LOWER PLATTE SOUTH NRD
WATER QUALITY
MANAGEMENT PLAN

PREPARED MAY 2019

FOR THE LOWER PLATTE SOUTH NRD
BY JEO CONSULTING GROUP, INC.

THIS PAGE LEFT INTENTIONALLY BLANK

Lower Platte South
Natural Resources District

District-Wide
Water Quality Management Plan

Prepared: March 2019
Accepted by EPA: May 2019

Acknowledgements

Preparation of this watershed plan was made possible by funding assistance provided by the Nebraska Department of Environmental Quality Nonpoint Source Pollution Management (CWA Section 319) Program.

Prepared for: *Lower Platte South Natural Resources District*

Prepared by: *JEO Consulting Group, Inc.*

JEO Project Number: *160602.00*

This watershed management plan was prepared to guide the Lower Platte South Natural Resources District in developing and implementing future projects to improve water quality, hydrology, and aquatic resources within their District. The plan may also serve as a basis for seeking financial support for those projects. It has been written with guidance published in EPA's "Handbook for Developing Watershed Plans to Restore and Protect Our Waters," updated March 2008, including EPA's Nine-Elements of a Successful Watershed Plan; as well as NDEQ's Guidance for Writing Basin Management Plans, updated November 2016. The planning process utilized a Community Based Approach.

Lower Platte South NRD Contact Information:

David Potter, Assistant General Manager
P.O. Box 83581
3125 Portia Street
Lincoln, NE 68501
402.476.2729
dpotter@lpsnrd.org

JEO Contact Information:

ADAM RUPE | Natural Resources Specialist
JEO CONSULTING GROUP INC
2700 Fletcher Avenue | Lincoln, Nebraska 68504-1113
d: 402.474.8742 | m: 402.322.0377 | o: 402.435.3080 | f: 402.435.4110
arupe@jeo.com

TABLE OF CONTENTS

LIST OF APPENDICIES

APPENDIX A: 11X17 MAPS

APPENDIX B: STAKEHOLDER AND PUBLIC PARTICIPATION MATERIALS

APPENDIX C: TECHNICAL MEMORANDUMS

APPENDIX D: WATER QUALITY MODELING RESULTS & REPORTS

APPENDIX E: BEST MANAGEMENT PRACTICES DESCRIPTIONS

APPENDIX F: ACPF ATLASES

APPENDIX G: NDEQ 5-ALT INFORMATION

APPENDIX H: BMP CALCULATOR TOOL

APPENDIX I: GLOSSARY

CD-ROM (in front cover pocket)

Digital copy of the plan, appendices, and maps in PDF format.

LIST OF TABLES

LIST OF FIGURES

Note: *Most maps in the main body of this plan are inset into the corresponding text, however select maps are available in a larger format, in Appendix A. Those maps are designated with an asterisk in the figure name.*

LIST OF ABBREVIATIONS AND ACRONYMS

ACPF	Agriculture Conservation Planning Framework
Acre-ft.	Acre-feet
ACS	American Community Survey
ACT	Avoid, Control, Trap
AFO	Animal Feeding Operation
AL	Aquatic Life
AWS	Agricultural Water Supply
BMP	Best Management Practice
BOC	Bureau of the Census (US Census Bureau)
BUL	Biologically Unique Landscape
CAC	Citizen Advisory Committee
CDL	Cropland Data Layer
CFS	Cubic feet per Second
CFU	Colony Forming Unit
Clearinghouse	Quality-Assessed Agrichemical Contaminant Database for Nebraska Groundwater
CP	Conservation Practices
CPA	Crete-Princeton-Adams
CRP	Conservation Reserve Program
CSA	Critical Source Area
CSD	Conservation Survey Division
CSP	Conservation Stewardship Program
CWA	Cold Water A
CWB	Cold Water B
CWSPA	Community Water System Protection Area
DHHS	Department of Health and Human Services
DV	Dwight-Valparaiso
EPA	Environmental Protection Agency
EQIP	Environmental Quality Incentives Program
FA	Fully Appropriated
FEMA	Federal Emergency Management Agency
FHWA	Federal Highway Administration
FIS	Flood Insurance Study
GIS	Geographic Information System
GWR	Groundwater Reservoir
HCA	Hydrologically Connected Area
HSG	Hydrologic Soil Groups
HUC	Hydrologic Unit Code
I&E	Information and Education
IMP	Integrated Management Plan
IPM	Integrated Pest Management

IR	Integrated Report
IWS	Industrial Water Supply
JEO	JEO Consulting Group, Inc.
LID	Low Impact Development
LPSNRD	Lower Platte South Natural Resources District
LULC	Land Use Land Cover
LWCF	Livestock Waste Control Facility
MCL	Maximum Contaminant Level
Mg/L	Milligram per liter
MS4	Municipal Separate Storm Sewer System
MST	Microbial Source Tracking
NASS	National Agriculture Statistics Service
NDEQ	Nebraska Department of Environmental Quality
NDOT	Nebraska Department of Transportation
NeDNR	Nebraska Department of Natural Resources
NESC	National Environmental Services Center
NET	Nebraska Environmental Trust
NFS	Nebraska Forest Service
NGPC	Nebraska Game and Parks Commission
NPDES	National Pollutant Discharge Elimination System
NPS	Nonpoint Sources
NRCS	Natural Resources Conservation Service
NRD	Natural Resources District
NWI	National Wetland Inventory
NWS	National Weather Service
OA	Over Appropriated
OWTS	On-site Wastewater Treatment System
Partnership	Saline Wetlands Conservation Partnership
PCR	Primary Contact Recreation
PDW	Public Drinking Water
PIP	Project Implementation Plans
Ppm	parts per million
QAPP	Quality Assurance Project Plan
RA	Remaining Area
SID	Sanitary Improvement District
SIPES	Social Indicator Planning & Evaluation System
SRA	State Recreation Area
STEPL	Spreadsheet Tool for Estimating Pollutant Loads
T&E	Threatened and Endangered
TAC	Technical Advisory Committee
TMDL	Total Maximum Daily Load
TN	Total Nitrogen

TP	Total Phosphorus
TSS	Total Suspended Solids
UNL	University of Nebraska Lincoln
USACE	United States Army Corps of Engineers
USBR	United States Bureau of Reclamation
USDA	United States Department of Agriculture
USFS	United States Forest Service
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
VTS	Vegetative Treatment System
WASCOB	Water and Sediment Control Basin
WBD	Watershed Boundary Dataset
WHP	Wellhead Protection
WLA	Waste Load Allocation
WMA	Wildlife Management Area
WQMP	Water Quality Management Plan
WQP	Water Quality Portal
WQS	Water Quality Standards
WWA	Warmwater A
WWB	Warmwater B
WWTF	Wastewater Treatment Facility

PLANNING PARTICIPANTS

TECHNICAL ADVISORY COMMITTEE

LOWER PLATTE SOUTH NATURAL RESOURCES DISTRICT

- Paul Zillig, General Manager
- David Potter, Assistant General Manager
- Dick Ehrman, Water Resources Specialist
- Ryan Rezac, Water Resources Compliance Specialist

NEBRASKA DEPARTMENT OF ENVIRONMENTAL QUALITY

- Carla McCullough, Section 319 Nonpoint Source Coordinator
- Brian Barnes, Program Specialist, Water Quality Planning Unit

NATURAL RESOURCES CONSERVATION SERVICE

- Cory Schmidt, District Conservationist

NEBRASKA GAME AND PARKS COMMISSION

- Jeff Jackson, Southeast Fisheries Supervisor

CITY OF LINCOLN

- Tom Malmstrom, Saline Wetlands Conservation Partnership
- Shannon Ideus, Watershed Management

CITIZEN ADVISORY COMMITTEE

The Citizen Advisory Committee (CAC) consisted of three representatives from the LPSNRD Board of Directors: Mark Spangler, Don Jacobson, and Bruce Johnson. Additionally, 31 members of the public attended CAC meetings, which were held as open house style meetings.

EXECUTIVE SUMMARY

The Lower Platte South Natural Resources District (LPSNRD), with technical and financial assistance from the Nebraska Department of Environmental Quality (NDEQ), has prepared a District-Wide Water Quality Management Plan (WQMP) to address issues and present solutions regarding non-point source pollution in the NRD. This effort produced a voluntary plan with a 5-year horizon which advises and guides the NRD by providing a framework on planning activities, identifies strategies to address and meet water quality standards, and prioritizes implementation of solutions at the subbasin and sub-watershed level.

This plan consists of numerous components including the following:

- Identification and evaluation of best management practices (BMPs) for applicability, effectiveness, and cost;
- Descriptions of information and education (I&E) strategies to successfully reach decision makers, stakeholders, and the public;
- Recommendations for monitoring and evaluation of BMP and I&E performance; and,
- Analysis of types and costs of implementation for projects with an evaluation of potential funding opportunities.

The result of this effort has been a planning document that serves as a road map to improve the water resources and water quality within the planning area.

The LPSNRD includes parts of six counties in southeast Nebraska and contains numerous communities, including the City of Lincoln. The district has a mixture of rural and urban environments, terrain, soils, vegetation, surface water and groundwater resources, and other parameters that are addressed in the plan. The WQMP planning area is intended to align with the LPSNRD boundary as closely as possible, while following watershed boundaries. The plan boundaries generally follow three major subbasins: Keg-Weeping Water, Lower Platte, and Salt. These subbasin are classified as hydrologic unit code 8 (HUC 8). It should be noted that the Platte and Missouri Rivers are not included as a part of this plan. In addition to the HUC 8 analysis, a more focused analysis occurred at the smaller HUC 12 subwatershed scale. Detailed planning, including numerical analysis, feasibility, and project prioritization for Target Areas, took place with the NRD. These Target Areas included: Middle Creek and Pawnee Lake, Twin lakes, Antelope Creek, Little Salt Creek, and Decker Creek.

This plan emphasizes that effective communication by project sponsors is critical to faciliate behavioral changes in those responsible for land management decisions. Outreach and education to stakeholders (producers, farm mangers, propery owners, land managers, water users, etc.) and the general public is vital to achieve the purpose of the plan. The success of this plan hinges on the voluntary efforts of these individuals. Because this plan is non-regulatory, participants must be engaged and educated throughout the process to understand and value the benefits of improved water quality. The goals and objectives identified in this plan by stakeholders were instrumental in making the WQMP relevant. Through stakeholder involvement and partner input the goals and objectives of the WQMP were established to connect this document to the *NDEQ 2015 State Nonpoint Source Management Plan*.

Funding will be critical to implement this WQMP. The planning level opinion of cost for needed improvements to achieve water quality goals in identified target areas is estimated at over $118 million dollars. Local funding (from the LPSNRD) will not be enough to address a problem of this magnitude, nor will it be solved in just 5-years. Therefore, prioritization will be essential to address the most critical or projects with the greatest potential to improve water quality first. Additionally, funding from federal, state, and other local sources, along with grants will need to be leveraged. Support from the general public and stakeholders will be vital to gain the backing and resources needed to implement identified projects. By combining the long-term vision detailed in this WQMP and proactive management by the project sponsors, the water resources in the LPSNRD can be improved and non-point source pollution can be prevented.

CHAPTER 1. INTRODUCTION AND BACKGROUND

1.01 PLAN PURPOSE

The Lower Platte South Natural Resources District (LPSNRD) District-Wide Water Quality Management Plan (WQMP) is intended provide a concise summary of the condition of water resources in the LPSNRD, as well as direction and a coordinated approach for addressing nonpoint source pollution. The WQMP is based upon the United States Environmental Protection Agency's (EPA) Nine-Elements of Watershed Planning (EPA, 2008), as well as basin planning guidance provided by the Nebraska Department of Environmental Quality (NDEQ) (NDEQ, 2016c).

The WQMP provides one overarching plan that will identify and focus on district-wide priorities. Once the plan is in place, efforts can be directed to project development and funding acquisition. District-wide plans provide numerous benefits including allowing access to Section 319 funding for nonpoint source (NPS) projects; enhancing project buy-in and grant funding potential by integrating LPSNRD, agency, and community priorities; providing supporting information for project and grant application development; aiding in LPSNRD and agency budget planning; and allowing for better coordination between funding sources for projects and activities.

This WQMP documents specific projects intended for implementation over the next five years. These projects and practices are aimed at improving water quality and removing targeted waterbodies from the Section 303(d) List of Impaired Waters.

1.02 PREVIOUS PLANNING EFFORTS

The LPSNRD and other area partners have a long history of managing water quality and completing watershed-based projects. There have been many projects, plans, and programs developed in recent years with similar purposes to this plan. While many included water quality, others focused only on water quantity; however, many lack the EPA's "Nine-Elements" of a watershed plan (discussed in more detail below). Even with these differences, these existing efforts provide a valuable framework and source of information for this plan. Where plans overlapped relevant information and data was incorporated into this plan. However, some of these plans (as referenced throughout this document) are still relevant and contain many details that will be necessary for implementation or a deeper understanding of the resources.

Previously Developed Related Plans and Reports:

- Antelope Creek Watershed Basin Management Plan, March 2012*
- Lower Platte River Corridor Alliance Water Quality Management Plan, See below*
- Conestoga Reservoir Water Quality Management Plan, 2011*
- City of Lincoln Watershed Master Plans (multiple plans covering multiple drainage areas), various years, most recent completed in 2018

- LPSNRD Groundwater Management Plan, 1995
- LPSNRD Voluntary Integrated Management Plan, 2014
- Upper Little Salt Creek Saline Wetlands Plan, 2015
- Holmes Lake Watershed Management Plan, 2003*
- Wagon Train Reservoir Watershed Management Plan, 2001*
- Norder Wetland Restoration Design Memorandum, 2018

**Indicates plan contains the nine-elements*

1.03 PLANNING AREA

OVERVIEW

The WQMP area is intended to match the LPSNRD boundary as closely as possible, while following watershed boundaries. Therefore, the actual plan area boundary doesn't coincide exactly with the LPSNRD boundary, as shown in Figure 1. The plan boundaries generally follow three major watersheds: Keg-Weeping Water, Lower Platte, and Salt. The Platte and Missouri Rivers are not included as a part of this plan but are provided in Figure 1 for reference.

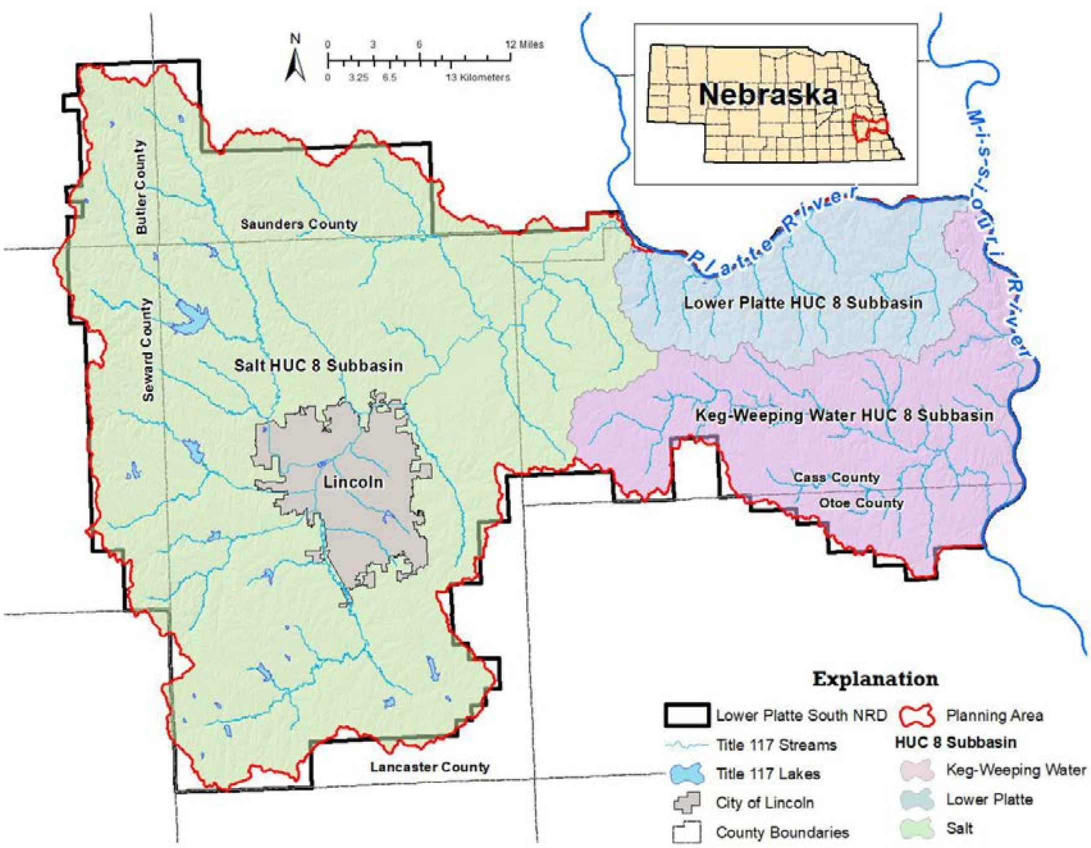


Figure 1: Plan Boundary

Watershed boundaries in the plan, unless noted otherwise, are derived from the Watershed Boundary Dataset (WBD), which is maintained by the United States Geological Survey (USGS), in cooperation with the Natural Resources Conservation Service (NRCS). The WBD is a nationally standardized database of multi-level watershed boundaries, each of which is assigned a hierarchical hydrologic unit code (HUC) number. The WBD is divided into six levels of HUCs, the boundaries of which are determined by science-based hydrologic principles without consideration for political or administrative boundaries (USGS, 2017).

The WQMP is based upon major HUC 8 subbasins, which serve as the basis for the planning document's organization. The boundaries for this plan were developed based on NDEQ basin planning guidance (NDEQ, 2015c), which instructs plan sponsors to include a subplan for each of the HUC 8 boundaries within the NRD, with targeted areas making up no more than 20% of an individual HUC 8. There are three chapters within this WQMP that focus specifically on these subbasins. The most up-to-date WBD data set for Nebraska was downloaded from the NRCS Geospatial Data Gateway to accurately identify the planning area boundaries (USGS, 2017). This plan's boundaries are based upon the partial boundaries of three HUC 8 subbasins: Keg-Weeping Creek (10240001) at 206,944 acres; Lower Platte River (10200202) at 115,394 acres; and Salt Creek (10200203), the largest at 726,436 acres, which also includes the entire City of Lincoln. More specifically, the boundaries follow, all or portions of, the following HUC 10 watersheds which are nested within each of the HUC 8s:

- HUC 8 Subbasin: Keg-Weeping Water
  - Weeping Water Creek: 102400102 (All)
  - Horse Creek-Missouri River: 1024000103 (Portion)
  - Indian Creek-Missouri River: 1023000606 (Portion)
- HUC 8 Subbasin: Lower Platte
  - Buffalo Creek-Platte River: 1020020202 (Portion)
- HUC 8 Subbasin: Salt
  - Oak Creek: 1020020304 (All)
  - Middle Creek: 1020020302 (All)
  - Rock Creek: 1020020305 (All)
  - Upper Salt Creek: 1020020301 (All)
  - Middle Salt Creek: 1020020303 (All)
  - Lower Salt Creek: 1020020309 (All)
  - Clear Creek-Wahoo Creek: 1020020310 (Portion)

Efforts were made to minimize splitting any WBD boundaries, however this was unavoidable where the Platte River and Missouri River split HUC 8 and/or HUC 10 boundaries, and in two specific HUC 12s. A small portion of the "Walnut Creek-Missouri River" HUC 12 subwatershed (102400010307) was included. The portion of this HUC 12 within the District is a hydrologically separate drainage area, which allowed more of the District boundaries to be included within the planning area. Additionally, a small portion of the "Wahoo Creek" HUC 12 subwatershed (102002031005) was included. This HUC 12 contains the outlet of Salt Creek to the Platte River.

Only the portion of these HUC 12s that are within the LPSNRD boundaries were included. This ensured a more complete and logical coverage of the true hydrologic boundaries was included.

BASIN SUMMARY

The LPSNRD is located in southeast Nebraska and covers approximately 977,525 acres including nearly all of Lancaster and Cass counties and parts of Butler, Otoe, Saunders, and Seward counties. According to 2015 data from the US Census Bureau (BOC), the population of the planning area is approximately 303,000, which includes both rural residents and residents of 36 communities (USBOC, 2015). The LPSNRD serves diverse rural and urban interests, as 85% of the land is rural, but 89% of the population is urban or located in a town. With a high population of urban residents, urban natural resource management is an important priority of the LPSNRD. Further details on the characteristics of the plan area are shown in Table 1.

Table 1: Plan Area Characteristics

Plan Area Component	Component Details
EPA Region	VII
8-digit Hydrologic Unit Code (HUC)	1) Keg-Weeping Water (10240001) 2) Lower Platte (10200202) 3) Salt (10200203)
Counties	Lancaster, Cass, Butler, Otoe, Saunders, and Seward
Tribes	None
Location of LPSNRD Office	Lincoln, NE
Latitude/longitude (LPS Office)	40.84353 / -96.69999
Estimated Population (year)	303,060 (2015)
Plan Area Boundary Size	1,048,774 acres
Basin length/width	65 miles / 45 miles
Major river watershed	Lower Platte and Missouri Rivers
Major streams	Salt Creek, Oak Creek, Weeping Water Creek
Major economic activity	Industry, commercial, and agriculture
Major crops	Corn, soybeans
Major livestock	Cattle, swine
TMDL pollutants	*E. coli* Bacteria, Atrazine, Siltation/Sedimentation, Dissolved Oxygen, Nutrients (Phosphorus and Nitrogen), Total Ammonia
Lake designated uses (number of applicable lakes)	Recreation (24) Aquatic Life (24) Public Drinking (0) Aesthetic (20) Industrial (0)
Stream designated uses (number of applicable lakes), not including Platte or Missouri Rivers	Recreation (11) Aquatic Life (22) Drinking Water (0) Agriculture (18) Industrial (0) Aesthetic (38)

LOWER PLATTE RIVER CORRIDOR ALLIANCE

The Lower Platte River Corridor Alliance (LPRCA) began in 1996 as a consortium of three Natural Resources Districts (NRDs) and six state agencies dedicated to working with people to protect the long-term vitality of the Lower Platte River Corridor. The Lower Platte River Corridor is generally defined as the Lower Platte River, the bluffs, and the adjoining public and private lands located within the floodplain of the Lower Platte River from Columbus to the mouth of the river near Plattsmouth (Figure 2). This area, which runs 110 miles, supports exceptional biodiversity and serves as a valuable resource for Nebraskans (LPRCA, 2018).

LPRCA is currently developing a WQMP which overlaps portions of the planning area covered by this plan (HDR, 2018). This area is primarily within the Platte River HUC Subbasin area. At the time of the preparation of this plan, the LPRCA WQMP was note yet finalized. However, pertinent information has been incorporated and referenced within this plan.

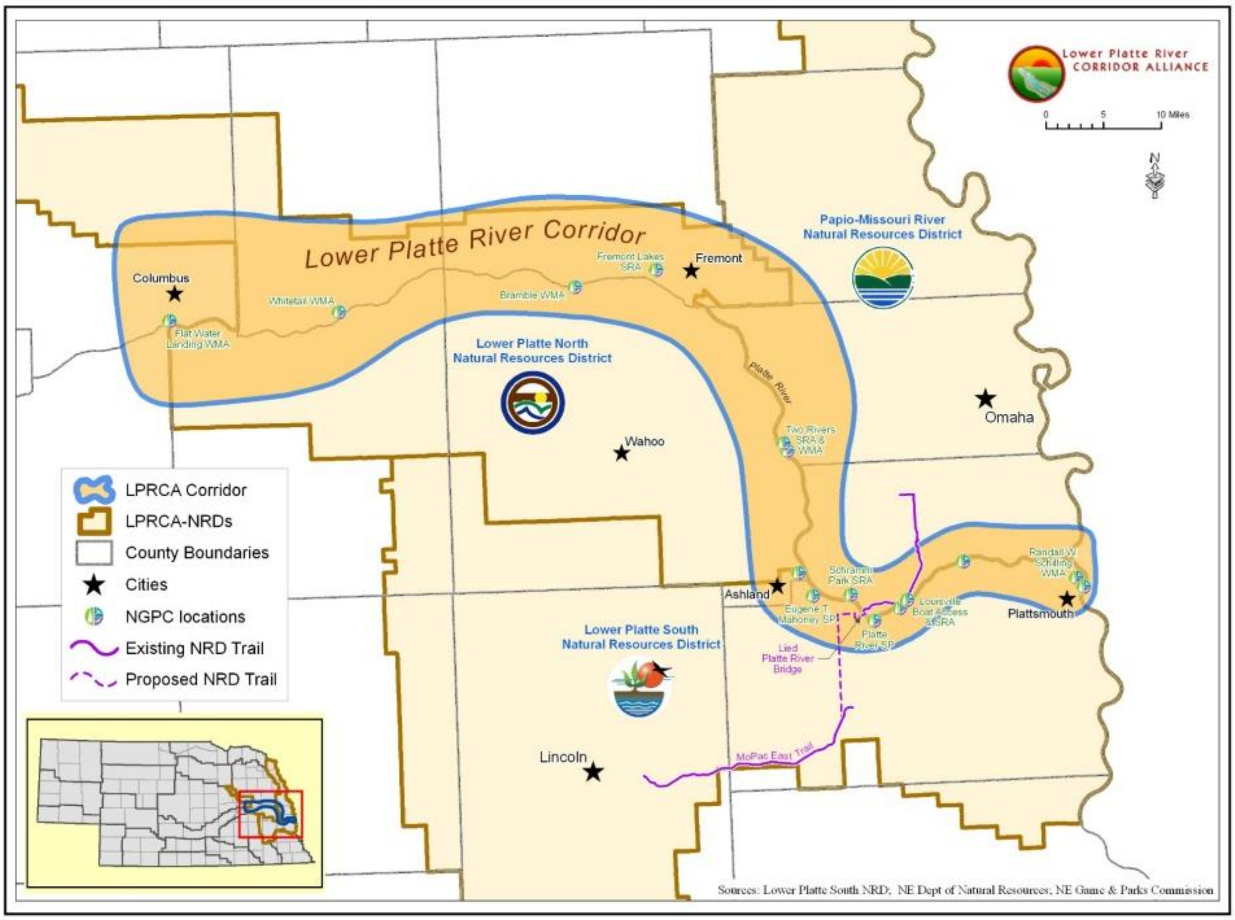


Figure 2: Lower Platte River Corridor Alliance Area

1.04 PLANNING PROCESS SUMMARY

HISTORY AND FUNCTION OF NRDS

Nebraska is unique in the United States in regards to its watershed-based natural resources management system. With the establishment of the state's Natural Resources Districts (NRDs) in 1972 (which are based on major river basins), local communities were empowered to protect, enhance, conserve, and restore their natural resources at a local level. NRDs are statutorily recognized government authorities governed by locally elected board members. Each NRD's board of directors oversees staff that perform their duties to meet the purposes of their NRD. The LPSNRD is highlighted in Figure 3, which illustrates the location of all the NRDs in relation to major river basin boundaries.

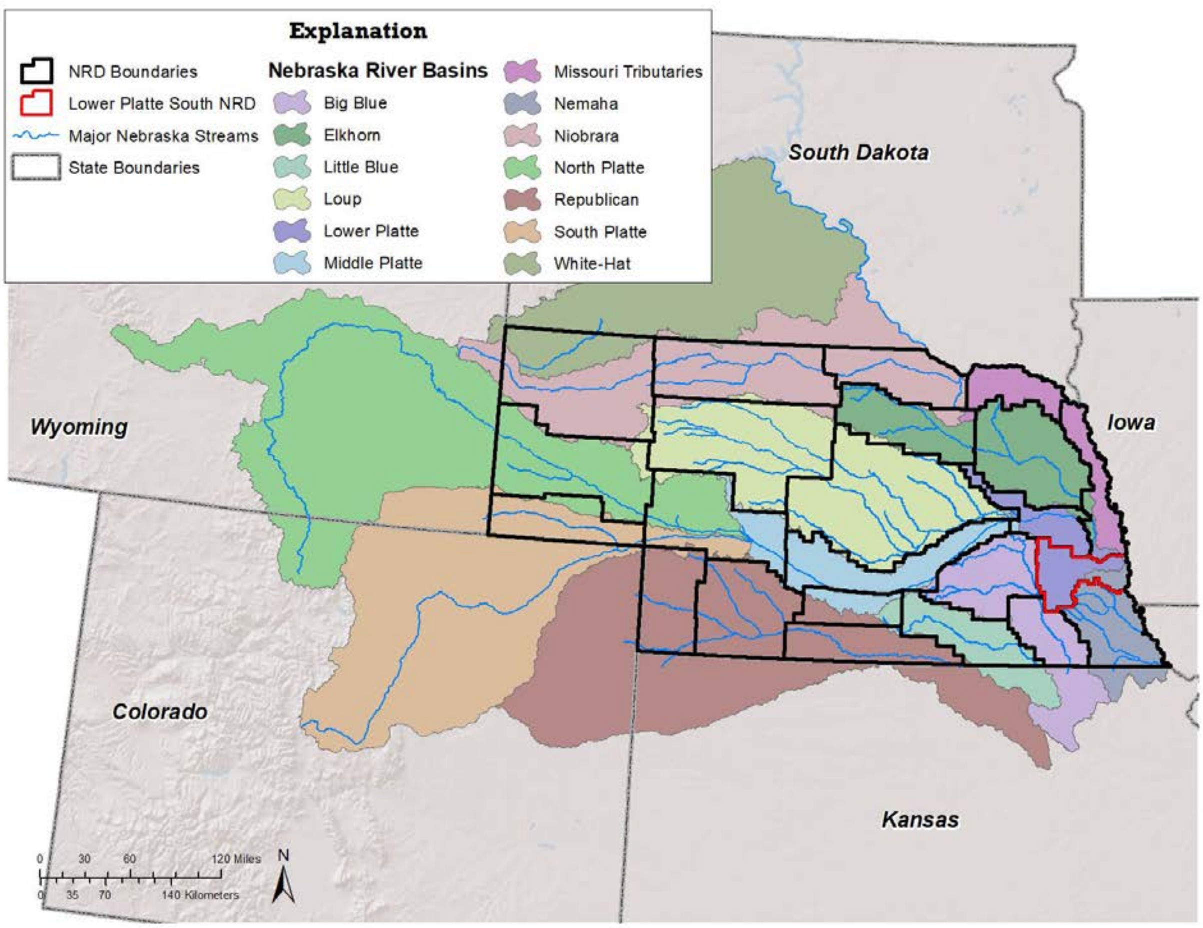


Figure 3: Nebraska's Natural Resources Districts

Watershed planning, which is a flexible framework for managing natural resources within specified drainage areas (watersheds), is a natural fit for the NRD system. Logically, NRDs develop and implement watershed-based plans at a local level, which are driven by stakeholder and community involvement and lead to long-term, proactive actions supported by science.

Using a watershed approach to restore impaired water bodies is beneficial because it addresses the problems in a holistic manner. Stakeholders and citizens were actively involved in selecting management strategies for this plan, thereby ensuring they are more likely to be successfully implemented.

NEBRASKA'S NONPOINT SOURCE MANAGEMENT PROGRAM

NDEQ is responsible for implementing the United States Clean Water Act, Section 319 Program for the State of Nebraska. This program focuses on the control of nonpoint sources of water pollution in order for water bodies to meet their beneficial uses. NDEQ's Nonpoint Source Management Program is guided by the *State Nonpoint Source Management Plan 2015 – 2030* (NDEQ, 2015b). This WQMP has been written to not only address local concerns, but also advance the goals and objectives laid out in the State Nonpoint Source Management Plan. NDEQ was an integral partner in developing this WQMP.

NINE-ELEMENTS OF WATERSHED PLANNING

The WQMP addresses the EPA's Nine-Elements, as defined in their *Handbook for Developing Watershed Plans to Restore and Protect our Waters* (USEPA, 2008). The EPA requires that the watershed projects receiving Section 319 funds be supported by a watershed plan that addresses the Nine-Elements or an equivalent plan. For each target area in the plan, each of the nine-elements can be found in it's appropriate subbasin HUC 8 chapter (Chapters 10 – 12). For items that address one of the Nine-Elements, that are not in a subbasin chapter, those are marked with a graphic throughout this plan, as displayed to the left. Table 2 also provides the reader a shortcut to the location of these element.

Table 2: Location of the Nine-Elements within the Plan

Element	Page Number
Pollution/impairment source identification	99, 101, 105, 110, 145
Estimate of pollutant loading reduction needs	163, 265, 303
Nonpoint source management practices needed	142, 143
Public information, education, and participation	8, 11, 125
Schedule for implementing management practices	163, 265, 299
Milestones to track progress in implementing the plan	163, 265, 300
Criteria to evaluate effectiveness of management practices	298
Monitoring to evaluate the impact of implementing management practices	79
Technical and financial resource needs	147, 301

*The implementation plans for each target area (Chapters 10 – 12) also address the nine-elements, but are not included in this table.

STAKEHOLDER PARTICIPATION AND PLANNING PROCESS

Bringing together people, policies, priorities, and resources through a watershed approach blends science and regulatory responsibilities, with social and economic considerations. Because watersheds typically don't follow political boundaries, gathering input from stakeholders and the general public is an important part of the planning process. Successful development and implementation of a WQMP depends primarily on the commitment and involvement of community members. Therefore, it was critical to build partnerships with key interested parties at the beginning of the planning effort.

Public involvement was a cornerstone in the development of the WQMP. Citizens, non-profit organizations, landowners, and other residents of the watershed all possess first-hand experience with the challenges faced in maintaining water quality, and the success or failure of projects within the NRD. Their experience and knowledge will continue to be a vital element in identifying opportunities, creating partnerships, and completing projects in the future implementation of this plan.

The LPSNRD began the process of developing the WQMP with the establishment of a Technical Advisory Committee (TAC), which consisted of representatives from resource management agencies (including NDEQ) and the consultant. The TAC was tasked with guiding the planning process, reviewing the plan and other technical analysis, and providing input in regards to agency priorities and capabilities. The TAC first met on June 22, 2017. JEO Consulting Group, Inc. (JEO) of Lincoln, Nebraska was contracted to guide and facilitate the planning process and assemble the plan. Ryan Rezac, LPSNRD Water Resources Compliance Specialist, led the development of the plan at the sponsor staff level and served as the Project Manager and primary point-of-contact throughout the project. A total of three TAC meetings were held throughout the development of this plan.

Additionally, the LPSNRD established a Citizens Advisory Committee (CAC), which consisted of representatives from LPSNRD Board of Directors. However, CAC meetings were held as public open house style meetings to allow for additional input from citizens. The first of three meetings was held on June 22, 2017. A final open house, for review of the final draft plan was held on August 30, 2018. This meeting provided attendees with an overview of the purpose of the plan and the opportunity to solicit public comments and questions and to identify any key water quality issues in the plan area. Further documentation of the public involvement process such as meeting minutes, sign-in sheets, and public involvement notification materials (copies and clippings) can be found in Appendix B.

PRIORITIZATION

A key part of the planning process and intent of a basin management plan is to identify priorities and associated target areas for plan implementation. This is an effort to achieve an economies-of-scale of the basin-wide planning process, while also avoiding a shotgun approach towards implementation. In order to achieve this, planning is done at the NRD scale and the *2015 State*

Nonpoint Source Management Plan specifies that target areas may only make up a maximum of 20% of a HUC 8 area (NDEQ, 2015b).

In order to achieve this intent and follow NDEQ guidance, a prioritization process was identified, which is discussed in more detail in Chapter 9. This process vetted possible priorities through technical expert and public reviews, and was shared with NDEQ and EPA, before plan approval by the project sponsor (LPSNRD) and acceptance by NDEQ and EPA. For each target area in the HUC 8s, the WQMP identifies pollutant sources, pollutant loads, pollutant load reductions, and an implementation strategy. These considerations allow the plan to become the guiding document for addressing nonpoint source pollution in the LPSNRD.

1.05 DOCUMENT ORGANIZATION AND UPDATES

The WQMP document has been prepared and organized based on discussions with NDEQ and LPSNRD throughout the planning process and is based upon published NDEQ guidance (NDEQ, 2015b and NDEQ, 2016c). The overall intent of the document is to guide readers through an overview of the existing resources and conditions within the plan area, identify which resources are a priority to implement water quality improvement projects, and to develop an implementation strategy to achieve the plan's goals. The HUC 8 chapters are intended to lay out a detailed nine-element based strategy of implementation for each priority area.

The WQMP will require updating every five years, therefore the format takes this into consideration and is designed to be dynamic rather than fixed, allowing for minimal updating effort. Future updates may include:

- Chapter 2
    - Revision of goals and objectives
- Chapter 5
    - Revised assessment of water quality data as compared to WQMP criteria
    - Determination of whether the current strategy is on track to meet plan goals; and, if needed, new nonpoint source load estimates
    - Updated management strategies and priorities
    - Updates to the resource and budget needs
- Chapter 9
    - Revised priority or target areas

THIS PAGE LEFT INTENTIONALLY BLANK

CHAPTER 2. GOALS AND OBJECTIVES

2.01 PLAN PURPOSE

The goals and objectives of the WQMP were established through the stakeholder involvement process (Figure 4) and provide a direct connection to the *2015 State Nonpoint Source Management Plan* (NDEQ, 2015b). A first step in developing plan goals was identifying a "vision", or an optimal desired future state, for the LPSNRD planning area. The goals then describe the preferred end result of action in support of that vision, while the objectives describe the steps necessary to achieve that goal. Stakeholders had multiple opportunities to help set goals and objectives, as well as review drafts throughout the process. The goals were written in a manner to provide guidance throughout the District, but flexible enough to enable various methods of implementation within the target areas described later in the WQMP.

The vision, goals, and objectives for the entire WQMP are summarized in

Table 3, while each goal, objective, and tasks are described subsequently in Table 4, Table 5, and Table 6. These goals and objectives provided direction for priority identification and implementation planning. Pollutant reduction goals specific to target waterbodies are described later in each respective subbasin chapter.

