingly important to rural water system operators and users. Water quality problems have been identified in glacial till and bedrock aquifers (U.S. Bureau of Reclamation 2003) among member entities in the adjacent Lewis & Clark Rural Water System District that included;

- iron concentrations above SDWA recommended limits (0.3 milligram/liter (mg/l));
- manganese concentrations above SDWA recommended limits (0.05 mg/l);
- sulfate concentrations above SDWA suggested limits (500 mg/l);
- total dissolved solids (TDS) concentrations above SDWA recommended limits (1,000 mg/l);
- nitrate concentrations that exceed 1 mg/l, indicating potential future nitrate

contamination problems; and
- radon concentrations exceeding 300 picocuries/liter.

Limited quantities and high amounts of dissolved solids and sulfates limit the use of the water from these aquifers as the level of total dissolved solids typically exceeds the Federal drinking water standards. However, the Missouri River water is of good quality and meets the national drinking water standards. Utilization of the Missouri River for drinking water has addressed the concerns regarding the low quality, vulnerability, and insufficient supply of water from the unconsolidated glacial till and bedrock aquifers. Currently, four rural water systems provide water to the counties within the project area; Aurora-Brule, Bon Homme-Yankton, Mid-Dakota, and Randall Community. Water from the Lewis and Clark Lake (the Missouri River) is an extremely valuable resource as it is suitable for domestic use, livestock use, and irrigation. The water has a low sodium hazard and a medium salinity hazard (USGS, Jorgensen 1971). The Missouri River and these rural water systems provide a high-quality, reliable domestic water supply to residents of Lewis & Clark Watershed Implementation Project area.

2.5 Water Bodies Studies and Current Status

The LCWIP was initially started at the request of local organizations who expressed concerns relative to the sediment loading of Lewis and Clark Lake. The original scope of the project was intended to identify areas and causes of sediment entering Lewis and Clark Lake, primarily from the watershed located east of the Missouri River. These concerns led to the Lewis and Clark watershed assessment project of 2003, with water quality data being collected in the watershed and from local lakes from 2003 to 2005.

The results of the assessment identified sediment, phosphorous, and coliform bacteria as sources of water contaminants. Segment 1, of the Project Implementation Plan (PIP) was implemented from 2006 to 2009 to address these pollutants. The PIP was later amended to include the remaining east river portion of the Lewis and Clark watershed, which added 747,000 additional acres to the project area in 2007.

Additional background information was needed to develop a more comprehensive monitoring plan and identify critical regions in the watershed and to develop a PIP targeting these areas for development of restoration alternatives. Thus, a steering committee was formed in 2007 with representative from eleven conservations districts and sponsoring federal and state agencies to help facilitate the efficient flow of cost effective Best Management Practices and make sure all needs were being met. Producer meetings and workshops were used to provide information on how producers might access Best management Practice design and installation. The west river portion of the Lewis and Clark Lake watershed and Lake Andes watershed were added to the project in 2008 at the request of local producers.

Segment 2 of Lewis and Clark Lake Watershed PIP was started in June of 2009 and completed in July 2011. This PIP was done in cooperation with the SDDENR and the State of Nebraska. The PIP was based on water quality data collected for this project and through water quality data collected throughout the Niobrara watershed in Nebraska (NDEQ 2005) as a part of their basin wide study conducted during the same time frame. The Lewis & Clark Project Strategic Plan will not address the watersheds west of the Missouri River, as those watersheds will be treated in a separate document.

Data from the Annualized Agricultural Nonpoint Source (AnnAGNPS) Model and Rapid Geomorphic Assessments (RGAs) identified approximately 500 animal feeding operations that contribute fecal coliform bacteria to tributaries in the watershed. One hundred of these were determined to be priority operations requiring the construction of animal waste management systems (AWMS) with accompanying nutrient management plans. High fecal levels were associated with land application of manure to include both excessive application rates and by not incorporating the applied manure after application.

The three primary sources of sediment loading were identified as (1) sheet and rill erosion of cropland, (2) degraded riparian areas, and (3) channel erosion. Degraded riparian areas and channel erosion were significant sources for sediment entering the reservoir. Eroded stream channels appeared to be related to several management practices:

- Season long grazing, overstocking, and grazing along stream banks
- Improper sizing and placement of road culverts
- Degraded rangeland

The *2012 South Dakota-DENR Integrated Report for Surface Water Quality Assessment* for the Lower Missouri River reported that dissolved oxygen (DO), high pH, and *Escherichia coli* and fecal coliform bacteria were the identified impairments listed within the LCWIP 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 Lower Missouri River Basin.

Table 2-2. Lewis & Clark 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*".)

AUID	LOCATION	ID	BASIS	USE	SUPPORT	CAUSE	SOURCE	CATEGORY	Priority
Lake Andes	**Charles Mix**	**L1**	**DENR**	**Fish/Wildlife Prop, Rec, Stock**	**FULL**			**5**	**YES-2**
SD-MI-L-Andes_01	**County**			**Immersion Recreation**	**NON**	**Oxygen, Dissolved**			
				Limited Contact Recreation	**NON**	**Oxygen, Dissolved**			
				Warmwater Semipermanent Fish Life	**NON**	**Oxygen, Dissolved**			
Corsica Lake	**Douglas**	**L6**	**DENR**	**Fish/Wildlife Prop, Rec, Stock**	**FULL**			**1***	**NO**
SD-MI-L-Corsica_01	**County**			**Immersion Recreation**	**FULL**				
				Limited Contact Recreation	**FULL**				
				Warmwater Permanent Fish Life	**FULL**				
Dante Lake	**Charles Mix**	**L8**	**DENR**	**Fish/Wildlife Prop, Rec, Stock**	**FULL**			**4A***	**NO**
SD-MI-L_Dante_01	County			**Immersion Recreation**	**FULL**				
				Limited Contact Recreation	**FULL**				
				Warmwater Permanent Fish Life	**NON**	**Oxygen, Dissolved**			
Geddes lake	**Charles Mix**	**L12**	**DENR**	**Fish/Wildlife Prop, Rec, Stock**	**FULL**			**5***	**YES-2**
SD-MI-L-Geddes_01	**County**			**Immersion Recreation**	**FULL**				
				Limited Contact Recreation	**FULL**				
				Warmwater Marginal Fish Life	**NON**	**Oxygen, Dissolved**			
						pH (High)			
Platte Lake	**Charles Mix**	**L16**	**DENR**	**Fish/Wildlife Prop, Rec, Stock**	**FULL**			**1**	**NO**
SD-MI-L-Platte_01	**County**			**Immersion Recreation**	**FULL**				
				Limited Contact Recreation	**FULL**				
				Warmwater Marginal Fish Life	**FULL**				
Lake Yankton	**Yankton**	**L23**	**DENR**	**Fish/Wildlife Prop, Rec, Stock**	**FULL**			**2**	**NO**
SD-MI-L-Yankton_01	**County**			**Immersion Recreation**	**NA**				
				Limited Contact Recreation	**NA**				
				Warmwater Semipermanent Fish Life	**FULL**				
Andes Creek	**Near Armour**	**R1**	**DENR**	**Fish/Wildlife Prop, Rec, Stock**	**NA**			**3**	**NO**
SD-MI-R-Andes_01_USGS	**South Dakota**			**Irrigation Waters**	**NA**				

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.

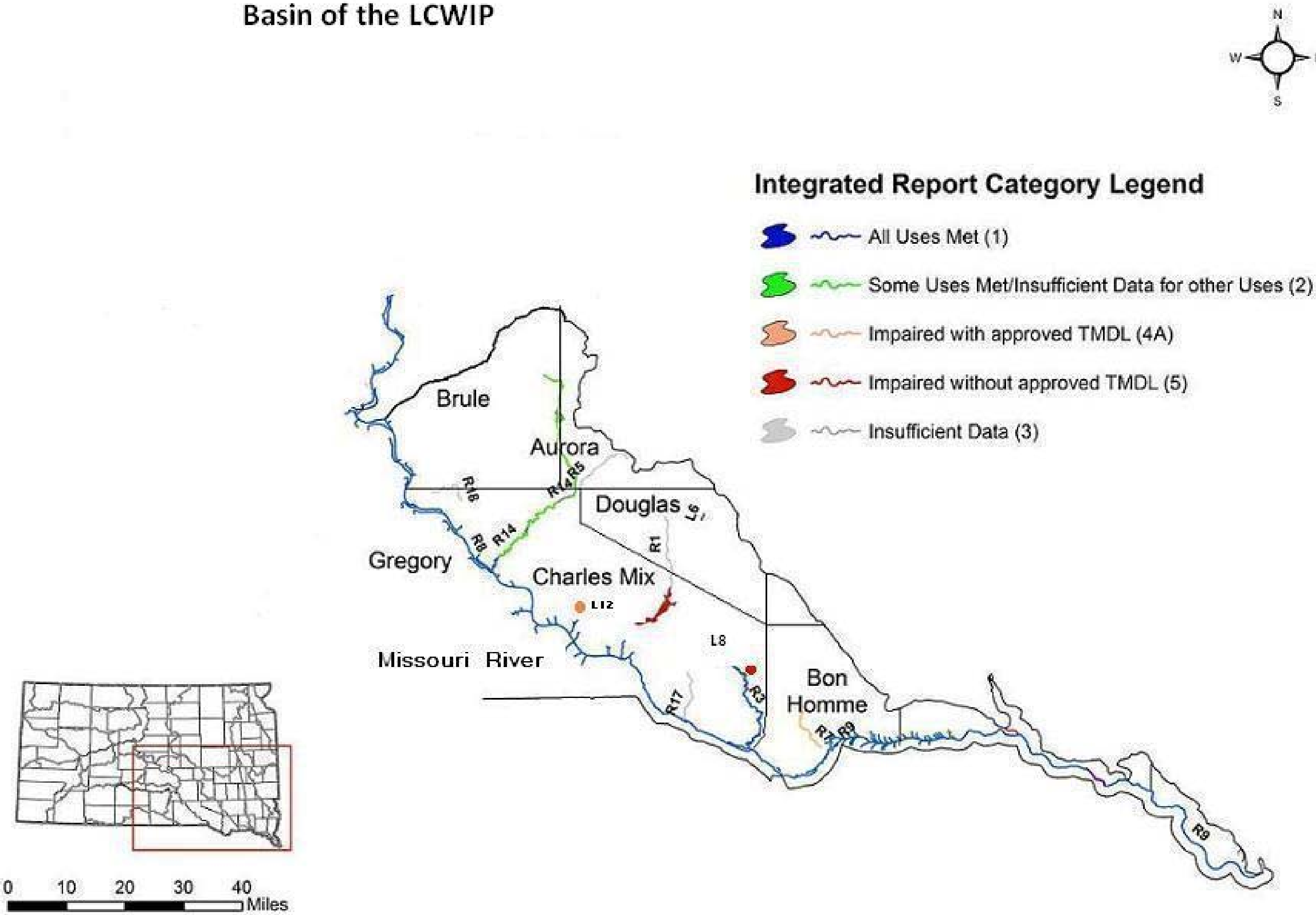
WATERBODY AUID	LOCATION	MAP ID	BASIS	USE	SUPPORT	CAUSE	SOURCE	EPA CATEGORY	303(d) Priority
Choteau Creek	Lewis & Clark	R3	DENR	Fish/Wildlife Prop, Rec, Stock	FULL			1*	NO
SD-MI-R-Choteau_01	Lake to S34		USGS	Irrigation Water	FULL				
	T96N-R63W			Limited Contact Recreation	FULL				
				Warmwater Marginal Fish Life	FULL				
East Fork Platte Creek	Near Aurora	R5	USGS	Fish/Wildlife Prop, Rec, Stock	INS			3	NO
SD-MI-R-East_Fork	Center			Irrigation Waters	INS				
_Platte_01_USGS	South Dakota								
Emanuel Creek	Lewis & Clark	R7	DENR	Fish/Wildlife Prop, Rec, Stock	INS			1	NO
SD-MI-R-Emanuel_01	Lake to S20			Irrigation Waters	INS				
	T94N-R60W			Limited Contact Recreation	NON	Escherichia coli			
						Fecal Coliform			
				Warmwater Marginal Fish Life	NON	Total Suspended Solids			
Missouri River	Fort Randall Dam	R9	DENR	Commerce & Industry	FULL			1	NO
Lewis & Clark Lake	to		USGS	Domestic Water Supply	FULL				
SD-MI-R-Lewis_Clark_01	North Sioux City			Fish/Wildlife Prop, Rec, Stock	FULL				
				Immersion Recreation	FULL				
				Irrigation Waters	FULL				
				Limited Contact Recreation	FULL				
				Warmwater Permanent Fish Life	FULL				
Platte Creek	Near Platte	R14	USGS	Fish/Wildlife Prop, Rec, Stock	FULL			2	NO
SD-MI-R-Platte_01_USGS	South Dakota			Irrigation Waters	FULL				
				Limited Contact Recreation	NA				
				Warmwater Permanent Fish Life	FULL				
Slaughter Creek	Missouri River	R17	DENR	Fish/Wildlife Prop, Rec, Stock	INS			3	NO
SD-MI-R-Slaughter_01	to			Irrigation Waters	INS				
	Headwaters								
Snake Creek	Headwaters	R18	USGS	Fish/Wildlife Prop, Rec, Stock	INS			3	NO
SD-MI-R-Snake_01_USGS	to			Irrigation Waters	INS				
	Academy Lake								

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 2-3: Summary of Lewis & Clark Watershed Water bodies Listed as 303(d) Impaired, Beneficial Use Impaired, and Cause. Data from "*The 2012 SD Integrated Report for Surface Water Quality Assessment*".

Water Body Impaired	Beneficial Use Impaired	Listed Cause of Impairment
Lake Andes - L1	Immersion Recreation	Oxygen, Dissolved
	Limited Contact Recreation	Oxygen, Dissolved
	Warmwater Marginal Fish Life	Oxygen, Dissolved
Dante Lake - L8	Warmwater Permanent Fish Life	Oxygen, Dissolved
Geddes Lake - L12	Warmwater Semipermanent Fish Life	Dissolved Oxygen
		pH (High)
Emanuel Creek - R7	Limited Contact Recreation	*Escherichia coli*
		Fecal Coliform

Figure 2-5. Locations of Identified Water Bodies in the Lower Missouri River Basin of the LCWIP



2.6.0 Description of the Impairments for 303(d) Water Body Listings in the Lewis & Clark Watershed Project

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.

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.

A pH range of 6.0 to 9.0 appears to provide protection for the life of freshwater fish and bottom dwelling invertebrates. Table 2-4 below gives some special effects of pH on fish and aquatic life.

Table 2-4. Effects of pH Levels and Minimum/Maximum Temperature Tolerances

Minimum	Maximum	Effects of pH and Minimum/Maximum Levels
3.8	10.0	Fish eggs could be hatched, but deformed young are often produced
4.0	10.1	Limits for the most resistant fish species
4.1	9.5	Range tolerated by trout
4.3	---	Carp die in five days
4.5	9.0	Trout eggs and larvae develop normally
4.6	9.5	Limits for perch
5.0	---	Limits for stickleback fish
5.0	9.0	Tolerable range for most fish
---	8.7	Upper limit for good fishing waters
5.4	11.4	Fish avoid waters beyond these limits
6.0	7.2	Optimum (best) range for fish eggs
1.0	---	Mosquito larvae are destroyed at this pH value
3.3	4.7	Mosquito larvae live within this range
7.5	8.4	Best range for the growth of algae

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 both 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* Bacteria

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.