Figure 4: Stakeholders attending a public meeting listen to an education presentation and participate in a discussion about watershed issues and priorities

Table 3: Goals and Objectives of the LPSNRD WQMP

Vision	Water resources within target areas will be locally managed to restore and/or maintain the quality, diverse uses, and ecosystem services of the streams, lakes, and wetlands for current and future generations using voluntary, economical, and environmentally friendly methods.	
Goal 1	The surface and groundwater resources within the LPSNRD target areas, or special priority areas, will be enhanced through a comprehensive and collaborative program that efficiently and effectively implements actions to restore and protect natural resources from degradation and impairment.	
Objectives	**1.1**	*Natural resources management actions will be based on sound data and effective directing of resources.*
	1.2	*Strong working partnerships and collaboration among appropriate local, state, and federal agencies; and non-governmental organizations, will be established and maintained regarding management of natural resources.*
	1.3	*Comprehensive and systematic strategies will be employed to restore and protect natural resources.*
	1.4	*The status, effectiveness, and accomplishments of projects and activities directed toward management of natural resources will be continually assessed and periodically reported to the public, stakeholders, and agencies.*
Goal 2	Resource managers, public officials, community leaders, and private citizens will be informed about the effects of human activities on water quality and change their behavior in order support actions to restore and protect water resources from impairment by nonpoint source pollution.	
Objectives	**2.1**	*Deficiencies in knowledge needed to improve decision making regarding management of natural resources will be identified and investigated.*
	2.2	*Products and tools to effectively transfer knowledge and facilitate actions regarding management of natural resources will be developed, improved and maintained.*
Goal 3	The water resources, land, and biological resources utilized for beneficial uses in the LPSNRD WQMP target areas will be healthy, productive, and sustainable through actions of the LPSNRD, communities, and other resource agencies.	
Objectives	**3.1**	*Reservoir, streams, and wetland systems will meet or exceed levels of quality necessary to serve the needs of the citizens.*
	3.2	*Land and stream resources in the target watersheds of the LPSNRD will be stable and productive.*
	3.3	*The riparian corridors along streams and tributaries within the LPSNRD will support native vegetation and provide a healthy and productive habitat for wildlife.*

Table 4: Goal 1 and related objectives and tasks

Goal 1	
The surface and groundwater resources within the LPSNRD target watersheds, or special priority areas, will be enhanced through a comprehensive and collaborative program that efficiently and effectively implements actions to restore and protect natural resources from degradation and impairment.	
Objectives / Tasks	
Objective 1.1: Natural resources management actions will be based on sound data and effective directing of resources.	
1.1.1	To review and revise monitoring and assessment methods and protocols to assure that data accurately detect and quantify water quality threats and impairments and that data are useful in guiding management decisions.
1.1.2	To evaluate threats and impairments to natural resources through ongoing monitoring, data assessment, and special studies, in coordination with other resource agencies.
1.1.3	To review and, as necessary, revise the lists of target areas, special priority areas, and special priority activities identified for restorative or protective management actions every five years.
1.1.4	To review and amend, as deemed necessary, the WQMP every five years, to update and keep current milestones and schedule for implementation.
Objective 1.2: Strong working partnerships and collaboration among appropriate local, state, and federal agencies; and non-governmental organizations, will be established and maintained regarding management of natural resources.	
1.2.1	To incorporate input from a variety of resource agencies and to communicate issues regarding management of natural resources.
1.2.2	To utilize local input through formation of a local stakeholder group, within each target area, to assist in planning and implementing natural resources management projects and activities.
1.2.3	To allocate necessary resources and utilize existing NRD staff and conservation programs in collaboration with those of other agencies to achieve complementary implementation of conservation programs, projects, and activities.
Objective 1.3: Comprehensive and systematic strategies will be employed to restore and protect natural resources.	
1.3.1	To develop project implementation plans (PIPs) that address actions outlined in the WQMP.
1.3.2	To implement projects in target areas that restore and protect natural resources, reduce pollution of water resources and lead to delisting of impaired waters or protection of high quality waters.
1.3.3	To utilize multiple conservation programs, both existing and newly developed, and complementary practices in implementing projects.
1.3.4	To create multi-beneficial integrated management projects, by incorporating water quality practices into the LPSNRD Voluntary Integrated Management Plan.
Objective 1.4: The status, effectiveness and accomplishments of projects and activities directed toward management of natural resources will be continually assessed and periodically reported to the public, stakeholders, and agencies.	

1.4.1	To conduct progress and financial reviews of grant-funded implementation projects.
1.4.2	To track and assess conservation and outreach activities to assure that restoration and protection of natural resources and distribution of project information are adequately addressed in a timely manner.
1.4.3	To summarize past accomplishments and make recommendations for further actions in implementing the WQMP in annual and final project reports, periodic reports to partners, and project success stories.

Table 5: Goal 2 and related objectives and tasks

Goal 2	
Resource managers, public officials, community leaders, and private citizens will be informed about the effects of human activities on water quality and change their behavior in order support actions to restore and protect water resources from impairment by nonpoint source pollution.	
Objectives / Tasks	
Objective 2.1: Deficiencies in knowledge needed to improve decision making regarding management of natural resources will be identified and investigated.	
2.1.1	To identify and define unique and underserved audiences to be engaged through outreach.
2.1.2	To identify and address known knowledge gaps in key audiences that impede their fuller participation in actions to manage natural resources.
Objective 2.2: Products and tools to effectively transfer knowledge and facilitate actions regarding management of natural resources will be developed, improved and maintained.	
2.2.1	To develop, expand, and improve the capability and capacity of local stakeholders to communicate effectively with other landowners and conservation partners to promote natural resources management.
2.2.2	To develop and improve effective outreach programs, projects and activities to educate key audiences about management of natural resources and options for conservation practices.
2.2.3	To compile and publicize information on opportunities for conservation practices, including contact information, program overview, and potential money available.
2.2.4	To develop and distribute audience-specific materials to inform and engage community leaders, local media, youth, educators, and other defined audiences regarding natural resources management.
2.2.5	To provide technical assistance to participants in conservation programs to help them select, install, and maintain appropriate practices.

Table 6: Goal 3 and related objectives and tasks

Goal 3	
The water resources, land, and biological resources utilized for beneficial uses in the LPSNRD WQMP target areas will be healthy, productive, and sustainable, through actions of the LPSNRD, communities, and other resource agencies.	
Objectives / Tasks	
Objective 3.1: Reservoir, stream, and wetland systems will meet or exceed levels of quality necessary to serve the needs of the citizens.	
3.1.1	To reduce pollutant loads, and to restore or protect designated beneficial uses of surface waters within target areas through implementation of conservation practices.
3.1.2	To implement conservation practices and activities sufficiently in order to reduce surface water pollutant loads to levels that support beneficial uses.
3.1.3	To implement conservation practices and activities that sufficiently reduce nitrate leaching to restore or maintain groundwater concentrations below 5.0 parts per million (ppm) (50% of maximum contaminant level [MCL])
3.1.4	To implement conservation practices or policies which will sufficiently restore or mitigate hydrologic modification of urban and rural areas that has led to or will lead to increased pollutant loading and decreased stream health
Objective 3.2: Surface and groundwater resources will be managed to maintain a balance between current and future water supplies and demands.	
3.2.1	To implement conservation practices and activities that sufficiently decrease withdrawal and/or increase recharge of groundwater and which avoid contamination of aquifers to maintain sustainable aquifers.
3.2.2	To implement practices in target areas that minimize public health and safety risks, which are primarily attributable to excessive runoff from agricultural facilities and crop ground (e.g., toxic algae blooms, elevated bacteria loads).
3.2.3	To target conservation practices that reduce pollutant loadings, but do not hinder existing agricultural production, or the financial capabilities of agricultural producers.
Objective 3.3: The riparian corridors along streams and tributaries within the LPSNRD will support native vegetation and provide a healthy and productive habitat for wildlife.	
3.3.1	To implement agricultural conservation practices and activities that improve soil health and fertility to support natural vegetation and ecosystem health by reducing erosion, increasing organic matter, and improving soil structure to retain nutrients and soil.
3.3.2	To implement practices and activities that repair and prevent bank erosion at critical infrastructure and promote dynamic equilibrium at non-critical sites to improve stream health.
3.3.3	To implement practices and activities that repair and prevent stream bed erosion at head cuts and reduce gully formation to improve stream health.

THIS PAGE LEFT INTENTIONALLY BLANK

CHAPTER 3. WATERSHED CHARACTERIZATION

3.01 DEMOGRAPHIC SUMMARY

POPULATION

The planning area encompasses portions of six counties: Butler, Cass, Lancaster, Otoe, Saunders, and Seward. There are no tribal lands located in the planning area. The planning area represents unique areas in the state of Nebraska, including Lincoln which is one of two metropolitan areas in the state, as well as agricultural lands. The area has 32 incorporated communities, including the state capital (Lincoln) and smaller communities, most of which are rural in nature (Table 7). Because the planning area does not fall along political boundaries, only estimates are available for demographic data. To more closely resemble geographic boundaries of the planning area, demographic information was gathered from the US Census Bureau's American Community Survey (ACS) TIGER files at the block group level. Data that was not available at the block group level is summarized for Cass and Lancaster counties.

The total population of the planning area is 329,961 (USBOC, 2015), with the majority (90%) residing in communities (Table 8). Much of the total population is concentrated in the City of Lincoln (82%), with the remainder split between rural communities and farms and/or acreages.

Table 7: Population of Communities

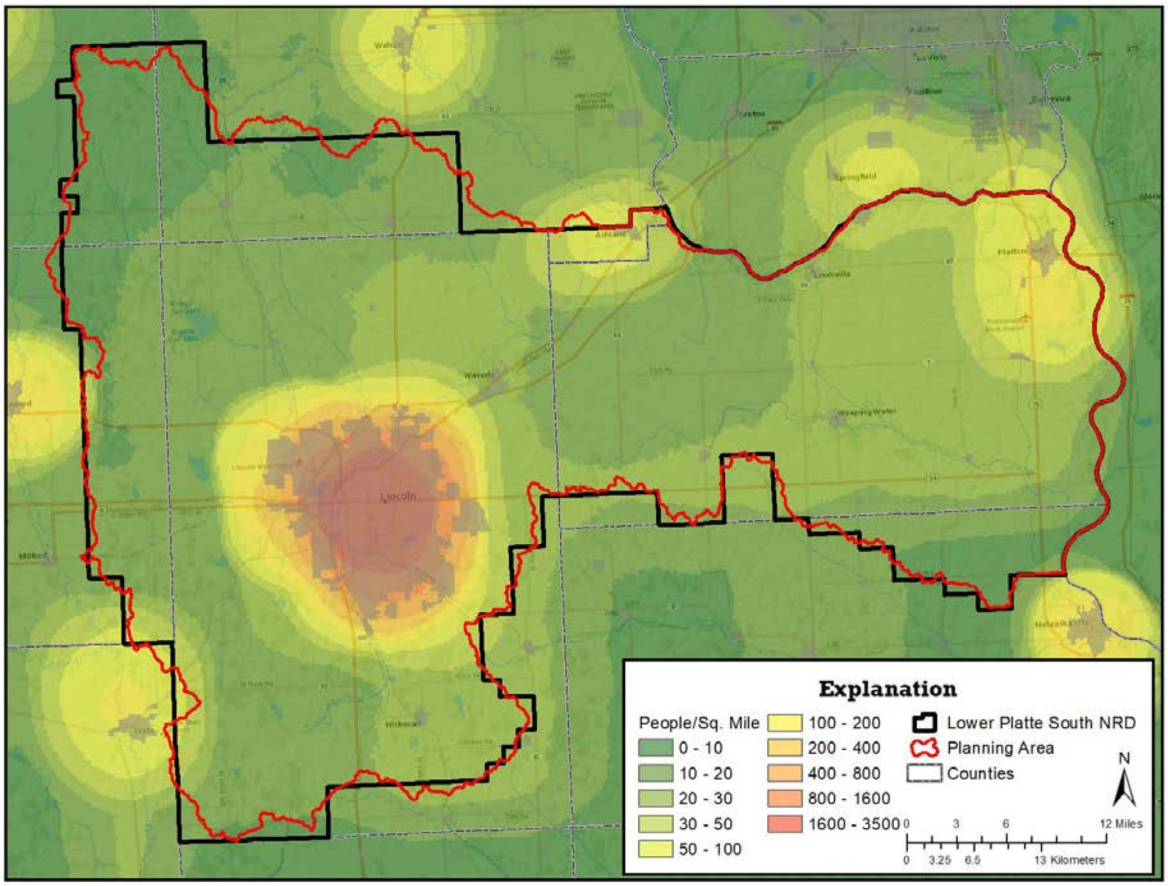
Community	Population	Community	Population	Community	Population
Alvo	125	Greenwood	578	Pleasant Dale	237
Ashland	2,419	Hallam	233	Raymond	139
Avoca	227	Hickman	1,888	Roca	220
Brainard	291	Lincoln	269,726	South Bend	94
Cedar Creek	394	Louisville	1,039	Sprague	142
Ceresco	945	Malcolm	363	Union	204
Davey	128	Manley	146	Valparaiso	708
Denton	240	Murdock	254	Walton	332
Eagle	1,043	Murray	417	Waverly	3,614
Elmwood	607	Nehawka	314	Weeping Water	1,180
Garland	243	Plattsmouth	6,475	--	--

Source: USBOC, 2015

Table 8: Urban and Rural Populations

Urban/Rural	Population	Percent
Urban (communities)	294,965	90%
Rural	34,996	10%
Total	**329,961**	**100%**

Source: USBOC, 2015



Source: ACS 2015 5-Year Estimates

Figure 5: Population Density

AREA DEMOGRAPHICS

The planning area has experienced significant growth in population and diversity. The population of the planning area has grown steadily and significantly from 2000 – 2015, and is currently estimated at 329,961. (Figure 6). Demographically, residents of the planning area are predominantly white (82% Caucasian, 62% Hispanic) (Figure 7). Much of the diversity throughout the planning area is concentrated in the City of Lincoln.

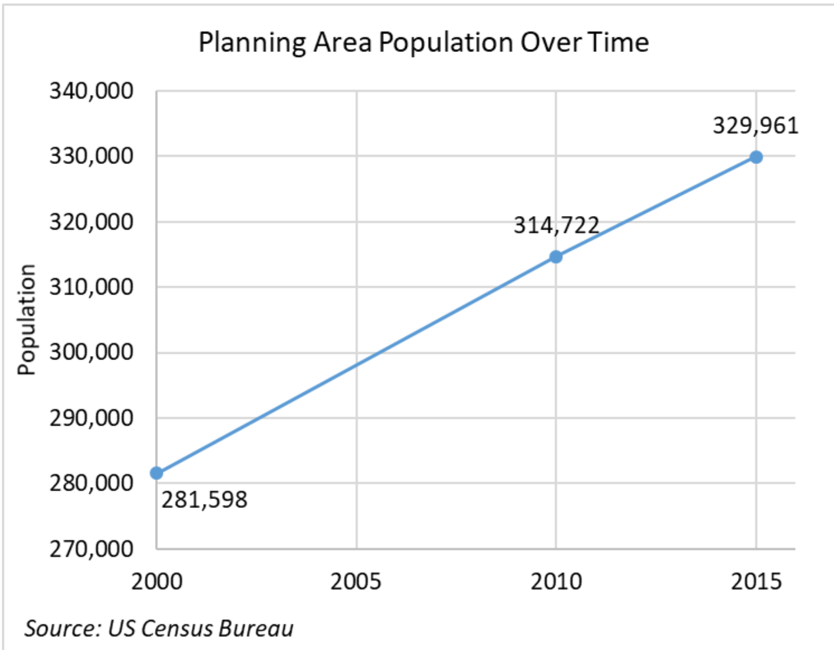


Figure 6: Population of the Planning Area 2000-2015

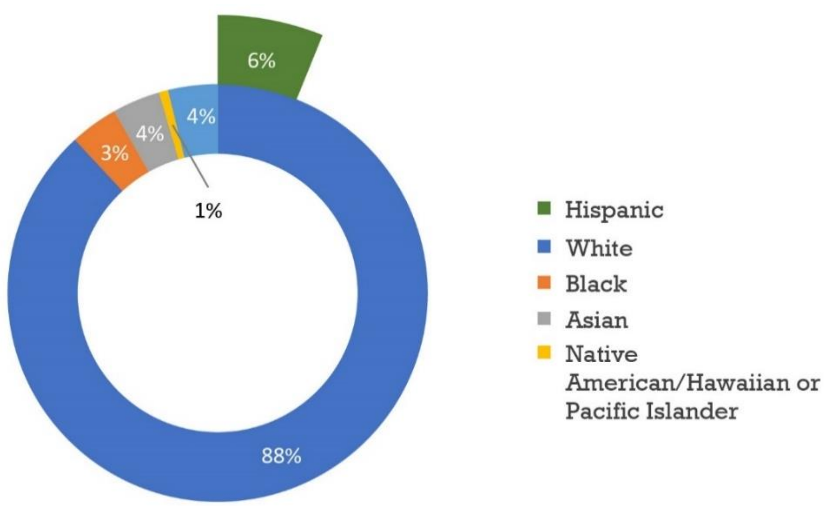
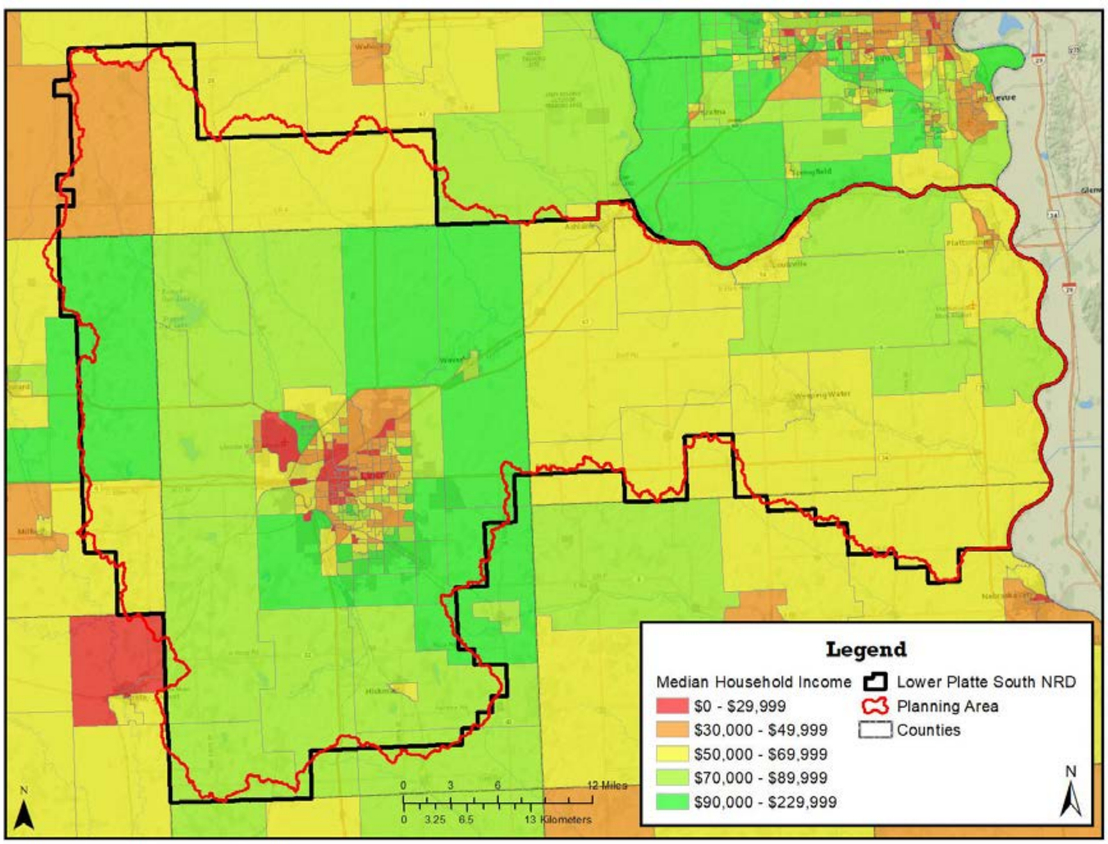


Figure 7: Race and Ethnicity of the Planning Area

Twelve percent of households in the planning area speak English as a second language. Behind English, Spanish is the most commonly spoken language, accounting for five percent of households in the planning area.

The planning area is well educated, where nearly 70% of persons over 25 have obtained some form of education above their high school diploma. Twenty-three percent of the population have a bachelor’s degree, likely due to the numerous colleges and universities in the planning area. Approximately 42% of the housing units in the planning area are renter-occupied. This is significant because renters may not have the ability to or have the incentive to make changes to their homes or properties which positively impact water quality.

Figure 8 show the distribution of median household incomes in the planning area. The median household income in Cass County ($65,619) is $12,000 higher than in Lancaster County ($53,760). However, there is a wider range of household incomes in Lancaster County than in the rest of the planning area. The lowest median income groups are located in the urban core of the City of Lincoln, while the highest incomes in the planning area are located on the outskirts of the City of Lincoln, specifically south and east of the city.



Source: ACS 2015 5-Year Estimates

Figure 8: Median Household Income in Planning Area (2015)

AGRICULTURAL STATISTICS

According to the United States Department of Agriculture (USDA) Census of Agriculture, the primary crops grown in the area include corn and soybeans. USDA Agriculture Census data is provided at the county level and summarized for Lancaster County and Cass County in Table 9 and Table 10. Cattle are also a very common agricultural activity. While many of the cattle are located in permitted facilities, approximately 15% are not. Additional discussion on animal feeding operations is in Chapter 5.07. Additionally, Table 11 demonstrates the agricultural activity changes within Lancaster and Cass Counties between 2007 and 2012. This data is notable as the types of nonpoint source pollutants generated from each agricultural activity can be considerably different in nature, concentrations, and distributions. The reader should note that some data is withheld by the USDA to ensure producers identifies are not disclosed or easily discoverable.

Table 9: Selected Data from the 2012 AgCensus

	Cass County	Lancaster County
Land in Farms (acres)	344,869	489,023
Crop Sales	$140,172,000	$146,709,000
Livestock Sales	$9,166,000	$31,057,000
Corn for Grain (acres)	136,271	167,950
Soybeans for beans (acres)	140,042	166,654

Source: USDA, 2014

Table 10: Livestock Summary from the 2012 AgCensus

	Cass County	Lancaster County
Cattle and calves	9,824	21,732
Hogs and pigs	2,669	13,772
Layers	1,545	9,130
Pullets for laying flock replacement	1,378	D
Horses and Ponies	879	3,117

Source: USDA, 2014

D – withheld to avoid disclosing data for individual operations

Table 11: Changes in Agricultural Activities from 2007 to 2012

Item	2007	2012	Percent Change
Land			
Number Farms	2,380	2,567	8%
Land in Farms (Acres)	702,329	833,892	19%
Average Size of Farms (Acres)	660	758	15%
Livestock (Number)			
Cattle and Calves	34,171	31,556	-8%
Beef Cows	17,284	10,130	-41%
Dairy Cows	2,637	2,263	-14%
Equine	2,606	3,996	53%
Sheep and Lambs	1,356	1,449	7%
Goats	539	1,533	184%
Hogs and Pigs	18,905	16,441	-13%
Broilers and other Meat Chickens	2,262	1,754	-22%
Chickens - Layers	4,565	10,675	134%
Crops (Acres)			
Corn for grain	240,397	304,221	27%
Corn for silage	2,010	3,739	86%
Soybeans	D	306,696	N/A
Forage	34,253	37,976	11%

Source: USDA, 2009 and USDA, 2014
D – withheld to avoid disclosing data for individual operations

ABSENTEE LANDOWNERS

Absentee landowners are defined as those who own agricultural property, but do not live or operate on the land. This includes a diverse cross section of people including: retired farmers/ranchers; those who have inherited or received land through gifts, marriage, divorce, etc.; and those who purchase land for investment or recreational purposes. Often, contacting absentee landowners or successfully encouraging them to participate in conservation practices can be challenging as these landowners are often distant from the specific conservation needs of the land. Understanding the level of absenteeism in the planning area is important to successfully develop outreach programs or targeting conservation programs.

Geographic Information System (GIS) land ownership records from Lancaster and Cass Counties were utilized to estimate levels of absenteeism within the planning area. This data was also used to map where absentee landowners live. This analysis showed that approximately 20% of all land owners live outside the county their land is located in; however, they own approximately 39% of the land. Approximately 7% of land owners live outside Nebraska and account for 10% of the land owned. Although a specific number was not identified, it could be safely assumed that many land owners do not live on their properties. Figure 9 shows the approximate number of landowners by location within the United States and Nebraska. As such, future updates to this plan should include additional research on absentee landowners.

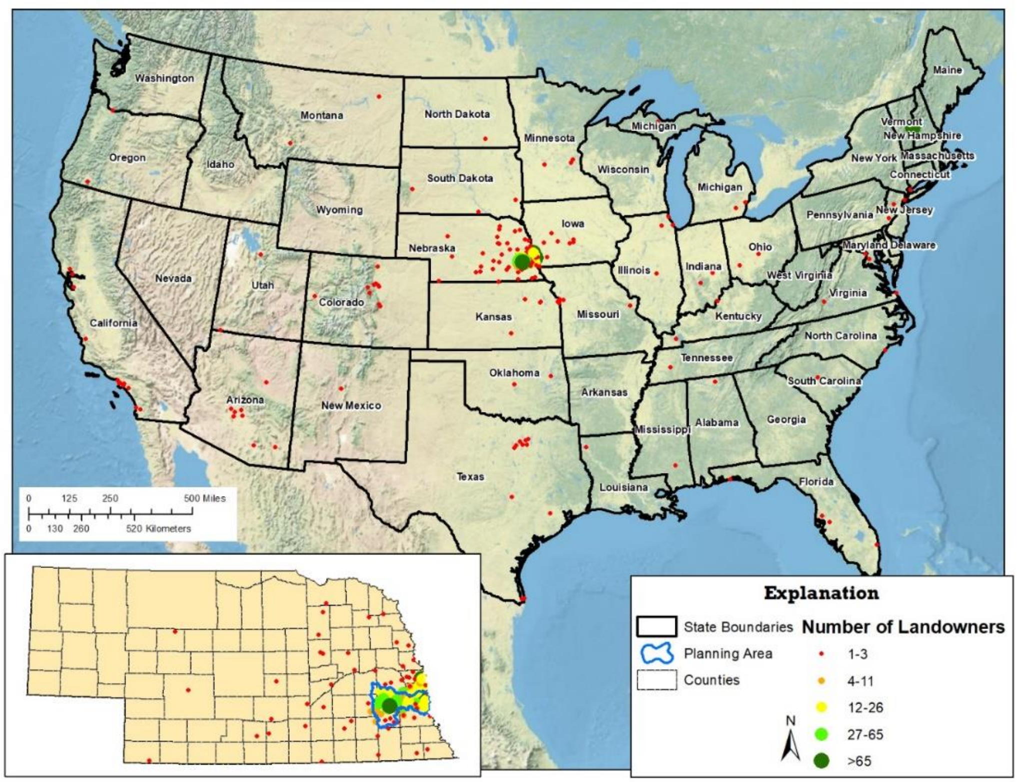


Figure 9: Location of Land Owners Within the Planning Area (Lancaster & Cass Counties)

3.02 PHYSICAL ENVIRONMENT

ECOREGION

The planning area encompasses several subbasins or partial subbasins. The Salt Creek subbasin, with a contributing drainage area of 1,135 sq. mi., comprises approximately 70% of the total plan area. The Lower Platte River subbasin has a drainage area of 180 sq. mi. This subbasin includes several tributaries to the Platte River including: Pawnee Creek; Mill Creek; Cedar Creek; Fountain Creek; Decker Creek; and Fourmile Creek. The Keg-Weeping Water subbasin has a drainage area of 323 sq. mi. and includes several tributaries to the Missouri River, the largest of which is Weeping Water Creek. Creeks within the planning area have generally well-defined channels of varying sizes. The Platte River and Missouri River are not part of this plan.

The EPA uses a series of ecoregions (described by Chapman, 2001), which are areas with similar ecosystems and environmental resources. Levels III and IV offer adequate detail to describe the planning area. The planning area lies completely within the ‘Western Corn Belt Plains’ EPA Level III ecoregion and consists primarily of two EPA Level IV Ecoregions: ‘Loess and Glacial Drift Hills’ and ‘Nebraska/Kansas Loess Hills’, as described below (Chapman and others, 2001) and shown in Figure 10. Additionally, there are small pockets of Missouri Alluvial Plains along the Missouri River.

1. **The Loess and Glacial Drift Hills** are characterized low, rolling loess-covered hills with areas of exposed glacial till. Loess deposits are generally thinner than those in other loess hills regions. Historically there was less oak-hickory forest and more extensive tallgrass prairie than found in neighboring loess hills. The flatter loess hills have a silty, clay loam soil that supports cropland, while rangeland is somewhat more extensive on the deep clay loams formed in glacial till soils.
2. **The Nebraska/Kansas Loess Hills** have greater relief and deeper loess hills than the adjacent flat alluvial valleys. Dissected hills with deep, silty, well drained soils supported a potential natural vegetation of tallgrass prairie with scattered oak-hickory forests along stream valleys. Cropland agriculture is now common and ample precipitation in the growing season supports dryland agriculture, with only a few areas requiring irrigation.

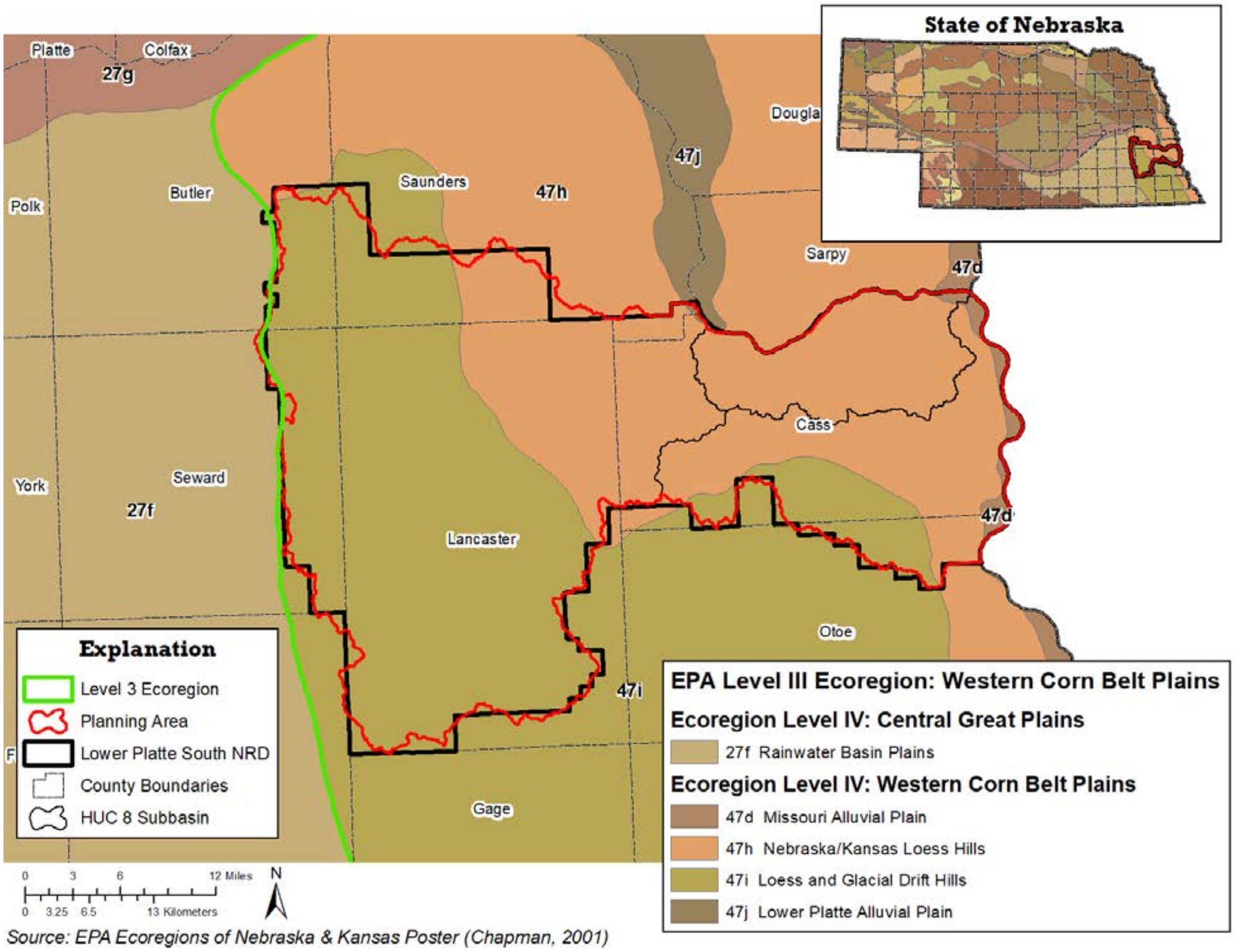


Figure 10: Ecoregion Map

CLIMATE

The climate of the planning area is considered “Humid Continental” on the Köppen-Geiger Climate Classification System (Kottek and others, 2006). This climate is characterized by large seasonal temperature differences, with hot, humid summers and cold winters. Precipitation is distributed throughout the year. The National Centers for Environmental Information maintains precipitation records from numerous stations within the planning area. Due to consistencies in climate conditions throughout the planning area, only data trends from Lincoln stations were evaluated. Average annual precipitation across the planning area is shown in Figure 11. Precipitation varies across the planning area, though a majority receive between 28 and 32 inches per year. May has the highest average monthly precipitation (4.5 inches), while January has the lowest (0.7 inches). Average high temperatures range from 87°F during the summer months to 32°F during winter months; average low temperatures range from 64°F during the summer months to 16°F during winter months. Average monthly temperature and precipitation variations are based on Lincoln, Nebraska Average Monthly Weather Conditions (NCEI, 2018) and are illustrated in Figure 12.

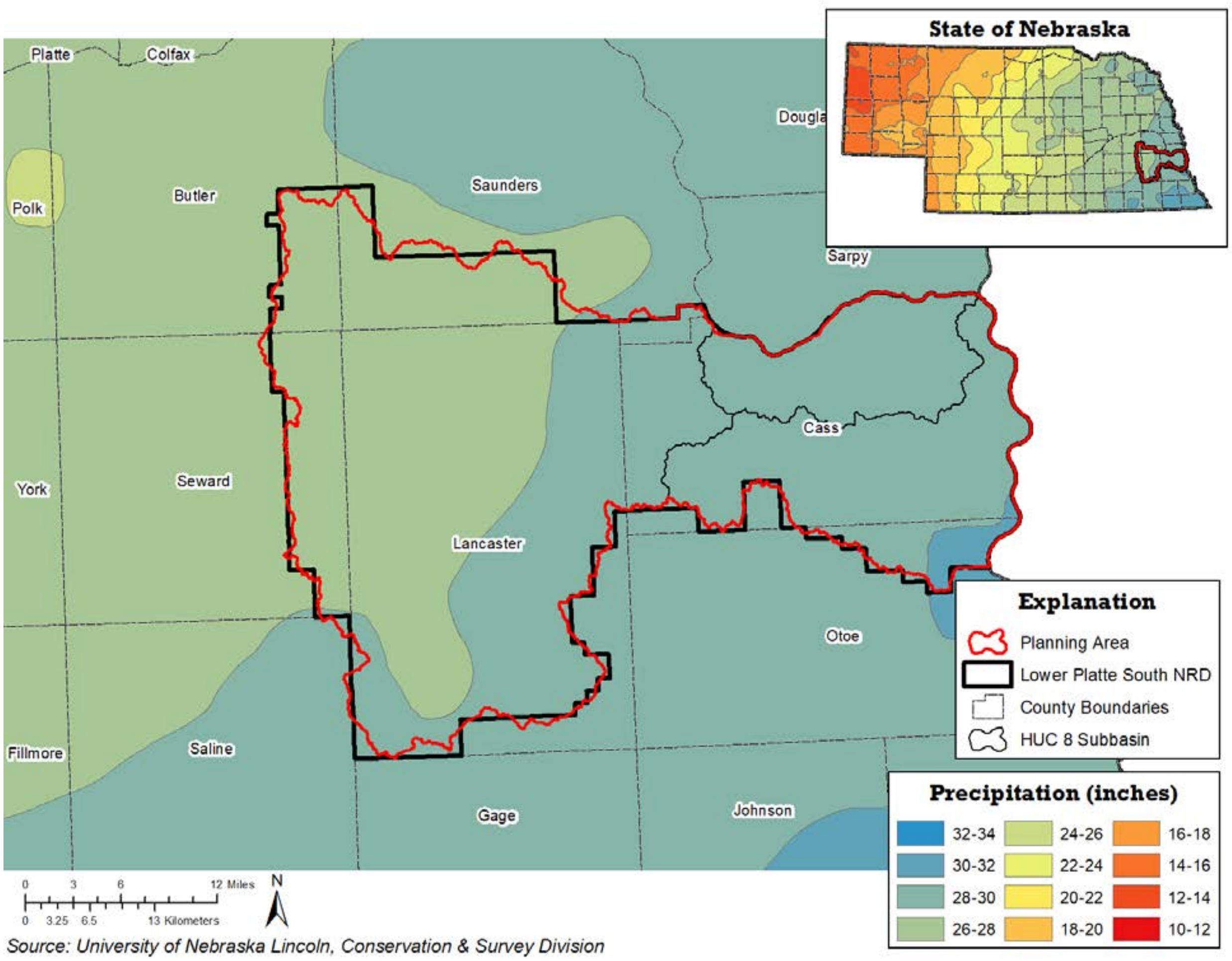
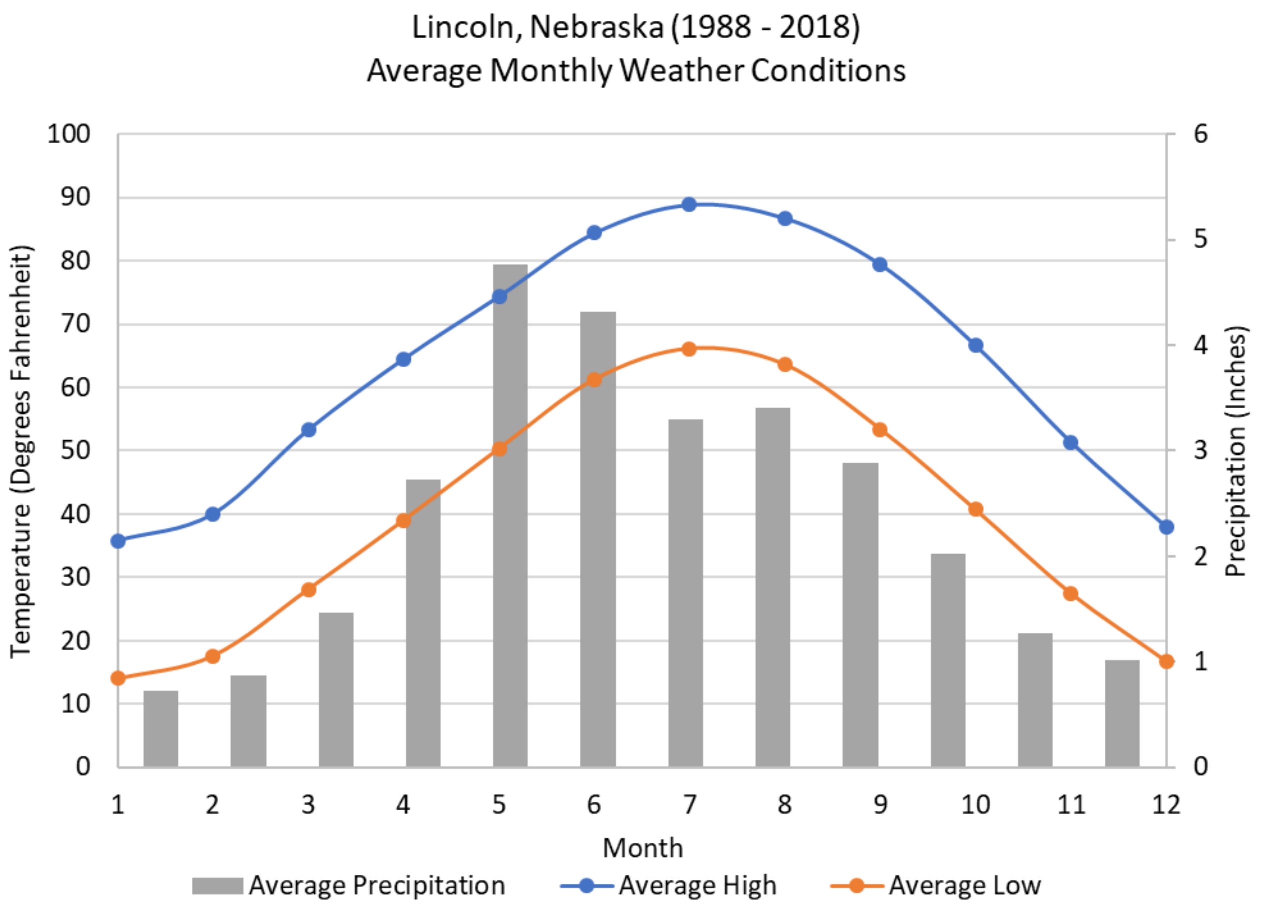


Figure 11: Annual Precipitation Map



Source: National Centers for Environmental Information (NCEI, 2018)

Figure 12: Average Monthly Temperature and Precipitation for Lincoln, NE

TOPOGRAPHY

The planning area lies in three of Nebraska's topographic regions: "Valleys", "Valley-Side Slopes" and "Bluffs and Escarpments" (Conservation and Survey Department [CSD], 2001). Differences in topography and elevation through the planning area influence drainage and land use patterns, as shown in Figure 13 and Figure 14. Valleys are flat-lying lands along major streams consisting of stream deposited silt, clay, sand and gravel. The valley-side slope areas comprise a large majority of the planning area, and consist of moderately sloping lands between valleys and major stream escarpments. Bluffs and escarpments are rugged lands with steep and irregular slopes, located along the Platte and Missouri Rivers. Bedrock materials such as sandstone, limestone, and shale are oftentimes exposed in these areas.

The Salt Creek subbasin drains in a northeasterly direction to the confluence with the Platte River at Ashland. The tributaries in the Lower Platte River subbasin generally drains in a northerly direction towards the Platte River, while the Keg-Weeping Creek subbasin drains easterly towards the Missouri River.

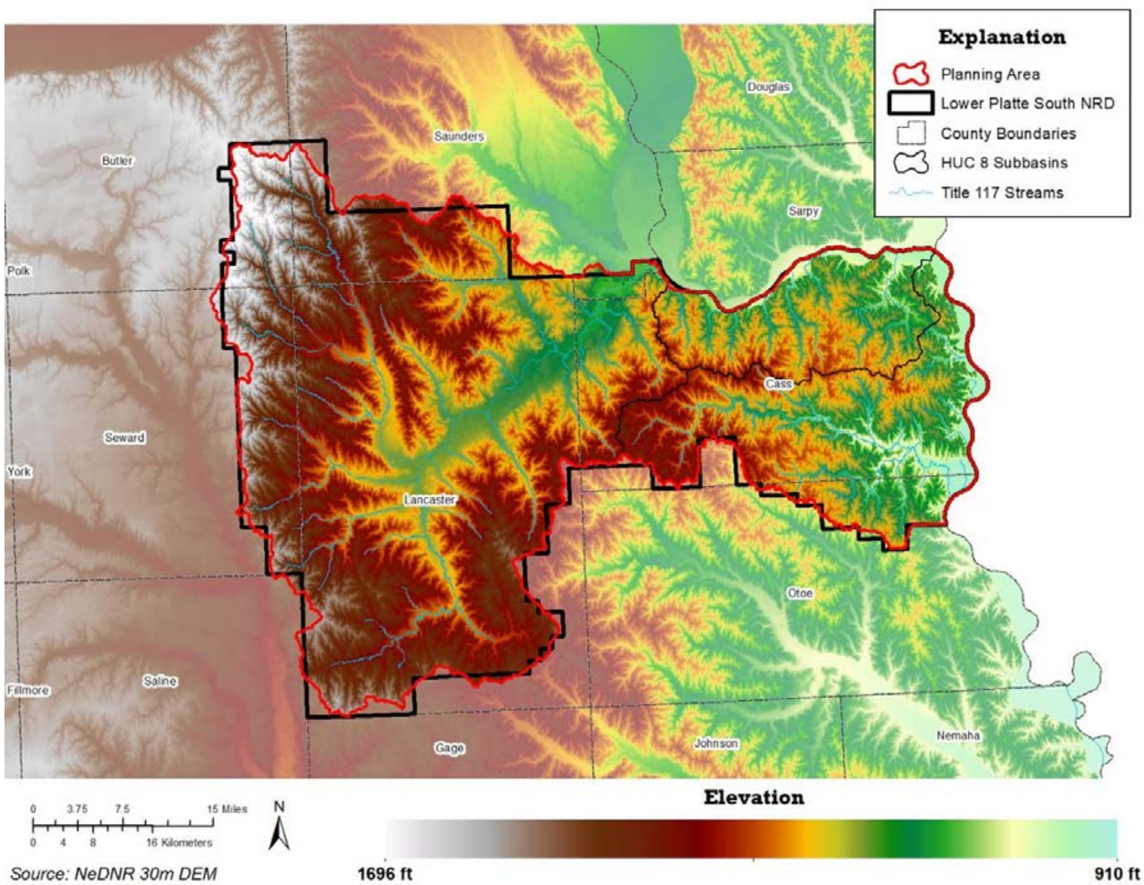


Figure 13: Elevation throughout the Planning Area

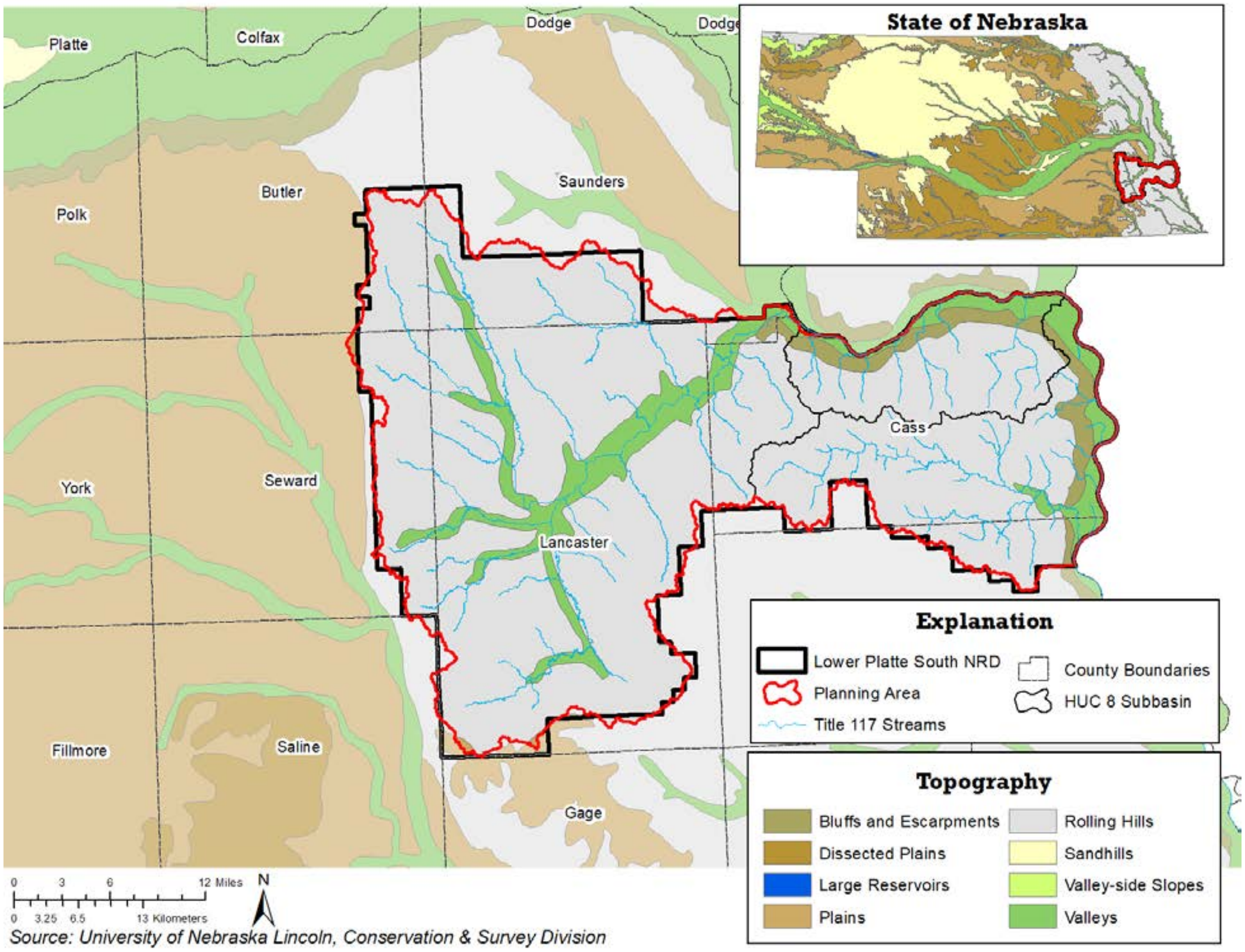


Figure 14: Topographic Regions Within and Near the Planning Area

GEOLOGIC HISTORY

The geologic history of a region is an important backdrop to explaining current conditions. The geologic history of Eastern Nebraska, where the planning area lies, is particularly unique. In contrast to the rest of the state, Eastern Nebraska's unique history of glaciation has made it one of the most complex areas in terms of water resources in the state. While the majority of Nebraska lies over the High Plains Aquifer, much of eastern Nebraska's topography, geology, and water resources were modified by the most recent ice age. This has resulted in more complex local hydrogeologic conditions than the rest of the state. Localized and finer scale studies are necessary to truly characterize water resources.

During the Pleistocene epoch (from about two million to 10,000 years ago), continental glaciers invaded the northern Great Plains multiple times. Glacial ice repeatedly blocked rivers, formed lakes, filled valleys with sediment, and diverted rivers. Rivers carried melt water from glaciers that contained heavy amounts of sand and silt, which was then deposited along floodplains. Wind eroded these deposits, creating fields of dunes and depositing a layer of loess on the uplands. As seen in Figure 15, the maximum extents of the glaciers extended across eastern Nebraska, where they left behind deposits of till, which consists of a mixture of clay, silt, sand and gravel (Wayne, 2011).

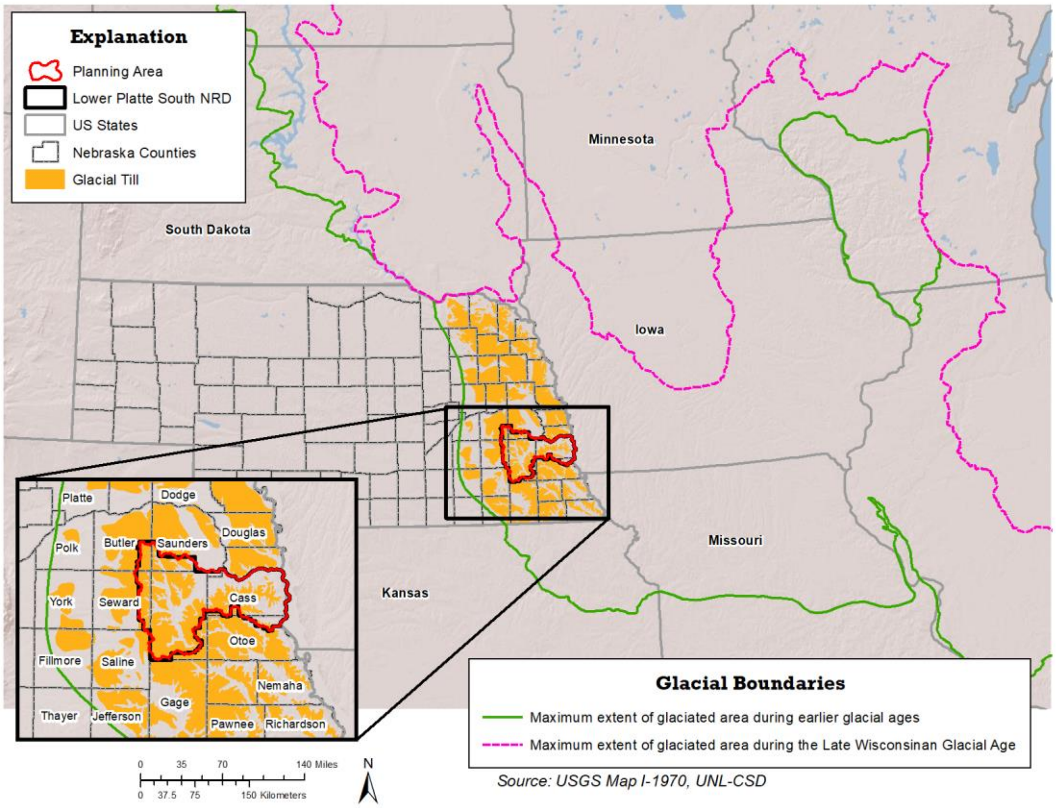


Figure 15: Regional Glacial Boundary Map and Nebraska Till Deposits

SOILS

Soil parent material, which is the underlying geological material in which soils form, has a major influence on soil characteristics (Figure 16). The soils of the area are moderately-fine to fine-textured, well-drained soils that developed in the Peorian loess on the uplands. The stream valleys are composed of well-drained to excessively well-drained alluvial soils. Surface soils within the planning area basin include glacial till, loess, clay, silt, and sand alluvium, and relatively small areas of exposed bedrock. The glacial till is moderately clayey and contains a few granite and quartzite boulders, some cobbles, and numerous pebbles. Peorian loess covers much of the uplands and is the principal parent material for the soils. Some of the valley areas are less productive because of a higher concentration of salt in the soils. These areas of high soil salinity tend to be small and isolated in nature. Bedrock in the study area is Pennsylvanian and Peruvian age limestone with interbedded shale and shaley limestone as well as interbedded shale and sandstone of the Dakota Group. Numerous small outcrops of rusty brown Dakota sandstone exist in and around Lincoln. (USDA, 1980).

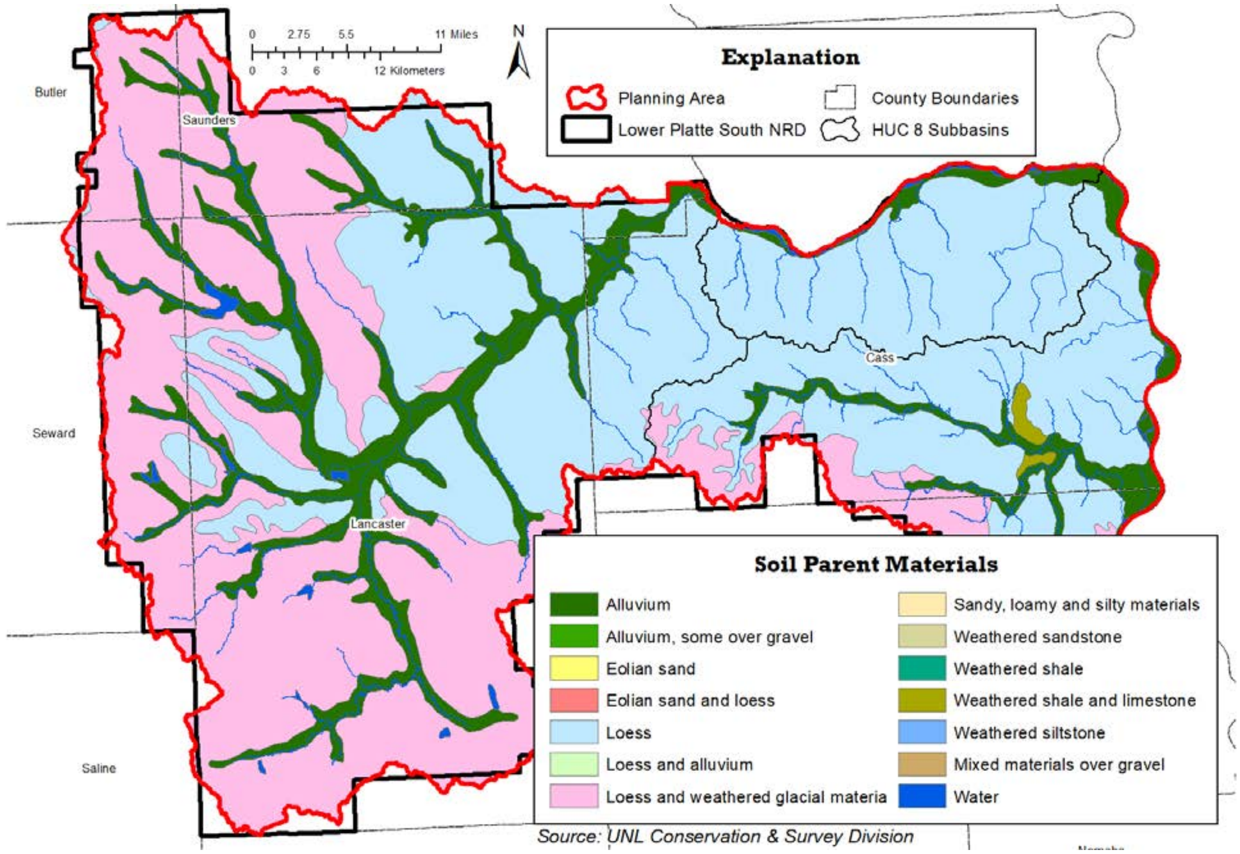


Figure 16: Soil Parent Materials

Soil characteristics, such as texture, infiltration rate, and slope directly influence the amount of runoff from the landscape and the potential for erosion. USDA soils data was analyzed specific to the planning area, and the results provided in the following sections.

Texture

Soil texture is given in the standard terms used by the USDA. These terms are defined according to percentages of sand, silt, and clay in the fraction of the soil that is less than 2mm in diameter. If the content of particles courser than sand is greater than 15%, an appropriate modifier is added. Table 12 gives the soil texture breakdown by HUC 8 subbasin, while Figure 17 displays the soils based upon texture. The clear majority (93%) of soils found in the planning area are comprise of silt loam, silty clay loam and clay loam. The distribution of these majority soil textures is generally consistent across subbasins, except for Salt Creek which has a higher proportion of clay loams.

Table 12: Surface Texture of Soils Within Each HUC 8 Subbasin

	Lower Platte		Salt		Keg-Weeping Water	
Soil Texture	**Acres**	**Percent**	**Acres**	**Percent**	**Acres**	**Percent**
Clay loam	23	0%	154,233	21%	2,926	1%
Silt loam	24,051	21%	146,862	20%	46,311	22%
Silty clay loam	82,410	72%	374,226	52%	145,580	70%
Other	8,600	7%	51,109	7%	11,985	6%
Total	**115,084**	**100%**	**726,430**	**100%**	**206,802**	**100%**

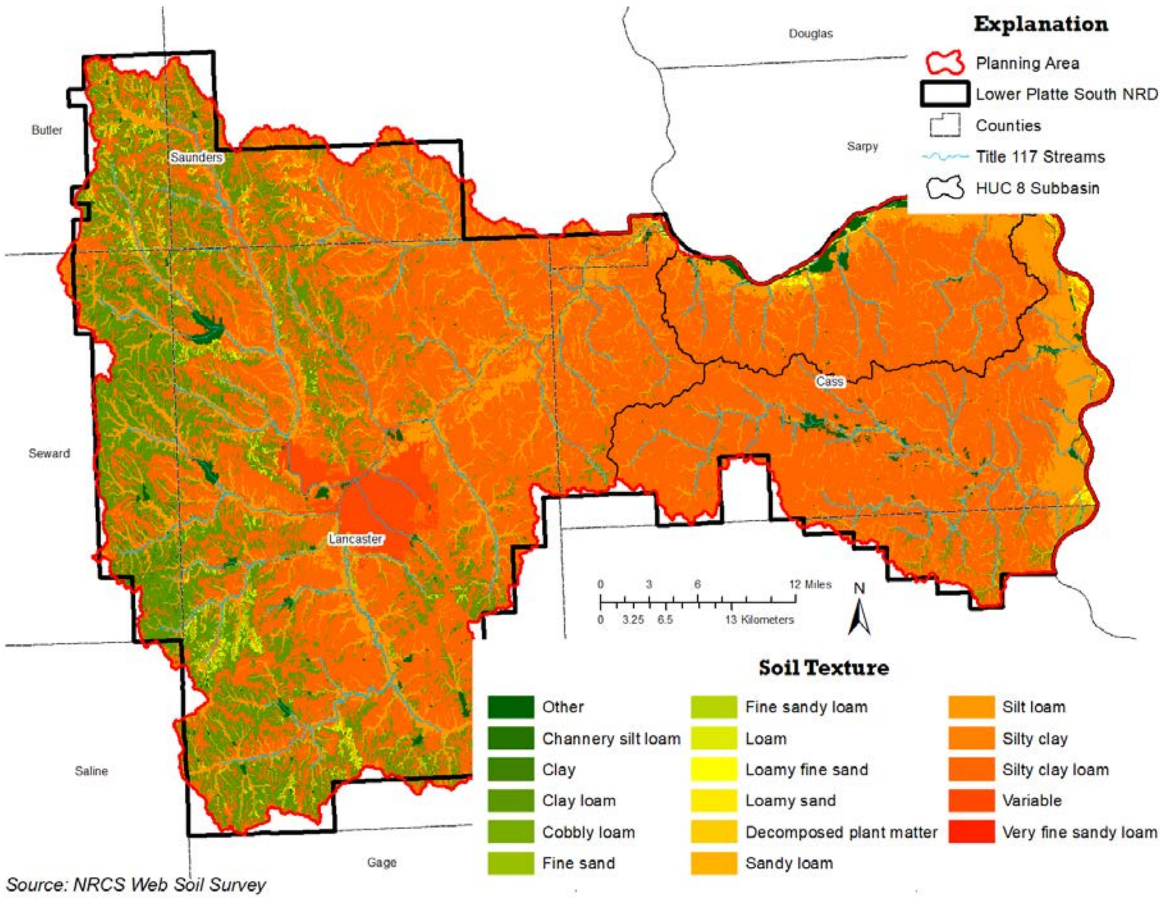


Figure 17: Soil Texture Map

Soil Infiltration

The NRCS classification system divides soils into four major hydrologic soil groups (HSG): A, B, C, and D; and three dual classes: A/D, B/D, and C/D. Table 13 provides a description of the role soils plays in the generation of runoff. Soils within each hydrologic group have similar runoff potential under similar storm and vegetative conditions. Table 14 gives the breakdown for soil groups by HUC 8 subbasin while Figure 18 illustrates the geographic distribution. The soils in the Salt Creek subbasin consist mostly of HSG C or D (89%), which contribute to higher runoff rates. The soils in the Lower Platte subbasin offer slightly higher infiltration rates with HSG B and C (93%). The Keg-Weeping Water subbasin has a more diverse soil composition with HSG B (18%), HSG C (59%) and HSG D (17%). These HSGs are consistent with the soil textures described above.

Table 13: Hydrologic Soils Groups and Descriptions

Soil Group	Description
A	Soils in this group have low runoff potential when thoroughly wet. Group A soils typically have less than 10 percent clay and more than 90 percent sand or gravel and have gravel or sand textures. Water is transmitted freely through the soil.
B	Soils in this group have moderate infiltration and transmission rate when thoroughly wetted. Group B soils consist chiefly of moderately well- to well-drained soils with moderately fine to moderately course textures. Water movement through these soils is moderately rapid.
C	Soils in this group have moderately high runoff potential when thoroughly wet. Group C soils typically have loam, silt loam, sandy clay loam, clay loam, and silty clay loam textures. Water transmission through the soil is somewhat restricted.
D	Soils in this group have high runoff potential when thoroughly wet. Group D soils typically have clayey textures. In some areas, they also have high shrink-swell potential. Soils with a depth to a water impermeable layer less than 20 inches, and all soils with a water table within 24 inches of the surface are placed in this group. Water movement through the soil is restricted or very restricted.
A/D B/D C/D	Soils are assigned to dual groups if the depth to a permanent water table is the sole criteria for assigning a soil to hydrologic group D. If these soils can be adequately drained, then they are assigned to dual groups (A/D, B/D, and C/D) based on their saturated hydraulic conductivity and the water table when drained. The first letter applies to the drained condition and the second to the undrained condition.

Source: USDA, 2017b

Table 14: Hydrologic Soils Groups Within Each HUC 8 Subbasin

	Lower Platte		Salt		Keg-Weeping Water	
Hydrologic Soil Group	Acres	Percent	Acres	Percent	Acres	Percent
A	1,825	2%	2,027	0.3%	2,960	1%
B	18,003	16%	59,731	8%	36,600	18%
B/D	0	0%	878	0.1%	88	0%
C/D	5,356	5%	19,775	3%	9,120	4%
D	670	1%	232,274	32%	35,423	17%
C	89,230	78%	411,746	57%	122,611	59%
Total	**115,084**	**100%**	**726,431**	**100%**	**206,802**	**100%**

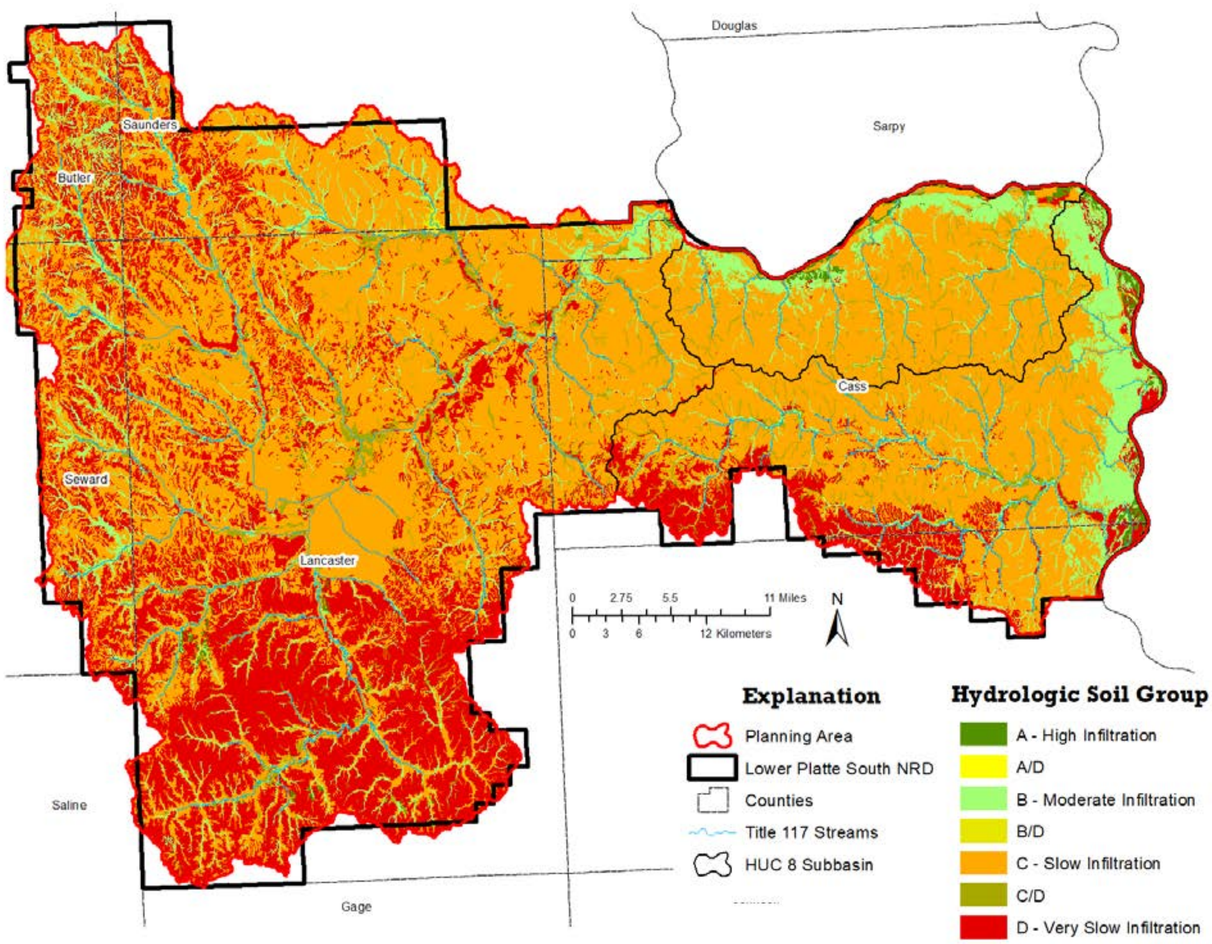


Figure 18: Hydrologic Soil Group Map

Soil Slope

Slopes across the three subbasins are consistent. Slopes in the range of 0.5% to 5% encompass 47% of the planning area while 41% of the slopes are in the range of 5% to 10%. Steep slopes lead to an increase in runoff rates and volumes. Runoff rates increase as surface velocities increase, which leads to flashier runoff events. Runoff volumes increase as the higher velocities allow for less infiltration. Not only do high slopes increase runoff, they also increase risk of surface erosion and transportation of pollutants. Table 15 gives the soil slope breakdown by HUC 8 subbasin while Figure 19 displays the geographic distribution.

Table 15: Soil Slopes Within Each HUC 8 Subbasin

	Lower Platte		Salt		Keg-Weeping Water	
Slope Classification	**Acres**	**Percent**	**Acres**	**Percent**	**Acres**	**Percent**
<0.5%	3,340	3%	29,889	4%	8,789	4%
0.5-5%	51,023	44%	348,662	48%	90,766	44%
5-10%	48,981	42%	300,007	41%	83,592	40%
>10%	12,090	10%	48,101	7%	23,853	12%
Total	**115,435**	**100%**	**726,658**	**100%**	**207,000**	**100%**

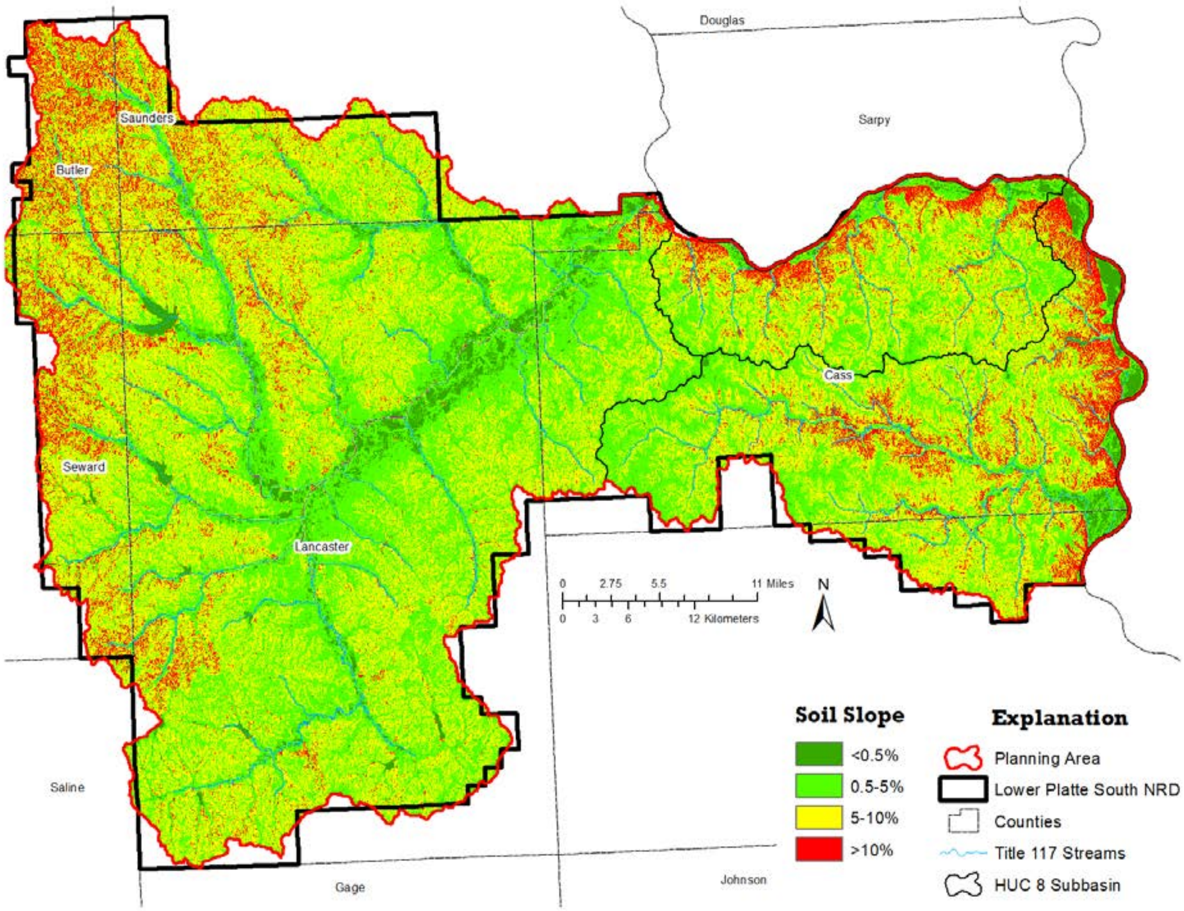


Figure 19: Soil Slope Map

LAND USE

Land use and land cover (LULC) are two separate terms, yet they are often used interchangeably. Land use describes how people utilize the land (i.e. urban or agriculture). Land cover describes the physical material of the earth's surface (i.e., type of vegetation). Understanding LULC is at the heart of watershed planning. The activities and uses of the land within a watershed often are the primary drivers in identify specific sources of pollutants. Understanding how LULC affects watershed functions (such as hydrology) requires an understanding of both the historical and present day LULC of the watershed. The streams and other biological communities evolved in this historic setting, and understanding those conditions, as well as the modern-day changes to them, is key to finding solutions to current problems.

Historical Land Use

A map of the historical land cover of the planning area, prior to European settlement (circa 1860), is shown in Figure 20. The map was developed primarily from field observations of native vegetation remnants, and modified from the original version prepared by Kaul and Rolfsmeier (1993) and provided by the CSD. The Nebraska Natural Legacy Project's State Wildlife Action Plan lays out a clear vision of historical land use in the planning area (Schneider and others, 2011):

> "Historically, tallgrass prairie was the predominant vegetative cover in the eastern fourth of the state. Refer to Figure 20 for a map of the native vegetation in the planning area. Today, approximately two percent of Nebraska's tallgrass prairie remains mostly as remnants, which are usually less than eighty acres in size. Glaciers, wind, and water have shaped the topography of the tallgrass region over the last several million years. Today, the land surface is mainly rolling hills intersected by stream valleys.
>
> Aside from tallgrass prairie, eastern Nebraska has a diversity of other community types ranging from deciduous woodlands to saline wetlands. Upland tallgrass prairie species can reach six feet or taller, especially when rooted in rich, moist stream valleys. Tallgrass prairies also include hundreds of species of wildflowers and other forbs. Native woodlands are found mainly in the more mesic and fire-protected stream valleys and bluffs. They are most extensive in the Missouri River valley and its lower tributaries. These woodland habitats, particularly oak and hickory bluff woodlands provide essential habitat for migrating birds. Wet meadows are found in stream valleys where the water table remains near the soil surface throughout the year. Marshes were common in river floodplains prior to settlement.
>
> In the early 19th century, the Great Plains was generally perceived as an area unfit for agriculture and settlement. By 1900, most prime farmland in eastern Nebraska was settled by inhabitants of European descent. The land use changes in Nebraska, due to the Homestead Act. led to the development of an agriculture-based economy. Major crops grown in the tallgrass region today include corn, soybeans, wheat, oats and alfalfa. Nebraska's dairy, pork and poultry industries are located primarily in the eastern portion of the state. Beef cattle production also occurs in the region. The livestock and poultry industries found here are great consumers of the corn, soybeans and other crops, helping to add value to these raw commodities. More recently, a significant proportion of the corn harvest has been used in ethanol production. In recent decades, Nebraska farms have trended towards becoming fewer in number and larger in size. Since the 1950's, machinery and modern farming methods have made agriculture more efficient, thereby decreasing the number of people employed directly by agriculture. This trend caused rural residents to move to larger communities in search of jobs. The state's largest urban centers, Lincoln and Omaha are located in the Tallgrass Prairie Ecoregion."

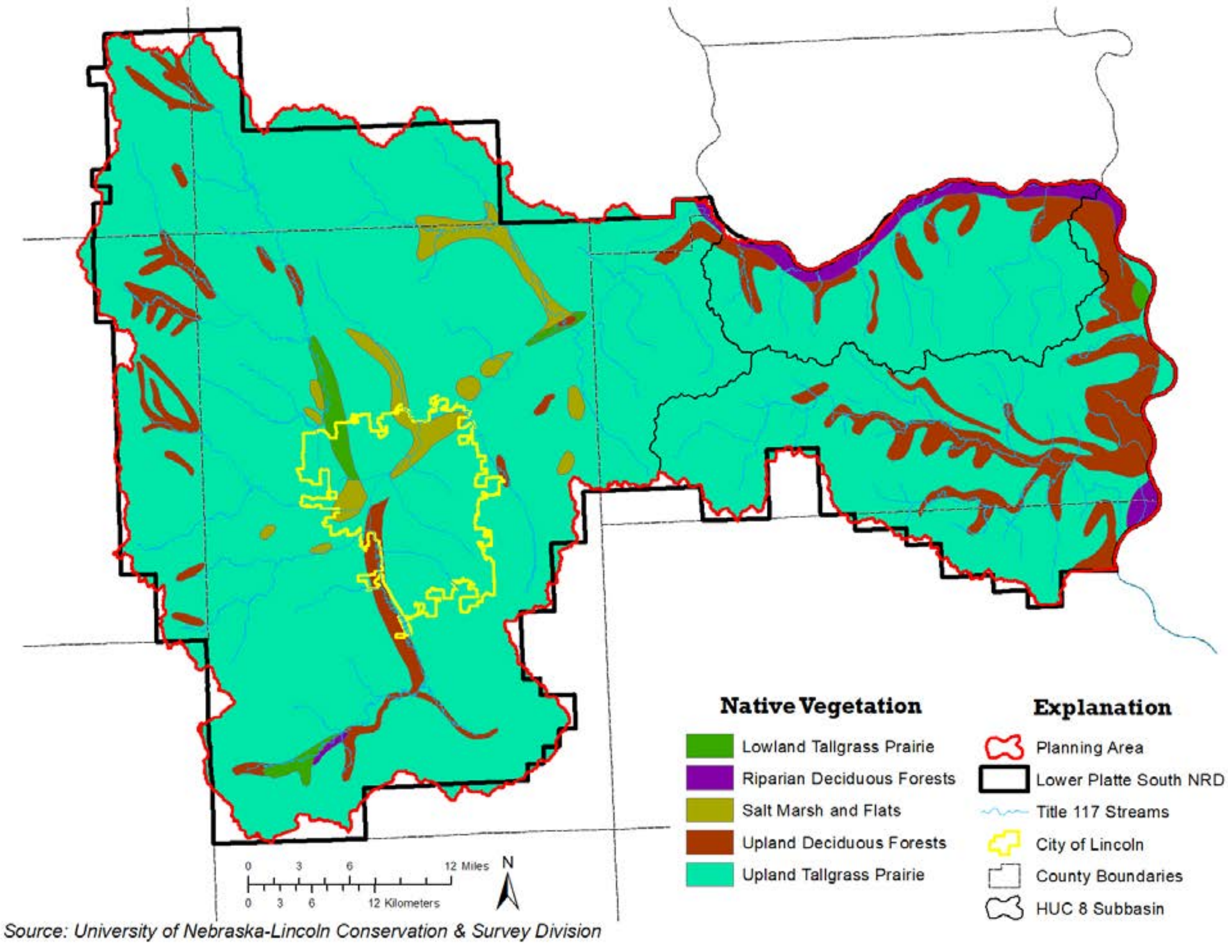


Figure 20: Native Vegetation of the Planning Area (circa 1860)

Present Day Land Use / Land Cover

Present day LULC in the planning area was determined by GIS analysis of the 2016 USDA-National Agriculture Statistics Service's (NASS) Cropland Data Layer (CDL), which is available at the USDA NRCS GeoSpatial Data Gateway. The CDL is a complete, geographically referenced classification of all satellite ortho-imagery data within a state by crop or land cover. The land use inventory allows appropriate runoff factors to be used to calculate pollutant loads from each land use type through water quality modeling. It also assists with identifying specific strategies to manage pollutants. As seen in Figure 21, corn and soybeans comprise a large percentage of the planning area. However, some areas of grass and pasture remain in the western-most areas. Lincoln makes up a large urban center in Lancaster County.