2.7.0 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 Lewis & Clark Watershed project 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 four water bodies listed as 303(d) impaired in the 2012 SD DENR Integrated Report; Lake Andes, Dante Lake, Geddes Lake, and Emanuel Creek. There were no point sources of pollutants of concern in the Dante Lake watershed (SDDENR 2006). Since there were no municipalities in the watershed, cattle were the most probable source of fecal coliform in the tributary, based on previous assessments in other similar watersheds. Geddes Lake was also determined to have no point source of pollutants in its watershed (SDDENR 2007).

The Lake Andes report had identified one permitted point source discharge located in the watershed (SDDENR 2010). SDDENR has issued a Surface Water Discharge Permit to the Town of Corsica for one outfall from their wastewater treatment facility. This outfall, located approximately 20 miles north of Lake Andes, discharges to Andes Creek approximately 2-3 times per year for periods of approximately 1-2 weeks. Due to low frequency and duration of discharges and the distance of the outfall from Lake Andes, this point source was not considered a significant source of phosphorus.

The SDDENR Emanuel Creek TMDL (2009) document reported that there were no municipal or other point source discharges to Emanuel Creek. The Waste Load Allocation for this TMDL was zero. Septic systems were determined to be an insignificant contributing source to the fecal loads in the creek based on the following information. The human population of Emanuel Creek from the 2000 census was estimated at 1,250 people, or 6.5 per square mile. When included as a total load in the watershed, human produced fecals accounted for 6% of all fecal coliforms produced. These bacteria should all be delivered to a septic system, which if functioning correctly would result in no fecal coliforms entering the stream. Septic systems failure rates were estimated at 3% and even assuming the complete pass through of bacteria by failing systems and direct delivery to the stream, the contributions from septic systems were estimated at less than 0.17% and considered negligible.

The conclusions repeated by other TMDL watershed studies in South Dakota on potential point sources of loadings also did not identify human fecal bacteria as being significant; James River, Yankton County (SDDENR 2011); Alexandria (SDDENR 2011) Dawson Creek study (SDDENR 2011). The 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**.** The estimation of 0.17% loading delivery to Emanuel Creek is similar to the percent of human contamination of 0.3% found in the James River (SDDENR 2011) and the North and South Forks of the Yellow Bank River (SDDENR 2012) at 0.3% and 0.2%, respectively.

2.7.2 Non Point Sources of Impairment

Non point sources of impairment have not been identified for all designated water bodies in the Lewis and Clark Project area 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 Corsica Lake, Platte Lake, Choteau Creek, and the Missouri River.

The water bodies of Lake Yankton, Andes Creek, Platte Creek, East Fork Platte Creek, Slaughter Creek, and Snake Creek were reported in the 2012 SD-DENR IR to have insufficient water quality data to ascertain whether they met the supporting criteria of 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 LCWIP have concluded that agricultural activities were the major nonpoint source of excessive nutrients to the watershed and that all 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 High pH – Geddes Lake, L12

Geddes Lake is listed 303(d) as High pH impaired for the support of Warm Water Semi-Permanent Fish Life in the 2012 SDENR-IR. Geddes Lake is a 70 acre lake located on Pease Creek in southwest Charles Mix County, South Dakota, approximately four miles south of the town of Geddes. The lake provides the recreational values of boating, fishing, and swimming and has a public access boat ramp. The lake has an average depth of 3.2 feet, a maximum depth of 12 feet, and a holding capacity of approximately 70 acre-feet of water. Geddes Lake is generally well mixed with few, if any, periods of stratification during the summer. The outlet for the lake empties into Pease Creek, which eventually reaches the Missouri River in Charles Mix County, South Dakota. The Geddes Lake 119 acre watershed is characterized by well-drained, nearly level to undulating, silty soils on uplands. The watershed is comprised of 78.8% cropland and 20.8% rangeland. Forest (farmstead woodlots), urban areas, and water make up the remainder of the watershed. Approximately 47 feedlots were located in the watershed (SDDENR 2007). Data collected from 1989 to 2000 indicate the lake that is hyper-eutrophic and deteriorating due to excessive nutrients and algae growth. Reductions in nutrient and sediment loadings to Geddes Lake are needed to help improve the condition of the lake.

The Trophic State Index (TSI) allows a lake's productivity to be compared to other lakes. Higher TSI values correlate with higher levels of primary productivity. A comparison of Geddes Lake to other lakes in the Northwestern Glaciated Plains Ecoregion shows that a high level of productivity is common for the ecoregion. Geddes Lake had a slightly higher than average level of productivity, with a TSI of 77.13 during the growing season; which gave Geddes Lake a hyper-eutrophic status. The mean Secchi chlorophyll-*a* TSI value for the ecoregion was 76.06.

The beneficial use of Warm Water Marginal Fish Life for Geddes Lake 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. 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 (>200 *mg/l* (milligrams/liter)) represents considerable buffering capacity and will reduce the effects of both photosynthesis and decay in producing large fluctuations in pH. The values recorded during the assessment remained within these limits except for surface and bottom samples taken at one sample. The chlorophyll-*a* concentration at one site was very high (159 µg/l) and the lake was supersaturated with dissolved oxygen (15.7 milligram/liter. It was assumed that the algae influenced pH even though the relationship between growing-season chlorophyll-*a* versus pH was weak. The composite algae sample taken indicated very high algae concentrations of mostly blue-green algae and diatoms. 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.

The total nitrogen (TN) to total phosphorus (TP) ratios for Geddes Lake ranged from 2.84:1 to 9.67:1 and averaged 6.44:1. The ideal ratio of nitrogen to phosphorus for aquatic plant growth is 10:1. Ratios higher than 10 indicate a phosphorus-limited system. Those that are less than 10:1 represent nitrogen limited systems. The data indicate a nitrogen-limited system. The most limiting nutrient, in this case nitrogen, should be reduced in the system to get the greatest response for a decrease in algae. However, nitrogen is difficult to control and certain blue-green algae may obtain or "fix" nitrogen from the atmosphere. Phosphorus, which is in abundance, is often controlled instead.

The BATHTUB model (U.S. Army Corps of Engineers eutrophication response model) was run for Geddes Lake. It was determined that a 92% reduction in tributary phosphorus concentration was needed to reach the target Secchi chlorophyll-*a* TSI value of 63.4. However, it is unlikely that a 92% reduction of tributary phosphorus concentrations can be attained without undue economic strain on the local landowners. This target was adjusted up to a median growing season Secchi chlorophyll-*a* TSI of 76.3, to reflect a more realistic view of what could be done in the watershed while still supporting the lakes beneficial uses. The monitoring data and the BATHTUB model runs indicated that the lake sediment was a phosphorus sink rather than a source. The sediment removal for nutrient control was not recommended until further evidence is gathered to quantify internal phosphorus loading and indicate it is a problem. However, the study determined that nearly 56% of the total lake depth is occupied by sediment. Although stopping or slowing sedimentation through the use of watershed BMPs is an obvious strategy, it was clear that removing sediment from a lake was an option to extend the useful life of the lake and maintain lake conditions related to lake depth and volume. Secondary benefits of sediment removal might be the removal of phosphorus-rich sediment that may release nutrients to the lake and improved dissolved oxygen through the removal of organics that decompose and create oxygen deficits.

A 30% reduction in phosphorus was determined to be the best attainable level of control while still supporting the lakes beneficial uses. It was estimated that a combination of feedlot improvement, use of no-till, converting crop to pasture or CRP, and decreasing fertilizer usage could achieve the 30% reduction in phosphorus. Based on a 30% reduction in phosphorus from watershed improvements, the target Secchi chlorophyll-*a* TSI should be changed from 63.4 to 76.3 when watershed improvement BMPs are the only lake restoration strategy. However, the original Secchi chlorophyll-*a* TSI target of 63.4 can still be used when in-lake restoration efforts such as phosphorus precipitation or algaecides are used. The study concluded that these in-lake strategies have a better chance of reaching the 63.4 target than the proposed watershed restoration practices.

2.7.2.2 Dissolved Oxygen – Lake Andes L1, Geddes Lake L12, and Dante Lake L8

L1 - Lake Andes:

Lake Andes is a shallow, prairie lake located east of the town of Lake Andes in northern Charles Mix County, South Dakota. Lake Andes was a natural lake in a bedrock valley buried by mostly glacial till. A high water elevation was established for Lake Andes in 1922, via the construction of an artificial outlet, resulting in a maximum pool depth of approximately 11 feet, at which the surface area of the lake is approximately 8.1 square miles. Other structures were constructed for the management of lake volume, including a dike and control structure constructed in 1936 on Owens Bay. In addition, two county roadway dikes were constructed in 1938-39 that divide the lake into three units.

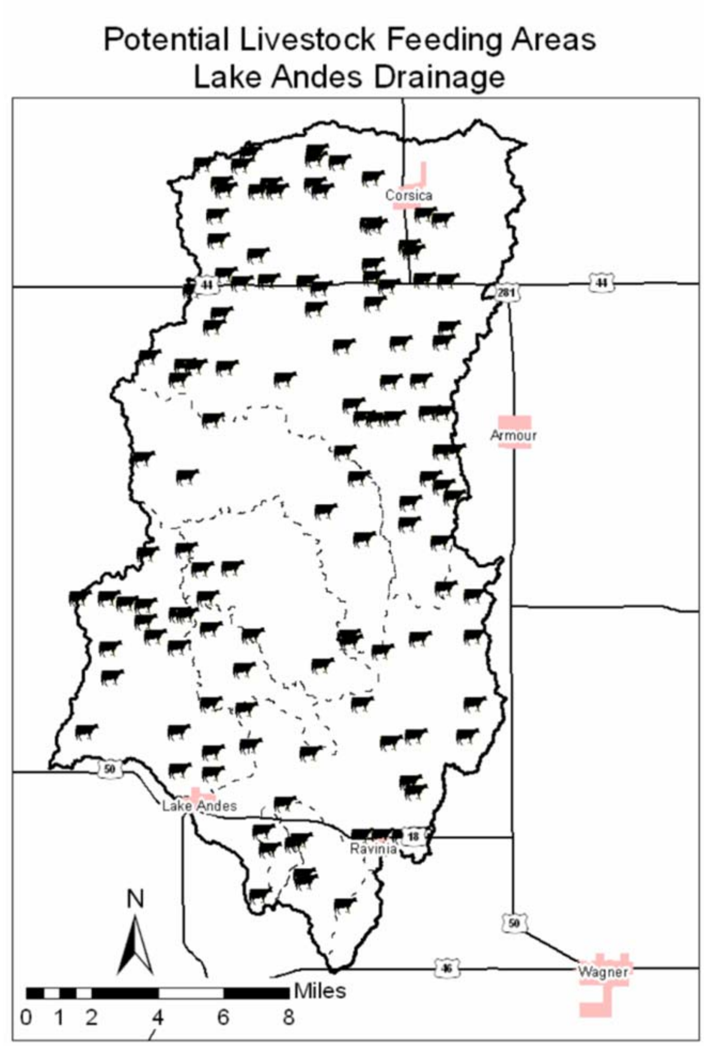
The Lake Andes water supply almost entirely originates from the 235.1 square miles of watershed runoff which is 90% agricultural land. It also has a minor source of water originating from an artesian well. Streams draining to Lake Andes are characterized as ephemeral and frequently experience periods of no flow. During the project period, May 2000 to May 2001, all streams draining the Lake Andes watershed were intermittent and flowed during rainfall runoff events. Lake Andes is occasionally completely dry. Based on historic accounts, the lake completely dried up approximately every 14 years prior to the creation of the outlet canal and approximately every 11.5 years after the completion of the outlet canal (SD DENR 1992). Nonpoint source nutrient loads from the Lake Andes watershed were reported to likely originate from a combination of agricultural uses, including row crop farming, grazing livestock, and animal feeding areas, as well as natural sources such as the leaching of phosphate-bearing minerals and organic matter decomposition.

Excessive nutrient loading to Lake Andes has likely contributed to a higher oxygen demand and resulted in seasonally low DO concentrations. Critical conditions occurred both during winter and summer time periods. Low winter temperatures cause the lake surface to freeze and snow to accumulate on the ice which does not allow light penetration to the lake water below the ice. Lack of light can cause massive algae and aquatic plant die-offs resulting in oxygen depletion due to decaying algae and fish kills. The summer months are a critical time period due to seasonal differences in precipitation patterns and land uses. Typically, croplands are fertilized and livestock are allowed to graze along the streams during the summer months. High-intensity rain storm events are common during the summer and, combined with a peak in nutrients, produce a significant amount of nutrient load due to wash-off from the watershed. A primary water quality goal for Lake Andes is to maintain DO concentrations ≥5 mg/l (milligram/liter). Because DO concentrations were found to be negatively correlated with lake Total Phosphorous (TP) concentrations (SD DENR 1992), a secondary goal of ≤0.2 mg/l TP concentration was established to increase DO levels and sustain the beneficial uses of the lake. Based on lake modeling results, this lake phosphorus concentration could be achieved by reducing TP loads from the watershed by approximately 50%.

External nutrient loading to Lake Andes and in-lake nutrient concentrations are directly related. The predicted in-lake concentrations of TP decreased as modeled stream loads decreased. Streams draining the Lake Andes watershed are characterized as ephemeral, flowing primarily during precipitation-driven runoff. Stream flow gaging site data collected during the South Central Lakes Watershed Assessment project displayed seasonal variation. Highest stream flows typically occur in the spring and stream flows typically ceased during the fall and winter months. Based on model results, a reduction in watershed nutrient loads of approximately 50% would be required for the area-weighted mean phosphorus concentration in Lake Andes to be decreased from 0.39 mg/l to 0.20 mg/l.

Livestock feeding areas were identified as possible sources of excessive nutrient loads to Lake Andes tributaries. Potential livestock feeding area locations were delineated using Geographic Information Systems (GIS), including aerial photographs of the watershed area. A total of 127 feeding areas were identified from the GIS survey as shown in Figure 2-6.

Figure 2-6. Animal Feeding Operations in the Lake Andes Drainage Basin



Restoration Strategy Recommended for Lake Andes

Best Management Practices can control the delivery of nonpoint source pollutants to receiving waters by minimizing pollutants available through source reduction, retarding the transport and/or delivery of pollutants, or by intercepting the pollutant before or after it is delivered to the water through chemical or biological transformation. The recommendations in the TMDL report were based on known best management practices. Management of nutrient loads from the watershed should be prioritized and ideally implemented prior to in-lake management practices. The Lake Andes TMDL recommended the following BMP's be implemented:

- **Riparian Zones**
  Proposed BMPs to address riparian area degradation include livestock use exclusion, stream bank stabilization and protection, and reseeding or manual planting of native plant species.