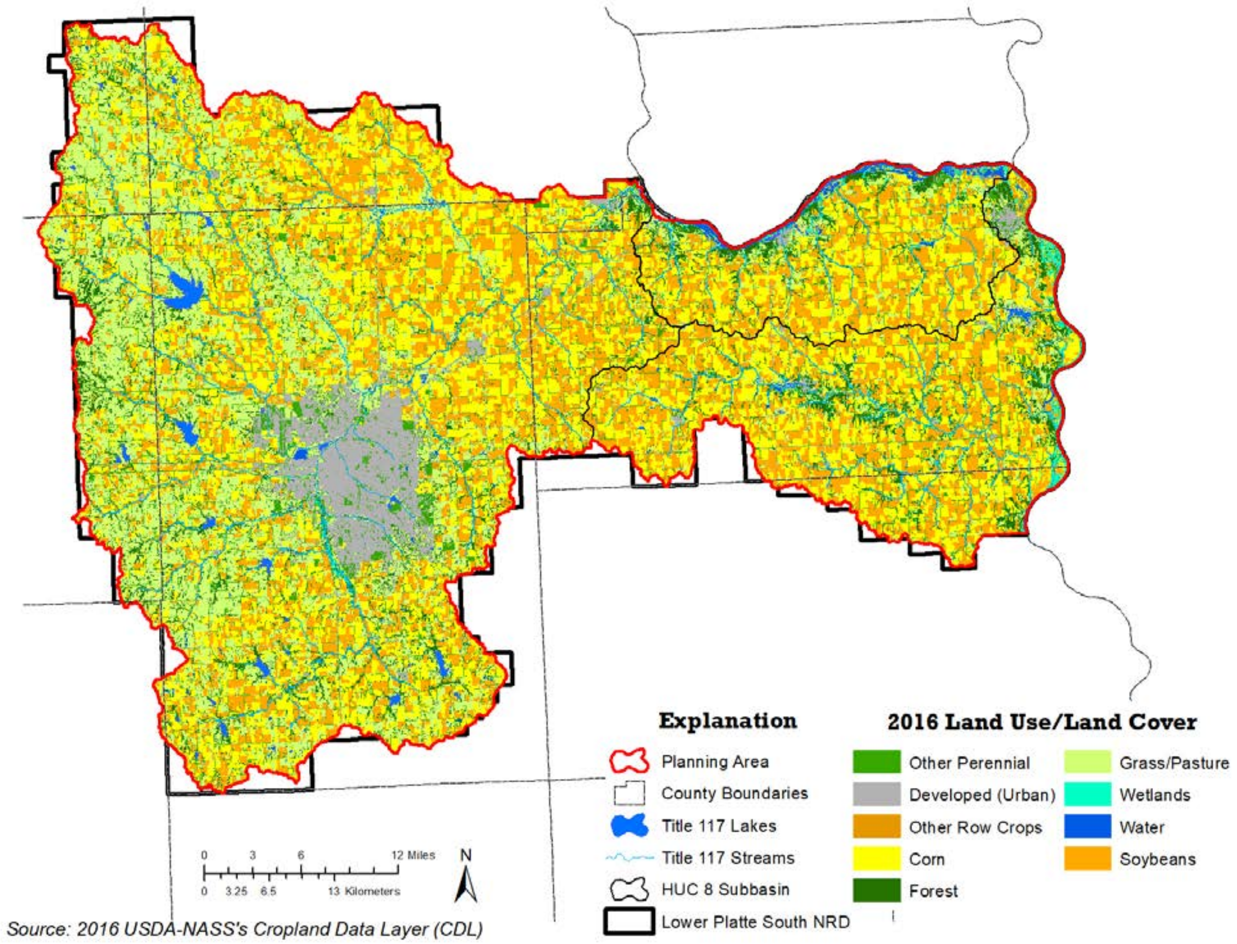


Figure 21: Present Day (2016) Land Use / Land Cover*

Land Use Change Assessment

Changes that may affect water quality in the planning area may be forecasted by evaluating changes in land cover. LULC information from the CDL was obtained for 2009 and 2016, and reclassified into nine common LULC classifications. A significant amount of land has been converted from grass/pasture to row crop. Throughout the entire planning area, a total of 85,350 acres (8.2%) has been converted to corn/soybeans. These changes can result in increased chemical applications, runoff, erosion, and pollutant loading to both groundwater and surface water. Changes in land use, especially within highly sensitive areas such as wellhead protection areas or above recreational water bodies, are important to consider when prioritizing conservation projects. The following tables (Table 16 through Table 19) display this information for the entire planning area and by each HUC 8 subbasin.

Table 16: Land Use Changes within the Planning Area (2009 - 2016)

Category	Acres (2009)	Acres (2016)	Acre Difference	% Change
Corn	252,805	308,985	56,180	22%
Soybeans	244,662	273,832	29,170	12%
Grass/Pasture	326,020	223,067	-102,953	-32%
Forest	64,400	85,445	21,045	33%
Developed (Urban)	51,682	58,168	6,486	13%
Water	15,519	17,748	2,229	14%
Wetlands	7,466	11,270	3,804	51%
Other Row Crops	10,042	5,625	-4,417	-44%
Other Perennial	72,747	61,170	-11,577	-16%

Source: USDA, 2017a

Table 17: Land Use Changes within the Salt Creek HUC 8 Subbasin (2009 - 2016)

Category	Acres (2009)	Acres (2016)	Acre Difference	% Change
Corn	152,942	193,465	40,523	26%
Soybeans	138,398	165,872	27,474	20%
Grass/Pasture	281,177	195,965	-85,212	-30%
Forest	36,483	54,698	18,215	50%
Developed (Urban)	45,514	51,104	5,590	12%
Water	8,180	9,582	1,402	17%
Wetlands	2,006	2,758	752	37%
Other Row Crops	7,978	3,647	-4,331	-54%
Other Perennial	50,124	45,697	-4,426	-9%

Source: USDA, 2017a

Table 18: Land Use Changes in the Keg-Weeping Water Creek HUC 8 Subbasin (2009 - 2016)

Category	Acres (2009)	Acres (2016)	Acre Difference	% Change
Corn	65,338	75,423	10,085	15%
Soybeans	68,366	69,820	1,455	2%
Grass/Pasture	28,013	16,234	-11,779	-42%
Forest	18,815	20,796	1,981	11%
Developed (Urban)	4,074	4,680	606	15%
Water	2,674	3,043	369	14%
Wetlands	3,665	5,748	2,083	57%
Other Row Crops	1,461	1,380	-81	-6%
Other Perennial	14,678	9,935	-4,743	-32%

Source: USDA, 2017a

Table 19: Land Use Changes in the Lower Platte HUC 8 Subbasin (2009 - 2016)

Category	Acres (2009)	Acres (2016)	Acre Difference	% Change
Corn	34,524	40,097	5,573	-14%
Soybeans	37,897	38,140	243	-1%
Grass/Pasture	16,831	10,868	-5,962	55%
Forest	9,101	9,952	850	-9%
Developed (Urban)	2,095	2,384	289	-12%
Water	4,664	5,122	458	-9%
Wetlands	1,795	2,764	969	-35%
Other Row Crops	602	597	-5	1%
Other Perennial	7,945	5,538	-2,407	43%

Source: USDA, 2017a

3.03 SURFACE WATER RESOURCES

STREAMS

The Salt Creek subbasin exhibits a dendritic drainage pattern (tree-like), and there are several perennial tributaries which contribute to surface water flows (Table 20). Salt Creek is composed of four stream segments, and numerous tributaries, totaling approximately 471 stream miles. The Lower Platte subbasin includes several tributaries to the Platte River including Pawnee Creek, Mill Creek, Cedar Creek, Fountain Creek, Decker Creek, and Fourmile Creek. In total, the Lower Platte subbasin includes approximately 89 stream miles of tributaries to the Platte River. The Keg-Weeping Water subbasin consists of several tributaries to the Missouri River, the largest of which is Weeping Water Creek. Total stream miles in this subbasin is approximately 209 miles. Figure 22 illustrates the Title 117 streams within the planning area.

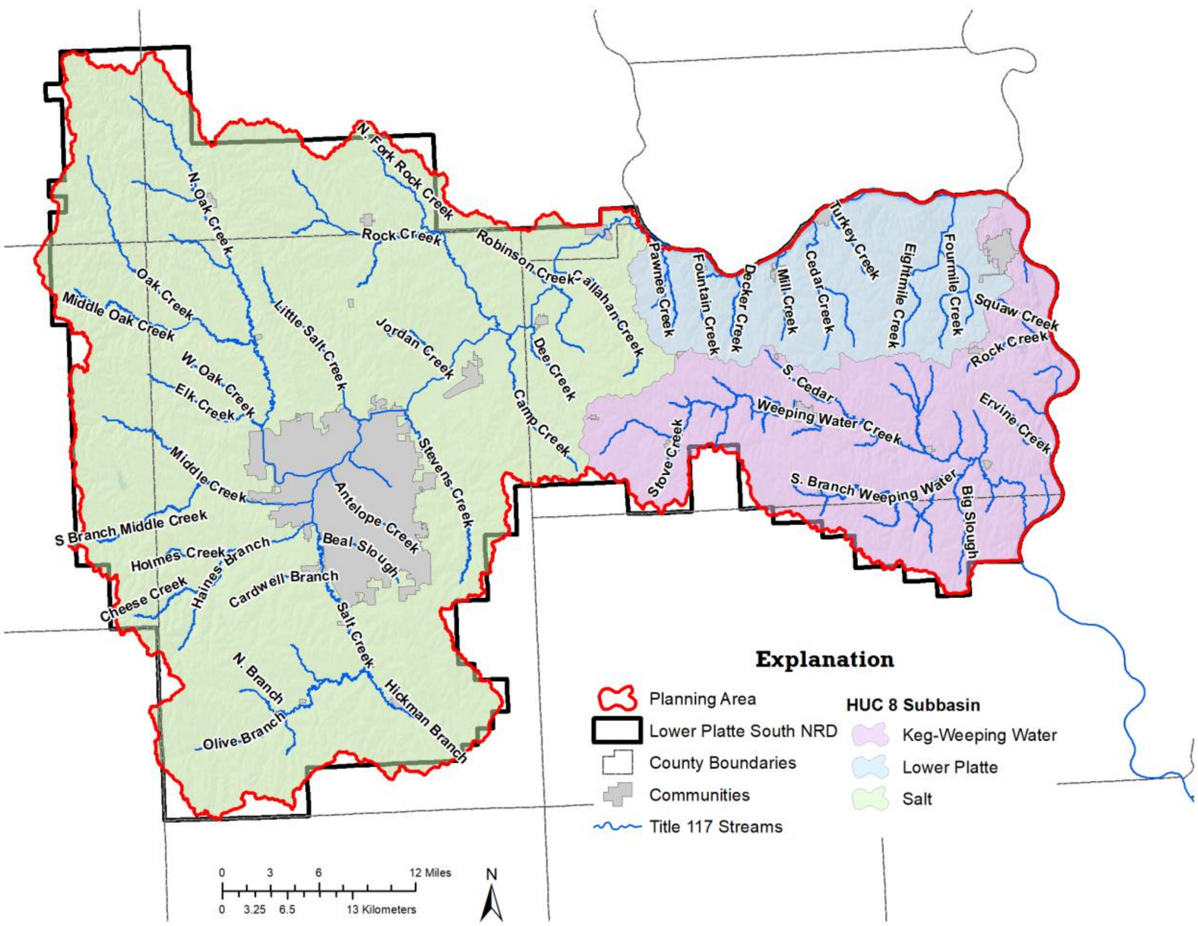


Figure 22: Designated Title 117 Streams in the Planning Area

Table 20: Summary of Streams within the Planning Area

HUC 8 Subbasin	Named Streams	Individual Segments	Total Stream Miles
Keg-Weeping Water	20	40	209
Lower Platte	10	16	89
Salt	34	46	471

Note: the statistics above do not include the Platte or Missouri Rivers
Source: (NDEQ, 2016b)

Wahoo Creek (not listed) is a tributary to Salt Creek, however it was not a part of this planning effort as it is a separate HUC 8. Wahoo Creek flows into Salt Creek near Ashland, just upstream of the confluence with the Platte River. It should be noted that Wahoo Creek has been identified as impaired due to bacteria. A separate watershed management plan has been previously developed for the Wahoo Creek watershed by the Lower Platte North NRD.

LAKES AND RESERVOIRS

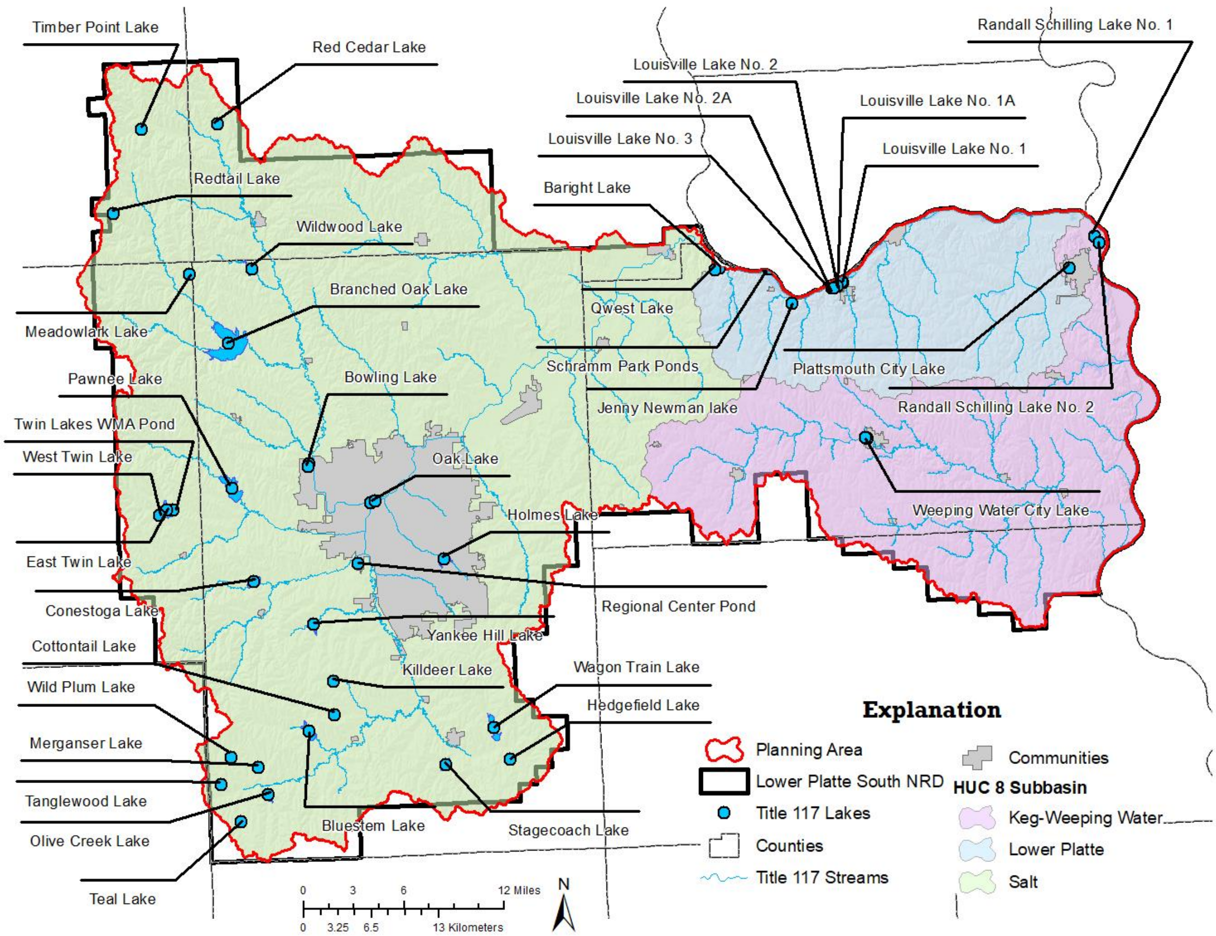
There are 39 Title 117 designated lakes, covering approximately 4,517 acres, in the planning area (Table 21 and Figure 23). Branched Oak Lake is the largest, covering 1,756 surface acres of permanent pool. Branched Oak is near Malcolm, approximately ten miles northwest of Lincoln. Pawnee Lake covers 620 surface acres and is located six miles west of Lincoln. Wagon Train Lake is located near Hickman, approximately six miles south of Lincoln and covers 300 surface acres. Bluestem Lake is located eight miles southwest of Lincoln with a surface coverage of 256 acres. Many lakes in the planning area offer recreational activities and facilities including: fishing, hiking, picnicking, and both electrical and primitive camping.

Table 21: Summary of Lakes within the Planning Area

Lake Name	Waterbody ID	Surface Area (acres)
Keg-Weeping Water HUC 8		
Plattsmouth City Lake	NE1-L0030	3.42
Randall Schilling Lake No. 1, WMA	NE1-L0040	29.16
Randall Schilling Lake No. 2, WMA	NE1-L0050	4.69
Weeping Water City Lake	NE1-L0020	4.92
	Subtotal	**42.19**
Lower Platte HUC 8		
Baright Lake, Mahoney State Park	LP1-L0090	3.77
Jenny Newman Lake, Platte River State Park	LP1-L0060	3.98
Louisville Lake No. 1, SRA	LP1-L0010	5.87
Louisville Lake No. 1A, SRA	LP1-L0020	5.21
Louisville Lake No. 2, SRA	LP1-L0030	18.98
Louisville Lake No. 2A, SRA	LP1-L0050	1.96

Louisville Lake No. 3, SRA	LP1-L0040	13.07
Qwest Lake, Mahoney State Park	LP1-L0080	9.42
	Subtotal	**62.28**
Salt HUC 8		
Bluestem Lake	LP2-L0110	256.34
Bowling Lake	LP2-L0100	26.65
Branched Oak Lake	LP2-L0150	1755.72
Conestoga Lake	LP2-L0130	189.60
Cottontail Lake, 17A	LP2-L0070	25.04
East Twin Lake	LP2-L0240	149.28
Hedgefield Lake, WMA	LP2-L0020	31.69
Holmes Lake	LP2-L0040	106.48
Killdeer Lake, WMA	LP2-L0080	18.56
Meadowlark Lake	LP2-L0220	47.19
Merganser Lake, 25A	LP2-L0170	36.82
Oak Lake	LP2-L0060	60.79
Olive Creek Lake	LP2-L0140	128.11
Pawnee Lake	LP2-L0160	619.63
Red Cedar Lake	LP2-L0190	47.15
Redtail Lake	LP2-L0280	23.83
Regional Center Pond	LP2-L0065	0.42
Stagecoach Lake	LP2-L0050	171.79
Tanglewood Lake, 27C	LP2-L0210	21.66
Teal Lake, 27C	LP2-L0180	22.61
Timber Point Lake, 6C	LP2-L0250	22.04
Twin Lakes WMA Pond	LP2-L0230	0.69
Wagon Train Lake	LP2-L0030	298.98
West Twin Lake	LP2-L0260	44.94
Wild Plum Lake, 26A	LP2-L0200	13.72
Wildwood Lake	LP2-L0120	109.87
Yankee Hill Lake	LP2-L0090	183.78
	Subtotal	**4413.40**
	Total	**4517.86**

Source: NDEQ, 2016



Note: Only public lakes, that are designated by NDEQ in Title 117, are shown on the map

Figure 23: Designated Title 117 Lakes in the Planning Area

Large Flood Control Reservoirs

Over the past century the need to address flooding within the planning area has grown as the population has expanded. To help mitigate flooding issues, flood control reservoirs, channel improvements, and levees have been constructed. The LPSNRD has been involved either directly or indirectly in many of these, particularly the larger projects. There have also been many smaller efforts by landowners, farmers, city and county governments, and others to reduce flooding. LPSNRD currently maintains approximately 200 smaller dams. While all these projects impact the water resources of the planning area in some way, the discussion below is limited to the major efforts, primarily those involving the federal government.

In the 1960s a robust levee system was completed along Salt Creek in Lincoln, and ten flood control reservoirs were constructed by the U.S. Army Corps of Engineers (USACE) in the Salt

Creek subbasin. In addition to flood control, these reservoirs also provide recreation, wildlife habitat, and water quality benefits. The reservoirs include:

- Branched Oak Lake
- Pawnee Lake
- Twin Lakes
- Conestoga Lake
- Yankee Hill Lake
- Blue Stem Lake
- Olive Creek Lake
- Stagecoach Lake
- Wagon Train Lake
- Holmes Lake

Private Lake Associations

Lake associations are private organizations similar to home owner groups for housing communities that are centered on a lake. They deal a wide array of neighborhood issues, but also things like boating concerns and environmental issues within their lakes. There is no centralized database of lake associations, however there is an estimated 20 of them within the LPSNRD (Table 22). A better identification of these groups is recommended, as these groups have the capability to help manage lake resources. Additionally, it is encouraged that each association become a member of the Nebraska Lakes Association (http://www.nebraskalakes.org/), which provides a forum for information and resources to educate members so their lake experience is safe, healthy and enjoyable.

Table 22: Private Lake Associations

Lake Association Name	
Beaver Lake	North Lake
Buccaneer Bay – SID #5	Omaha Fish and Wildflie Club
Capital Beach Lake	Oreapolis, NE
Cedar Creek Lake	Pine Lake Reservoir
Coddington Mills HOA	Sailboat Lake
Copper Dollar Cove	The Quarry
Diesel Lake	Waterford Lake
Hidden Hollow	Wedgewood Lake
Linde Lakes	Willow Point
Middle Island Lake	Wa-Con-Da Lake

WETLANDS

Information on Nebraska's wetlands are primarily documented in two NGPC publications: "Guide to Nebraska's Wetlands and their Conservation Needs" (LaGrange, 2005), and the "Wetland Program Plan for Nebraska" (LaGrange, 2015). Nebraska's wetland resources are diverse and dynamic. Many wetlands receive their water supply from groundwater, while others are dependent on precipitation and runoff. Wetlands are known to serve many functions and provide valuable services such as water purification, wildlife habitat, flood protection, and groundwater recharge. Wetlands are defined in Title 117 as:

> *"Those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas."*

Regional Wetland Complexes

The wetlands of Nebraska have been categorized into 14 complexes based on geography and distinct wetland forms and functions (LaGrange, 2005). It should be noted that if existing wetlands are not identified in one of these complexes, it does not indicate that they are unimportant or do not provide valuable functions. Within the planning area, two primary complexes are present (Figure 24): "Eastern Saline Wetlands" and "Riverine Wetlands".

> Eastern Saline Wetlands occur in swales and depressions within the floodplains of Salt Creek and its tributaries in Lancaster and southern Saunders counties. The wetlands receive their salinity from groundwater inflow that passes through an underground rock formation containing salts deposited by an ancient sea that once covered Nebraska.
>
> Riverine Wetlands are closely associated with the riparian zones and floodplains of all of Nebraska's rivers and streams. These riparian areas are complex systems with numerous inter-related components (e.g., wetlands, organic matter, sandbars, tree falls, side channels, etc.). Wetlands are an important component of this system by producing invertebrates and other organic matter that provide energy and food to the streams and rivers. Additionally, these wetlands provide habitat, spawning, and nursery areas for many different types of wildlife.

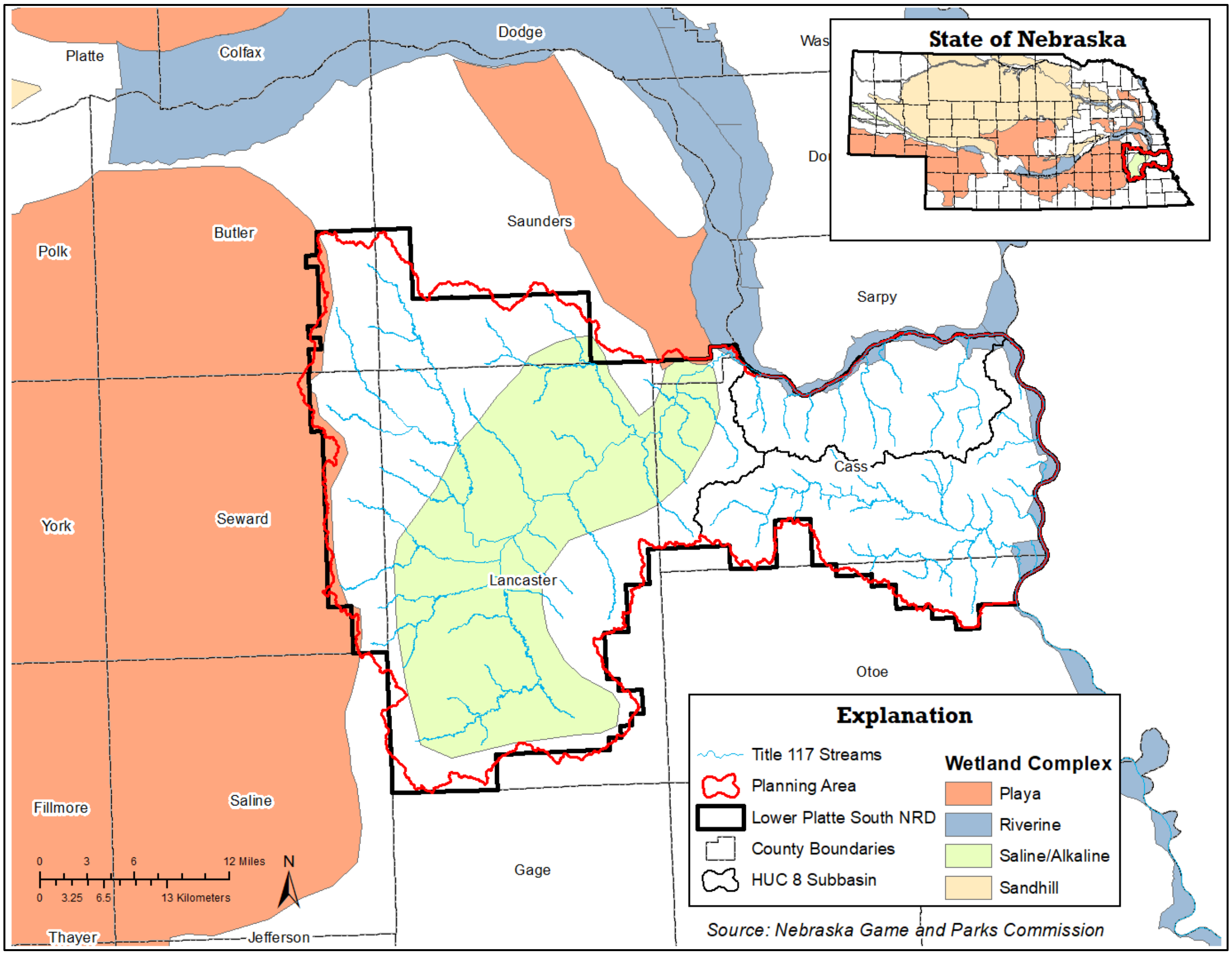


Figure 24: Regional Wetland Complexes

National Wetland Inventory

The United States Fish and Wildlife Service (USFWS) has established the National Wetland Inventory (NWI) to provide an estimate of all wetlands in the United States. The NWI was developed using remote sensing and aerial photography analysis, which is useful for a widescale inventory. However, the NWI often misses or does not include smaller wetlands due to the remote sensing techniques utilized. Therefore, while useful in understanding the type and scale of wetlands present, the NWI should not be considered a complete inventory of all wetlands and should not be used as substitute for on-the-ground surveys.

Analysis of NWI data indicates that there are approximately 73,600 acres of wetlands in the planning area (Figure 25). The wetlands in the planning area are primarily riverine and located along streams. It is likely that many of these wetlands in the inventory are Saline Wetlands and are not separately noted due to inherent limitations of the NWI. There are also pockets of emergent wetlands, forested wetlands, and lakes/ponds. The following is a breakdown of approximate acreages of NWI wetlands in the planning area:

- Emergent: 8,400 acres
- Forested/shrub: 4,050 acres
- Riverine: 51,300 acres
- Pond/Lake: 8,850 acres

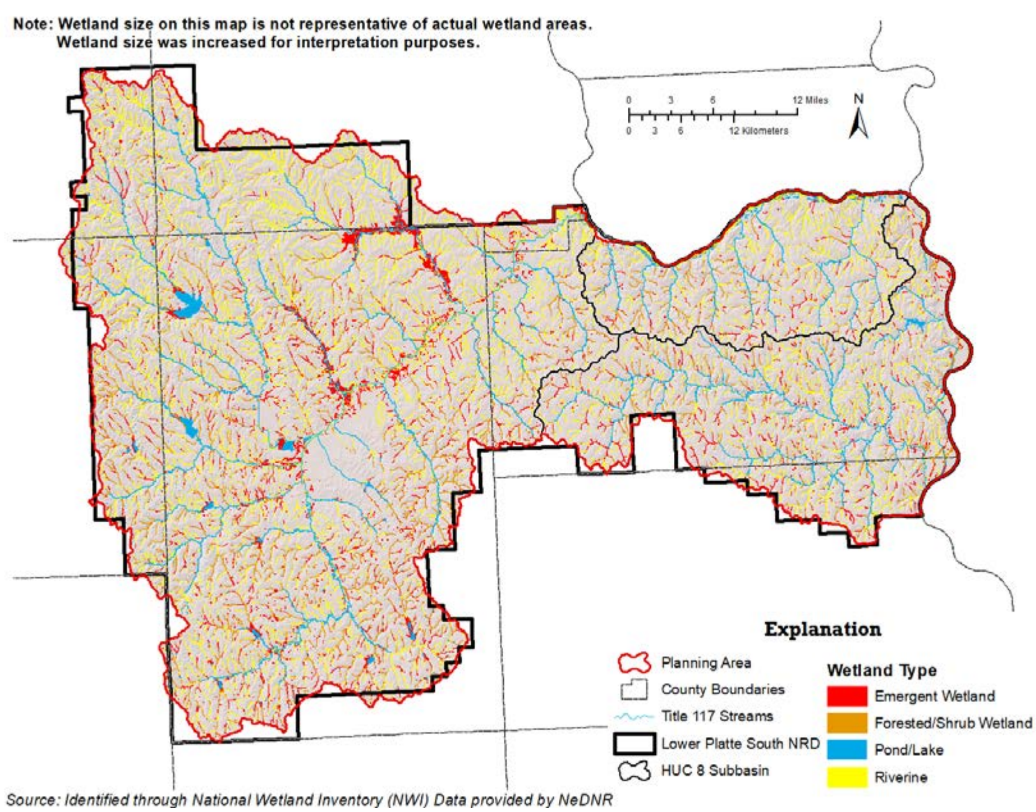


Figure 25: National Wetland Inventory (NWI) Identified Wetlands

Saline Wetlands

Saline wetlands form a regionally unique complex located in floodplain swales and depressions within the Salt Creek, Little Salt Creek, and Rock Creek drainages in Lancaster and southern Saunders counties (Figure 26). They are home to several rare, threatened, or endangered species including: Salt Creek Tiger Beetle, saltmarsh aster, saltwort, and Texas dropseed. The saline wetlands are considered critical habitat (USFWS, 2016) and are the most limited and endangered vegetation community in the state.

Saline wetlands are characterized by saline soils and salt-tolerant vegetation Highly saline wetlands usually have a central area that is devoid of vegetation and, when dry, exhibit salt encrusted mudflats. Wetlands with lower soil salinities are fully vegetated with salt-tolerant plants. Historically there have been extensive wetland losses from expansion of urban areas and agricultural activities. Existing saline wetlands have experienced recognizable degradation through drainage, diking, filling, farming and overgrazing, particularly in this watershed (LaGrange, 2005). There are approximately 4,305 acres of saline wetlands in the planning area, all within the Salt Creek HUC 8 Subbasin.

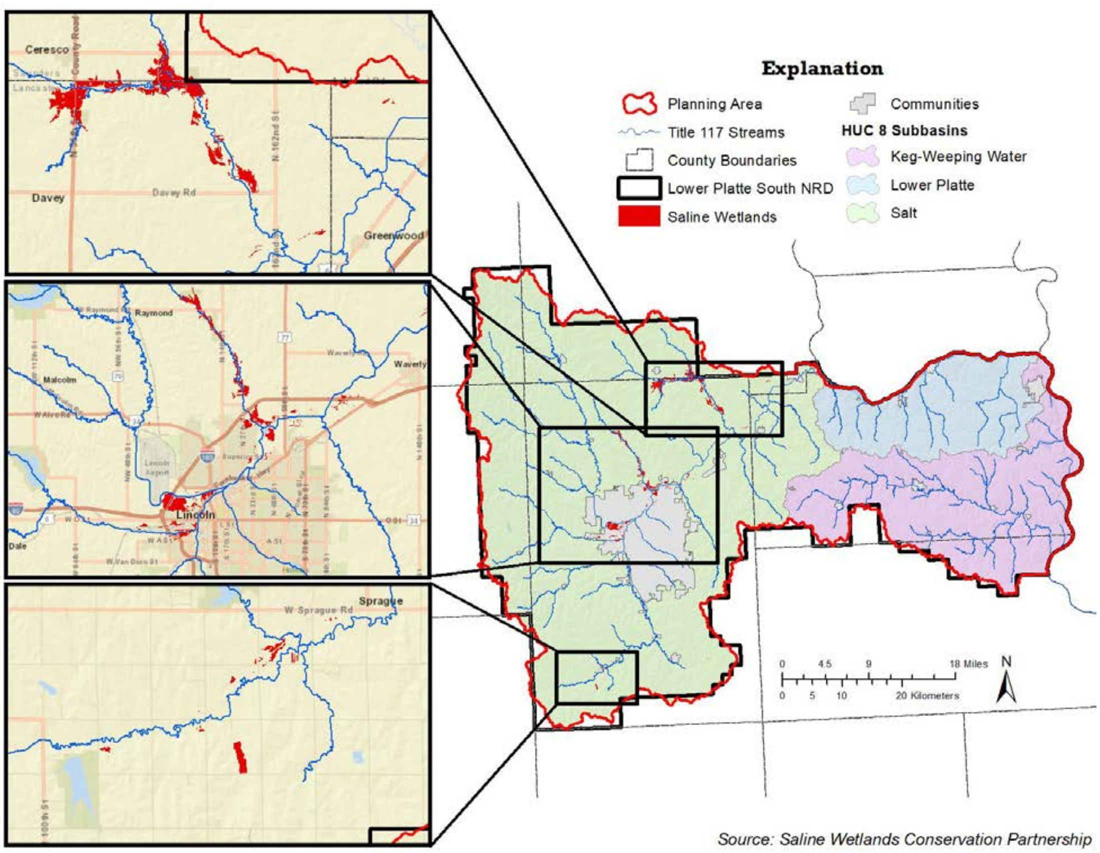


Figure 26: Saline Wetlands Location Map

A group of state and local agencies joined forces to establish the Saline Wetlands Conservation Partnership. The group developed an implementation plan in 2003 to address the preservation of these resources, and since then has addressed all objectives and strategies within the plan. More recently the “Upper Little Salt Creek Saline Wetlands Plan” (Lincoln Parks and Recreation, 2015) was developed (Figure 27), which details the next decade’s worth of additional projects for the conservation and restoration of these important resources.

The Partnership consists of the following entities:

- City of Lincoln
- Lancaster County
- Lower Platte South Natural Resources District
- The Nature Conservancy
- Nebraska Game and Parks Commission.

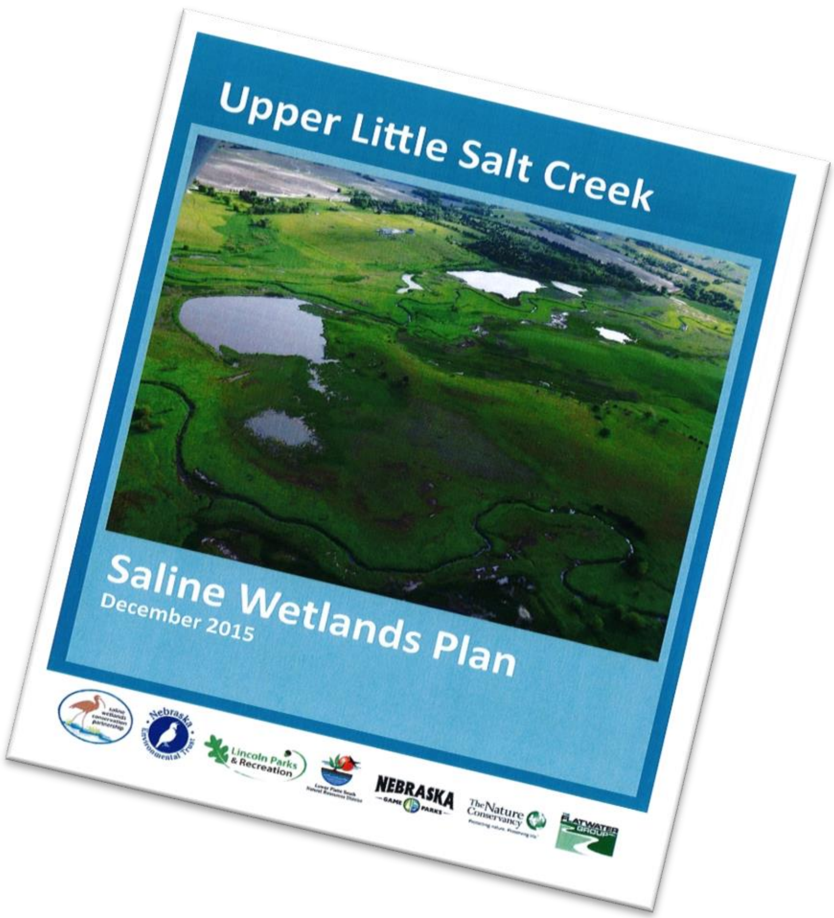


Figure 27: Cover Image of the Most Recent Plan to Conserve and Restore the Saline Wetlands

3.04 SURFACE WATER HYDROLOGY

INTRODUCTION

Characterizing the hydrologic regime of a watershed is an important aspect to understanding its susceptibility to alterations from land and water use practices, which in turn influence water quality. It is also critical to building a water quality model. Figure 28 contains a conceptual hydrograph and cutaway which illustrates these key concepts. When hydrologic alteration occurs, the stream system responds with changes in physical, chemical, and biological parameters. Physical changes may lead to increased flooding and reduced stream stability. These changes may in turn impact chemical parameters and ultimately the biological ecosystem. Additionally, changes in stream flow directly impact a stream's water quality. An increase in quantity can have the effect of improving water quality through dilution, and a decrease in quantity can have the opposite effect through concentrating pollutants.

Precipitation is a direct source and the most significant water supply to streams in the study area (Brown and Caldwell, 2012). For these reasons, surface runoff/interflow was reviewed on an annual and volumetric basis for this plan. Annual surface runoff/interflow originates as precipitation and becomes either overland runoff or water that flows through the unsaturated zone but returns to the surface or enters a stream prior to becoming groundwater (saturated zone).

Hydrologic processes are complex, involving many interactions that can be difficult to quantify. Additionally, impacts may be seen on both temporal and spatial scales. The location, extent, timing, and type of activities all play a role in alterations. Changes can be seen in the magnitude and timing of peak flows and low flows, or in year-to-year flow trends. Some activities (roads, seasonal irrigation withdrawals, etc.) cause short-lived alterations, while other activities (dams, urbanization, channelization, groundwater mining, etc.) can cause relatively permanent changes in the hydrology of a watershed (EPA, 2003b).

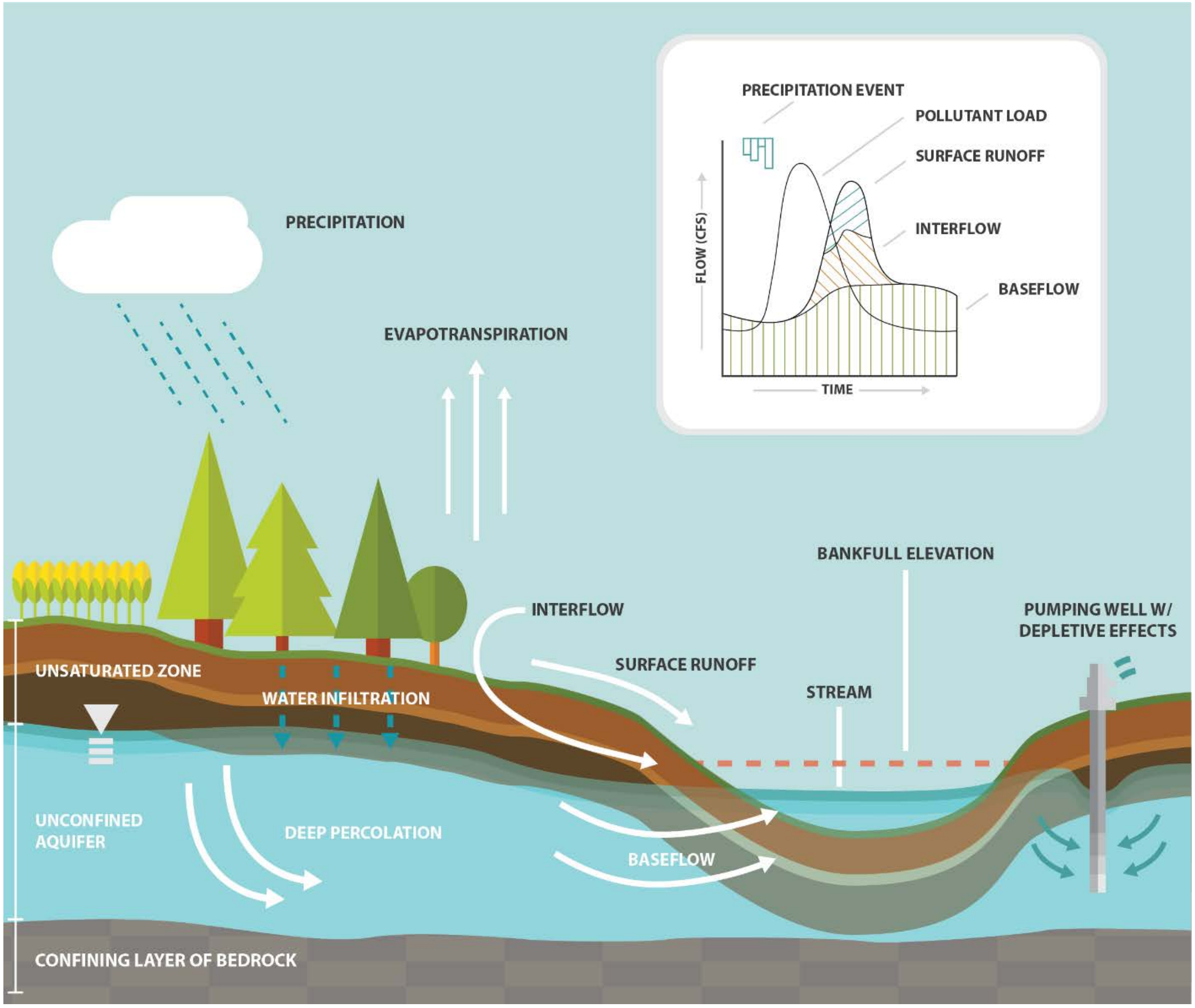


Figure 28: Illustration of a Conceptual Storm Hydrograph and Groundwater Flow System

STREAMFLOW

Streamflow regimes are composed of seasonally varying environmental flow components, including: high flows; base flows; pulses and floods that can be characterized in terms of their magnitude; frequency; duration; timing (predictability); and rate of change (flashiness) of hydrologic conditions (Poff and others, 1997).

To understand a typical hydrologic cycle and streamflow regime of the planning area, a representative stream gage was identified to review streamflow records. The USGS stream gage located on Salt Creek near Greenwood (06803555) has a long period of record (1951 – present) and is downstream to much of the planning area. However, while representative of the area and long-term trends, it should be noted that all streams have unique responses to storm events due to variability in precipitation patterns and effects of terrain, soils, and LULC. This creates both local and regional flow patterns. Additionally, many of the area streams are regulated by man-made structures such as flood control reservoirs and levees. A review of the discharge data for Salt Creek demonstrates a few trends which provide a basic understanding the dynamic hydrologic cycle of the planning area:

- Streamflow can vary considerably day-to-day, as precipitation is the most significant water supply to the planning area (Figure 29).
- A predictable seasonal pattern can be seen in streamflows. There is an increase in runoff in late winter/ early spring caused by snowmelt, leading to increased stream flows. There is also an increase in streamflows during the late spring and early summer storm season. Many years there are flood events in both the spring and fall rainy seasons.
- A long-term trend of increase in streamflows has been noted across the Midwest (Brown and Caldwell, 2012), including the planning area (Figure 30). This may be caused by a multitude of factors: increased rainfall; increased urbanization in the Lincoln area; and an increase in water importation from the Platte River for the City of Lincoln's drinking water supply.
- There are long-term patterns of wet and dry periods, as seen in the running 5-year average (Figure 30). The highest daily average streamflow recorded was 37,100 cubic feet per second (CFS) in 1984, and the lowest daily average was 14 CFS in 1957. The long-term average flow is 368 CFS.
- Stream flows are seasonally predicable across the planning area, but less predictable during high flow/ flood events due to natural and anthropogenic impacts which vary across subwatersheds.

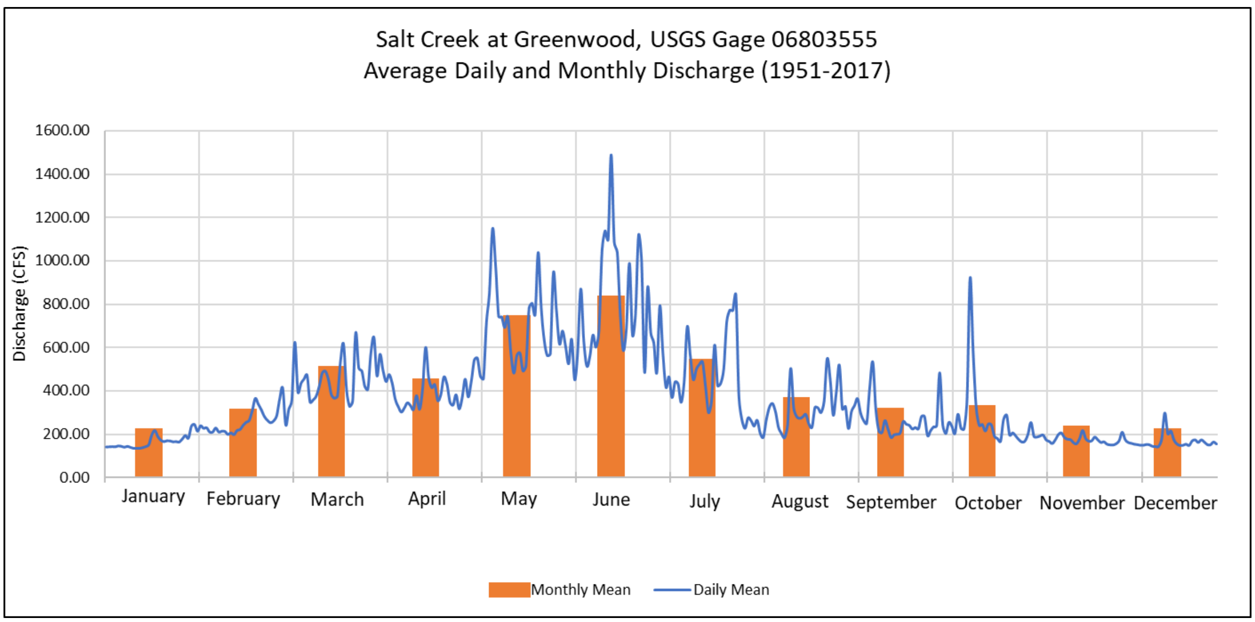


Figure 29: Streamflow Hydrograph of an Average Year for Salt Creek

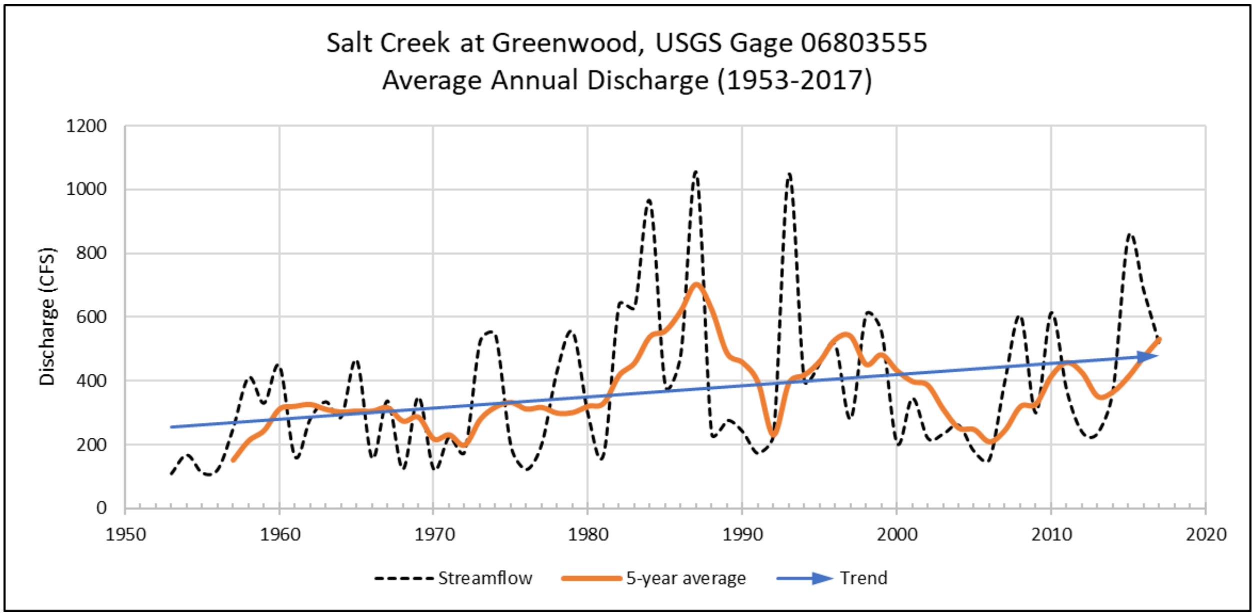


Figure 30: Long Term Streamflow Hydrograph for Salt Creek

Variations in stream flow levels, including high flow or flooding events, are an important part of the natural ecological function of streams. Many fish and aquatic organisms require habitat that cannot be maintained by minimum or even typical flows over the long term. A range of flows are necessary to scour and revitalize gravel beds, import wood and organic matter from the floodplain, and provide access to riparian wetlands. Additionally, these processes are important in the natural cycling/movement of nutrients and sediments (Poff and others, 1997). Understanding these hydrological conditions is important to making management decisions regarding watershed planning, especially in regard to stream restoration and management practices. However, extremely high flows may be considered flooding, which may cause damage to infrastructure, homes, businesses and other property, and endanger human life. Balance is needed in the management of streams within the planning area. It is important to note that flood risk reduction is a large part of the mission of the LPSNRD.

FLOOD RISK REDUCTION

The LPSNRD is very active and works with local, state, and federal partners on many projects to address flooding risks. It addresses risks from a multi-pronged risk management approach, which includes: mitigation, preparation, response (Figure 31**),** and recovery.

Figure 31: Crews deploying sandbags in Lincoln, NE during a May 2015 flooding event

A review of information documented in the Lancaster County Flood Insurance Study (FIS) (Federal Emergency Management Agency [FEMA], 2013) helps to provide a basic understanding of flooding within the planning area:

> *Low-lying areas of the County are subject to periodic flooding from the overflow of Salt Creek and its tributaries. The most severe flooding has occurred in the late spring and early summer as a result of snowmelt, heavy thunderstorm rainfall, ice jams, or combinations of the above. Completion of the Salt Creek project of Federal flood control dams and reservoirs has affected the historic flood frequency and magnitude in the study reaches. However, these improvements have not eliminated completely the flood problem throughout the County. Since 1900, many floods have been recorded along Salt Creek and its tributaries in Lincoln and vicinity. Of these, 17 are classed as major, 30 as moderate, and 49 as minor. Flooding duration on Salt Creek and Oak Creek typically is long duration with a slow rate of change (ample warning), while flooding on smaller tributaries (especially urbanized ones) is short duration with a rapid rate of change (flashy).*

A review of data from the USGS stream gage (06803555) located on Salt Creek near Greenwood provides an indication as to the magnitude and frequency of flooding that occurs in the planning area. Gage height data, which indicates the depth of water in the stream channel, was reviewed against the National Weather Service's (NWS) designated "flood stage", which is set at 20 feet. Figure 32 shows that over the last decade, the gage has recorded the river reaching the NWS flood stage during four events (2007, 2010, 2014, and 2015). The stream has been above its average level (3.35 feet) on numerous occasions where it may be considered a high flow event, but not a flooding event: 10 occurrences reached between 15-20 feet and 24 occurrences reached between 10-15 feet.

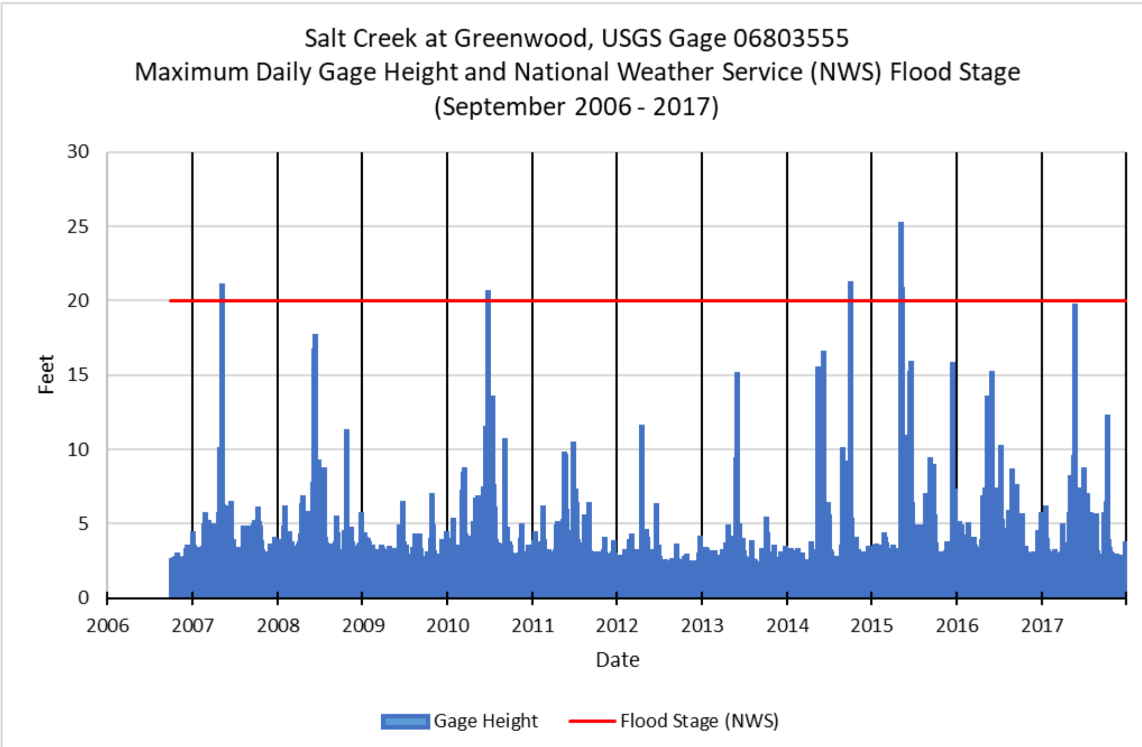


Figure 32: Maximum Daily Gage Height and Flood Stage Records for Salt Creek

RUNOFF

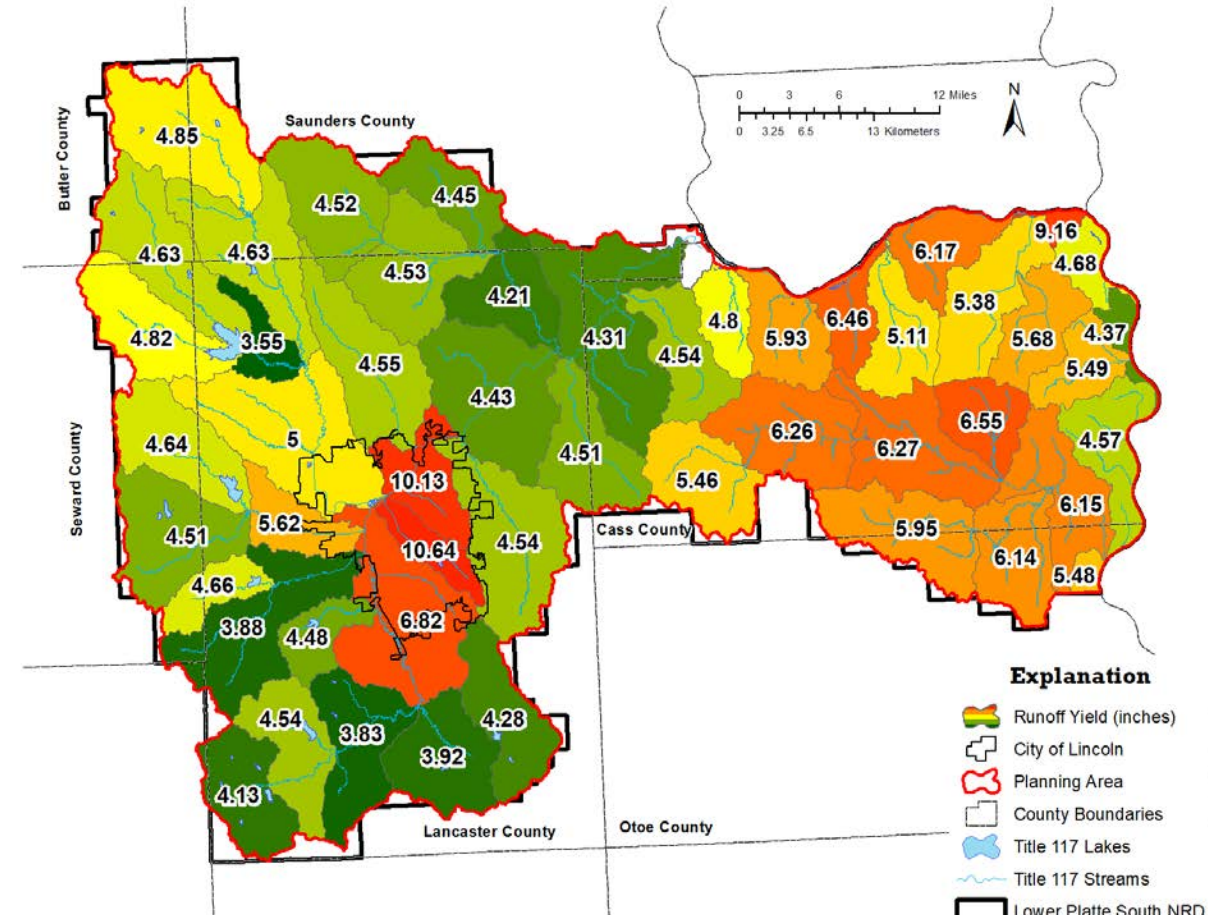
An analysis of runoff across the planning area was performed to estimate runoff yield from the planning area. These runoff yield estimates were then utilized to estimate pollutant loadings for individual HUC 12 subwatersheds. Runoff yield estimations were largely based on the interaction of runoff coefficients determined from soil type, land use, and slope of the contributing areas with estimated annual runoff values provided by USGS gaging stations with annual water summaries. Areas dominated by natural or perennial vegetation have the lowest amount of runoff when slope is not accounted for; however, increasing slope increases runoff.

Average runoff coefficients for each HUC 12 within the Lower Platte South NRD were determined using GIS-based analysis. Runoff depths for individual HUC 12s were then calculated based on regression analysis of stream gage data. Runoff coefficients were calibrated for better yield of runoff volumes determined through gage analysis. A detailed discussion on methodology is provided in Appendix C.

Runoff varies significantly across the planning area. The lowest runoff estimates were noted on the south and western side of the study area. Land use in this area consists mostly of perennial grass cover, with soils in the silt loam to clay loam range. As expected, the highest runoff values came from urbanized areas due to high amounts of impervious surfaces that do not allow for infiltration. Open water has a high yield because any precipitation that falls on stream, lakes, wetlands, etc. directly contributes to runoff. A summary of runoff volumes by land use is provided in Table 23 while the variation in runoff variation by HUC 12 is illustrated in Figure 33.

Table 23: Estimated Average Annual Runoff by Land Use

Land Use	Percent of Area	Percent of Runoff	Total Runoff (Acre-ft.)	Total Runoff Yield (in/unit)
Pasture, Hay, Barren, Herbaceous	27.9	24.1%	107,100	4.8
Cultivated Crops	55.6	57.8%	256,862	5.3
Developed/Urban	9.9	12.1%	53,772	6.2
Forest/Trees/Shrubland	5.5	3.7%	16,443	3.4
Open Water	1.1	2.3%	10,221	10.0
Total	**100%**	**100%**	**444,397**	**n/a**



Source: Identified through JEO Runoff Yield Estimation

Figure 33: Estimated Average Annual Runoff by HUC 12 Subwatershed

3.05 GROUNDWATER RESOURCES

AQUIFERS

The State of Nebraska is generally supplied with an abundant supply of groundwater, making it one of Nebraska's most important natural resources. The vast majority of the state overlays the High Plains Aquifer; however, due to the geologic history of eastern Nebraska, the High Plains Aquifer is not in the planning area. The groundwater resources of the planning area are variable from place to place. Therefore, the LPSNRD has delineated five major groundwater reservoirs (GWRs) in its jurisdiction. Details about each of the following GWRs can be found in the LPSNRD's Groundwater Management Plan (Ehrman and others, 2017).

- Crete-Princeton-Adams (CPA)
- Dwight-Valparaiso (DV)
- Lower Salt Creek
- Missouri River Valley
- Platte River Valley

These GWRs represent areas which useable amounts of good quality groundwater are generally available. Typically, the GWRs consist of sand and/or gravel deposits in buried paleovalley or present-day river valleys. The remainder of the district has been designated as the Remaining Area (RA), which includes the Dakota Formation aquifer and other small aquifers. Groundwater in the RA is discontinuous spatially, and variable in both quality and quantity. The location of the RA and GWRs has been overlaid with major Nebraska aquifer types in Figure 34.

Three main *types* of aquifers make up the GWRs and RA in the planning area (Korus and others, 2013; Divine, 2014):

- **Paleovalley aquifers** are the primary source of water to irrigation wells in the county. These large and fairly continuous aquifers were developed when ancient river valleys were filled with alluvium and eventually buried by even younger geologic materials.
- **Localized Sand and gravel deposits:**
    - Alluvial valley aquifers existing in the modern-day stream valleys of Nebraska, where alluvium has been deposited across wide floodplains. These typically have shallow depths to groundwater, high permeability, and are highly vulnerable to contamination
    - Glacial aquifers are widely separated and discontinuous local aquifers with varying properties. They were formed when glaciers repeatedly advanced and retreated across eastern Nebraska. In some areas sands and gravel deposits were left behind. Typically, these aquifers only support small-scale withdraws for domestic and livestock purposes.
- **The Dakota aquifer** is a secondary aquifer in the planning area and consists primarily of sandstone. The aquifer produces relatively lower yields of water, which are used primarily for irrigation as the aquifer can be high in salinity and other minerals.

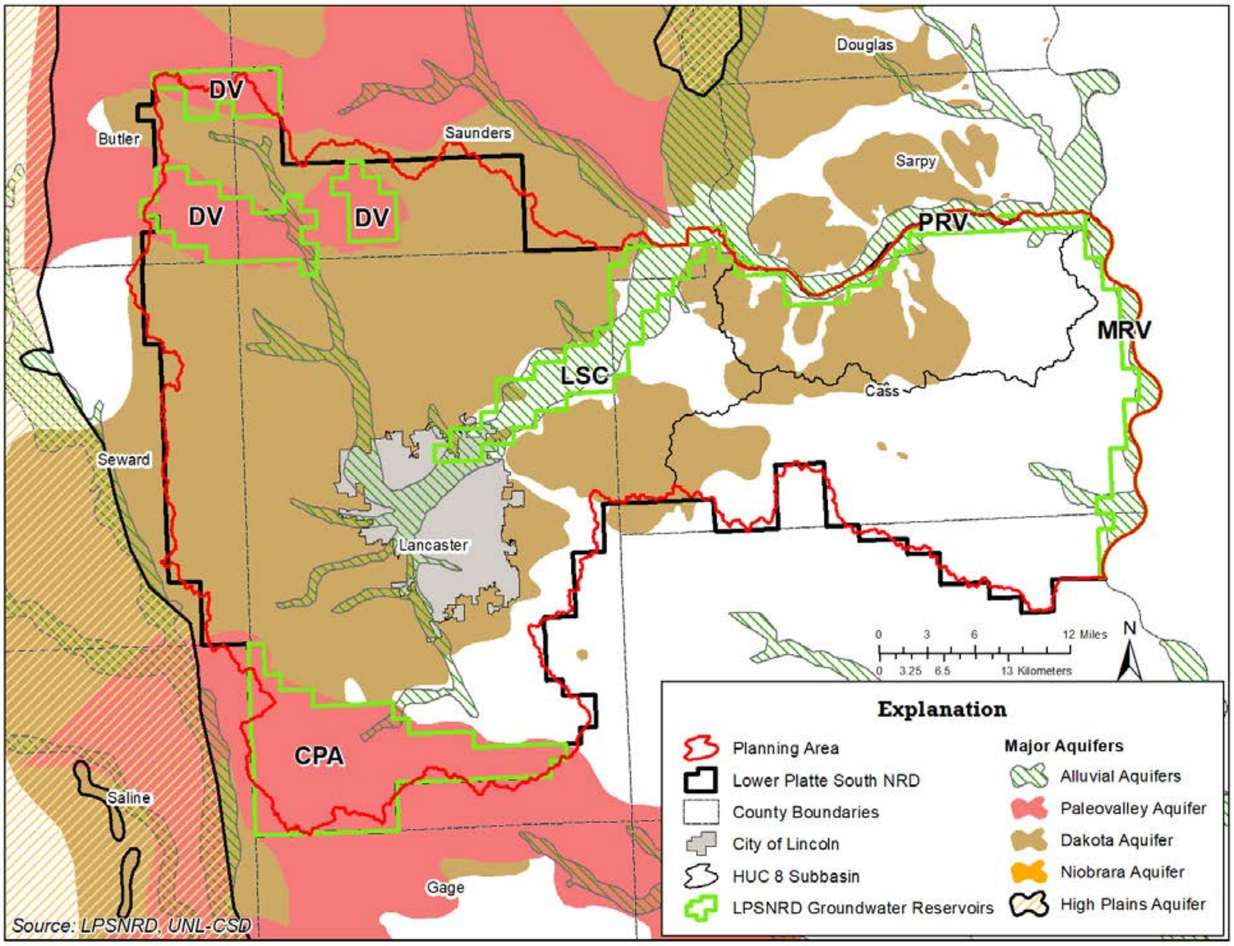


Figure 34: Groundwater Reservoirs and Major Nebraska Aquifers in the Planning Area

REGISTERED WELLS (NON-IRRIGATION)

There currently are 9,646 registered wells within the planning area (NeDNR, 2018). Refer to Figure 35 for the locations of these wells, except for irrigation use wells which are discussed in Section 3.06. Also refer to Figure 36 for a breakdown by use of all registered wells. The distribution of groundwater wells across the planning area is variable, following the variability of aquifers and the population. The majority of wells (54%) within the planning area are domestic use for private drinking water supplies. Locations of municipal (public drinking water supply) wells are not included in this data set due to public security reasons. Note that, prior to 1993, domestic wells were not required to be registered in Nebraska, therefore domestic wells completed prior to 1993 may not be represented here.

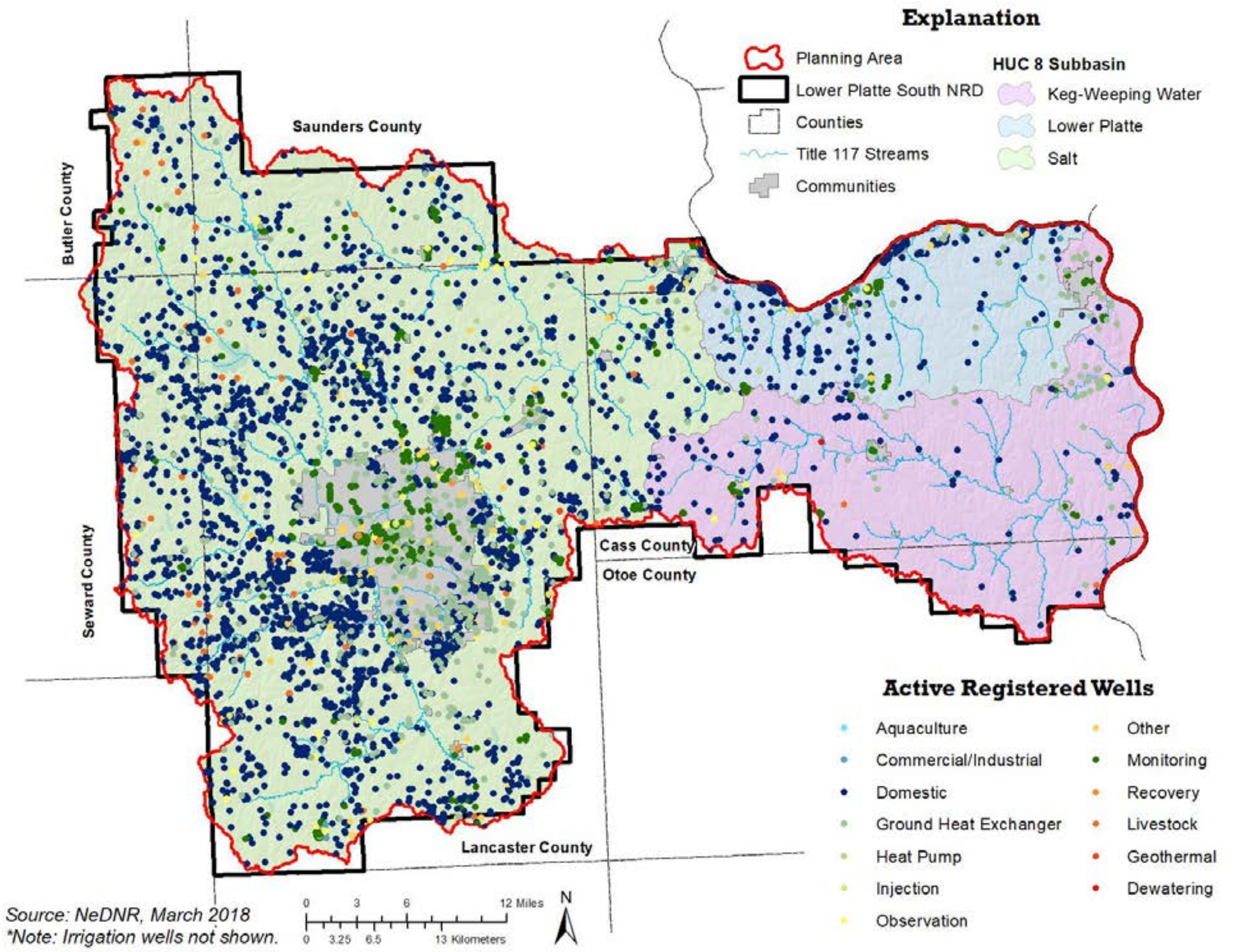


Figure 35: Registered and Active Wells in the Planning Areas (not including irrigation wells)

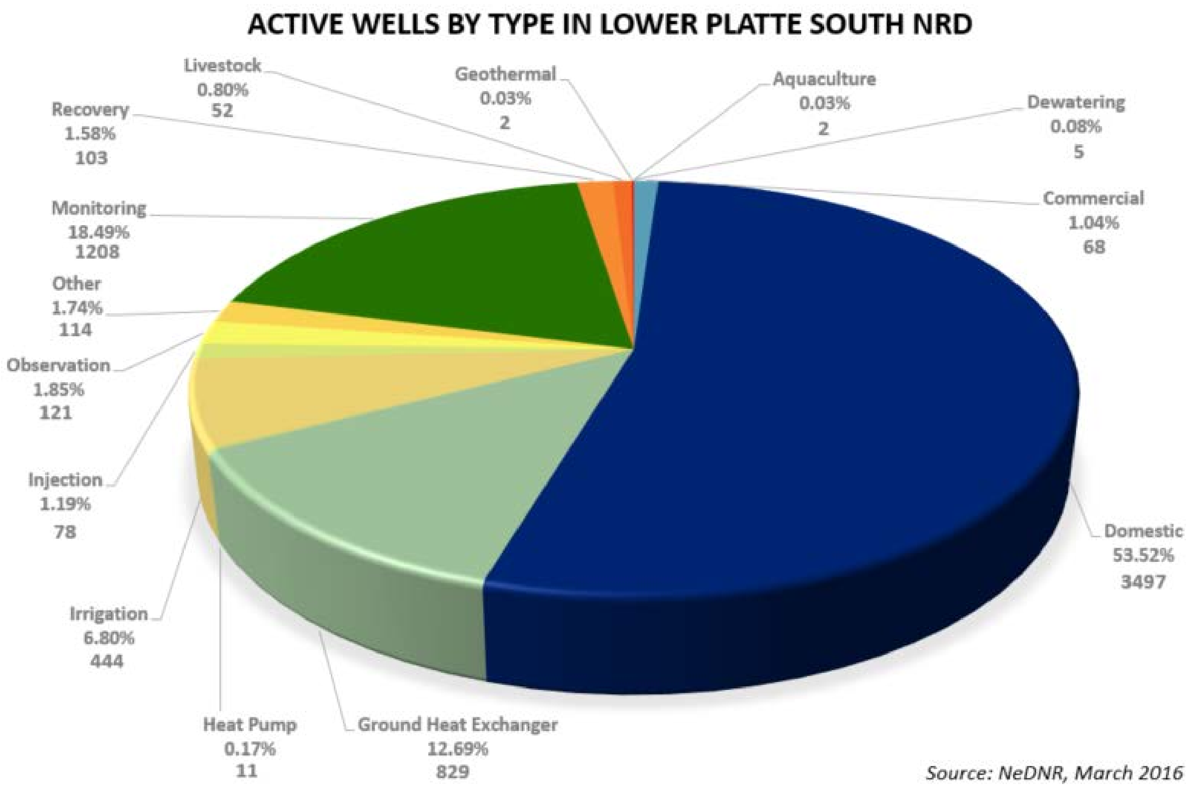
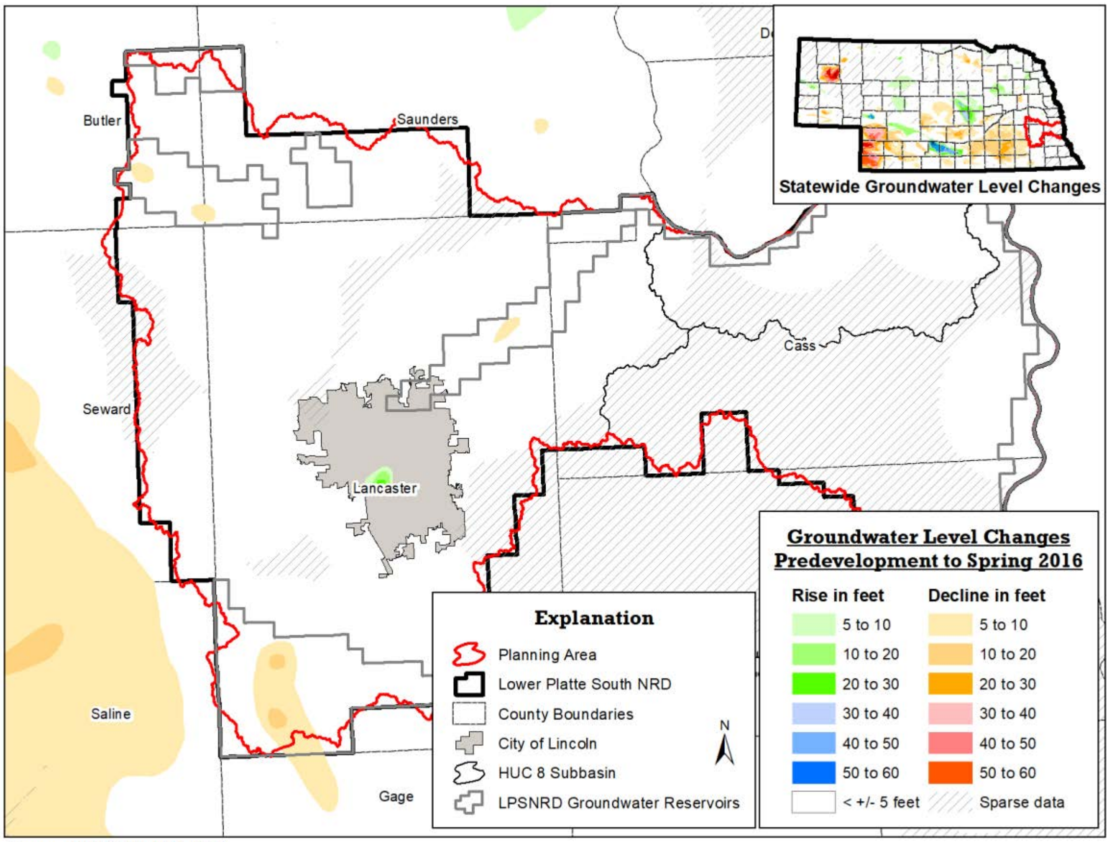


Figure 36: Distribution of Active Wells in the Planning Area

GROUNDWATER LEVELS

The LPSNRD is responsible for monitoring the groundwater levels within the planning area. Measurements are routinely taken from representatitive wells in both the spring and fall. For year-to-year comparisons spring measurements are used as they better represent aquifer conditions after they have had adequate time to return to static levels following summer irrigation.

Groundwater level fluctuations are highly variable across the planning area due to the complicated geology and aquifer conditions. From a long-term perspective, groundwater levels in the planning area are generally similar to their predevelopment (historical) levels (Figure 37). Predevelopment is identified as generally the early 1950s, prior to wide-spread irrigation well develoment. It is important to realize that this comparison is not spatially detailed and does not apply to any individual well or shorter time periods. Some areas of the LPSNRD have experienced continued groundwater level declines since the early 1980s. Additionally, seasonal declines in the northwestern portion of the district has prompted special management concerns (Ehrman and others, 2017). Additional details on groundwater levels can be found in the LPSNRD Groundwater Management Plan.



Source: LPSNRD, UNL-CSD

Figure 37: Groundwater Level Changes from Predevelopment to Spring 2016

GROUNDWATER NITRATE CONCENTRATIONS

Nitrate concentration in drinking water is a concern within the LPSNRD (Ehrman and others, 2017). Nitrate concentration data was compiled from the NDEQ Agrichemical Contaminant Database for Nebraska Groundwater (NDEQ, 2016a). As seen in Figure 38, nitrate levels amongst all wells varies widely across the planning area.