- **Livestock Grazing**
  Management of livestock should include prescribed grazing, constructing fences or other barriers to control concentrated livestock access to riparian areas, livestock crossing structures, alternative water supply, seasonal access, rotational grazing to reduce the intensity and duration of access to riparian zones and uplands.
- **Animal Nutrient Management Systems**
  Numbers or density of feeding areas did not correlate well with nutrient or sediment loads measured in the streams. High nutrient and sediment export coefficients were observed for several subwatersheds.
- **Cropland Conservation**
  Conservation practices that could be implemented on croplands are cover crop plantings, conservation crop rotation, residue management, reduced fertilizer application, and contour farming. These practices can be used to reduce sheet and rill erosion, reduce soil erosion from wind, maintain or improve soil organic matter content, and reduce the transport of sediment and nutrients.
- **Wetland Restoration**
  Wetlands benefit water quality due to natural processes as wetland plants assimilate nutrients, reducing concentrations in receiving waters. It was recommended that wetlands be restored and maintained, especially those on/near inlet streams, to reduce phosphorus loads from the watershed.
- **Lake Management**
  Several lake management alternatives for Lake Andes would include selective dredging with land-based removal of sediment and water level manipulation. Selecting dredging would remove nutrient-rich sediment, potentially slowing internal nutrient loading, and provide additional habitat for fish and other aquatic organisms. Lake management of water levels would allow for natural establishment of emergent and submersed aquatic vegetation in the littoral zones. Heavy stands of emergent and submerged macrophytes have been linked to a distinct reduction of phytoplankton. Macrophyte colonization also aids in stabilization of sediments in the littoral zone, provides habitat for fish and invertebrates, and maintains water clarity

L12 - Geddes Lake

Geddes Lake was discussed in section 2.7.2.1 above for its 303(d) listing for high pH; however, the lake is also listed for low Dissolved Oxygen (DO). The SD DENR TMDL report (2007) showed dissolved oxygen concentrations in Geddes Lake remained above the state standard (5 mg/l) during the spring and fall but nearly 24% of the DO measurements taken during the summer and early fall months were less than 5 mg/l. It was determined that bacterial decomposition of organic matter depleted oxygen levels near the bottom of the lake.

The low DO readings and high pH levels 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 macrophyte's acts to increase the pH of water. Conversely, the respiration and decomposition of this same organic matter reduced the DO levels.

Geddes Lake was not found to be a phosphorous-limited nutrient system, but the sediment in Geddes Lake was found to be a phosphorous sink with 56% of the total lake depth occupied by sediment. Control of the incoming phosphorous nutrient was determined to alleviate the low dissolved oxygen episodes in the lake. The anoxic factor (AF) model quantified duration days and extent of lake oxygen depletion, as positively correlated with average annual local phosphorous concentrations. Computer modeling show phosphorous and nitrogen nutrients control all trophic state indicators related to oxygen and phytoplankton in lakes and reservoirs. SD DENR concluded that the nutrient levels affected dissolved oxygen concentrations and algal populations in Geddes Lake. Thus reduction in nutrient (phosphorus) loads to the lake would improve dissolved oxygen concentrations and overall water quality in Geddes Lake. Excessive amounts of phosphorus produce algae and aquatic plants in large quantities and when these algae die, bacteria decompose them and use up oxygen resulting in low DO levels. A 30% reduction in phosphorus, by the use of agricultural BMPs, was determined to be the best attainable level to control phosphorous input to the lake and reduce algae and aquatic plants and the resultant oxygen loss. These BMPs were discussed in section 2.7.2.1.

Other direct alternatives to aid in increasing DO levels were aeration (adding oxygen) and circulation during the winter months; algicides and herbicides to control nuisance algae and aquatic macrohytes; and sediment removal which would increase lake depth and volume and remove phosphorous-rich sediments.

L8 - Dante Lake

Dante Lake is a small 18.7 acre artificial impoundment on Dante Creek which is a tributary of Choteau Creek. The lake is located approximately 2 miles north of the town of Dante near the southeastern boundary of Charles Mix County, South Dakota. The reservoir has an average depth of 11 feet and a maximum depth of 23 feet. Dante Lake has 0.7 mi of shoreline and holds 194 acre-feet of water. An unnamed creek (henceforth, Dante Creek) is the primary tributary to Dante Lake. The watershed is composed of 2,844 acres of mostly cropland with about a fifth of the acreage used for grazing. The level to rolling uplands of the watershed and surrounding area are cropped to sunflowers, wheat, millet, and barley. It is estimated that 78% of the land in the watershed is cropland, 20% rangeland and pasture, and 2% roads and residences. The riparian areas are usually grazed. The past water quality data as well as data collected during the assessment (SDDENR 2006) indicated that there is a long-term trend in declining water quality as a result of nutrients, sediment, and aquatic weed and algal growth.

Creeks often lose nutrient and sediment loads carried by their flowing water as they pass through impoundments. This was evident in Dante Lake as considerable phosphorus and nitrogen was retained in the small reservoir. Those nutrients were utilized by dense aquatic weed beds and large algae populations often present in Dante Lake. Dante Lake is a highly eutrophic lake with a high rate of algae and aquatic weed production. Decomposition of this organic material results in low oxygen concentrations, particularly in the deeper strata of the lake (hypolimnion). As algae photosynthesize during the day, they produce oxygen, which raises the concentration in the surface layers of the water column receiving sunlight (epilimnion). When photosynthesis ceases at night, respiration utilizes the available oxygen causing a decrease in concentration. These severe hot and dry conditions prevailed over the entire summer in Dante Lake during the assessment. The poor oxygen environment monitored in Dante Lake during this project was attributed to large amounts of accumulated oxidizable organic matter from previous years and periodic inputs of organic material in the form of livestock waste from watershed pastures and/or cattle grazing near Dante Creek.

Dante Lake is considered to be a macrophyte (aquatic rooted plants) dominated lake with large densities of submerged macrophytes. The majority of macrophyte growth begins in the late spring to early summer and continues into the fall. These high densities of submerged macrophytes in Dante Lake require a large quantity of both total and dissolved phosphorus for growth. This limited the amount of total phosphorus available during the summer months for algae growth and reproduction.

The correlation of temperature with DO was a very important factor in the lake, as when water temperature increases during the summer months, its ability to hold oxygen in solution declines. The extreme hot conditions and lack of rainfall for water inflow into the lake prevailed in Dante Lake over the entire summer during the assessment. When photosynthesis ceased at night, respiration utilized the available oxygen causing a decrease in concentration. In highly eutrophic lakes such as Dante, with a high rate of algae and aquatic weed production, subsequent decomposition of this organic material results in low oxygen concentrations, particularly in the deeper strata of the lake (hypolimnion). The study concluded that nutrients affect dissolved oxygen concentrations and algal populations in Dante Lake. The reduction in nutrient phosphorus loads to the lake may improve dissolved oxygen concentrations and overall water quality in Dante Lake. The approach to treat the sources of nutrients with Best Management Practices (BMPs) that reduce or eliminate nutrient loads to impaired water bodies is consistent with accepted watershed strategies to treat sources rather than symptoms.

The watershed of Dante Lake was examined using the AnnAGNPS model, which identified approximately 1,145 acres of critical areas for potential phosphorus loading. These cells represent 40.9 percent of the entire Dante Lake watershed upon which BMPs may need to be applied. Tributary loading for total nutrient and sediment loads for Dante Lake were calculated using FLUX, an Army Corps of Engineers eutrophication model. Targeted reductions for specific parameters and mean Trophic State Index (TSI) values were modeled using the BATHTUB reduction model. It was determined that hypolimnetic aeration may quickly improve organic matter reduction from anoxic, slow organic conversion, to a rapid organic conversion in the presence of oxygen. The installation of a mechanical aeration device in concert with implementation of tributary and in-lake BMPs will meet warm water permanent fish life propagation numeric standards for dissolved oxygen (> 5.0 mg/l) throughout the year.

No enduring oxygen/temperature stratification was identified in the lake. Dante Lake may be too shallow to maintain prolonged summer stratification. The temperature profiles showed a well-mixed water column from late spring to fall. This uniformity was also reflected by the DO profiles. Oxygen levels remained uniformly low (< 5 mg/l) throughout the summer from surface to bottom.

Nitrogen to Phosphorous (N:P) ratios for Dante Lake ranged from 6:1 to 50:1 with an average of 22. The lake was phosphorus-limited for most of the assessment year, even though elutriate analysis showed the lake sediments contained high concentrations of phosphorus. Due to in-lake stratification, sediment phosphorus was unavailable to the water column for algal growth during the summer. The report recommended placing a mechanical aeration device in the lake to breakup stratification. This would increase total phosphorus concentrations and algal growth producing increased surface water dissolved oxygen concentrations during the summer when little or no runoff occurs. Current data indicate that a 6.4 percent reduction in total phosphorus can be achieved in this watershed to meet the TMDL goal of a mean in-lake TSI of 63.86.

The average sediment depth in Dante Lake was 2.3 feet. Sediment depths ranged from 0.5 to 5.0 feet, with the majority of the sediment in the upper one-half of the lake . Seasonal loadings of sediment at Dante Lake occurred primarily during snowmelt and spring rain events and accounted for 97% of the sediment load during the project. Sediment volume in the lake was about 11.4% of the original lake volume. That sediment volume was determined to not appear to pose a threat to the useful life of the reservoir in the foreseeable future.

There were no significant point source contributions in this watershed. The nonpoint source allocations for phosphorous were assumed to be runoff from cropland and range/pastureland. Phosphorous reductions could be achieved through modifications to the critical cells identified in the watershed by AnnAGNPS. The TMDL report listed the following practices needed to meet 303(d) listing criteria; the conversion of a portion of the wheat and corn fields to grass, installation of a lake mechanical aeration system for use during the summer months, stream bank stabilization, cattle restriction to water, alternative watering, grazing management, fertilizer reduction, and in-lake treatment with aluminum sulfate.

2.7.2.3 *Escherichia coli* – Fecal Coliform. Emanuel Creek, R7.

Emanuel Creek is listed as 303(d) impaired for *Escherichia coli* and 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.

Emanuel Creek drains 120,000 acres in Bon Homme County, South Dakota, just west of the town of Tyndall and discharges to Lewis and Clark Lake. During the Emanuel Creek watershed assessment (SDDENR 2009), it was determined that the creek experiences periods of degraded water quality due to fecal coliform bacteria. The land use in the watershed is predominately agricultural consisting of cropland (61%) and grazing (32%), with the remaining portions of the watershed composed of water and wetlands (2%), roads and housing (4%), and forested lands (1%).

Water quality data on Emanuel Creek was collected from this watershed during the years 2003 to 2005. The purpose of the study was to locate and document sources of point and nonpoint source pollution in the watershed through water quality sampling and stage and discharge measurements. The study was completed for Emanuel Creek and resulted in Total Daily Maximum Load (TMDL) limits set for the identified impairments (SDDENR 2009).

The Annualized Agricultural Nonpoint Source Pollution Model (AnnAGNPS) was completed on each of the feeding areas in the watershed. Fecal decay rates were also used for targeting during the implementation phase. Stream miles and travel times were estimated through the use of AnnAGNPS to support the fecal decay rate equations. The Aquarius program was used to generate simulated discharge data using the 20 years of flow data from the long-term gauge at Choteau Creek.

There were an estimated 97 animal feeding operations in the Emanuel Creek Watershed, many of which are contributors to the bacteria load, particularly during runoff events. All 97 animal feeding areas were analyzed using the AnnAGNPS model. Based on the National Agricultural Statistics report, approximately 40% of the cattle present in the watershed were found in feedlots. Feedlots included any type of livestock confined to un-vegetated areas including wintering operations. Livestock on grass encompassed all remaining livestock within the watershed. The majority of pigs in the watershed were assumed to be in some type of confined feeding area. Table 2-5 lists the sources of fecal coliform by groups.

Table 2-5. Bacteria Source Allocations for Emanuel Creek Watershed, SDDENR 2009.

Bacterial Source Allocations for Emanuel Creek		
Sources	**Percent**	
Feedlots	**41.7**	
Livestock on Grass	**54.9**	
Wildlife	**3.5**	

Approximately 93% of the land use in the watershed is agricultural; therefore, the majority of the TMDL load has been allocated to these nonpoint source loads in the following stream flow load allocations. During the high flow regime, a 99% reduction in fecal coliform bacteria from anthropogenic sources (confined livestock, and those on pasture) is necessary to reach the target of a fecal concentration of less than 1000 colonies/ 100 milliliters. In the middle flow regime, a reduction of 23% is required to meet the TMDL goal. Reducing the highest samples below the chronic standard provide assurance that both standards will be met.

Other water quality studies in the adjacent James River watershed on Dawson Creek, Pierre Creek, Firesteel Creek, and the James River in Yankton County have reported similar findings on fecal bacterial sources. These reports found that fecal decay rates suggested that sources within 6.2 miles of the listed segments were most likely to contribute the largest portions of the load. Bacteria migration from feedlots and upland grazing was occurring during major storm run-off events (high flows), while the direct use of the stream by livestock was the source of bacteria at low flows. The relatively high fecal coliform concentrations and associated exceedance rate of both acute and chronic standards across flow zones suggested that the bacterial source was continual. Livestock grazing in the riparian zone was also identified as an additional source of fecal coliform and *E. coli* bacteria loading to water bodies. The majority of grassland pastures are located in close proximity to the stream corridors, which increases the chances that fecal material may be washed off into the streams. Livestock grazing in the riparian zone was identified as the main source of bacterial loading to Dawson Creek.

3.0 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. The Nonpoint Source Measures will be described and referenced to

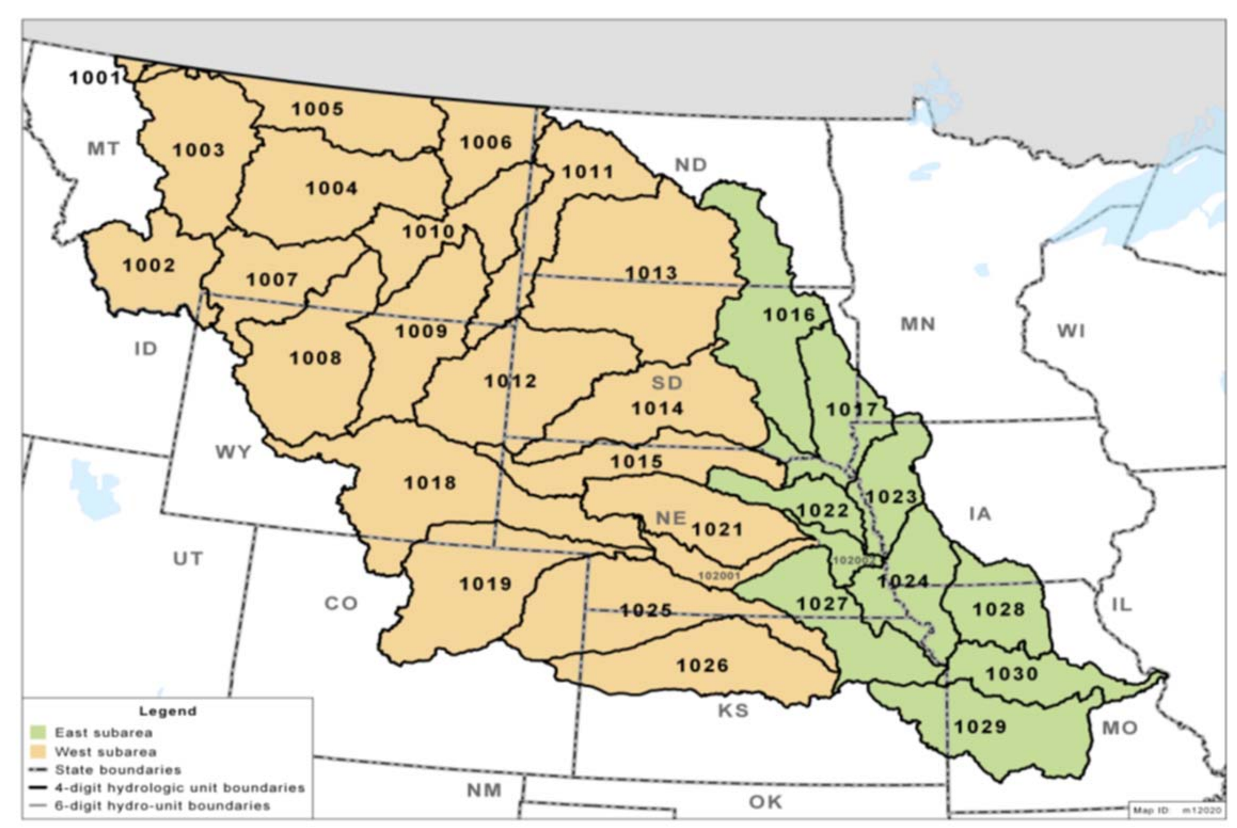
Best Management Practices (BMPs) as defined by the Natural Resources Conservation Service (NRCS), USDA; however, any related NRCS practices may be added to supplement these identified BMPs.

Table 3-1. Estimated BMP Reduction Efficiencies by Pollutant Type Evan et al. 2003/2008.

BMP SYSTEM/TYPE	NRCS PRACTICE CODE	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 original goals of CEAP were to estimate conservation benefits for reporting at the national and regional levels and to establish the scientific understanding of the effects and benefits of conservation practices at the watershed scale. The scope was expanded as CEAP evolved to provide research and assessment on how to best use conservation practices in managing agricultural landscapes to protect and enhance environmental quality. The studied subregions included in the LCWIP are the Missouri-Big Sioux-Lewis-Clark Lake (code 1017) and the Missouri-White River-Fort Randall Reservoir Basin (code 1014). Subregion code 1017 does include lands on both the west and east sides of the Missouri River. Lands west of the river generally contain more rangeland, while lands east of the river contain more cultivated cropland as subregion 1017 (East River) has approximately 67 percent of the watershed in cultivated cropland and subregion 1014 (West River) has 21%. Watersheds with similar land uses east of the Missouri River are the Missouri-Little Sioux River Basin (code 1023), with 78 percent cropland, and the James River Basin (code 1016), with 53 percent.

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



The CEAP study used the computer model HUMUS/SWAT to evaluate the transport of water, sediment, pesticides, and nutrients from the land to receiving streams and route the flow downstream to the next watershed and ultimately to estuaries and oceans. Conservation practices in use on cultivated cropland in 2003-06, including land in long-term conserving cover, have reduced sediment, nutrient, and atrazine loads delivered to rivers and streams from cultivated cropland sources per year, on average, by;

- 76 percent for sediment;
- 54 percent for nitrogen;
- 60 percent for phosphorus, and
- 36 percent for atrazine.

A Field-Level Cropland Model called APEX was used to simulate the effects of conservation practices at the field level. Computer model simulations show 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.

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

A Waste Storage Facility (313) 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.

Approximately 500 animal feeding operations that contributed fecal coliform bacteria to tributaries in the east river portion of the Lewis and Clark Lake Watershed were identified during the project assessments (Knippling 2012). Of this total, over 100 operations were determined to be priority operations by AnnAGNPS analysis requiring the constructions of animal waste management systems with an accompanying nutrient management plan to reduce the fecal load. Knippling reported (2009 Segment 1) that with the construction of 19 AWMS nitrogen was reduced by 126,148 pounds per year and phosphorous by 27,337 pounds per year. An additional 12 AWMS were completed under LCWIP Segment 2 that further reduced nitrogen by 138,160 pounds per year and phosphorous by 30,687 pounds per year.

The Emanuel Creek TMDL (SDDENR 2009), a subwatershed in the LCWIP, reported that 41.9% of the fecal source allocation was from cattle in feedlots. 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:

- The adjacent Lower James River watershed indicated that the most likely sources of the nutrient loading and fecal coliform bacteria were AFOs/CAFOs and intense season long grazing (SDDENR James River, Yankton 2011). The analysis of Firesteel Creek found that if all 116 animal feeding areas with an AGNPS non-corrected rating over 30 were treated, the soluble phosphorus concentrations delivered to Lake Mitchell would be reduced by approximately 51% which would reduce in-lake phosphorus by 17 percent (SDDENR, Firesteel Creek 1997; Kringen 2010).

- Study results in the Upper Minnesota River watershed indicated that the most likely sources of the nutrient loading and bacterial contamination were animal feeding operations and cattle grazing adjacent to water bodies. The analysis in Blue Dog Lake (SDDENR 1999) found that if the animal feeding areas, with an AGNPS rating over 55 were treated, the phosphorus load would be reduced by 17 percent and the nitrogen by 7.5 percent.

- The AGNPS computer modeling in the Clear Lake study (SDDENR 1999) indicated that major nutrient sources were streamside animal feeding operations and runoff from fertilized cropland. Twenty-five animal feeding areas were evaluated as part of the study. Sixteen were found to have an AGNPS rank of 50 or more and 10 had an AGNPS rank of 60 or more on a scale of zero (no impact) to 100 (severe). When the model was run with the ten feeding areas with an AGNPS rating > 60 taken out of the watershed, the dissolved phosphorous load into Clear Lake was reduced by 9.6% reduction and the dissolved nitrogen load was reduced by 10.7%.

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 first and second highest percentages of cropped acres with manure applied for all subregions were the Missouri-Little Sioux River Basin (code 1023) and the Missouri-Big Sioux-Lewis-Clark Lake (code 1017); both had manure applied to 16 percent of their total cropland acres. The Missouri-White River-Fort Randall Reservoir Basin (code 1014) had 4 percent of its cropland acres treated with manure. Knippling reported (2012) that the data indicated that high fecal levels were associated with the land application of manure to 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 TMDL studies within the LCWIP area that have identified livestock grazing as an additional source of nutrients and fecal bacteria are; Lake Andes 2010, Geddes Lake 2007, Dante Lake 2006, and Corsica Lake 2005. Other projects in South Dakota that have shown similar results with livestock grazing and access to water bodies, in addition to the animal feeding operations, are; the Yellow Bank TMDL (SDDENR 2012), Blue Dog Lake (SDDENR 1999), and the Minnesota Water Pollution Control Agency (2010). Evans etal. (2008), estimated a 34% reduction in phosphorous and a 43% reduction in nitrogen through proper grazing management.

Knippling (2012) reported 34,961 pounds per year reduction in nitrogen, 8,304 pounds per year of phosphorous, and 5,766 tons of sediment on 15,678 acres of grazing land management under the LCWIP Segments 1 and 2. This equates to 2.23 pounds of nitrogen/acre/year, 0.53 pounds of phosphorous/acre/year, and 0.37 tons of soil/acre/year. The Corsica Lake TMDL (SDDENR 2005) calculated phosphorus reductions from rangeland to be 16% for the watershed as a whole and that targeting the 3,840 critical rangeland acres in the watershed would result in a phosphorus reduction of approximately 4%. Kringen reported (Kringen 2010) rotational grazing systems on 14,421 acres to have reduced nitrogen by 2,575 pounds/year, phosphorous by 342.9 pounds/year, and sediment by 151 tons/year; this equates to 0.18 pounds of nitrogen/acre/year, 0.24 pounds of phosphorous/acre/year, and 0.01 tons/acre/year.

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. Phosphorus was reported to be reduced by 0.4 tons/year in the Firesteel Creek 319 Phase I Summary (Kringen 2006) by improved grazing management on 13,000 acres of grassland. The estimated P load reduction used for grazing management systems was 0.06 pounds of phosphorus reduction per acre per year. The application of this practice 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.

The Lake Andes TMDL (SDDENR 2010) reported that restricting cattle and other livestock access to Lake Andes and its tributaries and establishing buffer zones in the areas immediately adjacent to the lake and tributary streams should result in an appreciable reduction of sediment and nutrient loadings. 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-White River-Fort Randall Reservoir subregion (code 1014) had 0.8 percent of its subregion acres listed as under-treated, while the Missouri-Big Sioux-Lewis/Clark Lake subregion (code 1017) had 5.2 percent of its subregion acres listed as under-treated.

The remaining 82 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.

Twenty-six subregions were studied in the Missouri River study (NRCS 2012) and analyzed for the amount of nitrogen, phosphorous, and sediment delivered to the rivers and streams. The Lewis & Clark (code 1017) watershed was in the top seven subregions that delivered a total of 53 percent of the nitrogen from cultivated cropland. The Lewis & Clark watershed was also in the top eight subregions that delivered a total of 62% of the phosphorous load from cultivated cropland to rivers and streams. See Table 3-2 for the percent and amount per acre of delivery for the Lewis & Clark, Fort Randall, and James River Basin subregions.

The Corsica Lake Phase 1 and TMDL study (SDDENR 2005) also targeted priority areas through their analysis with the computer model AnnAGNPS . Targeting identified approximately 12,800 acres or 22.8% of the watershed for BMP implementation. A breakdown of this acreage shows that approximately 70% or 8,960 acres was cropland and 30% or 3,840 acres were rangeland. It was estimated that with a 3% participation by operators in critical cropland areas would result in a 6 % reduction of phosphorous from each 1,200 acres treated.

Table 3-2 Nitrogen, Phosphorous, & Sediment Delivery of Three Adjacent Subwatersheds. NRCS CEAP Study 2012.

Nitrogen, Phosphorus, and Sediment Delivery by Missouri River Subregion						
	Nitrogen		Phosphorous		Sediment	
Subregion	%	#/Ac/Yr	%	#/Ac/Yr	%	Ton/Ac/Yr
Missouri-Big Sioux-Lewis-Clark Lake	8	6.51	7	0.38	5	0.11
Code 1017						
Missouri-White River -Fort Randall Reservoir	2	3.76	2	0.24	3	0.14
Code 1014						
James River Basin	7	4.63	6	0.26	5	0.11
Code 1016						
NRCS 2012 Study Average	3.9	5.82	3.9	0.38	3.9	0.17

The Corsica Lake study simulated changing the cropping practices from minimum tillage in the current state to no-till for the corn and soybean acres, which comprised the majority of the cropland within this watershed. Sediment was reduced at the outlet by 46%, emphasizing the importance of conservation tillage to reducing sediment concentration in runoff. Nitrogen and phosphorus concentrations also dropped by 8% and 4% respectively by modeling the no-till practices.

Studies in other areas of South Dakota have utilized the Agricultural Nonpoint Source Model (AGNPS) to evaluate their watersheds and identify "target" areas. The Blue Dog Lake study (SDDENR 1999) found 2.9 % of its acres needed reduced tillage. By implementing no-till cropping practices on these cells, the AGNPS showed an 18% reduction in phosphorus, a 35% reduction in sediment, and an 8% reduction in nitrogen delivered to Blue Dog Lake.

The Rosehill/Sand Creek watershed study (SDDENR 2002), in the lower James River basin, used AGNPS to target critical cells that also needed reduced tillage; these acres represented only 7.6 percent of the total watershed acres. The emphasis for the implementation of BMPs should be targeted to cropland identified in the critical AGNPS cells as treatment of these critical acres will yield the most effective load reductions.

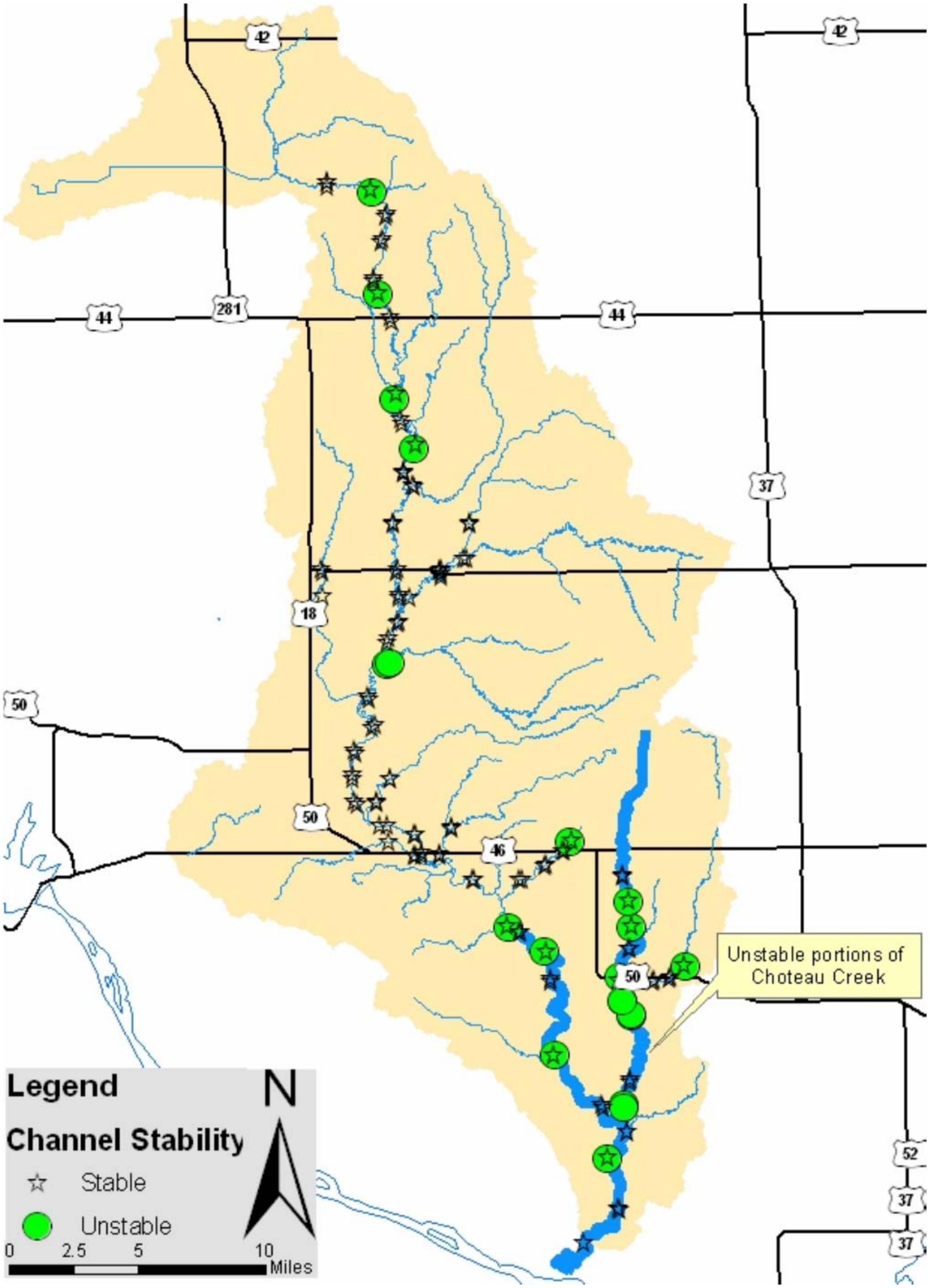
3.5 Streambank & Channel Stabilization. NRCS Practice Code 580

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 Emanuel Creek study (SDDENR 2009) found that 60% or more of the sediment was the result of bank failure through the use of ANNAGNPS and Rapid Geomorphic Assessments (RGA). Based on these assessments it was determined that approximately 50% of Emanuel Creek south of State Highway 50 was unstable and contributing to increased sediment loading. The suspected primary 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.

AnnAGNPS computer modeling does not address channel stability or channel erosion. The Dry Choteau Creek watershed generated an erosion rate of 2.3 tons/acre/years, which was higher than the main stem Choteau Creek, and when compared to the greater Lewis and Clark basin, the loadings were among the highest modeled. In the Choteau Creek study (SDDENR 2010) a number of stream miles were evaluated for channel stability using RGA. The RGA's were completed on both upstream and downstream portions of road crossings to determine the potential impacts of culverts and bridges. It appeared that on small streams, such as Choteau Creek, culverts and bridges were contributing to channel instability. Approximately 12% of the stream miles evaluated contained sites ranked as unstable and contributed to increased sediment loading. It was calculated that a load reduction of 89% in sediment transport was necessary to reach the expected loading of a stable channel. Their emphasis for BMPs was placed on riparian areas along the unstable segments of Dry Choteau creek channel. See Figure 3-2 for unstable segments of the Choteau Creek drainage.