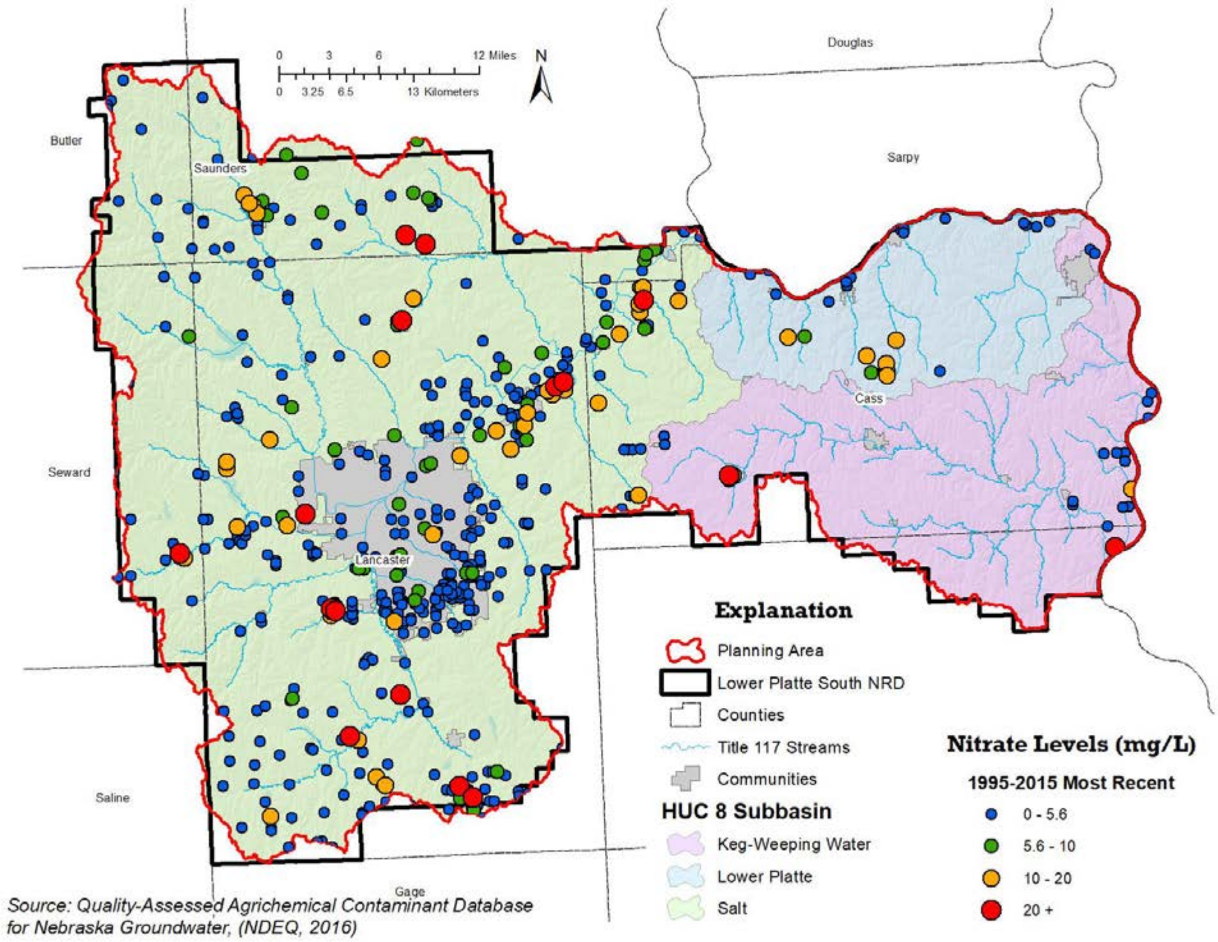


Figure 38: Most Recent Nitrate Concentrations from Wells Sampled in Last 20 Years

WELLHEAD PROTECTION AREAS

The NDEQ's Wellhead Protection Program is a voluntary program that helps community water systems protect groundwater through a series of steps including delineation and mapping of the Wellhead Protection Areas (WHP area). To delineate WHP areas, NDEQ uses groundwater modeling software to encompass delineate the WHP area around the 20-year time-of-travel zone for the supply wells in those systems. This is the area that groundwater is expected to be extracted from during 20 years of normal water use. LPSNRD has adopted the boundaries of the delineated WHP area for groundwater management through the LPSNRD Groundwater Management Plan.

In the LPSNRD, these areas are referred to as Community Water System Protection Areas (CWSPAs).

There are 34 designated WHP areas (CWSPAs) within the planning area. This plan recognizes each WHP area as a special resource area due to the influence a WHP area has on the management needs of source water aquifers and associated public drinking water systems. Table 24 provides details of each WHP area. Figure 39 illustrates the WHP areas within the planning area.

The LPSNRD provides groundwater monitoring services for each of the WHP areas within the District. The District samples each well for each water system annually, prior to the water entering the system. This provides the nitrate level for each well which gives a better indication as to the condition of the groundwater. However, it should be noted that many communities treat their drinking water or blend it from multiple wells to ensure they are delivering water to customers that meets drinking water standards.

The LPSNRD sampling data (1994 - 2017) was reviewed and the average nitrate value for each WHP area is provided in Table 24, and in Figure 39 each WHP area is color coded by the highest nitrate value found. The Federal drinking water standard, or Maximum Contaminant Level (MCL), for nitrate-nitrite is 10 milligrams per liter (mg/L). According to the data, nine communities have wells that are at or over the MCL: Ashland, Pleasant Dale, Waverly, Union, Lancaster County Sanitary Improvement District (SID) #6, Weeping Water, Davey, Hickman, and Elmwood. Several other communities have concentrations that are higher than 5.1 mg/L, but below the MCL: Valparaiso, Greenwood, and Sprague. These water systems' contaminant levels should be monitored closely in the future. The LPSNRD has a robust groundwater quality sampling program and detailed information on each of the GWRs and CWSPAs can be found in 2017 Groundwater Management Plan Review document (Ehrman and others, 2017).

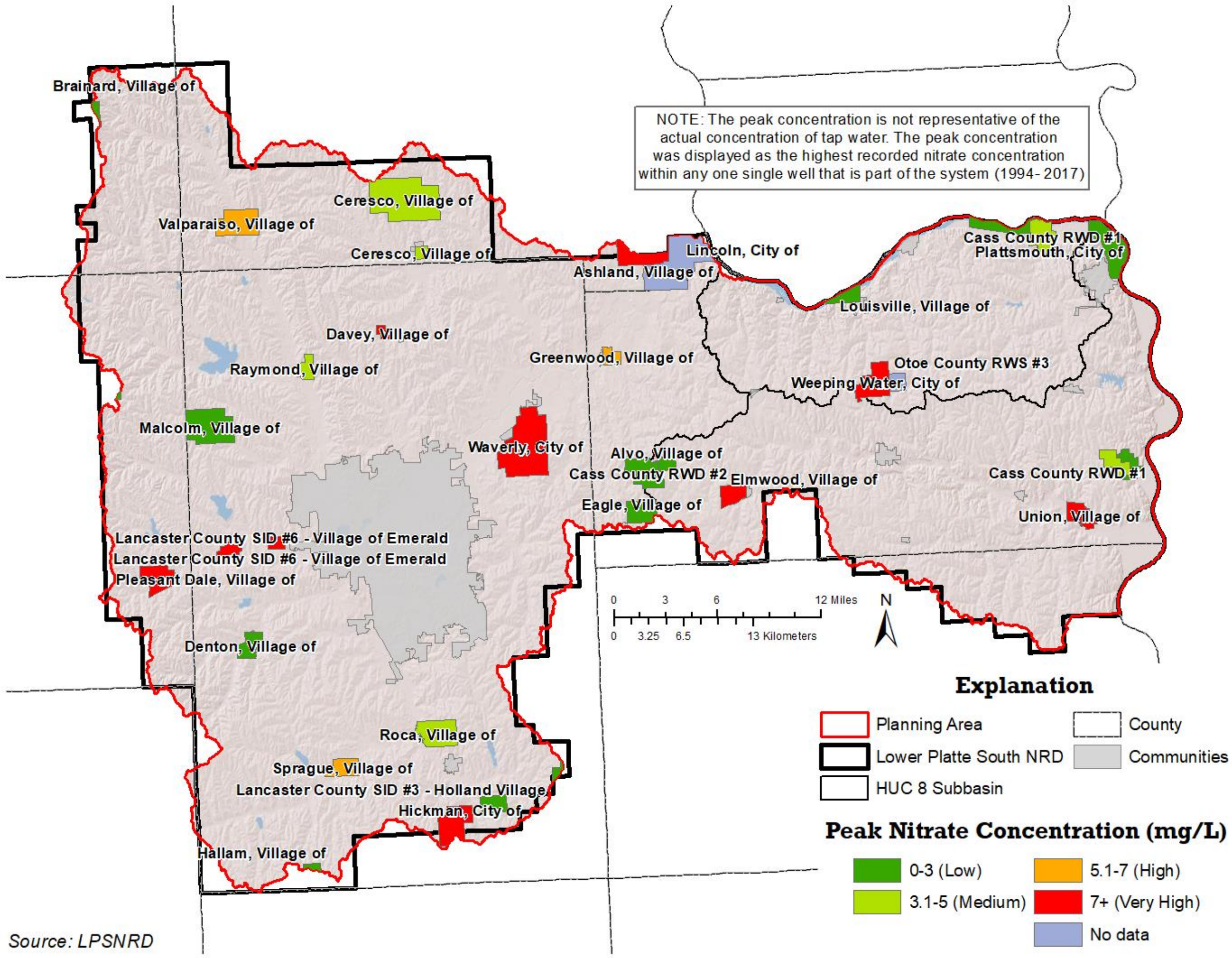


Figure 39: Wellhead Protection Areas and Maximum Nitrate Levels (1994 - 2017)

Table 24: Summary of Wellhead Protection Areas

Community Public Water Supply Name	WHP Area Map Delineation Approved	Approximate Size of WHP Area (acres)	Date of WHP Plan Approved	Average Nitrate-Nitrite Level (mg/L)
Alvo	6/3/2005	530	N/A	1.91
Ashland	2/17/2009	2,945	N/A	6.45
Brainard	2/11/2015	1,922	N/A	2.87
Cass Co. RWD #1	1/27/2014	2,493	N/A	4.27
Cass Co. RWD #2	8/23/2004	1,906	3/23/2003	3.00
Cass Co. SID #1	7/1/1996	1,251	N/A	1.32
Cass Co. SID #5	10/10/2012	985	N/A	2.84
Ceresco	12/24/2002	6,183	N/A	3.10
Lincoln	3/7/2013	25,515	N/A	24.05
Davey	3/24/2010	472	N/A	0.20
Denton	7/11/2003	1,083	N/A	1.05
Dwight	7/18/2003	2,131	5/1/2008	18.77
Eagle	12/30/2010	1,422	N/A	18.77
Elmwood	11/6/2002	1,023	N/A	0.20
Garland	2/14/2003	439	N/A	8.75
Greenwood	9/9/2005	585	N/A	0.20
Hallam	1/1/2003	478	N/A	14.30
Hickman	9/14/2010	2,308	N/A	0.90
Lancaster Co. SID #3	7/7/2004	968	N/A	1.05
Lancaster Co. SID #6	8/1/2011	1,131	1/22/2007	0.20
Louisville	7/27/2009	742	N/A	14.85
Metropolitan Utilities District	3/17/2011	39,154	10/30/2013	2.64
Malcolm	4/26/2001	3,273	N/A	No data
Otoe Co. RWD #3	2/18/2016	3,431	N/A	1.08
Panama	4/29/2014	1,134	N/A	8.32
Plattsmouth	8/27/2012	2,372	N/A	5.33
Pleasant Dale	3/5/2010	1,651	N/A	4.15
Raymond	4/28/2005	700	N/A	9.75
Roca	N/A	2,069	N/A	11.33
Sprague	6/26/2012	1,101	N/A	11.17
Union	6/14/2013	1,170	N/A	6.35
Valparaiso	6/25/2012	2,242	N/A	12.27
Waverly	6/30/2011	5,657	N/A	1.91
Weeping Water	3/4/2010	1,964	N/A	6.45

Source of Nitrate-Nitrate Data: LPSNRD
N/A – indicates no approved plan exists

3.06 WATER USE AND MANAGEMENT

OVERVIEW AND MANAGEMENT

Water resources management is not under one single jurisdiction or agency in Nebraska. In general, surface water quantity is administered by the Nebraska Department of Natural Resources (NeDNR), surface water quality is regulated by the NDEQ, and groundwater quality and quantity is regulated by the local NRD. Figure 40 illustrates the complicated water management structure in Nebraska. Because management actions directed at one aspect of water may have unintended consequences for another, resource agencies must work together to ensure responsible and sustainable management of water resources.

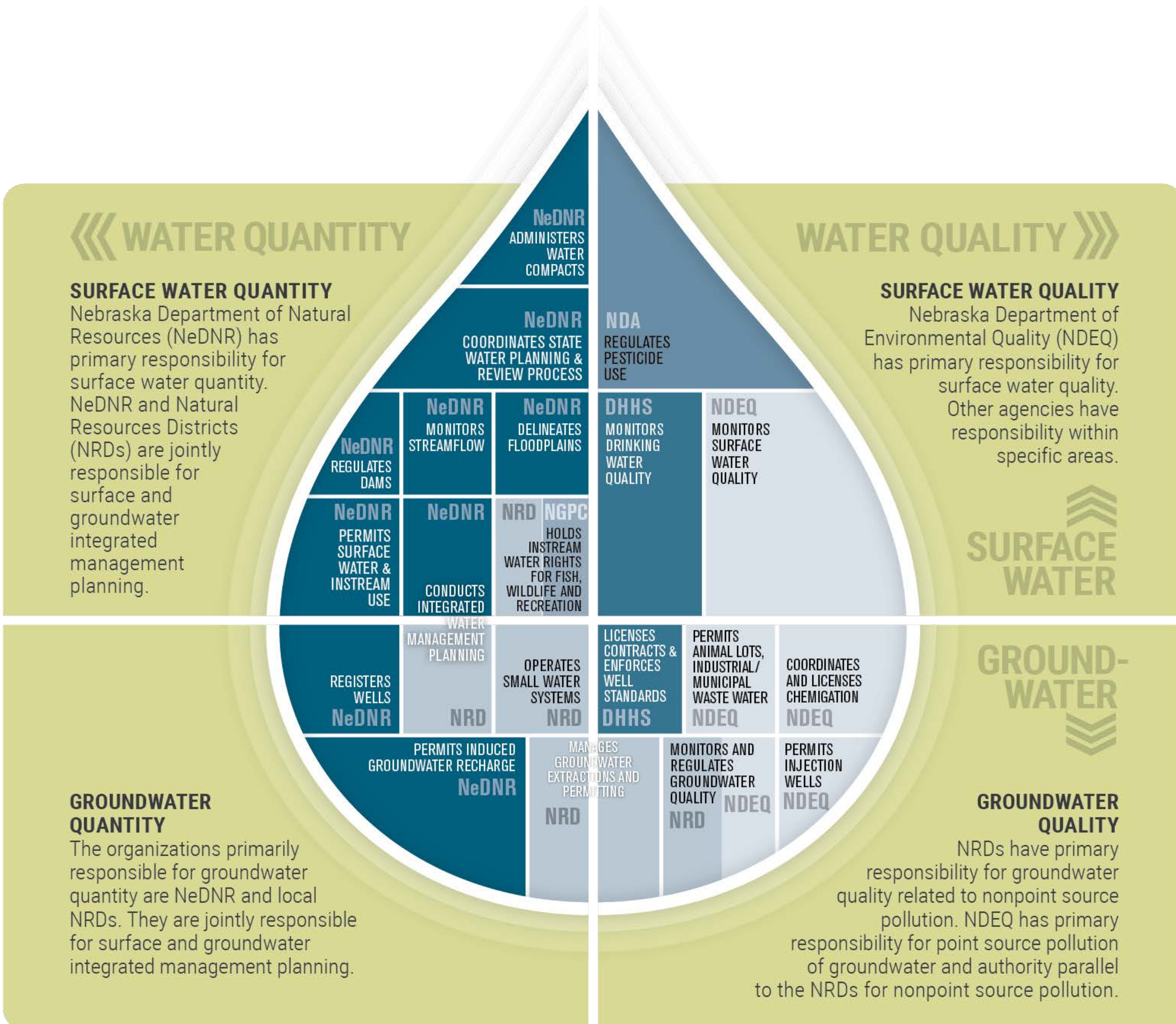


Image courtesy Nebraska Department of Natural Resources

Figure 40: Water Management Agencies and Roles in Nebraska

SURFACE AND GROUNDWATER BALANCE

Surface Water Law

The use of surface water in Nebraska is governed by the Doctrine of Prior Appropriation (First-in-Time, First-in-Right) which allows diversion of water from the surface waters of the state based upon the date the water right was obtained. Surface water rights entitle land owners or organizations to remove a set amount of water from a specific location. This system protects those with earlier water rights first during periods when the overall water supply is insufficient to meet all appropriated water rights. Thus, the entity with the earliest priority date (First-in-Time) is entitled to their full appropriation (First-in-Right) before a later priority date entity receives any water. These water rights are issued and regulated by the NeDNR.

Groundwater Law

Correlative Rights govern the use of Nebraska groundwater. Correlative Rights allow land owners to drill wells and extract groundwater from an underlying aquifer for beneficial purposes subject to management by the public. In 1957 the Unicameral passed legislation requiring the registration of all irrigation wells. To execute this right, land owners must first obtain a permit to drill a well from their local NRD, as required by the NRD Groundwater Management Plan. If approved, the well permit allows the land owner to drill a well and extract as much groundwater as needed, provided that the use is deemed beneficial. When the well development is completed, the well is registered with NeDNR, which places the information in a statewide database.

Integrated Management

In 2004, the Legislature enacted LB 962 which requires the NeDNR to take a proactive approach for the management of hydrologically connected surface and groundwater. NeDNR conducts an annual assessment of the water balance in each river basin in the state and classifies each as being under-appropriate, fully-appropriate (FA), or over-appropriated (OA). To complete this, all sources and uses of water (surface and groundwater) are measured or estimated using a combination of current water development records and model estimates. In areas designated as fully-appropriated, new high-capacity and new surface water rights are placed under a moratorium. While new development can be allowed in these areas, the irrigation needs to be offset by removing an existing user or some other means of replacing the impact to the water balance. Those areas deemed to be fully or over-appropriated are required to implement an integrated management plan (IMP) to aid in balancing water demands and supplies. However, in areas that have not been declared OA or FA, NRDs may elect to complete a voluntary IMP.

The voluntary IMP planning process provides an opportunity for NRDs and NeDNR to work collaboratively on water management in areas where surface water and groundwater are hydrologically connected. NRDs may also elect to manage their entire NRD through their voluntary IMP. The purpose of a required IMP or voluntary IMP is to sustain a balance between water uses and supplies.

Though not determined to be fully- or over-appropriated, the LPSNRD sought to be proactive and developed a voluntarily IMP. A district-wide voluntary IMP was developed by the LPSNRD and NeDNR and adopted in May 2014. The voluntary IMP uses a groundwater model to identify areas where surface water and groundwater are hydrologically connected. The hydrologically connected area (HCA), or 10/50 line, is defined by the NeDNR as the area where a well, located and pumped within that boundary, would result in a 10% or greater depletion in river flows over a 50-year period. Figure 41 illustrates the estimated limits of the HCA within the LPSNRD.

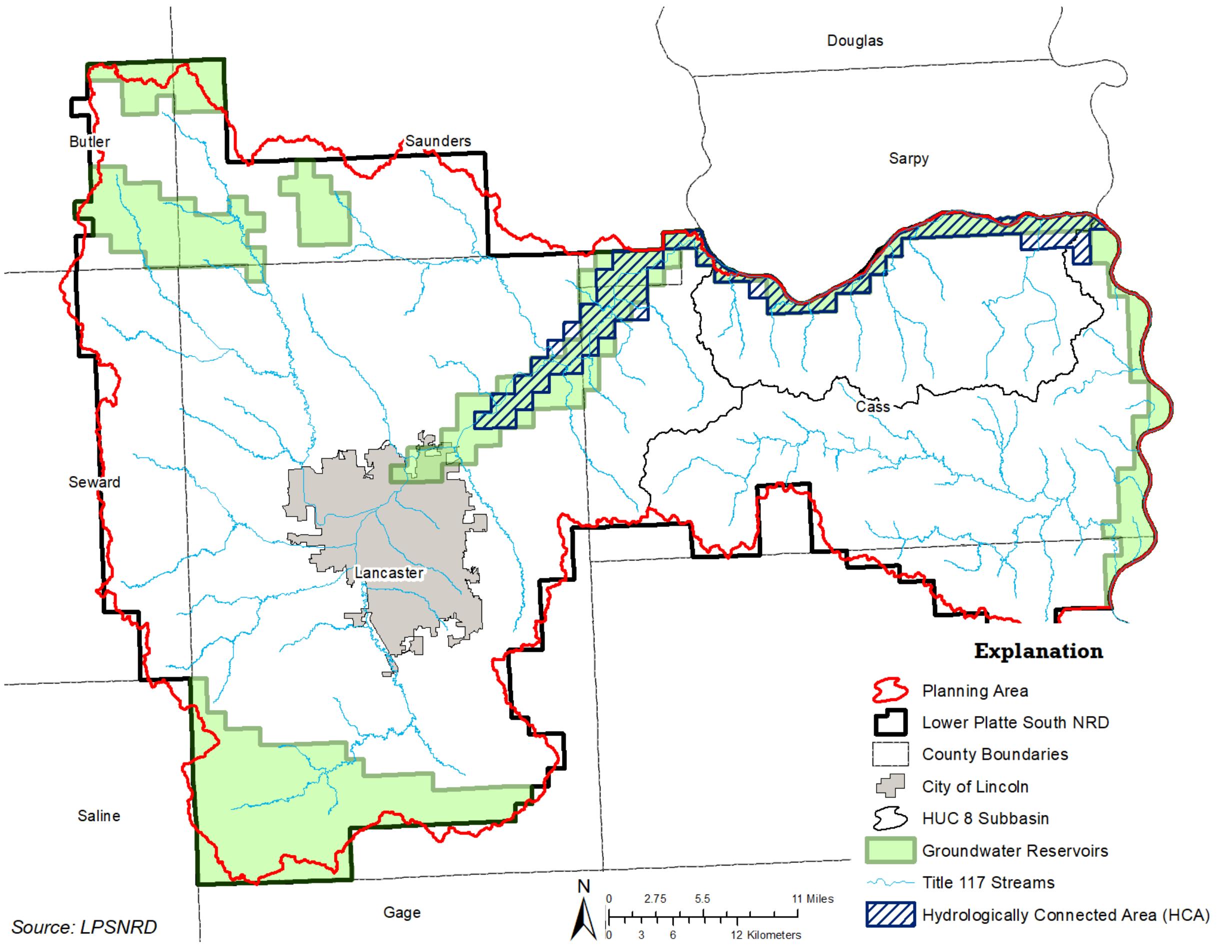


Figure 41: Hydrologically Connected Areas

AGRICULTURAL IRRIGATION

Irrigation is important to agricultural production in the planning area. According to the NeDNR Net Corn Crop Irrigation Requirement Map (prepared by Derrel Martin, University of Nebraska-Lincoln [UNL}), which identifies the net amount of irrigation water that must be applied for a full yield of an irrigated corn crop. Irrigation requirements in the planning area increase from east to west, ranging from approximately 6 to 7 inches per year (Figure 42) (Martin, 2005). Irrigation demand is primarily driven by rainfall.

Within the planning area there is approximately 26,000 acres certified by the LPSNRD for irrigation. The bulk of these are irrigated from groundwater wells. According to the NeDNR registered well database, there are 445 active irrigation wells in the planning area. There is limited surface water irrigation as there are no major irrigation or ditch project/districts located in the planning area. According to NeDNR records, there are 644 active surface water irrigation diversions in the planning area. Refer to Figure 42 for locations of irrigated acres, irrigation wells and surface water diversions.

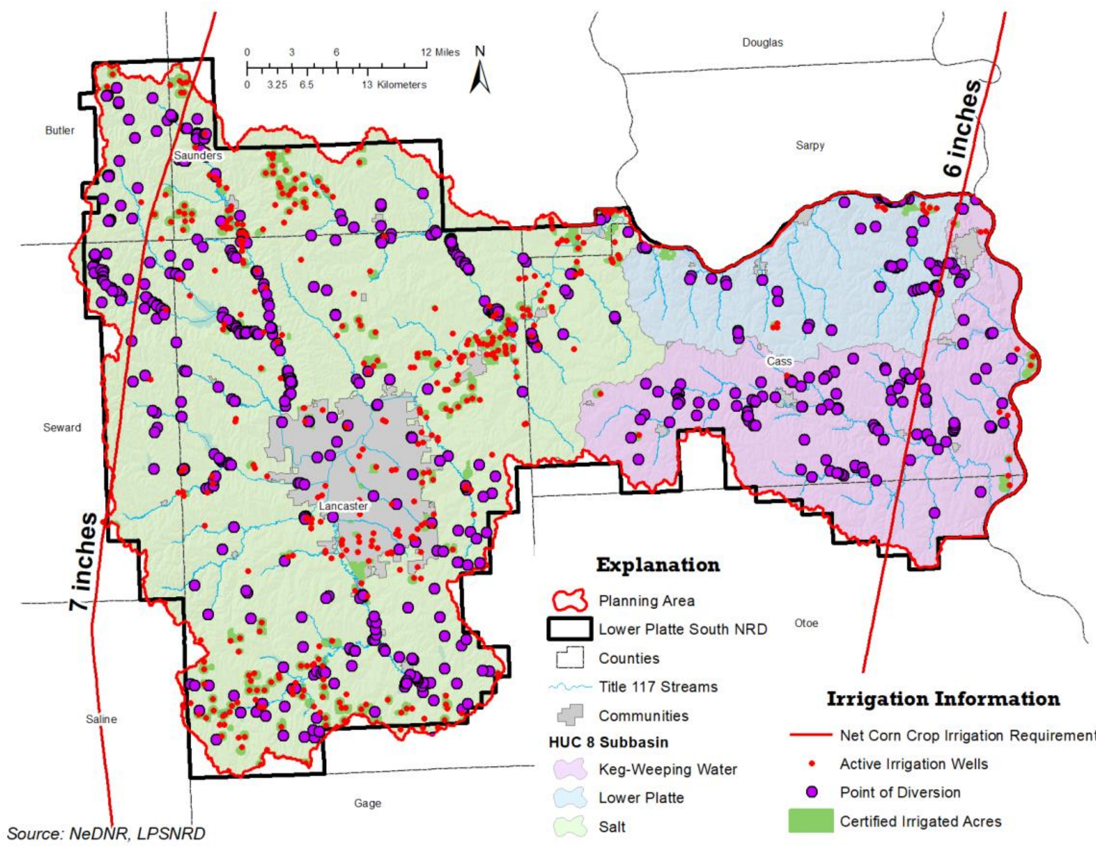


Figure 42. Agricultural Irrigation within the Planning Area

3.07 BIOLOGICAL COMMUNITIES

KEY AQUATIC SPECIES

The presence or absence of sensitive species is one metric that NDEQ uses to assess water quality. According to Title 117, the following key species are located within the planning area. Descriptions are provided by the Nebraska Natural Legacy Project (Schneider and others., 2011) and *The Fishes of Nebraska* (Hrabik and others, 2015).

- **Brook Stickleback** (*Culea inconstans*) is a small freshwater minnow-like fish that reaches 3.5 inches long and is considered "sensitive" in its native watersheds, which includes the LPSNRD watershed. This fish is also listed as Tier II Species at Risk, a species that is at risk in Nebraska, but is doing well in other parts of its native range, by the Nebraska Natural Legacy Project. Primary threats to the species are believed to be from pollution, river siltation, and deforestation. This species occurs in pools and backwaters of cool to cold creeks and small rivers with mild to moderate currents and sand, gravel, or muddy river bottoms.
- **Walleye** (*Sander vitreus)* is a large river species found throughout Nebraska in lakes, pools, backwaters, and medium to large rivers. They are frequently 8 pounds and can reach 3 feet long. The species is one of Nebraska's most sought-after gamefish and is identified as a "recreationally important" species.
- **Channel catfish** (*Ictalurus punctatus*) is the most numerous of catfish species and is found throughout Nebraska. Channel catfish prefer streams and rivers with low to moderate gradients, well defined pools or riffles and holes such as cut banks and deep areas formed by log jams. It is a common gamefish and identified as a "recreationally important" species.

Image courtesy of Nebraska Game and Parks Fish ID

Figure 43: Illustration of a Brook Stickleback

THREATENED AND ENDANGERED SPECIES

Critical habitat has been identified within saline wetlands for two Threatened and Endangered (T&E) species within the planning area by the USFWS and Nebraska Game and Parks Commission (NGPC). The saline wetlands provide habitat for Salt Creek tiger beetle, which is a state and federally listed endangered species, and saltwort, which is a state-listed endangered species. Saline wetlands occur in the floodplains of Salt Creek, Little Salt Creek, and Rock Creek and their surrounding uplands (see Chapter 3.03). There is high interest in avoiding further loss or degradation of the saline wetland resource. If avoidance and minimization of impacts to saline wetlands are not possible and mitigation is necessary, the "Mitigation Guidelines for Nebraska's Eastern Saline Wetlands" (Taylor and Krueger, 1997) would be applicable. Consultation with the USFWS and NGPC will be initiated for specific project sites, where threatened or endangered species' habitats may exist.

The scope of this planning effort did not include identifying any additional specific locations or habitat for T&E species in the planning area. However, the following list identifies those T&E species that do have ranges within the planning area (NGPC, 2017a).

- American Ginseng (*Panax quinquefolium*)
- Lake Sturgeon (*Acipenser fulvescens*)
- Western Prairie Fringed Orchid (*Platanthera praeclara*)
- Piping Plover (*Charadrius melodus*)
- Interior Least Tern (*Sterna antillarum)*
- River Otter (*Lontra canadensis)*
- Salt Creek Tiger Beetle (*Cicindela nevadica lincolniana*)
- Saltwort (*Salicornia rubra)*
- Pallid Sturgeon (*Scaphirhynchus albus*)
- Sturgeon Chub (*Macrhybopsis gelida*)
- Southern Flying Squirrel (*Glaucomys volans*)

AQUATIC INVASIVE SPECIES

Aquatic invasive species are non-native organisms introduced into rivers, streams, lakes, and wetlands. They generally have no predators or other natural controls such as disease or competition, allowing their populations to grow unchecked. Once established, these species may cause irreparable harm by introducing disease, out-competing native species, changing the physical characteristics of waters, damaging equipment, clogging water delivery systems, and negatively impacting local and national economies. While there is not a complete list of locations where invasive species are found, the Nebraska Invasive Species Program maintains information on potential invasive species in Nebraska (UNL, 2018). The following invasive may exist within the planning area:

Aquatic Invasive Animal Species

- Zebra & Quagga Mussel
- Asian Clam
- Bighead Carp
- Chinese Mysterysnail
- Chytrid Fungus
- Heterosporosis
- Largemouth Bass Virus
- New Zealand Mud Snail
- Round Goby
- Rudd
- Rusty Crayfish
- Silver Carp
- Snakehead
- Viral Hemorrhagic Septicemia
- Whirling Disease

Aquatic Invasive Plant Species

- Algae - Didymo
- Brittle Naiad
- Eurasian Watermilfoil
- Giant Reed
- Giant Salvinia
- Hydrilla
- Japanese & Giant Knotweed
- Phragmites - Common Reed
- Purple Loosestrife
- Water Hyacinth
- Japanese, Morrow's & Hybrid Honeysuckle
- Common Watercress
- Narrow-Leaf Cattail
- Creeping Foxtail

Prevention is the strongest defense against invasive species. Posting signs, distributing educational information, or other public education efforts are methods to prevent the introduction or spread of these species into the planning area. However, if these or other invasive species are found to be in the planning area, future education efforts could be designed to target their reduction and/or elimination. The Nebraska Invasive Species Program can provide additional information and guidance: www.neinvasives.com.

BIOLOGICALLY UNIQUE LANDSCAPES

In 2005, the NGPC published the Nebraska Natural Legacy Project as the state's first Wildlife Action Plan, which was subsequently updated in 2011 (Schneider and others, 2011). Landowners, partner organizations, public land managers, and many others have voluntarily used the State Wildlife Action Plan to guide conservation work that benefits wildlife, habitat, and the residents of Nebraska. One of the goals of the Nebraska Natural Legacy Project is to identify a set of priority landscapes that, if properly managed, would conserve the majority of Nebraska's biological diversity. These landscapes, called Biologically Unique Landscapes (BUL), were selected based on known occurrences of at-risk species and natural communities.

While the planning area (Figure 44) does technically touch the Rainwater Basin BUL and Missouri River BUL, they are not part of the plan. Discussion here will be limited to the Lower Platte River BUL, Saline Wetlands BUL (including the Saline Wetland Complex), and nearby demonstration sites.

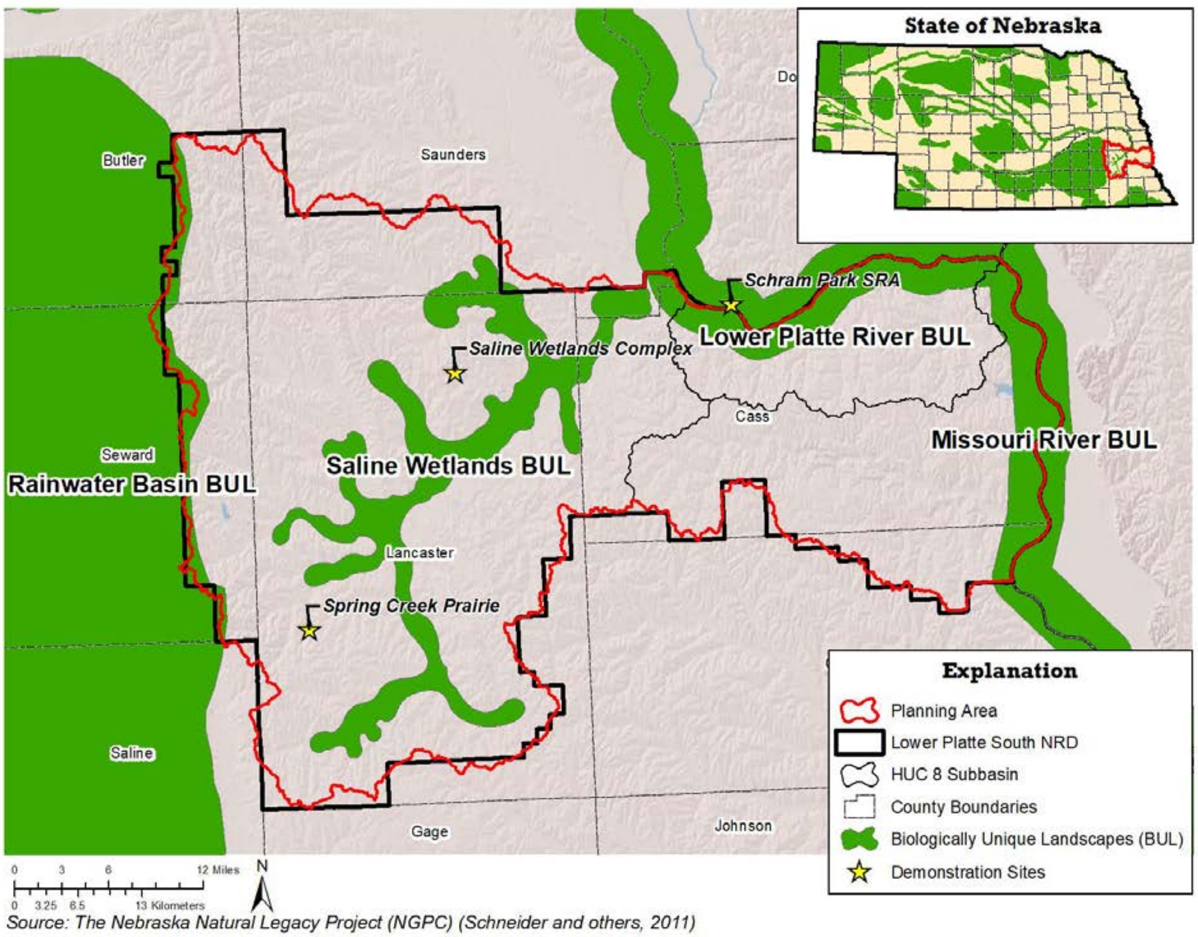


Figure 44: Biologically Unique Landscapes within the Planning Area

The following descriptions were developed based on the State Wildlife Action Plan (Schneider and others, 2011). Additional details on stresses, conservation strategies, and species can be found in the State Wildlife Action Plan.

Lower Platte River

This landscape includes the Platte River and its floodplain. The Lower Platte River is a large, shallow, braided river with many sandbars and wooded islands within the channel. The river supports many large river fish, including the federally-listed lake sturgeon and pallid sturgeon. The sandbars within the river provide nesting habitat for many different bird species, including the federally-listed piping plover and interior least tern. Construction of dikes and levees has constricted the natural channel and has resulted in high flow events, washing away plover and tern nests. The banks of the Lower Platte River are dominated by cottonwood and eastern red cedar. Sandpits and cabins are commonly found along the river. Much of the river's floodplain is now cropped with scattered wet meadows and marshes present.

1) SCHRAMM PARK STATE RECREATION AREA – NATURAL LEGACY DEMONSTRATION SITE

Natural Legacy Demonstration Site 16 Schramm Park State Recreation Area: Nebraska Game and Parks Commission Schramm Park State Recreational Area is a relatively small but surprisingly biologically-rich area on the Lower Platte River. Uplands are covered with oak forest with small patches of prairie. The floodplain has a large area of mature riparian forest. Natural communities at the area include dry-mesic bur oak forest, woodland, and upland tall-grass prairie. One of the main needs at this park is cedar tree removal and invasive species management. Limited resources have restricted habitat management.

Saline Wetlands

The Saline Wetlands BUL is the only saline wetlands located in Nebraska and occurs in floodplain swales and depressions along Salt Creek, Little Salt Creek, and Rock Creek and surrounding areas. The salinity originates from salt-rich artesian groundwater inflows that are derived from underground rock formations. The wetlands have saline soils that provide habitat for salt-tolerant species such as saltgrass, sea-blite, saltwort, and the federally-listed Salt Creek tiger beetle. Over 90% of the original saline wetlands within this landscape have been lost or highly degraded. The Saline Wetland Complex includes Jack Sinn Wildlife Management Area (WMA) (NGPC), Arbor Lake (City of Lincoln), Whitehead Saline Wetlands (Lower Platte South NRD), and Frank Shoemaker Marsh (City of Lincoln). Eastern saline wetlands are considered critically imperiled. These locations have restored wetlands and habitat for listed species. Natural communities at this location include Eastern saline meadow and Eastern saline marsh. The Saline Wetland Conservation Partnership has been fundamental in facilitating collaboration between local entities to restore the few remaining saline wetlands.

2) SALINE WETLAND COMPLEX - NATURAL LEGACY DEMONSTRATION SITE 15

The Saline Wetland Complex includes Jack Sinn WMA (NGPC), Arbor Lake (City of Lincoln), Whitehead Saline Wetlands (Lower Platte South NRD), and Frank Shoemaker Marsh (City of Lincoln). Eastern saline wetlands are considered critically imperiled. These locations have restored wetlands and habitat for listed species. Natural communities at this location include Eastern saline meadow and Eastern saline marsh. The Saline Wetland Conservation Partnership has been fundamental in facilitating collaboration between local entities to restore the few remaining saline wetlands.

Other Demonstration Sites

The Spring Creek Prairie site is not within a BUL and the description is included here.

3) SPRING CREEK PRAIRIE - NATURAL LEGACY DEMONSTRATION SITE 17

Spring Creek Prairie is owned by the National Audubon Society and is one of the few large tracts of tallgrass prairie (800 acres) located within easy driving distance from Lincoln. It is managed using prescribed burning and grazing and provides education to the public via an education center.