Figure 3-2. Unstable Segments of the Choteau Creek Drainage



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.

Knippling reported 99.3 acres of grassed waterways being constructed during LCWIP Segments 1 and 2. Sediment was reduced by 1,472 tons at a rate of 4.82 tons/acre/year; nitrogen was reduced by 6,636 pounds at a rate of 66.83 lbs/acre/year; and phosphorous was reduced by 1,666 pounds at a rate of 16.78 lbs/acre/year.

Kringen, in the James River watershed (2010), reported load reductions on 2.9 acres of constructed waterways (2,253 LF) that reduced sediment by 16.7 tons/acre/year; nitrogen by 124.3 pounds/acre/year; and phosphorous by 32.6 pounds/acres/year. His calculations were based on 110 acres of cropland watersheds contributing runoff to the waterways. Jensen (2007) calculated load reductions in the Little Minnesota River study on 111.9 acres (76,031 LF) of constructed waterways that represented 9,978 acres of watershed contributing sediment at 27.46 tons/acre/year and phosphorous at 52.3 lbs/acre/year. The differences in the load reduction between the two studies may have been that Jensen's contributing watershed acres per acre of constructed waterway was approximately 2.4 times larger than Kringen's.

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. Sediment and phosphorous reductions were reported as 91,579 tons/pond lifespan and 174,000 lbs/pond lifespan, respectively. For this reason, wetland restoration, pond construction, water and sediment control structures, and structures for water control will be part of the Lewis & Clark project's 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 LCWIP area and evaluating them before BMP's are installed.

Using AnnAGNPS management scenarios in the Corsica Lake TMDL (SDDENR 2005) the phosphorus reductions practices for the conversion of critical cropland acres to grass would result in measurable reductions. Reductions were calculated basin wide, but if targeted areas were converted, a margin of safety is generated. Converting cropland to grassland through critical area seeding, CRP, and riparian buffers would result in 1% reductions in phosphorus, nitrogen, and sediment for every 200 acres; for example, an estimated 3% participation by operators in critical areas would result in a 6% reduction from 1,200 acres.

Knippling reported 378.8 acres of grass seedings completed for Segments 1 and 2 of the Lewis & Clark Watershed Implementation Project (2012). Sediment load reductions were 1,652 tons at a rate of 4.36 tons/acre; nitrogen load reductions were 7,167 pounds at a rate of 18.92 pounds/acre; and phosphorous reductions were 2,189 pounds at a rate of 5.78 pounds/acres.

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). The conversion to grassland was also reported to reduce total soil erosion by approximately 1.6 tons/acre/year in the Little Minnesota River study (Jensen 2007).

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

3.91 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 crops.
- 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 LCWIP 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;
- 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 Lewis & Clark Watershed Project area as contributing to water quality degradation in the following SDDENR water quality reports; Lake Andes 2010, Corsica Lake 2005, Dante Lake 2006, Choteau Creek 2010, and Geddes Lake 2007,

3.92 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 (Practice Code 380) 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.
- 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. Jensen reported (2007) a riparian forest buffer was installed on a tributary of the Little Minnesota River consisting of a four acre buffer of 885 rod rows of trees and shrubs. A 5.4 acre filter strip of native grasses was also planted adjacent to the trees to reduce sediment delivery from an adjoining crop field. Sediment delivery from the field was reduced by approximately 1.623 tons/acre/year and phosphorous was reduced by 3.08 pounds/acre/year.

3.11 Nutrient Management Plan - Cropland. NRCS Practice Code 590

This nutrient management practice (590) 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 at efficiencies at 70% reduction for nitrogen and a 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 Lewis & Clark Watershed Implementation Project.

3.12 Terraces - NRCS Practice Code 600.

A terrace is an earth embankment, or a combination or 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 LCWIP 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. Knippling (2012) reported on 4,233.1 acres of installed filter strips under LCWIP Segments 1 and 2. Load reductions for sediment were 14,096 tons at a rate of 3.33 tons/acre; nitrogen load reductions were 62,153 pounds at a rate of 14.68 pounds/acre; and phosphorous reductions were 19,650 pounds at a rate of 4.64 pounds/acre. However, load reductions on grazed or hayed buffer strips were reported by Knippling at the lower rates of 0.69 tons/acre for sediment, 4.83 lbs/acre of nitrogen, and 1.35 lbs/acre of phosphorous. These lower rates will be used for the non-CRP filter strips.

4.0 LOAD REDUCTIONS

4.1 Animal Waste Storage Facilities

The Lewis & Clark Phase I Diagnostic Feasibility Study (SDDENR 1983) identified 500 animal feeding operations east of the Missouri River with more than 100 of the feedlots determined to be priority operations requiring the construction of an animal waste management systems. Since that time, approximately 32 feedlots have had Animal Waste Storage Facilities (AWSF) constructed under the two LCWIP Segments. The CD/NRCS field offices in the Lewis & Clark Project area were contacted for the number of AWSF's that are needed in each county to address their nonpoint source pollution concerns. Their combined estimated need was for 79 AWSFs to be constructed within the LCWIP area. Based on the field office's response they calculated an average constructions rate of 14 AWSF's per year. At this construction rate it will take an additional year beyond the 5 years addressed in this plan to complete the needed AWSF's. Load reductions used were those calculated from AWMS's installed in the LCWIP Segments 1 and 2 that averaged reductions of 12,612 pounds of nitrogen and 2,753 pounds of phosphorous per system. Refer to Table 4-1 for projected load reductions and yearly applications.

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

Estimated Nitrogen (N) and Phosphorous (P) Load Reductions (LR) Associated with Animal Waste Storage Facilities (AWSF)						
Year	# Goal	% Goal	N #/System	Total N #/Syst	P #/System	Total P #/Syst
1	8	10.1	12,612.0	100,896	2,753.0	22,024
2	14	17.7	12,612.0	176,568	2,753.0	38,542
3	16	20.3	12,612.0	201,792	2,753.0	44,048
4	16	20.3	12,612.0	201,792	2,753.0	44,048
5	16	20.3	12,612.0	201,792	2,753.0	44,048
Subtotal	70	88.7		882,840		192,710
6-10	9	11.3	12,612.0	113,508	2,753.0	24,777
Total	79	100		996,348		217,487

Nutrient reduction estimates from STEPL: Spreadsheet Tool for the Estimation of Pollutant Load. Knippling 2012

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. Fourteen facilities with 940 animal units constructed on average each year would require approximately 13,160 acres in the NMPs; however, only about 1,316 acres would receive the manure each year. Load reductions used were calculated from NMPs installed in the LCWIP Segments 1 and 2 and averaged reductions of 11,143 pounds of nitrogen per system and 2,445 pounds of phosphorous per system. 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 LR	P #/YR	Total P #/YR LR
1	8	10.1	11,143	89,144	2,445	19,560
2	14	17.7	11,143	156,002	2,445	34,230
3	16	20.3	11,143	178,288	2,445	39,120
4	16	20.3	11,143	178,288	2,445	39,120
5	16	20.3	11,143	178,288	2,445	39,120
Subtotal	70	88.7		780,010		171,150
6-10	9	11.3	11,143	100,287	2,445	22,005
Total	79	100.0		880,297		193,155

Nutrient reduction estimates from STEPL: Spreadsheet Tool for the Estimation of Pollutant Load. Knippling 2012

4.3 Prescribed Grazing Systems

4.3.1 Upland Prescribed Grazing Systems

The CD/NRCS field offices in the LCWIP watershed were contacted for the number of acres of grazing lands that need a grazing management system for each county. The estimated need was for 158,400 acres of prescribed grazing systems to be planned and implemented. The estimated yearly average implementation rate was 18,620 acres per year. At the end of this five year Strategic Plan only 93,100 acres (58.8%) 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 by Knippling (2012) of 2.23 pounds of nitrogen/acre/year, 0.53 pounds of phosphorous/acre/year, and 0.37 tons of sediment/acre/year. Prescribed grazing systems are figured on 500 acres per system, with a rural water hook-up, three tanks, water pipeline footage of 2,500 feet, and 2,500 feet of fencing per system.

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

Estimated Nitrogen (N), Phosphorous (P), and Sediment (S) Load Reductions (LR) for Prescribed Grazing								
Year	Acres	% Goal	N #/Ac/Yr	Total #N/YR-LR	P #/Ac/YR	Total #P/YR-LR	Sed T/Ac/YR	Total T/YR-LR
1	18,620	11.8	2.23	41,522.60	0.5296	9,861.15	0.3678	6,848.44
2	18,620	11.8	2.23	41,522.60	0.5296	9,861.15	0.3678	6,848.44
3	18,620	11.8	2.23	41,522.60	0.5296	9,861.15	0.3678	6,848.44
4	18,620	11.8	2.23	41,522.60	0.5296	9,861.15	0.3678	6,848.44
5	18,620	11.8	2.23	41,522.60	0.5296	9,861.15	0.3678	6,848.44
SubTotal	93,100	59.0		207,613.00		49,305.76		34,242.18
6-10	65,300	41.0	2.23	145,619.00	0.5296	34,582.88	0.3678	24,017.34
TOTAL	158,400	100.0		353,232.00		83,888.64		58,259.52

Load Reduction Estimates from Knippling 2012

4.3.2 Riparian Area Grazing

Grazing management systems will be implemented on 69,300 linear feet (LF) of stream to reduce nutrient and sediment transport to water bodies. These footages were estimated by CD/NRCS field office staff in the watershed counties. However, local field offices (FO) also estimated a total need of 160,560 LF of riparian areas needed to resolve resource problems which would require additional years to achieve. Load reductions were calculated from Knippling (2012) analysis using STEPL from systems installed in Segments 1 and 2 of the LCWIP. His figures were converted to linear feet using 124 acres of installed riparian grazing area and dividing by an average riparian grazing area width of 1,325 feet. 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 69,300 linear feet of riparian management for the LCWIP watershed during the first five years of the Strategic Plan.

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

Riparian Area Management Load Reductions of Nitrogen, Phosphorous, and Sediment by Linear Foot								
Year	Linear Feet (LF) Planned	% Goal	N Reduction Lbs/LF	Total N Reduction Lbs/Year	P Reduction Lbs/LF	Total P Reduction Lbs/Year	Sediment Reduction Tons/LF	Total Sediment Tons/Year
1	13,860	8.6	0.1469	2,036.0	0.4100	5,682.6	0.0209	289.0
2	13,860	8.6	0.1469	2,036.0	0.4100	5,682.6	0.0209	289.0
3	13,860	8.6	0.1469	2,036.0	0.4100	5,682.6	0.0209	289.0
4	13,860	8.6	0.1469	2,036.0	0.4100	5,682.6	0.0209	289.0
5	13,860	8.6	0.1469	2,036.0	0.4100	5,682.6	0.0209	289.0
Subtotal	69,300	43.2		10,180.2		28,413.0		1,444.9
6-10	69,300	43.2	0.1469	10,180.2	0.4100	28,413.0	0.0209	1,444.9
11-15	21,960	13.6	0.1469	3,225.9	0.4100	9,003.6	0.0209	457.9
Total	160,560	100.0		23,586.3		65,829.6		3,347.7

N, P, and Sediment Load Reduction estimates from STEPL: Knippling 2012

4.4 Residue & Tillage Management on Cropland

Field Offices estimated 282,200 acres of conservation tillage would be needed to solve resource concerns. At the rate of 22,820 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 use of AGNPS cells in the Lake Mitchell/Firesteel Creek Diagnostic Study (1997) identified that certain cells had cropland soil erosion in excess of 4.0 tons/acre/year. The critical cells identified averaged 8.6 tons/acre/year of soil erosion. Applying Evans estimate of soil reductions by conservation tillage practices, soil loss could be reduced by 64 percent to 3.1 ton/acre/year; saving 5.5 tons/acre/year. This is a sediment load reductions of 2.2 tons/acre/year using an estimated 40 percent delivery rate to a water course. The Firesteel Creek 319 Application (Kringen 2006) reported P load reduction for cropland was 0.5 pounds of phosphorus reduction per ton of soil saved; saving 2.75 pounds of P per acre. Nitrogen load reductions along the Big Sioux River were calculated at 9.81 pounds/acre/year (Berg, 2010) on cropland management practices.

Nitrogen, phosphorus, and sediment load reductions were not calculated in the LCWIP reports. Therefore, phosphorous and sediment load reductions reported in the adjacent Lake Mitchell/Firesteel Creek study will be used to estimate sediment and phosphorous load reductions. The values for nitrogen loss are those calculated by Berg (2010) along the Big Sioux River. 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 on Critical Cells								
Year	Acres	% Goal	N #/Ac/Yr	Total #/YR-LR	P #/Ac/YR	Total #YR-LR	Sed T/Ac/YR	Total T/YR-LR
1	22,820	8.1	9.81	223,864.2	2.75	62,755.0	2.20	50,204.0
2	22,820	8.1	9.81	223,864.2	2.75	62,755.0	2.20	50,204.0
3	22,820	8.1	9.81	223,864.2	2.75	62,755.0	2.20	50,204.0
4	22,820	8.1	9.81	223,864.2	2.75	62,755.0	2.20	50,204.0
5	22,820	8.1	9.81	223,864.2	2.75	62,755.0	2.20	50,204.0
Subtotals	114,100	40.5		1,119,321.0		313,775.0		251,020.0
6-10	114,100	40.4	9.81	1,119,321.0	2.75	313,775.0	2.20	251,020.0
11-15	54,000	19.1	9.81	529,740.0	2.75	148,500.0	2.20	118,800.0
Total	282,200	100.0		2,768,382.0		776,050.0		620,840.0

Phosphorous and Sediment Load Reduction Estimates from STEPL: Spreadsheet Tool for the Estimation of Pollutant Load v. 4.0. Evans/Kringen . Nitrogen from Berg .

4.5 Streambank Stabilization

The planned bank stabilization footages were estimated by field office staff as 25,500 linear feet (LF) of stream bank stabilization. The field offices estimated that an average of 2,000 LF could be completed each year, which may require eight additional years to achieve. Table 4-5 presents load reductions for nitrogen as calculated using STEPL from 15,400 linear feet of 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 Per Linear Foot (LF)								
Year	Linear Feet Planned	% Goal	N Reduction Lbs/LF	Total N Reduction Lbs/LF	P Reduction Lbs/LF	Total P Reduction Lbs/LF	Sediment Reduction Tons/LF	Total Sediment Tons/LF
1	2,000	7.8	2.60	5,200.0	1.0	2,000.0	1.83	3660.0
2	2,000	7.8	2.60	5,200.0	1.0	2,000.0	1.83	3660.0
3	2,000	7.8	2.60	5,200.0	1.0	2,000.0	1.83	3660
4	2,000	7.8	2.60	5,200.0	1.0	2,000.0	1.83	3660
5	2,000	7.8	2.60	5,200.0	1.0	2,000.0	1.83	3660.0
Subtotal	10,000	39.0		26,000.0		10,000.0		18,300.0
6-10	10,000	39.0	2.60	26,000.0	1.0	10,000.0	1.83	18,300.0
11-15	5,500	22.0	2.60	14,300.0	1.0	5,500.0	1.83	10,065.0
Total	25,500	100.0		66,300.0		25,500.0		46,665.0

Nitrogen, Phosphorous, and Sediment Load Reduction 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 525,500 feet. At 15,500 LF per year; 77,500 LF will be completed in the five years of the Strategic Plan, which is only 15% 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 calculations use in LCWIP reports for Segments 1 and 2. The load reductions are converted to linear feet of waterway based on an average waterway width of 35 feet. 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								
Year	Linear Feet (LF) Planned	% Goal	N Reduction Lbs/LF	Total N Reduction Lbs/Year	P Reduction Lbs/LF	Total P Reduction Lbs/Year	Sediment Reduction Tons/LF	Total Sediment Tons/Year
1	10,000	3.3	0.054	540.0	0.0135	135.0	0.0112	112.0
2	17,000	5.8	0.054	918.0	0.0135	229.5	0.0112	190.4
3	17,000	5.8	0.054	918.0	0.0135	229.5	0.0112	190.4
4	17,000	5.8	0.054	918.0	0.0135	229.5	0.0112	190.4
5	16,500	5.5	0.054	891.0	0.0135	222.8	0.0112	184.8
Subtotal	77,500	26.3		4,185.0		1,046.3		868.0
6-10	77,500	26.3	0.054	4,185.0	0.0135	1,046.3	0.0112	868.0
11-15	77,500	26.3	0.054	4,185.0	0.0135	1,046.3	0.0112	868.0
16-20	62,600	21.1	0.054	3,380.4	0.0135	845.1	0.0112	701.1
Total	295,100	100.0		15,935.4		3,983.9		3,305.1

N, P, and Sediment reduction estimates from STEPL: Spreadsheet Tool for the Estimation of Pollutant Load . Knippling 2012

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 1,587 to meet estimated load reductions. Thirty-one basins are restored or constructed each year on average. At the end of the Strategic Plan, approximately 39% 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.