CHAPTER 4. MONITORING

4.01 INTRODUCTION

Monitoring and assessment are vital components of water resource management. The collection and assessment of data is necessary to evaluate overall resource health, direct management activities, and evaluate the effectiveness of practices, projects, and programs targeted at improving or protecting water quality. Monitoring goals established by the LPSNRD are generally achieved through coordinated monitoring, partnerships, and by using other available data that meets the desired quality. Steps are taken to ensure collected data is scientifically valid, which may include the development of Quality Assurance Project Plans (QAPP) for state and federal review.

The intent of this chapter is to summarize ongoing monitoring efforts in the planning area, present current data gaps, and provide recommendations for expanded monitoring. Detailed descriptions of monitoring and assessment components for priority areas are provided in respective chapters. It should be noted that all impoundment types (i.e. reservoirs, sandpits, oxbows) will be referred to as “lakes”. Monitoring recommendations in this chapter pertaining to lakes may not be applicable to all lake types and should be evaluated for applicability on a case-by-case basis.

4.02 PURPOSE OF MONITORING

To adequately design monitoring networks that facilitate water resources management, it is critical to collect and use data for its intended purposes. Data collected from physical, chemical, and biological monitoring networks in the planning area are generally used for one or a combination of purposes listed below:

- Evaluate current water quality conditions.
- Provide water quality information to water users.
- Maintain long-term data sets for trend assessments.
- Support water project or activity development.
- Identify causes and sources of water quality problems.
- Estimate pollutant transport and quantify loadings.
- Evaluate water management effectiveness.
- Support future modeling and assessment.
- Monitor status of compliance with state and federal standards.
- Evaluate water infrastructure for maintenance and repair.

4.03 DATA NEEDS AND USES

Several local, state, and federal agencies are currently conducting monitoring in the planning area. Current monitoring targets a broad range of data needs to support non-targeted implementation across the planning area as well as targeted implementation on specific waterbodies. In some cases, current networks do not provide adequate information to fully evaluate individual nonpoint sources. Recommendations for expanded monitoring and assessment efforts were developed from a review of current monitoring networks and critical data needs, which are presented later in this chapter.

4.04 CURRENT MONITORING NETWORKS

An extensive amount of physical, chemical, and biological information has been collected at numerous sites across the planning area. While data have been collected by multiple entities, as shown in Table 25, NDEQ either collected or coordinated the collection of most data used for the development of this plan. The LPSNRD also conducts monitoring to support their groundwater programs in addition to actively assisting NDEQ with surface water quality monitoring at selected sites across the planning area. A brief description of significant monitoring programs/networks is provided below. Additional details on these programs can also be found in the 2017 Nebraska Water Monitoring Programs Report (NDEQ, 2018c).

Table 25: Current Monitoring Programs and Activities in the Planning Area

Monitoring Networks	LPSNRD	NDEQ	NeDNR	NGPC	USGS	USACE	Municipal /Facility	Private Owner
Surface water								
Stream Flow			X		X			
Ambient Stream		X			X	X		
Basin Rotation		X						
Beach		X						
Lake		X				X		
Stream Biological		X		X				
Fish Tissue		X						
Fisheries				X				
NPDES permit		X					X	
Groundwater								
Ambient quality	X	X			X		X	
Levels	X				X		X	
Nitrate monitoring	X				X		X	X

SURFACE WATER

Stream Flow Gaging

The Nebraska Department of Natural Resources (NeDNR) and United States Geological Survey (USGS) monitor the water flowing in Nebraska's streams, rivers, and canals. There are 19 USGS gaging sites located within the within the planning area (Figure 45), which does not include those found on the Platte or Missouri Rivers. There are no NeDNR sites within the planning area. LPSNRD provides partial funding for some of these sites. Additional data for each site can be found on the NeDNR website : https://nednr.nebraska.gov/RealTime/ or via the USGS website: https://maps.waterdata.usgs.gov/mapper/.

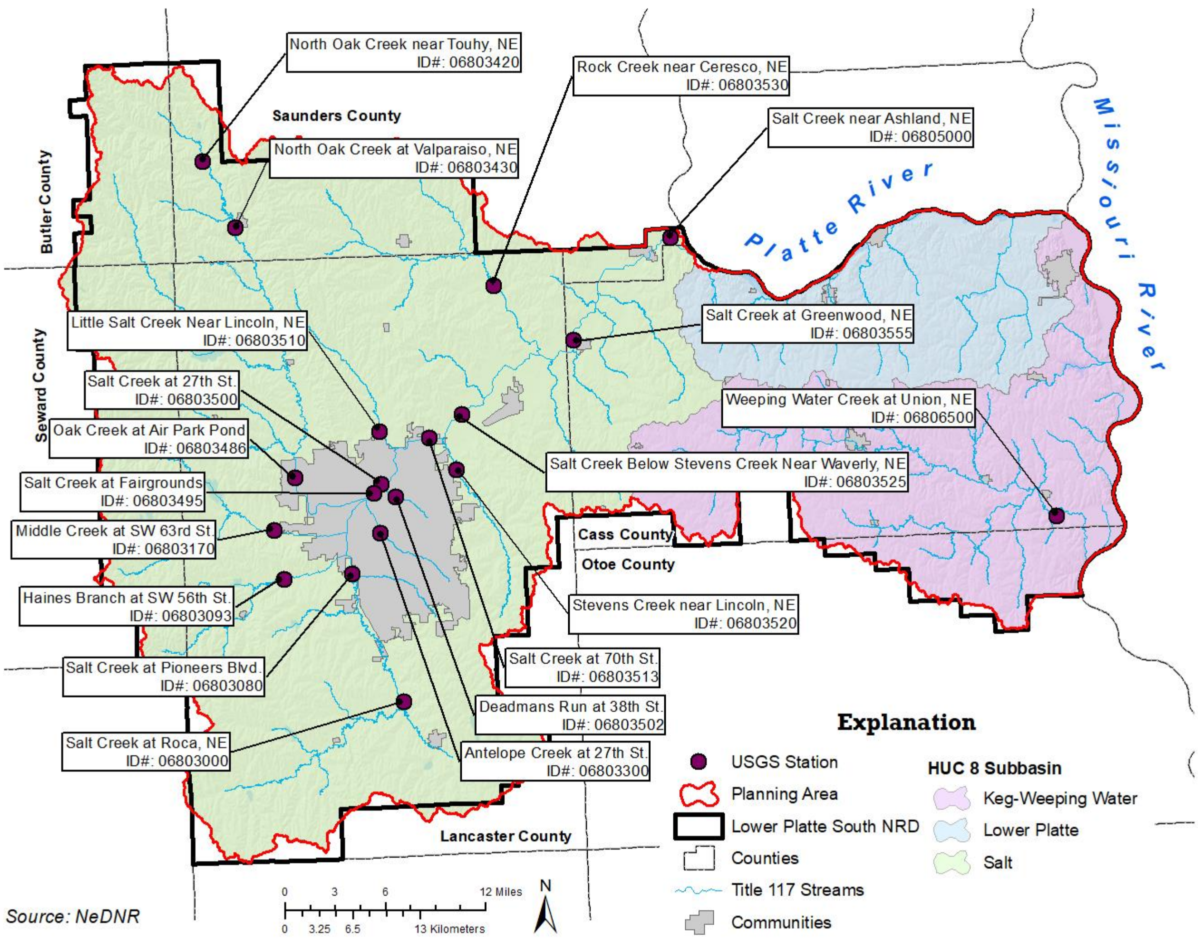


Figure 45: Stream Gaging Site Locations in the Planning Area

Ambient Stream Monitoring

The NDEQ maintains an “Ambient” monitoring network across the state for streams and rivers. There are five sites in the planning area (Figure 46). Ambient monitoring consists of fixed sites that are sampled continuously throughout the year. In addition to being able to assess current conditions, consistent monitoring at the same location allows for the establishment of long term data sets for trend assessments. Sites are monitored monthly for the following parameters: water temperature; dissolved oxygen; pH; conductivity; total suspended solids; ammonia; total nitrogen; total phosphorus; total chlorides; pesticides (April through September only); and metals (quarterly). Data collected is available to resource managers and the public through the national Water Quality Portal (WQP), which is accessed at: https://www.waterqualitydata.us/

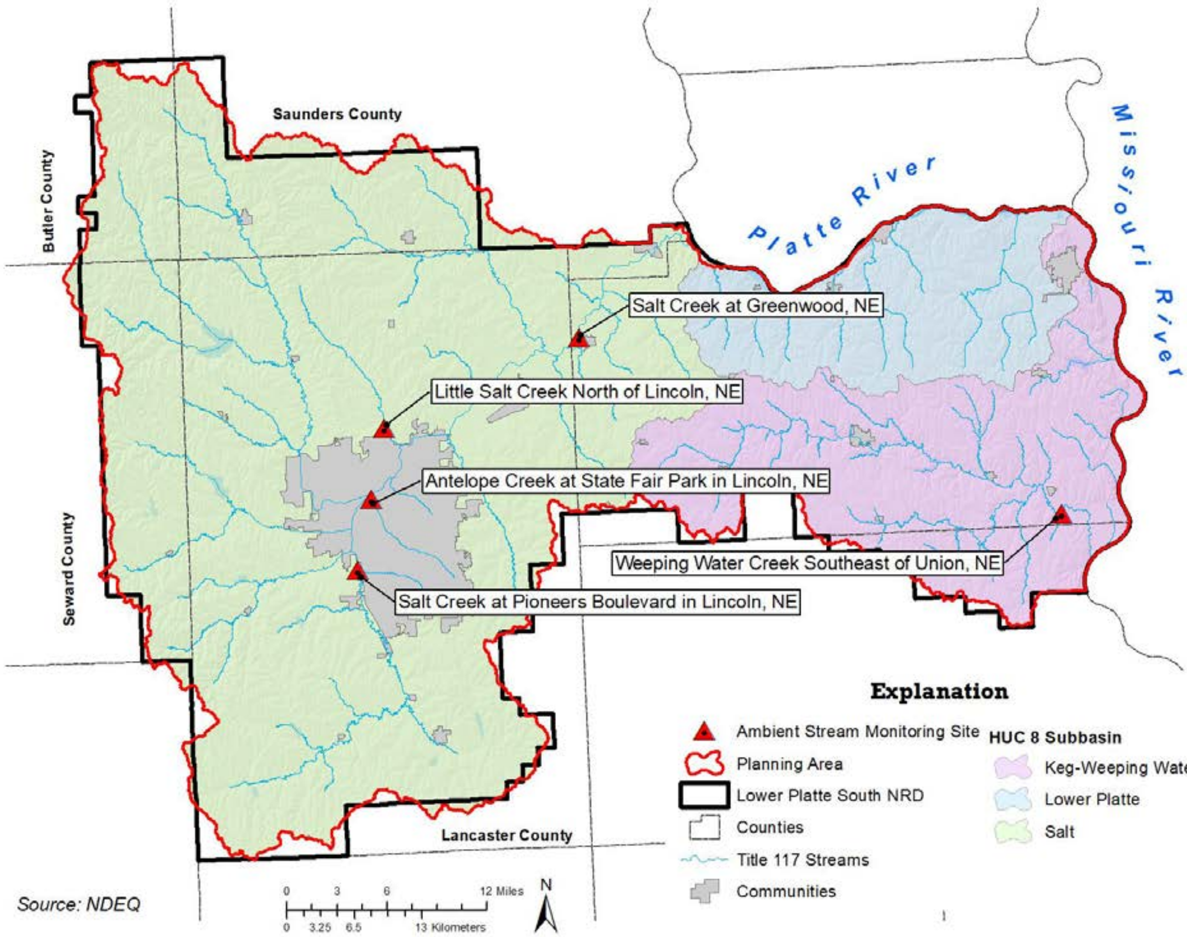


Figure 46: Ambient Stream Monitoring Site Locations in the Planning Area

Basin Rotation Monitoring

Each year the NDEQ selects "Basin Rotation" monitoring sites on flowing and impounded waters which are focused in specific basins across the state (Figure 47). Each basin in the state is targeted for sampling every six years. The Lower Platte River Basin was last monitored in 2015, setting the next rotation for 2021. A total of 34 basin rotation sites were identified in the planning area (Figure 47). From the months of May through September, streams and rivers are sampled weekly while lakes are sampled monthly. Data collected is available to resource managers and the public through the WQP. Information from past basin rotation monitoring can be used as a pre-project benchmark for water quality improvement tracking in the planning area.

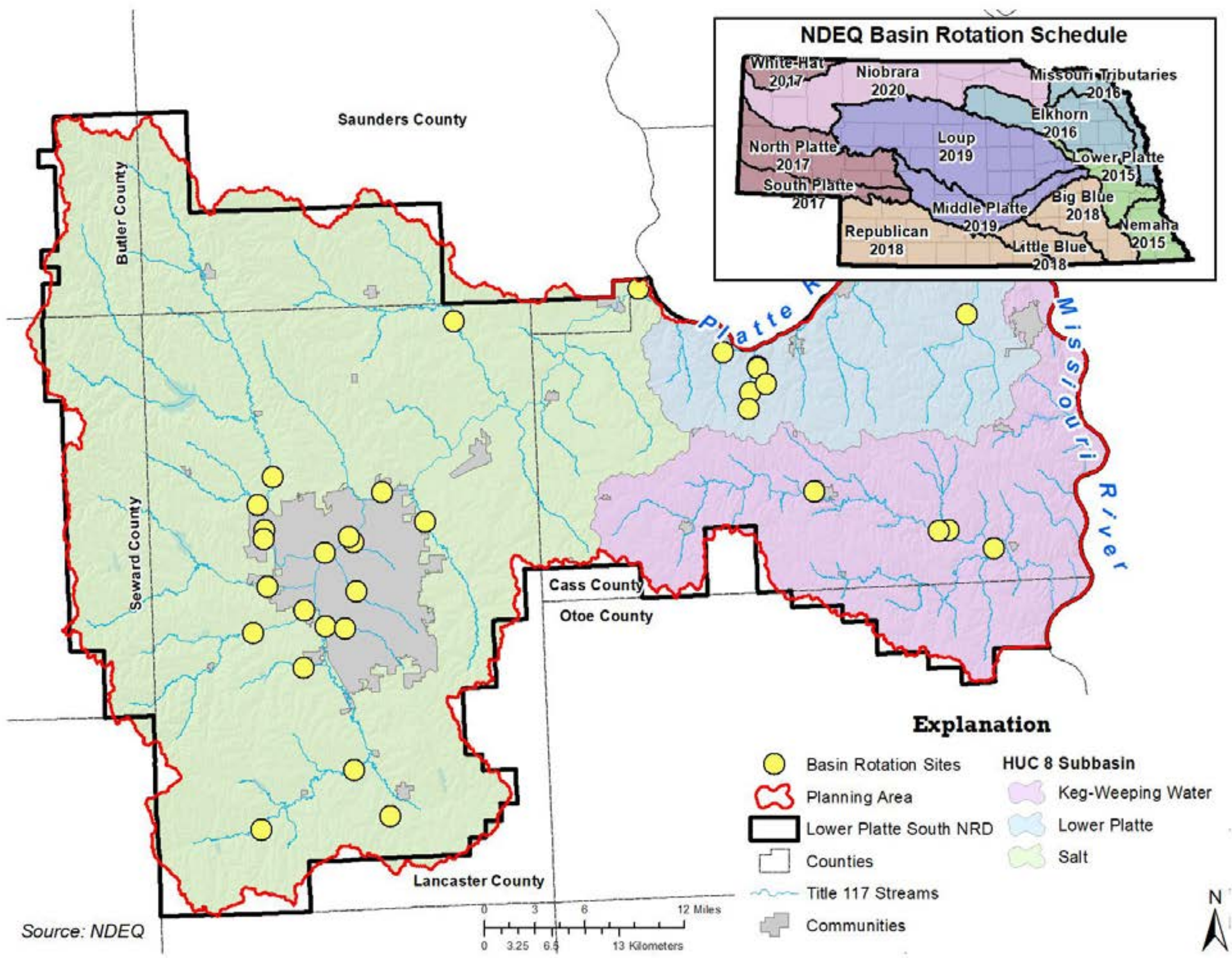


Figure 47: NDEQ Basin Rotation Sites in the Planning Area and 6-year Monitoring Schedule

Lake Monitoring

NDEQ conducts monitoring statewide on all types of man-made and natural lakes. Physical, chemical, and biological data are gathered from May through September. These data are used to document existing water quality conditions, evaluate long-term trends, design watershed and lake restoration/protection projects, and evaluate project effectiveness. A total of 97 lake monitoring sites were identified in the planning area (Figure 48). It should be noted that some of those sites are at the same lake but cover a different location in the waterbody (beach, deep water, etc.). Monitoring focuses on nutrients, sediment, pesticides, heavy metals, dissolved oxygen, pH, temperature, conductivity, and water clarity. In addition to NDEQ monitoring, the USACE has its own annual monitoring program for the following reservoirs in the planning area: Bluestem, Branched Oak, Conestoga, Holmes, Olive Creek, Pawnee, Stagecoach, Twin, Wagon Train, and Yankee Hill. Many of these sites overlap with the NDEQ data.

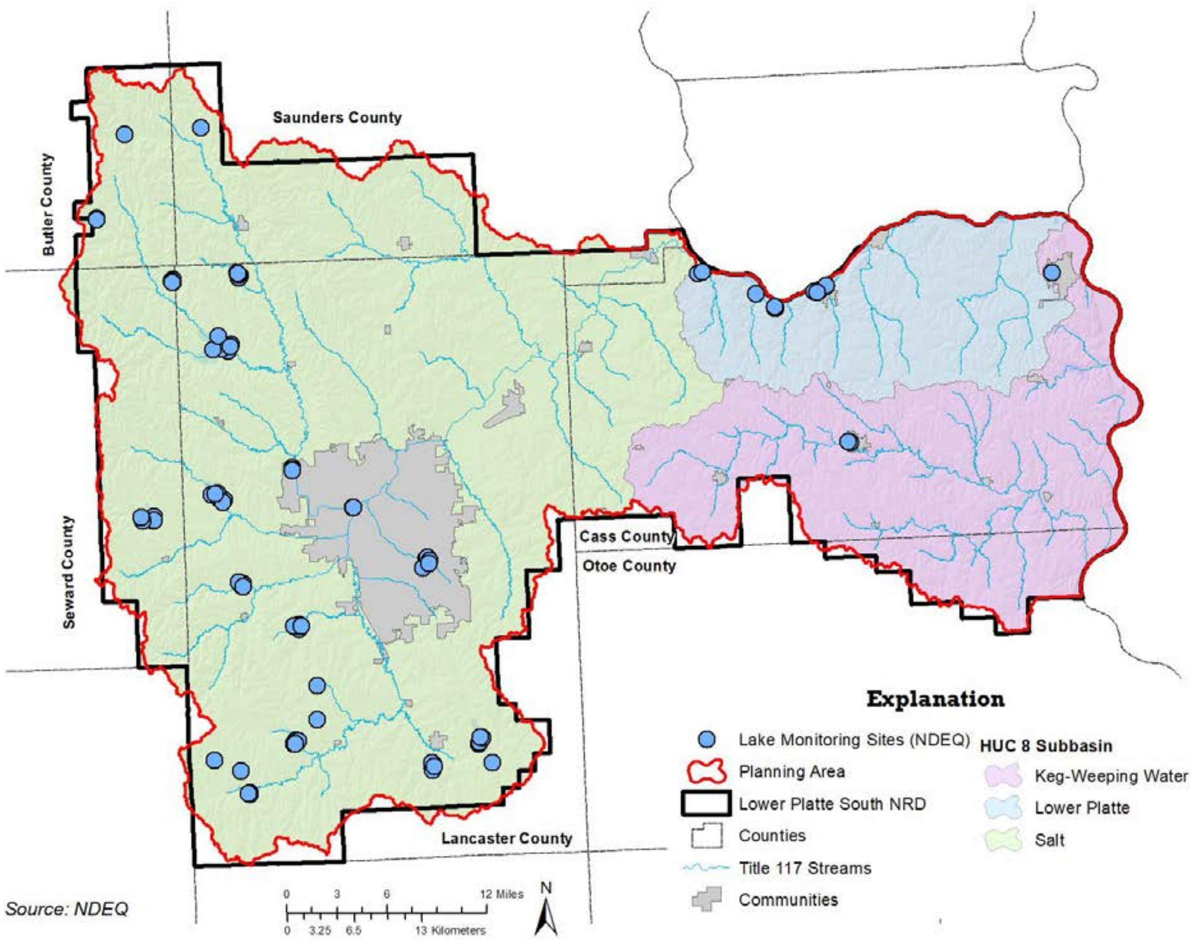


Figure 48: Lake Monitoring Site Locations in the Planning Area

Beach Monitoring

Swimming beaches are monitored annually to determine the suitability for body contact recreation. Beach monitoring for *E. coli* bacteria and the microcystin toxin produced by blue green algae is conducted during the recreation season (May 1 – September 30). Monitoring results are posted on the NDEQ website on a weekly basis (www.deq.state.ne.us). The following beaches/lakes in the planning area are currently monitored:

- Bluestem Lake
- Branched Oak Lake – Area 10 Beach
- Broached Oak Lake – Liebers Point Beach
- Holmes Lake
- Louisville Lake No. 2 (SRA)
- Pawnee Lake – East Beach
- Pawnee Lake – West Beach
- Wagon Train Lake

Fish Tissue Monitoring

Since the 1970s, NDEQ has monitored fish from flowing and impounded waters to determine the suitability for human consumption. Efforts are made to collect tissue samples from "sport" fish species (catfish, bass, etc.) in waterbodies that are commonly fished. When concentrations of contaminants indicate a health risk for consumers, fish consumption advisories are issued by the Nebraska Department of Health and Human Services (DHHS) for those waterbodies. Sampling under this program is in coordination with the NDEQ basin rotation monitoring approach, therefore the most recent sampling in the watershed was conducted in 2015. Table 26 summarizes the findings from the most recent fish tissue report for waterbodies in the watershed (NDEQ, 2017c).

Table 26: Fish Tissue Sampling Summary

Waterbody Name	Waterbody ID	Health Risk Criteria Violated
Hedgefield Lake - WMA	LP2-L0020	Mercury
Cottontail Lake	LP2-L0070	Mercury
Yankee Hill Lake	LP2-L0090	Mercury
Bowling Lake	LP2-L0100	Mercury
Olive Creek Lake	LP2-L0140	Mercury
Pawnee Lake	LP2-L0160	Mercury
Merganser Lake	LP2-L0170	Mercury
Red Cedar Lake	LP2-L0190	Mercury
Wild Plum Lake	LP2-L0200	Mercury
Meadowlark Lake	LP2-L0220	Mercury
Timber Point Lake	LP2-L0250	Mercury
Redtail Lake	LP2-L0280	Mercury
Oak Creek	LP2-20500	Hazard Index due to Mercury

Source: (NDEQ, 2017c)

Stream Biological Monitoring

The planning area's streams and rivers contain a rich diversity of aquatic life including aquatic insects, fish, amphibians, and mammals. Since aquatic communities are in constant contact with the water, the health of these communities can provide insight on stressors that may not show up through traditional chemical and physical parameter monitoring. NDEQ's Stream Biological Monitoring Program uses fish and aquatic insect communities to provide statewide assessments of the biological conditions of Nebraska's streams. Each year 34 to 40 randomly selected wadable stream sites (i.e. streams that are shallow enough to sample without boats) are chosen for study in two or three river basins throughout Nebraska (Bazata, 2011).

The NDEQ has evaluated biological communities at 12 locations on 10 streams in the Lower Platte and Salt Creek Watersheds (Table 27). Three different metrics pertaining to habitat, insect communities, and fish communities are used to determine impairment. Five of the sites monitored were determined to be impaired. Sites that were monitored prior to 2008 were summarized in a report prepared by NDEQ (Bazata, 2011), which provided more detail on the specific cause of impairment.

Table 27: Summary of Biological Community Sampling in the Planning Area

Subbasin	Segment ID	Stream Name	Habitat Metric	Insect Metric	Fish Metric	Overall Rating	Aquatic Life Support
Lower Platte	LP1-10110	Eight Mile Crk.	Excellent	Fair	Good	Fair	Full
Salt Creek	LP2-10800	Dee Crk.	Good	Good	Good	Good	Full
Salt Creek	LP2-11010	N. F. Rock Crk.	Poor	Excellent	Good	Good	Full
Salt Creek	LP2-11100	Rock Crk.	Fair	Good	Good	Fair	Full
Salt Creek	LP2-20000	Salt Creek Crk.	Poor	Poor	Good	Poor	Impaired
Salt Creek	LP2-20300	Little Salt Crk.	Unknown	Unknown	Unknown	Unknown	Impaired
Salt Creek	LP2-20600	Oak Crk.	Unknown	Unknown	Unknown	Unknown	Impaired
Salt Creek	LP2-20612	Bates Crk.	Good	Fair	Fair	Fair	Full
Salt Creek	LP2-21000	Middle Crk.	Good	Poor	Fair	Poor	Full
Salt Creek	LP2-20710	Middle Crk.	Fair	Good	Good	Good	Full
Salt Creek	LP2-30000	Salt Crk.	Unknown	Unknown	Unknown	Unknown	Impaired
Salt Creek	LP2-40300	Olive Crk.	Good	Good	Poor	Poor	Impaired

Source: Bazata, 2011

Fisheries Sampling

An unbalanced fish population can be indicative of water quality or habitat issues. The NGPC samples game fish across Nebraska in many of the most popular streams, lakes, and reservoirs. Monitoring is typically conducted to document species composition and abundance. Fish populations are sampled at most major reservoirs every year, while smaller waters are sampled less often. Sampling results are shared with the public through fish sampling reports and an annual fishing forecast. These reports allow anglers and managers to review trends in the fish populations over time. These results are one additional piece of data that can be used in conjunction with other water quality or biological monitoring data to assist in assessing the health of the whole ecosystem. Recent reports can be found on NGPC's website: http://outdoornebraska.gov/fishingguidesandreports/

GROUNDWATER

Groundwater typically migrates slowly (a few inches to a few feet per day), which creates a slower changing chemical environment when compared to surface water resources. Therefore, monitoring programs are typically designed to assess long term trends. Groundwater monitoring in the planning area is primarily focused on groundwater levels and on nitrate-nitrogen; however, pesticides are also included. A majority of groundwater sampling is conducted on existing wells (domestic or irrigation); however, the LPSNRD and USGS continue to install wells dedicated specifically for monitoring. Groundwater monitoring results are reported to the Quality-Assessed Agrichemical Contaminant Database for Nebraska Groundwater (Clearinghouse) The Clearinghouse brings together groundwater data from many different sources, from 1974 to the present, and provides public access to this data. The Clearinghouse can be accessed via: https://clearinghouse.nebraska.gov/Clearinghouse.aspx.

Locations of current monitoring wells utilized by the LPSNRD are shown in Figure 49. LPSNRD conducts annual groundwater sampling work. In 2017, LPSNRD collected 242 samples and 68 quality control samples from 229 different wells. Additional details on LPSNRD's groundwater sampling program can be found in the *2017 Groundwater Management Plan* report (Ehrman and others, 2017).

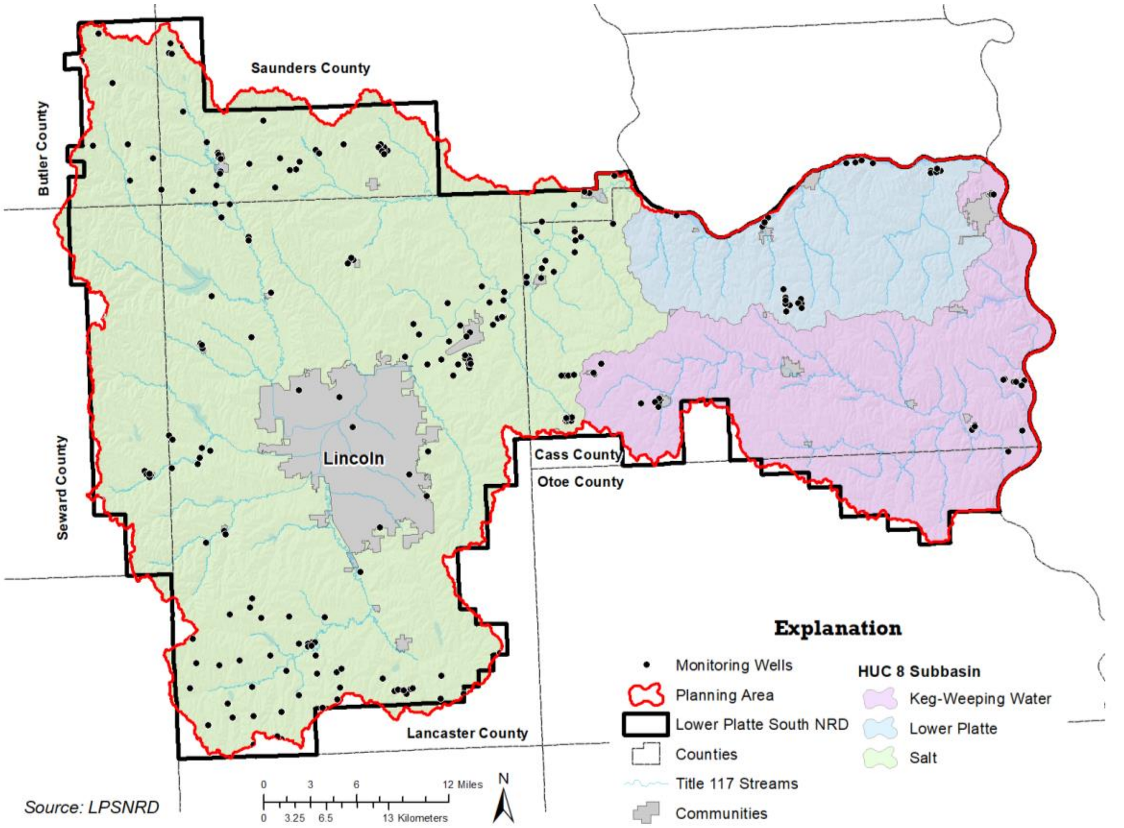


Figure 49: Groundwater Monitoring Site Locations in the Planning Area

4.05 OTHER STUDIES AND EFFORTS

NGPC Louisville SRA and Platte River State Park

Potential impacts of eutrophication (i.e. harmful algal blooms, fish kills, poor water clarity) led the NGPC to study nutrient levels at four lakes within Louisville State Recreation Area (SRA) and Jenny Newman Pond within Platte River State Park (Blank and Jackson, 2017). The objectives of the study are to provide baseline nutrient data (phosphorus, nitrogen and chlorophyll *a*) and make future recommendations in dealing with the impacts of eutrophication.

Nutrient samples were collected bi-weekly from late May to early November in 2013, 2014 and 2015 at Louisville lakes 1, 1a, 2, and 3 as well as Jenny Newman Pond. Nutrients sampled included total phosphorous, total nitrogen and chlorophyll *a*. Additionally, a suite of in-field parameters (dissolved oxygen profiles, secchi disk, and turbidity) were collected.

The following summary was provided in the report:

> *Nutrient concentrations at all study lakes were above impaired standards, but so were many lakes throughout the state. As budget issues have arose in the past few years, prioritization of lake rehabilitations is increasingly important. There were*

no lakes in this study that warrant any sort of rehabilitation in the near future; however, there are issues happening at each lake that should not be looked over. Spot treatments of macrophyte growth at these small, but very popular lakes, can make a big difference in angler and park user attitudes and should continue. It is also imperative to test the inflow pipe and septic fields at Jenny Newman as this may be a major source of nutrient inputs. The aluminum sulfate treatment in 2012 should have been more successful in phosphorous reduction as the lake is almost back to pre-treatment levels. If the water from the pipe or septic fields is in fact a source, NGPC personnel will have to figure out a way to fix the problem.

City of Lincoln Antelope Creek Sampling

Following completion of the Antelope Creek Watershed Basin Management Plan (EA, 2012), the City of Lincoln initiated a 5-year sampling program to further understand fecal bacteria (*E. coli*) contamination to Antelope Creek and monitor water quality during dry and wet weather. The Final Report (Darshan and others, 2017) was published during the completion of this plan, allowing for the inclusion of its findings. The following summary is provided in the report:

This study was carried out over a 5-year period (2013-2017), with the first 4 years (2013-2016) focusing on sampling and analysis and the fifth year (2017) focusing on data analysis and report preparation. Grab samples of water (during dry and wet weather condition) and stream bed sediment from four sites in Antelope Creek were collected over multiple events in the summers of 2013, 2014, and 2015. Additional samples of potential sources of fecal contamination such as embankment soil, erodible soil from around the watershed, street sweepings, feces of animals and birds, water from Holmes Lake were also collected. DNA was also extracted from the samples.

DNA analysis was carried out based on overall microbial community to estimate the proportional contribution of fecal contamination from potential sources to Antelope Creek water as well as selected environmental compartments (embankment soil, erodible soil, street sweepings, Holmes Lake water, and stream bed sediment). The major findings are as follows:

- *E. coli levels in wet weather water collected from Antelope Creek were considerably higher than in dry weather water suggesting that the contamination is from non-point sources which is being flushed into the creek by stormwater.*
- *In dry weather water collected from Antelope Creek, water from Holmes Lake was predicted to be the largest contributor of fecal contamination based on.*
- *In wet weather water collected from Antelope Creek, stormwater runoff collected from storm drain outfalls was predicted to be the largest contributor of fecal contamination.*

- *In stormwater runoff collected from storm drain outfalls, street sweeping (representing contaminants that are washed off from impervious surfaces) was predicted to be the largest known contributor of fecal contamination.*
- *Results suggest that efforts should be made to reduce to remove direct connection between impervious surfaces and Antelope Creek in order to manage the problem of elevated E. coli concentration.*

Beaver Lake Cyanotoxin Monitoring

Beaver Lake is a private lake community that uses surface water for its water supply. Utilizing surface water for drinking water poses a unique human health threat due to the possibly of blue-green algae blooms and associated elevated levels of microcystin toxins. Beginning in 2018, the Nebraska Department of Health and Human Services (DHHS) began working with NDEQ, and several public water systems (including Beaver Lake) to monitoring for harmful algae blooms (HAB). The goal of the HAB public water system project is to collect preliminary data about the presence of microcystin at several public water systems. Raw and finished water samples are collected at least monthly from May or June through September. Raw water samples are analyzed for microcystin; finished water samples are only analyzed if microcystin is present in raw water. Sampling results were not available to be included in this plan (DHHS, personal communication, May 7, 2018).

4.06 DATA GAPS AND EXPANDED MONITORING

INTRODUCTION

Currently, “routine” and “ambient” monitoring networks are in place to evaluate existing water quality conditions, based on the available resources (time, money, etc.). Expanded monitoring efforts may be needed to better understand conditions at the subwatershed or resource level, to better direct management activities, and to evaluate the effectiveness of practices, projects, and programs targeted at improving or protecting water quality. This portion of the chapter describes additional monitoring identified to fill data gaps in water quality and resource conditions. Monitoring activities funded through Section 319 funds are required to be conducted under an approved Quality Assurance Project Plan (QAPP).

New monitoring approaches or data collection efforts can be considered to enhance spatial data coverage, the amount of data available, and/or to address specific data gaps. Generally, this would include adding new monitoring sites, increasing data collection frequency, or using new technology and approaches. Additionally, it may be appropriate to conduct site or field scale monitoring to determine best management practice (BMP) effectiveness. When designing additional monitoring programs or sites, the following should be considered:

- The purpose and goals of any monitoring program should be well defined, as to what you are trying to monitor, and the program built around that.

- Monitoring programs should be holistic. Consideration should be given to water quality, habitat quality, biotic integrity, water quantity, and land use.
- It is critically important to prepare a monitoring project that clearly defines how the monitoring project will be evaluated. The plan should include:
    - Clearly and narrowly defined monitoring objectives;
    - A project description which identifies the monitoring network design and rationale, the parameters to be monitored, and their frequency and method of collection;
    - Fiscal information;
    - A schedule of tasks and products;
    - Personnel responsibilities;
    - Data management provisions;
    - Reporting requirements; and
    - Appropriate quality assurance/quality control provisions.
- Monitoring should allow for water quality assessment by hydrologic units. A "paired watershed" or "upstream-downstream" monitoring design should be used whenever possible. This includes monitoring both upstream and downstream of a project site to evaluate the effectiveness of a practice or determine the contribution of a pollutant from a site. This paired approach allows a site or stream segment to be isolated. This is similar to tributary monitoring discussed below.
- Variability attributed to flow and seasonality are often ignored in monitoring water quality. These sources of variability are important in assessing water quality and must be accounted for to the degree possible. In general, as stream flow decreases, influences from baseflow and/or point source discharges become more significant. One should also use caution in evaluating improvements solely from data collected under extremely high flows.

RECOMMENDATIONS

The following monitoring recommendations have been developed to enhance nonpoint source assessments and implementation across the planning area. Some of these approaches were incorporated into monitoring recommendations for priority areas, which can be found in their respective chapters.

Tributary Monitoring

Pollutant load estimates for priority waterbodies are largely based on samples collected near the bottom of the drainages. While this information provides a sound basis for estimating overall pollutant loads it provides minimal insight on potential contributions from individual sources. Strategically locating monitoring sites in upstream tributaries will allow for pollutant source bracketing, resulting in a better estimate of source contributions and a more effective implementation strategy. Sampling points located below a single source (e.g., urbanized land, cultivated fields, animal feeding areas, pasture) provides information on pollutant yield source which is an important factor in pollutant load modeling.

Lake Shoreline Erosion

Shoreline erosion has been identified as one of the primary sources of sediment to Pawnee and East Twin lakes, however, additional information is needed to verify shoreline erosion estimates, map bank migration, and establish shoreline erosion patterns. Direct measurement of the distance between the shoreline and static points on the ground, and comparison of successive measurements over time can provide an exact understanding of the extent and location of erosion. When direct field measurements can be impractical and expensive, a digital analysis of high resolution aerial photography taken over defined temporal periods can be used as a practical alternative to direct measurements in estimating actual and projected recession of the shoreline.

Lake Sediment Resuspension and Phosphorus Release

Sediment plays an important role in the overall nutrient dynamics of shallow lakes (Søndergaard and others, 2003). Lakes in the planning area are generally shallow, wind-mixed lakes that can experience turnover multiple times per year. Lake beds can serve both as a sink or source of phosphorus to the lakes water column. Phosphorus bound in lake bottom sediments may eventually be released to the lake water. The amount of phosphorus released from sediment can increase when the lower portions of the lake's water column becomes anoxic, or void of dissolved oxygen.

The resuspension of lake bottom sediment can also introduce phosphorus into the water column. Sediment resuspension increases lake water turbidity and nutrient availability resulting in impacts to primary producers, benthic and zooplankton communities, aquatic vegetation, fish predation, and recreation use of the lake. Studies have shown that elevated sediment resuspension simultaneously decreases the Nitrogen:Phosphorus ratio in the water column and decreases light penetration into the water, which favors blue green algae (Horppila and Nurmenen, 2001; Niemisto, 2008). These studies also revealed that sediment resuspension can be the primary cause of late summer algae blooms.

An understanding of the quantity and quality of sediment deposited in a lake is necessary for effective water quality management. It is recommended that lakes targeted for nutrient TMDL development or projects that have nutrient reduction goals undergo specialized monitoring to evaluate sediment quality and quantify phosphorus loading stemming from internal processes. Pawnee Lake would be a candidate for this work given the current public use, water quality concerns, and most current assessment results. The development of sampling and monitoring approach should be specific for the lake being studied and should be done as a collaborative effort between resource managers and researchers; however, it should at a minimum include an evaluation of sediment quality, sediment phosphorus release rates, and quantification of impacts from resuspension.