Calculated total sediment and phosphorous load reductions data expected from the constructed ponds/basins and restored wetlands are from multi-purposed ponds constructed in the Little Minnesota River/Big Stone Lake implementation project (Jensen 2007). 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 in Jensen’s load reduction calculation. However, the water and sediment basins should result in similar control of the sediment delivery and sediment attached phosphorous. Jensen based the phosphorous and sediment load reductions on five acres of watershed protection (WSAc) around the restored wetlands/ponds over an estimated 20 year lifespan.

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

Wetland Restoration and Pond Construction Load Reductions							
Year	No. Ponds Wetlands Planned	% Goal	Watershed Acres Restored	P Reduction Lbs/WS Ac Lifespan	Total Lbs P Reduction Lifespan	Sed Reduct Lifespan Tons/ WS Ac	Total Tons Sediment Reduction
1	31	2.0	4,340	29.76	129,158.4	15.67	68,008
2	31	2.0	4,340	29.76	129,158.4	15.67	68,008
3	31	2.0	4,340	29.76	129,158.4	15.67	68,008
4	31	2.0	4,340	29.76	129,158.4	15.67	68,008
5	31	2.0	4,340	29.76	129,158.4	15.67	68,008
Subtotals	155	10.0	21,700		645,792.0		340,039
6-10	155	10.0	21,700	29.76	645,792.0	15.67	340,039
11-15	155	10.0	21,700	29.76	645,792.0	15.67	340,039
16-50	1,122	70.0	157,080	29.76	4,674,700.8	15.67	2,461,444
Total	1,587	100.0	222,180		6,612,076.8		3,481,561

Phosphorous and Sediment Load Reduction Estimates from Jensen 2007

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 8,660 acres for the LCWIP watershed. The calculated load reductions of nitrogen, phosphorous and sediment were those reported by Knippling (2012) in Segments 1 and 2 of the LCWIP. His sediment load reductions were 4.36 tons/acre, nitrogen load reductions were 18.92 pounds/acre, and phosphorous reductions were 5.78 pounds/acres. 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-LR	P #/Ac/YR	Total #P/YR-LR	Sed T/Ac/YR	Total T/YR-LR
1	280	3.3	18.92	5,297.6	5.78	1,618.4	4.36	1,220.8
2	780	9.0	18.92	14,757.6	5.78	4,508.4	4.36	3,400.8
3	780	9.0	18.92	14,757.6	5.78	4,508.4	4.36	3,400.8
4	780	9.0	18.92	14,757.6	5.78	4,508.4	4.36	3,400.8
5	780	9.0	18.92	14,757.6	5.78	4,508.4	4.36	3,400.8
Subtotal	3,400	39.3		64,328.0		19,652.0		14,824.0
6-10	3,400	39.3	18.92	64,328.0	5.78	19,652.0	4.36	14,824.0
11-15	1,860	21.4	18.92	35,191.2	5.78	10,750.8	4.36	8,109.6
Total	8,660	100.0		163,847.2		50,054.8		37,757.6

Nitrogen, Phosphorous and Sediment reduction estimates from STEPL: Knippling 2012.

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 233,400 acres for the LCWIP; 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 was not been analyzed in the LCWIP area. 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 0.051 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 Cover Crops on Cropland

Estimated Nitrogen (N), Phosphorous (P), and Sediment (S) Load Reductions (LR) for Cover Crops on Cropland								
Year	Acres	% Goal	N #/Ac/Yr	Total #/YR-LR	P #/Ac/YR	Total #YR-LR	Sed T/Ac/YR	Total T/YR-LR
1	5,280	4.4	6.85	36,168.0	1.61	8,500.8	0.051	269.3
2	11,530	4.4	6.85	78,980.5	1.61	18,563.3	0.051	588.0
3	11,530	4.4	6.85	78,980.5	1.61	18,563.3	0.051	588.0
4	11,530	4.4	6.85	78,980.5	1.61	18,563.3	0.051	588.0
5	11,530	4.4	6.85	78,980.5	1.61	18,563.3	0.051	588.0
Subtotals	51,400	22.0		352,090.0		82,754.0		2,621.4
6-10	51,400	22.0	6.85	352,090.0	1.61	82,754.0	0.051	2,621.4
11-15	51,400	22.0	6.85	352,090.0	1.61	82,754.0	0.051	2,621.4
16-20	51,400	22.0	6.85	352,090.0	1.61	82,754.0	0.051	2,621.4
21-25	27,800	12.0	6.85	190,430.0	1.61	44,758.0	0.051	1,417.8
Total	233,400	100.0		1,598,790.0		375,774.0		11,903.4

Projected Estimates from Hargrove 1991 and TMDL Clear Lake SDDENR 1999
LR Estimates are for Cover Crop Use Only. The Addition of Crop Rotation with a Cover Crop May Give Higher LR (Hargrove 1991)

4.10 Windbreak/Shelterbelt Establishment. NRCS Practice Code 380

Windbreak or Shelterbelt Establishment (NRCS Practice Code 380**)** 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 LCWIP. Kringen (2010) reported riparian projects of 349 acres within the Firesteel Creek Riparian Area Management Program averaged a nitrogen load reduction at 3.65 pounds/acre/year, phosphorus at 2.52 pounds/acre/year, and sediment at 0.09 tons/acre/year. Estimated load reductions for the LCWIP 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-LR	P #/Ac/YR	Total #P/YR-LR	Sed T/Ac/YR	Total T/YR-LR
1	168	7.4	3.65	613.2	2.52	423.4	0.873	146.7
2	168	7.4	3.65	613.2	2.52	423.4	0.873	146.7
3	168	7.4	3.65	613.2	2.52	423.4	0.873	146.7
4	168	7.4	3.65	613.2	2.52	423.4	0.873	146.7
5	168	7.4	3.65	613.2	2.52	423.4	0.873	146.7
Subtotal	840	37.0		3,066.0		2,116.8		733.3
6-10	840	37.0	3.65	3,066.0	2.52	2,116.8	0.873	733.3
11-15	585	26.0	3.65	2,135.3	2.52	1,474.2	0.873	510.7
Total	2,265	100.0		8,267.3		5,707.8		1,977.3

Load reduction estimates from STEPL: Spreadsheet Tool for the Estimation of Pollutant Load v. 4.0. Kringen 2010

4.11 Nutrient Management Plan - Cropland

This nutrient management practice (590) is intended for cropland acres where animal manures are not used on cropland fields and the fields are fertilized with commercial fertilizers. 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 manures. The Field Offices estimated a total need of 329,000 acres of nutrient management plans on cropland where manure is not applied in the LCWIP. With approximately 11,000 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 can be developed to manage the amount, source, placement, form, and timing of the application of plant nutrients and soil amendments necessary to sustain plant growth and production goals. The NMP should minimize agricultural nonpoint source pollution of surface waters and result in reduced nutrient loading. Estimated load reductions for 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	Acre	% Goal	N #/AC/YR	Total N #/YR LR	P #/YR/AC	Total P #/YR LR
1	5,200	3.3	9.8	51,012	0.6	3,120
2	12,200	3.3	9.8	119,682	0.6	7,320
3	12,200	3.3	9.8	119,682	0.6	7,320
4	12,200	3.3	9.8	119,682	0.6	7,320
5	12,200	3.3	9.8	119,682	0.6	7,320
Subtotal	54,000	16.5		529,200		32,400
6-10	54,000	16.5	9.8	529,200	0.6	32,400
11-15	54,000	16.5	9.8	529,200	0.6	32,400
16-40	167,000	50.5	9.8	1,636,600	0.6	100,200
Total	329,000	100.0		3,224,200		197,400

Nutrient reduction estimates from STEPL: Spreadsheet Tool for the Estimation of Pollutant Load v. 4.0. Kringen 2010

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 30,000 LF of terrace construction to address these steeper slopes in the LCWIP; completing 3,000 LF per year would require approximately ten years to complete their goal. Soil loss calculations projected before and after terrace construction were based on average soil losses computed by several field offices in the LCWIP. The average soil loss of steeper field slopes in the LCWIP that would need terracing was estimated at 7.0 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. Czar 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 based on terrace length times an estimated 180 feet cropping interval between terraces.

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

Terrace Load Reductions for N, P, 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	3,000	12.3	10.0	25.4	312.4	9.8	120.5	5.0	61.5
2	3,000	12.3	10.0	25.4	312.4	9.8	120.5	5.0	61.5
3	3,000	12.3	10.0	25.4	312.4	9.8	120.5	5.0	61.5
4	3,000	12.3	10.0	25.4	312.4	9.8	120.5	5.0	61.5
5	3,000	12.3	10.0	25.4	312.4	9.8	120.5	5.0	61.5
Subtotal	15,000	61.5	50.0		1,562.1		602.7		307.5
6-10	15,000	61.5	50.0	25.4	1,562.1	9.8	602.7	5.0	307.5
Total	30,000	123.0	100.0		3,124.2		1,205.4		615.0

4.13 Filter Strips - Non-CRP

The need for Non-CRP filter strips was estimated by Field Offices to be 3,875 acres within the LCWIP watershed. Installing 340 acres annually would require another seven years to meet the estimated goal. The load reduction for nitrogen, phosphorous, and sediment for grassed filter strips were calculated from 124 acres of grazed buffers installed in the LCWIP Segment 2 report. It is unknown whether the non-CRP filter strips will be harvested for hay or grazed, so the load reduction calculations will be based on the more severe land use of grazing. 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-LR	P #/Ac/YR	Total #P/YR-LR	Sed T/Ac/YR	Total T/YR-LR
1	340	8.8	4.83	1,642.2	1.35	459.00	0.69	234.60
2	340	8.8	4.83	1,642.2	1.35	459.00	0.69	234.60
3	340	8.8	4.83	1,642.2	1.35	459.00	0.69	234.60
4	340	8.8	4.83	1,642.2	1.35	459.00	0.69	234.60
5	340	8.8	4.83	1,642.2	1.35	459.00	0.69	234.60
SubTotal	1,700	44.0		8,211.0		2,295.00		1,173.00
6-10	1,700	44.0	4.83	8,211.0	1.35	2,295.00	0.69	1,173.00
11-15	475	12.0	4.83	2,294.3	1.35	641.25	0.69	327.75
TOTAL	3,875	100.0		18,716.3		5,231.25		2,673.75

Load Reductions data from LCWIP Final Report Knippling 2012.

5.0 TECHNICAL AND FINANCIAL ASSISTANCE NEEDED

The Randall Resource Conservation &Development (RRCD) will be administratively responsible for the project implementation and will be the lead sponsor. A project coordinator will manage all water quality project activities among the watershed counties which will include 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 be provided through existing partnerships with Aurora, Bon Homme, Brule-Buffalo, Charles Mix, Davison, Douglas, Hutchinson, and Yankton County Conservation Districts; the Randall Resource Conservation &Development, Lower James Resource Conservation & Development, Pheasants Forever; South Central Water Development District; SD Grassland Coalition; the SD Association of Conservation Districts; SD Game, Fish and Parks (SD GF&P); SDDENR; SD Department of Agriculture (SDDOA); SD Extensions Service; US Environmental Protection Agency; US Fish and Wildlife Service; USDA Farm Service Agency; and USDA Natural Resources Conservation Service.

The sources of funds accessed for financial assistance during LCWIP Segments 1 and 2 included:

- SD Department of Agriculture - SD Soil and Water Conservation Grant awarded through the SD Conservation Commission,

- SD Game, Fish, & Parks - State Acres for Wildlife Enhancement (SAFE),
- SD Department Environment & Natural Resources – Consolidated Water Facilities Construction Fund Program,
- USDA NRCS – Environmental Quality Incentive (EQIP) and Wildlife Habitat Incentive(WHIP) and Farm Bill Implementation Technical Assistance Programs,
- USDA Farm Service Agency – Conservation Reserve and Continuous Conservation Reserve Programs (CRP and CCRP),
- USDI Fish & Wildlife Service – Annual appropriation for SD habitat projects, and
- USDI Environmental Protection Agency - Clean Water Act Section 319 Implementation Project Grant and 303(d) Watershed

Additional funding for the implementation of the BMPs will be solicited from these partners through their programs such as; the NRCS Environmental Quality Incentive Program and Wetland Reserve Program; FSA Conservation Reserve Program and Conservation Reserve Enhancement Program; SD GF&P Wildlife Partnership Program and Wetland and Grassland Habitat Program; and US-FWS Grassland and Wetland Easement Programs and Private Land Programs.

The Lewis and Clark watershed basin land use is fairly homogenous east of the Missouri River and the impairment problems have been consistently identified as agricultural in nature for both cropland and animal uses. The extrapolations have been conservative and the expected outcome to be consistent. 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	8	$ 160,000	Grazing System, EA	$ -	36	$ -
	AWSF	$200,000	8	$ 1,600,000	Rural Water, EA	$ 2,000	36	$ 72,000
	Const Mgmt	$ 18,750	8	$ 150,000	Pipeline, LF	$ 5	90,000	$ 450,000
	NMP	$ 2,500	8	$ 20,000	Tanks, EA	$ 1,500	108	$ 162,000
	Cultural Study	$ 500	8	$ 4,000	Fencing, LF	$ 1	450,000	$ 450,000
				$ 1,934,000				$ 1,134,000
Year	BMP - Riparian Areas				BMP - Bank Stabilization			
1	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Grazing AC	$ -	1,000	$ -	Rock, Fabric/LF	$ 110	2,000	$ 220,000
	Fencing LF	$ 1	39,600	$ 39,600				$ -
				$ 39,600				$ 220,000
Year	BMP - Residue & Tillage Manage				BMP - Grassed Waterways			
1	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Cost Incentive/AC	$ 10	22,820	$ 228,200	Dirt Work, Seed/ LF	$ 2.20	10,000	$ 22,000
				$ 228,200				$ 22,000
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	31	$ 86,800	Tillage/Seeding AC	$ 46	280	$ 12,880
				$ 86,800				$ 12,880

Table 5-1: Continued. Technical & Financial Resources Needed					Year 1			
Year	BMP - 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	5,280	$ 200,640	Cost Incentive/AC	$ 3.58	5,200	$ 18,616
				$ 200,640				$ 18,616
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	3,000	$ 10,500
				$ 67,200				$ 10,500
Year	BMP - Filter Strips, Non-CRP							
1	Components	Costs	Quantity	Total Costs				
	Cost Incentive/AC	$ 46	340	$ 15,640				
				$ 15,640	TOTAL BMP COSTS			$ 3,990,076

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	14	$ 280,000	Grazing System, EA	$ -	36	$ -
	AWSF	$200,000	14	$ 2,800,000	Rural Water, EA	$ 2,000	36	$ 72,000
	Const Mgmt	$ 18,750	14	$ 262,500	Pipeline, LF	$ 5	90,000	$ 450,000
	NMP	$ 2,500	14	$ 35,000	Tanks, EA	$ 1,500	108	$ 162,000
	Cultural Study	$ 500	14	$ 7,000	Fencing, LF	$ 1	450,000	$ 450,000
				$ 3,384,500				$ 1,134,000
Year	BMP - Riparian Areas				BMP	- Bank Stabilization		
2	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Grazing AC	$ -	1,000	$ -	Rock, Fabric/LF	$ 110	2,000	$ 220,000
	Fencing LF	$ 1	39,600	$ 39,600				$ -
				$ 39,600				$ 220,000
Year	BMP - Residue & Tillage Manage				BMP -	Grassed Waterways		
2	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Cost Incentive/AC	$ 10	22,820	$ 228,200	Dirt Work, Seed/ LF	$ 2.20	17,000	$ 37,400
				$ 228,200				$ 37,400
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	31	$ 86,800	Tillage/Seeding AC	$ 46	780	$ 35,880
				$ 86,800				$ 35,880

Table 5-2: Continued. Technical & Financial Resources Needed					Year 2			
Year	**BMP - 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	11,530	$ 438,140	Cost Incentive/AC	$ 3.58	12,200	$ 43,676
				$ 438,140				$ 43,676
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	3,000	$ 10,500
				$ 67,200				$ 10,500
Year	**BMP - Filter Strips, Non-CRP**							
2	**Components**	**Costs**	**Quantity**	**Total Costs**				
	Cost Incentive/AC	$ 46	340	$ 15,640				
				$ 15,640	**TOTAL BMP COSTS**			**$ 5,741,536**

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	20	$ 400,000	Grazing System, EA	$ -	36	$ -
	AWSF	$200,000	16	$ 3,200,000	Rural Water, EA	$ 2,000	36	$ 72,000
	Const Mgmt	$ 18,750	16	$ 300,000	Pipeline, LF	$ 5	90,000	$ 450,000
	NMP	$ 2,500	16	$ 40,000	Tanks, EA	$ 1,500	108	$ 162,000
	Cultural Study	$ 500	20	$ 10,000	Fencing, LF	$ 1	450,000	$ 450,000
				$ 3,950,000				$ 1,134,000
Year	BMP - Riparian Areas				BMP	- Bank Stabilization		
3	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Grazing AC	$ -	1,000	$ -	Rock, Fabric/LF	$ 110	2,000	$ 220,000
	Fencing LF	$ 1	39,600	$ 39,600				$ -
				$ 39,600				$ 220,000
Year	BMP - Residue & Tillage Manage				BMP -	Grassed Waterways		
3	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Cost Incentive/AC	$ 10	22,820	$ 228,200	Dirt Work, Seed/ LF	$ 2.20	17,000	$ 37,400
				$ 228,200				$ 37,400
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	31	$ 86,800	Tillage/Seeding AC	$ 46	780	$ 35,880
				$ 86,800				$ 35,880

Table 5-3: Continued. Technical & Financial Resources Needed					Year 3			
Year	BMP - 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	11,530	$ 438,140	Cost Incentive/AC	$ 3.58	12,200	$ 43,676
				$ 438,140				$ 43,676
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	3,000	$ 10,500
				$ 67,200				$ 10,500
Year	BMP - Filter Strips, Non-CRP							
3	Components	Costs	Quantity	Total Costs				
	Cost Incentive/AC	$ 46	340	$ 15,640				
				$ 15,640	TOTAL BMP COSTS			$ 6,307,036

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	20	$ 400,000	Grazing System, EA	$ -	36	$ -
	AWSF	$200,000	16	$ 3,200,000	Rural Water, EA	$ 2,000	36	$ 72,000
	Const Mgmt	$ 18,750	16	$ 300,000	Pipeline, LF	$ 5	90,000	$ 450,000
	NMP	$ 2,500	16	$ 40,000	Tanks, EA	$ 1,500	108	$ 162,000
	Cultural Study	$ 500	20	$ 10,000	Fencing, LF	$ 1	450,000	$ 450,000
				$ 3,950,000				$ 1,134,000
Year	BMP - Riparian Areas				BMP	- Bank Stabilization		
4	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Grazing AC	$ -	1,000	$ -	Rock, Fabric/LF	$ 110	2,000	$ 220,000
	Fencing LF	$ 1	39,600	$ 39,600				$ -
				$ 39,600				$ 220,000
Year	BMP - Residue & Tillage Manage				BMP -	Grassed Waterways		
4	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Cost Incentive/AC	$ 10	22,820	$ 228,200	Dirt Work, Seed/ LF	$ 2.20	17,000	$ 37,400
				$ 228,200				$ 37,400
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	31	$ 86,800	Tillage/Seeding AC	$ 46	780	$ 35,880
				$ 86,800				$ 35,880

Table 5-4: Continued. Technical & Financial Resources Needed					Year 4			
Year	BMP - 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	11,530	$ 438,140	Cost Incentive/AC	$ 3.58	12,200	$ 43,676
				$ 438,140				$ 43,676
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	3,000	$ 10,500
				$ 67,200				$ 10,500
Year	BMP - Filter Strips, Non-CRP							
4	Components	Costs	Quantity	Total Costs				
	Cost Incentive/AC	$ 46	340	$ 15,640				
				$ 15,640	TOTAL BMP COSTS			$ 6,307,036

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	8	$ 160,000	Grazing System, EA	$ -	36	$ -
	AWSF	$200,000	16	$ 3,200,000	Rural Water, EA	$ 2,000	36	$ 72,000
	Const Mgmt	$ 18,750	16	$ 300,000	Pipeline, LF	$ 5	90,000	$ 450,000
	NMP	$ 2,500	16	$ 40,000	Tanks, EA	$ 1,500	108	$ 162,000
	Cultural Study	$ 500	8	$ 4,000	Fencing, LF	$ 1	450,000	$ 450,000
				$ 3,704,000				$ 1,134,000
Year	BMP - Riparian Areas				BMP	- Bank Stabilization		
5	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Grazing AC	$ -	1,000	$ -	Rock, Fabric/LF	$ 110	2,000	$ 220,000
	Fencing LF	$ 1	39,600	$ 39,600				$ -
				$ 39,600				$ 220,000
Year	BMP - Residue & Tillage Manage				BMP -	Grassed Waterways		
5	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Cost Incentive/AC	$ 10	22,820	$ 228,200	Dirt Work, Seed/ LF	$ 2.20	16,500	$ 36,300
				$ 228,200				$ 36,300
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	31	$ 86,800	Tillage/Seeding AC	$ 46	780	$ 35,880
				$ 86,800				$ 35,880

Table 5-5: Continued. Technical & Financial Resources Needed					Year 5			
Year	BMP - 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	11,530	$ 438,140	Cost Incentive/AC	$ 3.58	12,200	$ 43,676
				$ 438,140				$ 43,676
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	3,000	$ 10,500
				$ 67,200				$ 10,500
Year	BMP - Filter Strips, Non-CRP							
5	Components	Costs	Quantity	Total Costs				
	Cost Incentive/AC	$ 46	340	$ 15,640				
				$ 15,640	TOTAL BMP COSTS			$ 6,059,936

TABLE 5-6. SUMMARY OF 5 YEAR COSTS LWCIP						
BMP IMPLEMENTATION COSTS	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	TASK TOTAL
Animal Waste Manage System	$1,934,000	$3,384,500	$3,950,000	$3,950,000	$3,704,000	$16,922,500
Prescribed Grazing	$1,134,000	$1,134,000	$1,134,000	$1,134,000	$1,134,000	$5,670,000
Riparian Area	$39,600	$39,600	$39,600	$39,600	$39,600	$198,000
Bank Stabilization	$220,000	$220,000	$220,000	$220,000	$220,000	$1,100,000
Residue & Tillage Manage	$228,200	$228,200	$228,200	$228,200	$228,200	$1,141,000
Grassed Waterways	$22,000	$37,400	$37,400	$37,400	$36,300	$170,500
Wetland/Pond/Basin Restoration	$86,800	$86,800	$86,800	$86,800	$86,800	$434,000
Cropland Conversion to Grass	$12,880	$35,880	$35,880	$35,880	$35,880	$156,400
Conservation Cover Crop	$200,640	$438,140	$438,140	$438,140	$438,140	$1,953,200
Nutrient Manage Plan, Non AWMS	$18,616	$43,676	$43,676	$43,676	$43,676	$193,320
Windbreak/Shelterbelt	$67,200	$67,200	$67,200	$67,200	$67,200	$336,000
Terraces	$10,500	$10,500	$10,500	$10,500	$10,500	$52,500
Filter Strips Non-CRP	$15,640	$15,640	$15,640	$15,640	$15,640	$78,200
BMP SUB TOTAL COSTS	$3,990,076	$5,741,536	$6,307,036	$6,307,036	$6,059,936	$28,405,620
PERSONNEL SUPPORT						
Project Coordinator - 60% East River	$36,000	$37,000	$39,000	$42,000	$45,000	$199,000
Assist. Coordinator - 60% East River	$24,000	$25,000	$27,000	$29,000	$32,000	$137,000
Admin. Assistant - 60% East River	$15,000	$16,000	$17,000	$18,000	$19,000	$85,000
OPERATIONS						
Vehicle, Fuel, Travel, Insurance	$18,000	$20,000	$22,000	$24,000	$26,000	$110,000
ADMINISTRATION						
Computer, Supplies, Telephone,	$13,000	$14,000	$15,000	$16,000	$17,000	$75,000
RC&D Office, Postage						
PERS/ADMIN SUB TOTAL COSTS	$106,000	$112,000	$120,000	$129,000	$139,000	$606,000
YEARLY TOTALS	$4,096,076	$5,853,536	$6,427,036	$6,436,036	$6,198,936	$29,011,620

6.0 PUBLIC OUTREACH

The Lewis and Clark Watershed Assessment was initiated during January of 2003 at the request of several local organizations that expressed concerns relative to sediment loading of Lewis and Clark Lake. The project goal was based on water quality data collected during watershed and lake assessments initiated in 2003. The original scope of the project was intended to identify areas and causes of sediment entering the impoundment. The goal of the Lewis and Clark Implementation Plan is to restore the beneficial uses of Lewis and Clark watersheds through the installation of Best Management Practices (BMPs) that target sources of sediment, nutrients, and fecal coliform bacteria.

The success of the studies completed in 2006 and resulting implementation of BMP's led to the addition of the remaining 747,000 acres east of the Missouri River portion of the Lewis and Clark Lake watershed. At the request of landowners in 2007, the west river portion of the Lewis and Clark Lake watershed and the Lake Andes watershed became part of the project in 2008. A steering committee was formed in 2007 to facilitate tracking progress toward completion of tasks associated with reaching project objectives and attaining the project goal. Committee member included representatives from 11 conservation districts and other local, state and federal agencies, and organizations. Best management conservation practices (BMPs) were adapted for the project as the LCWIP grew in scope and size and as additional water quality assessments and TMDLs identified resource concerns. The 2007 and 2008 expansions resulted in a project area that encompasses nearly 1.5 million acres on both the east and west sides of the Missouri River and resulted in the development and implementation of several TMDLs in the LCWIP area. However, this Strategic Plan document only addresses the LWIP watershed east of the Missouri River.

Producer meetings, workshops and the print and electronic media were used to promote project awareness and provide information regarding how producers might access BMP design and installation assistance from the project and its partners. Notable among the outreach activities included the holistic grazing school sponsored by the project. As a result of the school, interest in the installation of managed grazing systems increased significantly.

Public involvement continued through the use of Local Work Groups (LWG). These LWGs are sponsored by each of the eight counties Soil and Water Conservation Districts' encompassed by the implementation projects. Segments I and II implementation projects have utilized participant local match, State funding, EPA 319, USDA EQIP and PL-566 funds. 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. This outreach momentum has continued as its success results in the watershed project area increasing in size by the addition of more subwatersheds.

The USDA NRCS offices are usually co-located with the CD 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. Annual meetings with be held by the LCWIP Project Coordinator and the District Managers of each CD to provide them with information on the BMPs available to each county.

A project steering committee will meet twice each year to provide input for project management and coordination of resources. The committee will consist of representatives from Aurora, Bon Homme, Brule-Buffalo, Charles Mix, Davison, Douglas, Gregory, Hutchinson, and Yankton Conservation Districts'; the Lower James Resource Conservation & Development District, the Randall Resource Conservation & Development District, and the South Central Water Development District. Watershed assessment needs are determined by Local Work Groups. Technical and financial assistance are provided by the SD Game, Fish, & Parks, SD Department Environmental Natural Resources, SD Department of Agriculture, SD Association of Conservation Districts, South Dakota State University Extension Service, USDA Natural Resources Conservation Service, USDA Farm Service Agency, and the US Fish & Wildlife Service.

Public outreach will come through:

- Informational public meetings. Nineteen meetings have been held to date.
- Presentations will be held for public and private organizations; thirty have been presented to date.
- Field tours are scheduled to show the completed and functioning BMPs. Five have been completed, including the holistic grazing workshop.
- Newsletters from the CDs
- Articles in the local newspapers of Springfield, Tyndall, Tabor, Avon, Scotland, Corsica, Armour, Chamberlain, Kimball, Lake Andes, Charles Mix County News, Mitchell, Platte, Tripp, Wagner, and Yankton.
- Continued contact with the Charles Mix County lake Restoration Organization
- Postcards sent to landowners along tributaries for CRP
- WEB page articles by several Conservation Districts and City of Delmont
- Personal contact of landowners by Project staff
- Development of display for the local county fairs

7.0 IMPLEMENTATION SCHEDULE

The implementation of this project will be through voluntary programs with producers and landowners over an eight county-wide watershed area and will be coordinated by the project coordinator. The implementation of the practices is 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 Schedule for LCWIP

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		70		8	7	7	10	10	10	10	4	4
Animal Waste Storage Facilities		70		8	7	7	8	8	8	8	8	8
Construction Management		70		8	7	7	8	8	8	8	8	8
Nutrient Management Plan		70		8	7	7	8	8	8	8	8	8
Cultural Resource Study		70		8	7	7	10	10	10	10	4	4
Task 2: Grassland Management	1,2,4											
Product 2: Prescribed Grazing Systems (Ac)		93,100		18,620		18,620		18,620		18,620		18,620
Product 3: Riparian Areas (LF)		69,300		13,860		13,860		13,860		13,860		13,860
Task 3: Streambank Stabilization	2,4											
Product 4: Streambank Stabilization (LF)		10,000		2,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Task 4: Cropland Management	1,2,4											
Product 5: Residue & Tillage Manage (Ac)		114,100		22,820	11,410	11,410	11,410	11,410	11,410	11,410	11,410	11,410
Product 6: Grassed Waterways (LF)		77,500		10,000	8,000	9,000	8,000	9,000	8,000	9,000	8,000	8,500
Product 7: Wetland & Pond Construct (No)		155		31	15	16	15	16	15	16	15	16
Product 8: Conversion of Crop to Grass (Ac)		3,400		280	390	390	390	390	390	390	390	390
Product 9: Conservation Cover Crop (Ac)		51,400		5,280	5,765	5,765	5,765	5,765	5,765	5,765	5,765	5,765
Product 10: Cropland NMP (Ac)		54,000		5,200	6,100	6,100	6,100	6,100	6,100	6,100	6,100	6,100
Product 11: Windbreak/Shelterbelt (Ac)		840		168		168		168		168		168
Product 12: Terraces (LF)		15,000		3,000	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500
Product 13: Filter Strips, Non-CRP (Ac)		1,700		340	170	170	170	170	170	170	170	170

Table 7-1 Continued: Implementation & Task Assignment Schedule for LCWIP

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 2: INFORMATION OUTREACH												
Task 5: Information Distribution												
Product 14: Articles, Newsletter, Radio, WEB	1,2,3,4											
CD Newsletters		20	2	2	2	2	2	2	2	2	2	2
Newspaper Articles		10	1	1	1	1	1	1	1	1	1	1
Radio Spots		5		1		1		1		1		1
Fair Demonstrations		10		2		2		2		2		2
WEB Site Listing		10	2		2		2		2		2	
OBJECTIVE 3: PROJECT REPORTS												
Task 6: Semi-annual, Annual, Final												
Product 15: Reports	1,2											
Semi-Annual		5	1		1		1		1		1	
Annual		5		1		1		1		1		1
Final		1										1

8.0 SHORT-TERM CRITERIA AND MILESTONES FOR BMP IMPLEMENTATION 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, pH, 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 Lewis & Clark Watershed basin. 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 team 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	
BMP or Activity	Quantity	Year 1	Year 2	Subtotal	Year 3	Subtotal	Year 4	Subtotal	Year 5
Engineering Studies - AWMS	70 No.	8	14	22	20	42	20	62	8
Animal Waste Storage Facilities	70 No.	8	14	22	16	38	16	54	16
Construction Management - AWMS	70 No.	8	14	22	16	38	16	54	16
Nutrient Management Plan	70 No.	8	14	22	16	38	16	54	16
Cultural Resource Study - AWMS	70 No.	8	14	22	20	42	20	62	8
Prescribed Grazing Systems	93,100 Ac	18,620	18,620	37,240	18,620	55,860	18,620	74,480	18,620
Riparian Areas	69,300 LF	13,860	13,860	27,720	13,860	41,580	13,860	55,440	13,860
Streambank Stabilization	10,000 LF	2,000	2,000	4,000	2,000	6,000	2,000	8,000	2,000
Residue & Tillage Manage	114,100 Ac	22,820	22,820	45,640	22,820	68,460	22,820	91,280	22,820
Grassed Waterways	77,500 LF	10,000	17,000	27,000	17,000	44,000	17,000	61,000	16,500
Wetland/Pond/Basin Construction	155 No.	31	31	62	31	93	31	124	31
Conversion of Crop to Grass	3,400 Ac	280	780	1,060	780	1,840	780	2,620	780
Conservation Cover & Crop Rotation	51,400 Ac	5,280	11,530	16,810	11,530	28,340	11,530	39,870	11,530
Nutrient Management Plan	54,000 Ac	5,200	12,200	17,400	12,200	29,600	12,200	41,800	12,200
Windbreak/Shelterbelt	840 Ac	168	168	336	168	504	168	672	168
Terraces	15,000 LF	3,000	3,000	6,000	3,000	9,000	3,000	12,000	3,000
Filter Strips Non-CRP	1,700 Ac	340	340	680	340	1,020	340	1,360	340
CD Newsletters	20	4	4	8	4	12	4	16	4
Newspaper Articles	10	2	2	4	2	6	2	8	2
Radio Spots	5	1	1	2	1	3	1	4	1
Fair Demonstrations	10	2	2	4	2	6	2	8	2
WEB Site Listing	10	2	2	4	2	6	2	8	2
Semi-Annual Reports	5	1	1	2	1	3	1	4	1
Annual Reports	5	1	1	2	1	3	1	4	1
Final	1	0	0	0	0	0	0	0	1

9.0 MONITORING AND EVALUATION PLAN

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 SDDENR also maintains three ambient water quality monitoring sites within the watershed; two stations are located on the Missouri River in Charles Mix County (site #460673) and one in Yankton County (site #460674). The third site is at the mouth of Choteau Creek in Bon Homme County (site # 460134). The data from these 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.

The effectiveness of BMPs installed relative to the improvement in water quality will be evaluated using the appropriate tools and models available such as AnnAGNPS, RUSLE2, and STEPL models. The AnnAGNPS model 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. Any 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.

10.0 BIBLIOGRAPHY

1. Berg, Barry. 2010. *Final Report Lower Big Sioux River Watershed Implementation Project – Segment 1*. South Dakota Association of Conservation Districts. Pierre, South Dakota.

2. Czapar, G.F., J.M. Laflen, G.F. McIsaac, and D.P. McKenna. 2005. Effects of erosion control practices on nutrient loss. *In* Final Report: Gulf Hypoxia and Local Water Quality Concerns Workshop, Ames, Iowa, September 26-28, 2005, 117-127. Ames, IA: Upper Mississippi River Sub-basin Hypoxia Nutrient Committee.

3. Evans, Barry M., David W. Lehning, and Kenneth J. Corradini. June 2003, Revised February 2008. PRedICT Version 7.1, Users Guide for the Pollutant Reduction Impact Comparison Tool. Penn State Institutes of Energy and the Environment, The Pennsylvania State University, University Park, PA 16802.

4. Foster, G. R. and R. E. Highfill. 1983. *Effect of terraces on soil loss: USLE P factor values for terraces*. Journal of Soil and Water Conservation 38(1):48-51. Soil and Water Conservation Society. Ankeny, Iowa.

5. Hargrove, W.L., ed. 1991. *Cover Crops for Clean Water*. Ankeny, IA: Soil and Water Conservation Society

6. Jensen, Mike. February 2007. *Little Minnesota River Watershed/Big Stone Lake Restoration/Continuation Project.* Roberts Conservation District. Sisseton, South Dakota.

7. Jessop, Joseph. September 2010. *Clean Water Act Section 319 Nonpoint Source Control Program Final Report Medicine Creek Watershed Project.* American Creek Conservation District. Kennebec, South Dakota.

8 Knippling, Rocky. November 2009. *Watershed Project Final Report, Corsica Lake / Lewis & Clark Lake Watershed Improvement Project Segment 1.* Randall Resource Conservation & Development Association. Lake Andes, South Dakota.

9. Knippling, Rocky. March 2012. *Final Report Lewis & Clark Watershed Implementation Project, Segment 2.* Randall Resource Conservation & Development Association. Lake Andes, South Dakota.

10. Kringen, David. September 2010. Section 319 Nonpoint Source Pollution Control Program Watershed Project Final Report, Firesteel Creek/Lake Mitchell Watershed Project – Segment 2. Davison County, South Dakota.

11. Minnesota Pollution Control Agency. 2010. *Big Stone Lake.* RMB Environmental Laboratories. Minnesota River Basin, Upper Minnesota River Watershed. Saint Paul, Minnesota.

12. Nebraska Department of Environmental Quality. *Total Maximum Daily Loads for the Niobrara River Basin (Segments NI2-10000, NI3-10000, NI3-12300, NI3-13000,NI3-13100, NI3-21900, NI3-22500 and NI4-10000) Parameter of Concern: E. coli Bacteria.* December 2005. Nebraska Department of Environmental Quality, Planning Unit, Water Quality Division. Lincoln, Nebraska.

13. North Dakota State University Extension Service. August 2006. Water Quality and Wetland Function in the Northern Prairie Pothole Region. Bruce Seelig and Shawn DeKeyser. North Dakota State University, Fargo, North Dakota 58105.

14. SDDENR (South Dakota Department of Environment and Natural Resources). 1992. *Lake Assessment Project Report, Lake Andes, Charles Mix County, South Dakota.* South Dakota Clean Lakes Program, Division of Water Resources Management. SDDENR, Pierre, SD.

15. SDDENR. March 1997. *Phase I, Diagnostic Feasibility Study, Final Report Lake Mitchell / Firesteel Creek, Davison County, South Dakota.* SDDENR. Pierre, South Dakota.

16. SDDENR. June 1999. *Phase I Watershed Assessment Final Report. Clear Lake, Deuel County, South Dakota*. South Dakota Water Resources Assistance Program, Division of Financial and Technical Assistance SDDENR. Pierre, South Dakota.

17. SDDENR . September 1999. *Phase I Watershed Assessment Final Report. Blue Dog Lake, Day County, South Dakota*. South Dakota Water Resources Assistance Program, Division of Financial and Technical Assistance SDDENR. Pierre, South Dakota.

18. SDDENR. January 2002. *Phase I Watershed Assessment and TMDL Final Report, Rose Hill Lake/Sand Creek, Hand County, SD.* Sean Kruger and Andrew Repsys. South Dakota Watershed Protection Program Division of Financial and Technical Assistance. SDDENR, Pierre, South Dakota.

19. SDDENR. 2004. *Total Maximum Daily Load for Ammonia in Dry Choteau Creek near Avon, South Dakota.* South Dakota Watershed Protection Program, SDDENR, Pierre, South Dakota.

20. SDDENR . February 2005. *Phase I Watershed Assessment and TMDL Final Report, Corsica Lake, Douglas County, South Dakota.* South Dakota Watershed Protection Program South Dakota Department of Environment and Natural Resources, Pierre, South Dakota.

21. SDDENR. January 2006. *Phase I Watershed Assessment and TMDL Final Report, Dante Lake, Charles Mix County, SD.* Sean Kruger and Andrew Repsys. South Dakota Watershed Protection Program Division of Financial and Technical Assistance. Pierre, South Dakota.

22. SDDENR. April 2006. *Phase I Watershed Assessment Final Report Burke Lake, Gregory County, South Dakota.* Richard A. Hansen. South Dakota Watershed Protection Program, SDDENR. Pierre, South Dakota.

23. SDDENR. March 2007. *Phase I Watershed Assessment and TMDL Final Report, Geddes Lake, Charles Mix County, South Dakota.* Richard A. Hansen. South Dakota Watershed Protection Program Division of Financial and Technical Assistance, SDDENR. Pierre, South Dakota.

24. SDDENR. April 2009. *Fecal Coliform Total Maximum Daily Load Evaluation for Emanuel Creek, Bon Homme County, South Dakota.* SDDENR, Pierre, South Dakota.

25. SDDENR. May 2009. *Total Suspended Solids Total Maximum Daily Load Evaluation For Emanuel Creek, Bon Homme County, South Dakota.* SDDENR, Pierre, South Dakota.

26. SDDENR. February 2010. *Dissolved Oxygen Total Maximum Daily Load (TMDL) Lake Andes, Charles Mix County, South Dakota.* Aaron M. Larson. Water Resources Assistance Program. Pierre, South Dakota.

27. SDDENR. February 2010. *Total Suspended Solids Total Maximum Daily Load Evaluation for Choteau Creek, Bon Homme and Charles Mix Counties, South Dakota.* SDDENR. Pierre, South Dakota.

28. SDDENR. September 2011. Jesse Wilkens. *Escherichia coli Total Maximum Daily Load Evaluation of Pierre Creek, Hanson County, South Dakota.* SDDENR. Pierre, South Dakota.

29. SDDENR. January 2011. *Fecal Coliform Total Maximum Daily Load Evaluation of James River, Yankton County, South Dakota.* SDDENR. Pierre, South Dakota.

30. SDDENR. January 2011. *Fecal Coliform and Escherichia coli Bacterial Total Maximum Daily Load Evaluations for Dawson Creek, Hutchinson and Bon Homme Counties, South Dakota.* SDDENR. Pierre, South Dakota.

31. SDDENR. January 2011. *Fecal Coliform Total Maximum Daily Load Evaluation of James River, Yankton County, South Dakota*. SDDENR, Pierre, South Dakota.

32. SDDENR. June 2012. *The 2012 South Dakota Integrated Report Surface Water Quality Assessment*. SDDENR, Pierre, South Dakota.

33. SDDENR. June 2012. *Escherichia coli Bacteria Total Maximum Daily Load Evaluations for the North and South Forks of the Yellow Bank River – Grant, Codington, and Duel Counties, South Dakota*. SDDENR, Pierre, South Dakota

34. Sheffield, R. E., S. Mostaghimi, D. H. Vaughan, E. R. Collins Jr., and V. G. Allen. 1997. Offstream Water Sources from Grazing Cattle as a Stream Bank Stabilization and Water Quality BMP. American Society of Agricultural Engineers. Vol. 40: 595–604.

35. U.S. Bureau of Reclamation. Lewis And Clark Water Supply Project. *Finding of No Significant Impact and Final Environmental Assessment for the Lewis and Clark Water Supply Project, South Dakota, Minnesota, and Iowa.* March 2003. Prepared by TRC Mariah Associates Inc., Laramie, Wyoming MAI Project 27487. U. S. Bureau of Reclamation, Dakotas Area Office, Bismarck, North Dakota.

36. USDA (United States Department of Agriculture) NRCS (Natural Resources Conservation Service.) June 2009. *Phase II Sedimentation Assessment for the Upper Missouri River Basin USDA Nebraska, South Dakota, North Dakota, Montana, and Wyoming.* In Cooperation with Missouri Sedimentation Action Coalition.

37. USDA-NRCS. June 2012. *Assessment of the Effects of Conservation Practices on Cultivated Cropland in the Missouri River Basin.* Conservation Effects Assessment Project.
36. USDA (United States Department of Agriculture. Natural Resources Conservation Service. *Land Resource Regions and Major Land Resource Areas of the United States, the Caribbean, and the Pacific Basin.* United States Department of Agriculture Handbook 296, Issued 2006.

38. U.S. Army Corps of Engineers (USACE). December 2004. Gavins Point Dam/Lewis and Clark Lake Master Plan Missouri River, Nebraska and South Dakota. Update of Design Memorandum MG-123. Omaha District, Nebraska.

39. USGS (United States Geological Survey, Department of Interior). 1971. *Geology and Water Sources of Bon Homme County, South Dakota. Part II.* Donald G. Jorgensen. Bulletin 21. Prepared in cooperation with the South Dakota Geological Survey, County of Bon Homme, and Fort Randall Water Conservancy Sub-District.

40. USGS. 1972. Major Aquifers in Charles Mix and Douglas Counties, South Dakota. Jack Kume. South Dakota Geological Survey. Information pamphlet No. 2. Prepared in Cooperation with the South Dakota Geological Survey, Counties of Charles Mix and Douglas, and Fort Randall Conservancy Sub-District.

41. USGS. 1980. Major Aquifers in Aurora and Jerauld Counties, South Dakota. Louis J. Hamilton. South Dakota Geological Survey. Information pamphlet No. 23. Prepared in Cooperation with the South Dakota
Geological Survey, Counties of Aurora and Jerauld, and Lower James Conservancy Sub-District.

42. USGS. 2003. Water and Sediment Quality of the Lake Andes and Choteau Creek Basins, South Dakota, 1983-2000. Steven K. Sando and Kathleen M. Neitzert Water-Resources Investigations Report 03-4148. U.S. Geologial Survey Information, Denver, Colorado.

43. Strom, Roger. 2010. *Final Report Central Big Sioux River Watershed Project – Segment 1*. East Dakota Water Development District, Brookings, South Dakota.

44. Yagow, G., Dillaha, T., Mostaghimi, S., Brannan, K., Heatwole, C., and Wolfe, M.L. 2001. *TMDL modeling of fecal coliform bacteria with* HSPF. ASAE meeting paper No.01-2006. St. Joseph, Michigan.

45. Yuan, Y., R.L. Bingner, and J. Boydstun. Development of TMDL Watershed Implementation Plan Using Annualized AGNPS. Land Use and Water Resources Research 6 (2006) 2.1-2.8