Real-Time Bacteria Monitoring

Continuous in-stream water quality monitors can be installed at selected stream gaging stations to provide continuous real-time measurements of specific conductance, pH, water temperature, dissolved oxygen, turbidity, and total chlorophyll. In addition, periodic water samples can be collected manually and analyzed for pollutants such as bacteria and phosphorus. Real-time and manual measurement data can then be used to develop regression equations to predict bacteria levels in streams. Over time, these equations can allow for continuous real-time predictions of pollutant concentrations for pollutants such as bacteria and phosphorus. This information enhances the overall understanding of system function and facilitates more accurate pollutant loading estimates. Continuous, real-time data can also be used to evaluate or predict the recreational suitability of a waterbody, develop and monitor TMDLs, adjust land treatment strategies, and evaluate progress in improving water quality.

Bacteria Source Quantification

Historically, assessment techniques have not allowed for an accurate account of surface water bacteria load contributions from specific types of sources. The nature and survival of bacteria in stream and lake bottom sediment has added to this assessment uncertainty. If bacteria survive longer in sediment than in the overlying stream or lake water, then sampling the water may provide an incorrect indication of the level of contaminants that may be present in that whole environment. Additionally, the uncertainty surrounding contributions from natural sources such as wildlife may lead resource managers and public to have unrealistic expectations, establish unachievable management goals, or incorrectly prioritize efforts.

More recent technology and methods have been developed to identify and quantify waterbody specific bacteria sources using DNA. A five-year Microbial Source Tracking (MST) study conducted on Antelope Creek within the City of Lincoln indicated sizable contributions from natural sources such as geese, ducks, swallows, pigeons, and small mammals in addition to sanitary sewage (Baral and others, 2017). It is recommended that streams or lakes targeted for bacteria TMDL development or projects with bacteria reduction goals undergo specialized monitoring to quantify source contributions.

Bathymetric Surveys

Sediment management in respect to lakes involves controlling erosion at the source, trapping sediment before it reaches the lake, and reclaiming lost storage capacity in the lake and upstream sediment basins. The loss of reservoir conservation pool storage capacity can result in deteriorated water quality and the loss of aquatic habitat. Information gathered from bathymetric surveys (or surveys used to map the bottom of lakes) can be used for several water quality planning purposes such as: (a) tracking reservoir sedimentation rates over time, (b) determining sediment trapping efficiencies of wetland/ sediment basins, (c) estimating reservoir and sediment basin maintenance requirements and financial needs, and (d) planning for in-lake management measures.

Current bathymetric information is lacking for most of the larger or recreational lakes in the planning area. The identification of priorities for future surveys was based on (a) sites that have had completed nonpoint source projects, (b) sites that are a priority in this plan, or (c) sites that serve as major public recreation areas (Table 28). Sediment basins would be best surveyed every three to five years, as opposed to every seven to ten years for reservoirs. Significant dry or wet periods might warrant longer or shorter intervals between survey periods. To ensure data comparability, it is critical to maintain consistent boundaries across survey periods. The measurement of soft sediment thickness should accompany bathymetric surveys at sites where in-lake improvements are planned. This information is valuable to develop strategies for re-claiming lost lake storage capacity and for locating in-lake sediment control structures.

Table 28: Priority Sites for Bathymetric Surveys

Waterbody	Last Survey Completed	Justification
Pawnee Lake	2002	Plan Priority Area
Twin Lakes	2002	Plan Priority Area
Branched Oak	2003	Largest Lake in planning area
Conestoga	2004	Lake Renovation in Progress
Wagon Train	2002	Lake Renovation-Sediment Basin Construction-Watershed Treatment Completed 2002
Yankee Hill	2005	Lake Renovation-Sediment Basin Construction-Watershed Treatment Completed 2005
Wildwood	2003	Lake Renovation-Sediment Basin Construction-Watershed Treatment Completed 2003

Vadose Zone Monitoring

Implementation of a vadose zone monitoring program focused on WHP areas (also referred to as CWSPAs in the LPSNRD), areas with elevated nitrate concentrations, and groundwater management areas is recommended. The program could include a combination of deep vadose sampling (i.e., ground surface to aquifer) and shallow vadose sampling (i.e., ground surface to a depth of 15 feet), using similar methods and procedures.

The deep vadose sampling would be done at the same locations each time, with a sampling frequency of every 10 years. This sampling interval is more practical as nitrates move slowly through the soil profile, which lessens the value of annual sampling at the same site. The deep sampling would be used to track long-term trends of nitrate leaching from the surface to the saturated zone. Two to three shallow sampling events would occur between the 10-year deep vadose sampling. Analyses would be completed to establish trends between the shallow and deep nitrate loads to determine effectiveness of management practices. Detailed land management information from each sampling site is necessary to make accurate comparisons between nitrate management practices. Efforts would require detailed reporting forms, completed by the producers and/or land managers, to track nitrate application, inhibitor application, crop type, use of a crop consultant, and other relevant factors. Collection of this information would greatly increase the value of a vadose zone monitoring program. A non-financial incentive to encourage participation in the program also could be used to waive training requirements for fields that sample below certain limits.

POINT SOURCE CONTRIBUTION MONITORING

This plan assumes that all permitted facilities are meeting their National Pollutant Discharge Elimination System (NPDES) permit parameters and are in compliance. This permitting system is administered by NDEQ. However, due to the potential of point source contributions influencing nutrient and bacteria concentrations at low flow conditions, periodic compliance monitoring may be necessary. Periodic compliance monitoring should be conducted at NPDES permitted facilities (or waste application sites) to verify that they adhere to permit conditions. Facilities are selected randomly or in response to inspection or reported information. NPDES permits require self-monitoring of the effluent by the permittee with frequency of the monitoring being based on the discharge characteristics. The data are then reported to the NDEQ quarterly, semiannually, or annually, and entered into the EPA's Permitting Compliance System

4.07 QUALITY ASSURANCE, DATA MANAGEMENT, ANALYSIS, AND ASSESSMENT

A variety of tools and procedures exist for compiling, managing, and analyzing data, with costs ranging from inexpensive to very expensive. No single method is applicable to all situations. As a result, managers need to use a blend of methodologies specific for the situation, intended use of the data, and available funds. In most cases, data collection procedures, data management protocol, and quality assurance procedures are in place at the local or state level. Future monitoring activities may be incorporated into established frameworks or addressed in a separate QAPP to ensure the scientific validity.

Any LPSNRD effort resulting in the collection of data and/or information will follow proper data management protocol. The LPSNRD maintains several databases pertaining to water monitoring activities, and use methods to ensure data quality. LPSNRD databases are considered public information and can be obtained upon request at any point. However, data collected by other agencies, such as the NeDNR, NDEQ, NGPC, or others, will not be managed by the LPSNRD unless specific arrangements for doing so have been made in advance. In most cases, water quality data are entered into publicly accessible databases such as the WQP and Clearinghouse.

4.08 REPORTING AND INFORMATION DISSEMINATION

The LPSNRD will utilize all pertinent data and information to make informed resource decisions. The LPSNRD staff utilizes the following established processes to disseminate data and information to the board: monthly board meetings, subcommittee updates, special meetings, and presentations by professionals and interested or concerned citizens.

The LPSNRD is continually disseminating data and information to the general public. Dissemination processes for the public include: NRD Newsletters, NRD website, social media, public meetings, and special events. Communication and outreach efforts are further described in Chapter 6.

Raw data, reports, and other information gathered by entities outside the NRD may not be made directly available to the LPSNRD. Data collected by NDEQ can be found in many different reports. The Federal Clean Water Act requires the State to provide certain reports and lists, including the Section 305(b) Water Quality Inventory Report and Section 303(d) List of Impaired Waters. In some cases, data and information will be reported in other documents such as standards revisions, water quality based permits, total maximum daily loads, and various nonpoint source management plans. Data from the groundwater level monitoring network is currently available to anyone through the Conservation Survey Division (CSD) and the NeDNR.

4.09 GENERAL SUPPORT FOR MONITORING ACTIVITIES

The LPSNRD will continue to be active in gathering data to support management decisions. The NRD annually evaluates current and future monitoring resources needed to support and facilitate nonpoint source management, especially related to groundwater management. This includes staff and training, travel, equipment, supplies, laboratory resources, and funding.

4.10 MONITORING PROGRAM REVIEW

The LPSNRD will work with its partners to conduct periodic reviews of the sampling and monitoring programs that are in operation within the district. This will be to ensure they are meeting the management needs for the district. This should involve evaluating and determining how needed changes and additions are incorporated into future monitoring cycles. This evaluation will take into consideration the effects of funding changes on its monitoring program strategy. Since water quality monitoring programs are effective only when they meet the information needs of water quality resource managers, the LPSNRD will have a feedback mechanism for reporting useful information to water managers and incorporating their input on future data needs. Information needs may include site-specific criteria modification studies, support for enforcement actions, validation of the success of control measures, water quality modeling, monitoring unassessed waters, and other activities. Decision-makers at the national, regional, state, and local levels should be considered in this process.

CHAPTER 5. WATER QUALITY ASSESSMENT

5.01 INTRODUCTION

The intent of this chapter is to provide an overview of protected beneficial uses, impaired surface waters, and general water quality assessment approaches used to develop this plan. These were also used in the prioritization process. The 2016 Integrated Report prepared by NDEQ was used as a basis for determining current impairment status to streams and lakes (NDEQ, 2016b). 5-alt data (NDEQ, 2017b) was utilized to supplement existing data. More detailed analysis was conducted to estimate pollutant loads, pollutant loading capacities, and the load reduction needed for priority waterbodies to meet water quality standards. This additional analysis is discussed in Chapters 10, 11, and 12.

NDEQ's Integrated Report is organized by major river basins, therefore it is important to clarify that only a portion of the Lower Platte River Basin falls within the jurisdiction of the LPSNRD (Figure 50). As such, several stream segments and lakes in the Lower Platte River Basin will not be addressed in this plan. Of note, the Platte and Missouri Rivers are not addressed for any management actions in this plan. The Platte River is addressed within the Lower Platte River Corridor Alliance WQMP (HDR, 2018).

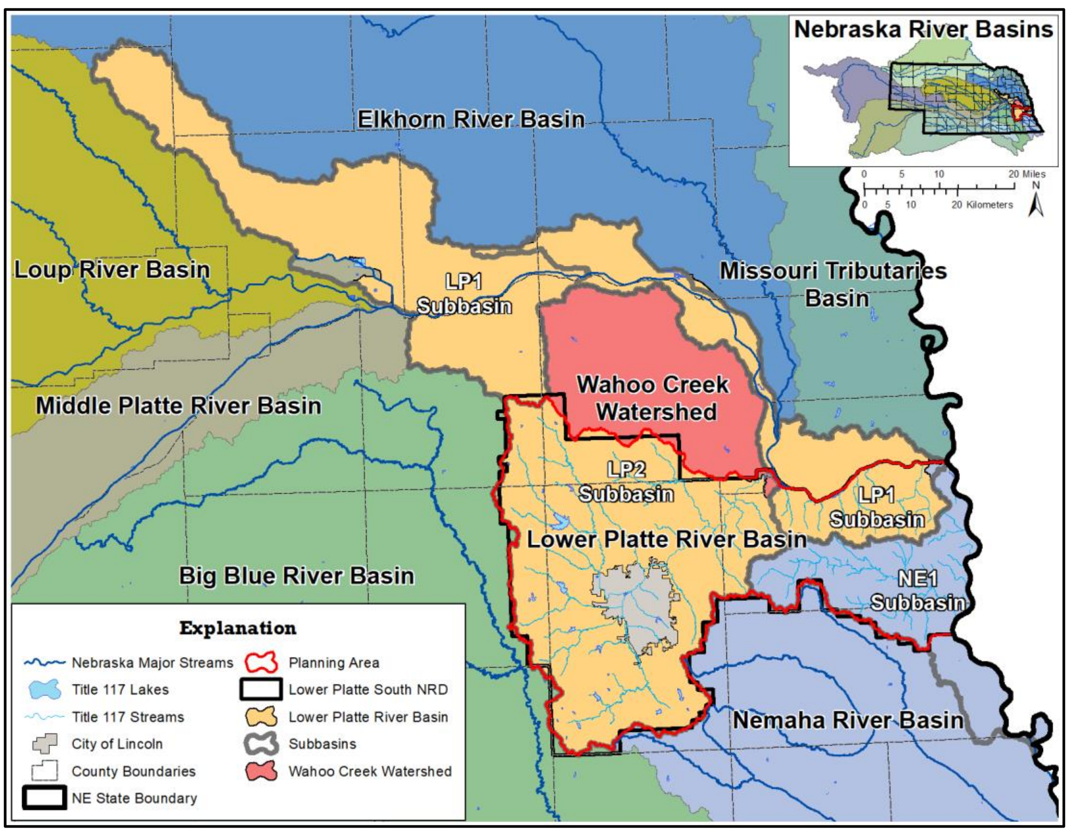


Figure 50: Lower Platte River Basin and Planning Area

5.02 PERTINENT POLICY AND REGULATIONS

AMBIENT WATER QUALITY STANDARDS

The Nebraska Water Quality Standards (WQS) (NDEQ, 2014) are in place to protect the quality of surface water for human consumption, wildlife, industry, recreation, and other productive or beneficial uses. Beneficial uses are also protected by permits, which may be issued for activities if they meet the WQS and NDEQ requirements for applicable treatment levels or control for point and nonpoint pollution sources. It should be noted that these standards apply to all surface waters of the State, except as noted in Title 117, even if they are not specifically assigned a beneficial use in Title 117.

Title 117 provides numerical standards for water quality from many potential pollutants based on the waterbody's assigned beneficial use. Some uses require higher water quality than others. When multiple uses are assigned to the same waters, all assigned uses will be protected. This plan has been written to address nonpoint source pollutant loadings from bacteria (*E. coli*), nutrients (phosphorus and nitrogen), and sediment. Additionally, impairments to the aquatic life are also addressed. A list of Nebraska's WQS utilized for the development of this plan is below in Table 29.

Table 29: Applicable Water Quality Standards

Parameter	Beneficial Use	Chronic Standard
E. coli Bacteria	Primary Contact Recreation	Geometric Mean-126 col./100mls
Dissolved Oxygen	Aquatic Life	Warmwater A & B: One-day minimum of not less than 5.0 mg/L. Multiple criteria in place for one, seven, and 30 day averages
Atrazine	Aquatic Life	12.00 µg/L
Ammonia	Aquatic Life	Water temperature and pH specific.
pH	Aquatic Life	Acceptable Range = 6.5 – 9.0
Lakes Only (Eastern)		
Total Phosphorus	Aquatic Life	50 µg/L
Total Nitrogen	Aquatic Life	1000 µg/L
Chlorophyll-a	Aquatic Life	10 mg/m3
Sedimentation	Aesthetics	Total Conservation Pool Volume Loss > 25% Conservation Pool Volume Loss < 0.75%/year

SAFE DRINKING WATER ACT

In 1974, the Safe Drinking Water Act directed the EPA to establish national drinking water standards – these are known as Maximum Contaminant Levels (MCLs). These standards set limits on the amounts of various substances allowed in public drinking water. The Nebraska Department of Health and Human Services (DHHS) is the primary agency responsible for enforcing the federal drinking water regulations in Nebraska. Because the majority of drinking water in Nebraska originates as groundwater, the NDEQ and numerous Natural Resources Districts (including LPSNRD) are also involved in helping communities protect groundwater water through the Wellhead Protection Program.

Groundwater pollution throughout Nebraska depends on the type of pollutant and scale of the contamination. The most pervasive groundwater pollutant is nitrate-nitrogen (nitrate). Nitrate is known to cause a disease called methaemoglobinaemia (colloquially known as "blue baby syndrome") which primarily effects infants but may also impact pregnant women and health-compromised adults. High nitrate levels in groundwater are typically caused by nonpoint source pollution and are thus of interest in this planning effort. The MCL for nitrate-nitrogen in drinking water is 10 milligrams per liter (mg/L) or parts per million (ppm).

TOTAL DAILY MAXIMUM LOADS

A Total Maximum Daily Load (TMDL) is developed when a waterbody has been identified as both "impaired" for at least one designated beneficial use and as a Category 5 water body. TMDLs establish the maximum allowable load of a pollutant a specific waterbody can receive and still meet water quality standards. The NDEQ has developed six TMDLs for waterbodies in the planning area (Table 30). All completed TMDLs can be found on NDEQs website: http://deq.ne.gov/NDEQProg.nsf/OnWeb/TMDL.

Table 30: Completed TMDLs for the Planning Area

TMDL Date	Stream Segment/Lake ID	Waterbody Name	Pollutant
2002	LP2-L0030	Wagon Train Lake	Sediment, Phosphorus
2002	LP2-L0090	Yankee Hill Lake	Sediment, Phosphorus
2003	LP2-L0040	Holmes Lake	Sediment, Phosphorus
2007	LP2-20900	Antelope Creek*	*E. coli*
2007	LP2-21000	Middle Creek	Atrazine
2007	LP1-10000, LP1-20000,	Platte River, Salt Creek,	*E. coli*
	LP2-10000, LP2-10100,	Salt Creek, Wahoo Creek*,	
	LP2-20000, LP2-20400	Salt Creek, Dead Man's Run,	
	LP2-20500, LP2-30000	Oak Creek, Salt Creek	

Note: Wahoo Creek is not included in the planning area

**During the development of this plan, Antelope Creek (LP2-20900) was determined to no longer be impaired due to E. coli (NDEQ, 2018). However, implementation of activities identified in this plan are still a priority for the LPSNRD and City of Lincoln.*

ADDITIONAL 5-ALT COMPONENTS

NDEQ and EPA have created an alternative process to developing TMDLs for impaired waterbodies. The process, called "5-alt." was created to facilitate TMDL implementation by providing data and planning information for areas identified as a priority for project implementation. As part of this planning process, NDEQ has provided LPSNRD 5-alt analysis for nine streams in the planning area (NDEQ, 2017b), shown in Table 31. The 5-alt analysis provides numerical water quality targets for each site.

Table 31: Sites in the Planning Area with Completed 5-Alt Assessments

Subbasin	Stream Segment	Waterbody Name	Pollutant
Lower Platte	LP1-11200	Decker Creek	*E. coli*
Salt Creek	LP2-10000	Salt Creek	*E. coli*
Salt Creek	LP2-20000	Salt Creek	*E. coli*
Salt Creek	LP2-20300	Little Salt Creek	*E. coli*
Salt Creek	LP2-20600	Oak Creek	*E. coli*
Salt Creek	LP2-20900	Antelope Creek	*E. coli*
Salt Creek	LP2-21500	Beal Slough	*E. coli*
Salt Creek	LP2-30000	Salt Creek	*E. coli*
Salt Creek	LP2-30100	Cardwell Branch	*E. coli*

As part of a 9-element WMP, the project sponsor is expected to reference existing EPA-approved TMDLs in addition to utilizing 5-alt data and providing 5-alt graphs and charts in an appendix. The data provided by NDEQ can be found in Appendix G. Throughout this plan, language that directly addresses a 5-alt item is marked with the graphic displayed to the right. Table 32 also provides the reader a shortcut to the location of each 5-alt component.

Table 32: Location of 5-alt Components within the Plan

Component	Page Number
Management Measures	134
Management Measures	145
Causes/Sources	119
Causes/Sources	119
Causes/Sources	116
Evaluate Effectiveness	304
Evaluate Effectiveness	298

CITY OF LINCOLN MUNICIPAL SEPARATE STORM SEWER SYSTEM

The City of Lincoln is required by federal law to comply with the provisions of the Federal Clean Water Act in managing municipal stormwater. NDEQ has the authority to ensure Lincoln is compliant with stated conditions. The City of Lincoln complies with these mandated regulations through a state-issued National Pollutant Discharge Elimination System permit for Municipal Separate Storm Sewer System (NPDES-MS4 permit). The permit authorizes the City of Lincoln to discharge stormwater into Salt Creek. MS4s are considered a point source of pollution. The permit requires a mixture of components including: inspections, pollutant monitoring, reporting, and educational activities that will complement any voluntary nonpoint source efforts implemented within the city limits.

The implementation strategy described later in Chapter 10 includes several management practice recommendations for areas within the City of Lincoln. However, it should be noted that any programs or projects listed in the implementation strategy are actions above and beyond actions listed in the City's current MS4 permit. Implementation strategies provided in this plan are specific to address nonpoint source impairments identified in this plan.

5.03 OVERVIEW OF EXISTING WATER QUALITY DATA

The general condition of water resources in the planning area is based on completed beneficial use support assessments, water quality assessments, planning documents completed by resource agencies, and resource assessments conducted as part of the development of this plan. Additional input and information was acquired through stakeholder input. Waterbody impairment was based on the most current beneficial use support assessment results provided in the NDEQ's 2016 Integrated Report (IR) (NDEQ, 2016b).

Detailed assessments conducted on target areas were based on the most recent 5-year data period (2012-2016). Raw data for all streams and lakes in the planning area were collected and provided by NDEQ and USACE. Pollutant loading assessments conducted for target areas utilized the 2016 USDA Cropland Data Layer for landuse/landcover data.

5.04 OVERVIEW OF BENEFICIAL USES

Nebraska's surface water quality standards protect streams and lakes for the following beneficial uses: Water Supplies, Aquatic Life, Primary Contact Recreation (PCR), and Aesthetics (NDEQ, 2014). Water supplies are divided into three discrete categories based on the specific use: Public Drinking Water (PDW), Agricultural Water Supply (AWS), and Industrial Water Supply (IWS). While all streams and lakes are assigned the AWS use, the PDW and IWS uses only pertain to specific waters. All streams and lakes are assigned the Aesthetics and Aquatic Life uses. In order to provide varying levels of protection, the Aquatic Life use is divided into four discrete classes based on stream characteristics and the type of biota they support: Cold Water A (CWA), Cold Water B (CWB), Warmwater A (WWA), and Warmwater B (WWB). While all lakes are assigned the Primary Contact Recreation use, only streams that meet certain physical characteristics have this designation. In some cases, site specific criteria for a pollutant are assigned to a particular waterbody.

Beneficial uses are assigned to 105 stream segments and 39 lakes in the planning area, as shown in Table 33. The Platte River and Rock Creek (NE1-13700) located in the Keg-Weeping Water Creek Subbasin is also designated as a PDW supply. There are no streams or lakes assigned the IWS use. All 39 lakes and 12 of the 105 stream segments addressed in this plan are designated for primary contact recreation (PCR) use. While all 39 lakes in the planning area have a WWA designation, the 105 stream segments are split between the WWA (9) and WWB (96) classes, as shown in Table 34.

One segment of the Platte River and three segments of Salt Creek are assigned site specific criteria related to ammonia; the Platte River (LP1-10000) and Salt Creek (LP2-10000, LP2-20000, LP2-30000) segments. Three lakes are designated as State Resource Waters: Quest Lake (LP1-L0080) and Baright Lake (LP1-L0090) in Mahoney State Park and Jenny Newman Lake (LP1-L0060) located in Platte River State Park.

Beneficial use support summaries for streams and lakes were generated from completed beneficial use support assessments listed in the 2016 IR. Individual beneficial use support assessment results for all waterbodies in the planning area can be found in Appendix C.

Table 33: Beneficial Use Designations for Streams and Lakes in the Planning Area

Subbasin	# in Title 117	PDS	PCR	AL	AWS	Aesthetics	Site Specific Criteria
Salt Creek							
Stream Segments	46	0	9	46	46	46	3
Lakes	27	0	27	27	27	27	0
Lower Platte							
Stream Segments	18	1	2	18	18	18	1
Lakes	8	0	8	8	8	8	0
Keg-Weeping Water							
Stream Segments	41	1	1	41	41	41	0
Lakes	4	0	4	4	4	4	0

Note: PDW – Public Drinking Water Supply, PCR – Primary Contact Recreation, AL – Aquatic Life, AWS – Agricultural Water Supply. Source: NDEQ, 2016b

Table 34: Distribution of Aquatic Life Classes in the Planning Area

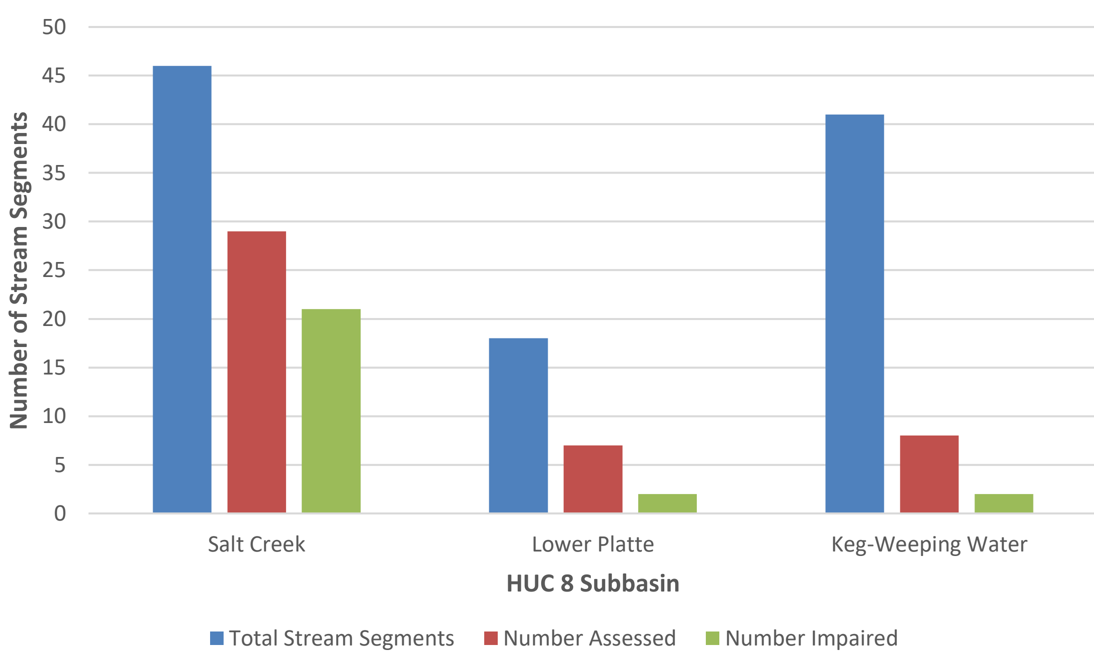
Subbasin	# in Water Quality Standards	Cold Water A	Cold Water B	Warm Water A	Warm Water B
Salt Creek					
Stream Segments	46	0	0	5	41
Lakes	27	0	0	27	0
Lower Platte					
Stream Segments	18	0	0	1	17
Lakes	8	0	0	8	0
Keg-Weeping Water					
Stream Segments	41	0	0	3	38
Lakes	4	0	0	4	0

STREAMS

NDEQ has conducted beneficial use support assessments on 44 of the 105 stream segments in the basin planning area, as listed in Table 35 and visualized in Figure 51. Of the 44 stream segments assessed, 25 are impaired. The highest level of stream impairment occurs in the Salt Creek Watershed where 46% of the total stream segments and 72% of the assessed segments are impaired.

Table 35: Beneficial Use Support Summary for Stream Segments in the Planning Area

	Salt Creek	Lower Platte	Keg-Weeping Water
Total Number of Stream Segments	46	18	41
Number Assessed	29	7	8
Number Impaired	21	2	2
% of Total Segments Impaired	46%	11%	5%
% of Assessed Segments Impaired	72%	29%	25%
Total Stream Segment Miles	471	125	210
Miles Assessed	333	67	87
Miles Impaired	248	40	36
% of Total Miles Impaired	53%	32%	17%
% of Assessed Miles Impaired	74%	60%	41%



Source: NDEQ (2016b)

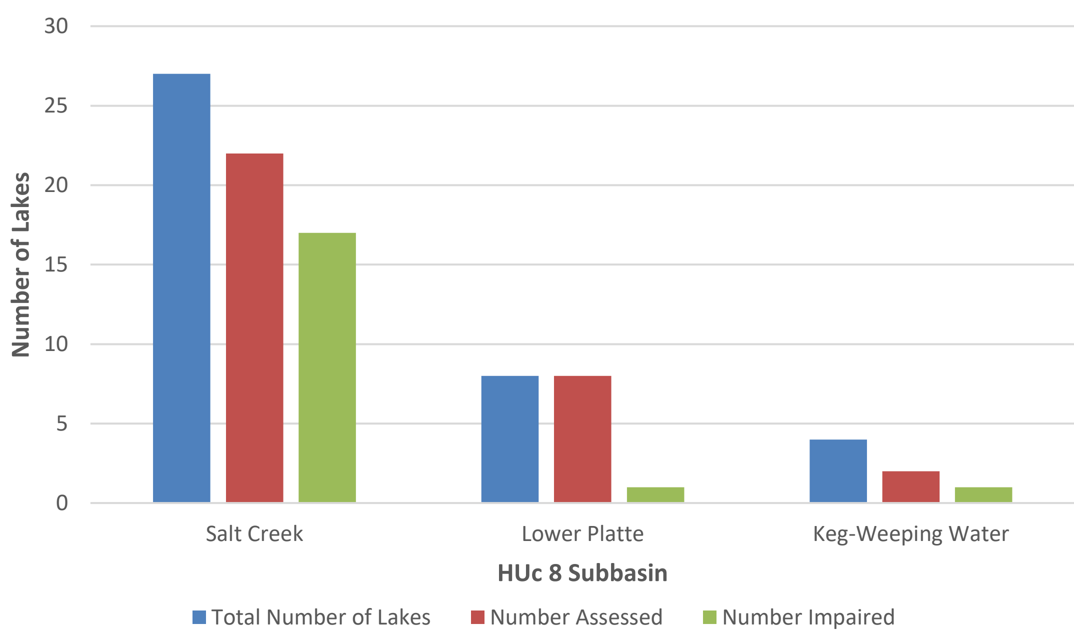
Figure 51: Beneficial Use Support Summary for Streams in the Planning Area

LAKES

NDEQ has conducted beneficial use support assessments on 32 of the 39 lakes in the planning area, as listed in Table 36 and visualized in Figure 52. Of the 32 lakes assessed, 19 are impaired. The highest level of lake impairment occurs in the Salt Creek Subbasin where 63% of the total lakes and 77% of the assessed lakes are impaired.

Table 36: Beneficial Use Support Summary for Lakes Planning Area

	Salt Creek	Lower Platte	Keg-Weeping Water
Total Number of Lakes	27	8	4
Number Assessed	22	8	2
Number Impaired	17	1	1
% of Total Lakes Impaired	63%	13%	25%
% of Assessed Lakes Impaired	77%	13%	50%
Total Number of Acres	4397	62	40
Acres Assessed	4320	62	6
Acres Impaired	4193	4	3
% of Total Acres Impaired	95%	6%	8%
% of Assessed Acres Impaired	97%	6%	50%



Source: NDEQ (2016b)

Figure 52: Beneficial Use Support Summary for Lakes Planning Area

5.05 HIGH QUALITY AND IMPAIRED WATERS

HIGH QUALITY WATERS

The 2015 Nebraska Nonpoint Source Management Plan (NDEQ, 2015b) identifies two high quality streams in the planning area: Middle Creek (LP2-21000) and Holmes Creek (LP2-21210). Both streams are within the Salt Creek Subbasin. Holmes Creek segment LP2-21210 falls above Conestoga Reservoir and was most recently addressed in a Watershed Management Plan completed by the LPSNRD and NDEQ in 2011. That plan is currently being implemented and the lake is currently undergoing a renovation project. Middle Creek segment LP2-21000 falls below Pawnee Reservoir.

IMPAIRED WATERS

Aquatic communities have been assessed as impaired on five stream segments in the planning area. The impairment is based on three individual metrics relating to aquatic habitat, aquatic insects, and fish (NDEQ, 2011a). While impaired aquatic communities can generally be tied to nonpoint source pollution, there are no specific pollutants or loads associated with this cause of impairment.

Based on completed beneficial use support assessments, the primary pollutants causing water quality degradation in streams include bacteria, dissolved oxygen, atrazine, and ammonia. All impairments relate to the Primary Contact Recreation and Aquatic Life uses. Dissolved oxygen and ammonia are the partial cause of impairment on one stream segment with atrazine being the sole cause of impairment on three segments. Bacteria is the most prevalent concern as 11 of the 12 segments assessed were determined to be impaired for this parameter (Figure 53).

Based on completed beneficial use support assessments, the primary pollutants causing water quality degradation in lakes include sediment, nutrients, dissolved oxygen, chlorophyll-a, pH, and ammonia (Figure 54). All impairments relate to the Aquatic Life and Aesthetic uses and are directly or indirectly associated with nutrient and sediment loading.

Twenty-five segments with stream impairment were all related to the Primary Contact Recreation and Aquatic Life uses (Table 37). Seven of the segments were impaired solely from iron stemming from natural sources, while naturally occurring selenium was the partial cause of impairment on four segments. Impairments identified for 19 lakes were related to the aquatic life and aesthetics uses (Table 38).

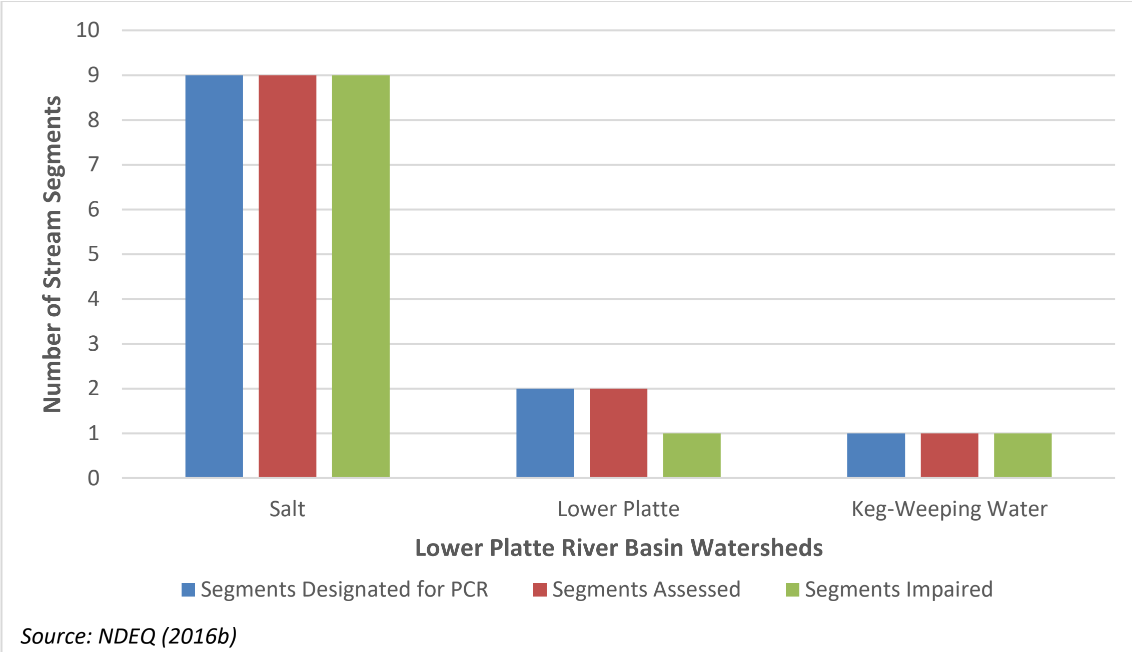


Figure 53: Primary Contact Recreation Assessments on Streams in the Lower Platte River Basin

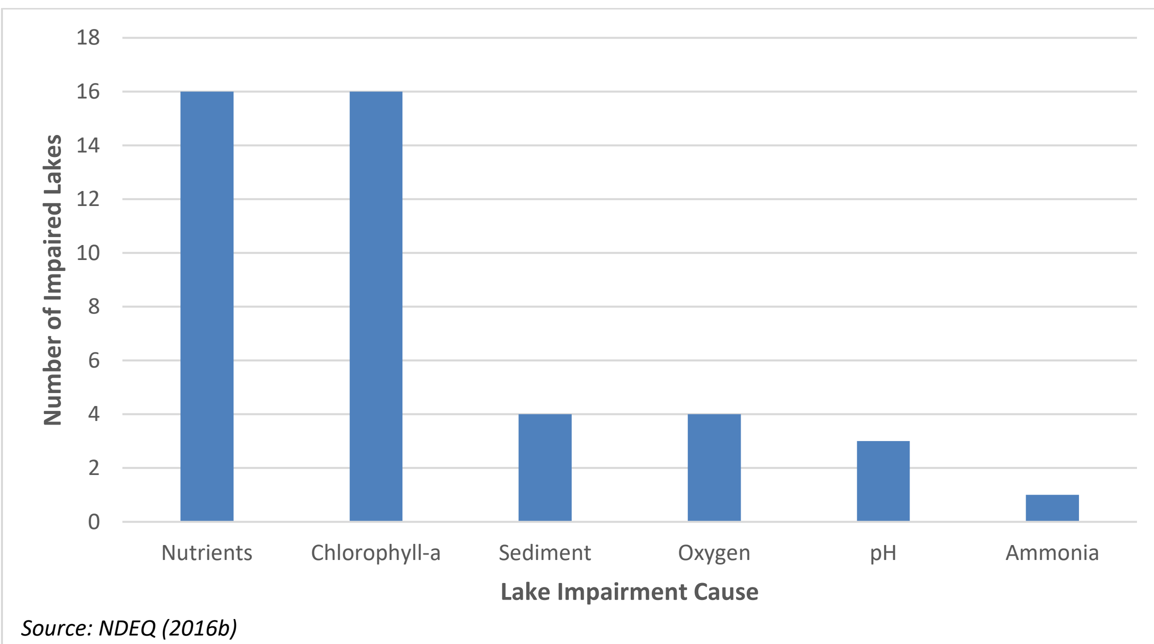


Figure 54: Causes of Lake Impairment in the Lower Platte River Basin Planning Area

Table 37: Impaired Stream Segments in the Planning Area

Watershed	Stream Name	Segment	Beneficial Use (Pollutant Causing Impairment)
Lower Platte	Platte River	LP1-10000	Aquatic Life (Selenium, Fish Consumption Advisory)
	Decker Creek	LP1-11200	Recreation (Bacteria)
Salt Creek	Salt Creek	LP2-10000	Recreation (Bacteria), Aquatic Life (Selenium)
	Callahan Creek	LP2-10500	Aquatic Life (Iron)
	Robinson Creek	LP2-10600	Aquatic Life (Iron)
	Greenwood Creek	LP2-10700	Aquatic Life (Iron)
	Dee Creek	LP2-10800	Aquatic Life (Iron)
	Camp Creek	LP2-10900	Aquatic Life (Iron)
	Rock Creek	LP2-11000	Aquatic Life (Iron)
	North Fork Rock Creek	LP2-11010	Aquatic Life (Iron)
	Salt Creek	LP2-20000	Recreation (Bacteria), Aquatic Life (Fish Consumption Advisory, Impaired Aquatic Community)
	Little Salt Creek	LP2-20300	Aquatic Life (Copper, Selenium, Ammonia, Impaired Aquatic community)
	Dead Man's Run	LP2-20400	Recreation (Bacteria), Aquatic Life (Naturally High pH, Dissolved Oxygen)
	Oak Creek	LP2-20500	Recreation (Bacteria), Aquatic Life (Chloride, Fish Consumption Advisory)
	Oak Creek	LP2-20600	Recreation (Bacteria), Aquatic Life (Impaired Aquatic Community)
	Middle Oak Creek	LP2-20710	Aquatic life (Atrazine)
	Oak Creek	LP2-20800	Aquatic life (Atrazine)
	Antelope Creek*	LP2-20900	Recreation (Bacteria), Aquatic Life (Selenium, Copper)
	Middle Creek	LP2-21100	Aquatic life (Atrazine)
	Beal Slough	LP2-21500	Recreation (Bacteria)
	Salt Creek	LP2-30000	Recreation (Bacteria), Aquatic Life (Impaired Aquatic Community)
	Cardwell Branch	LP2-30100	Recreation (Bacteria)
	Olive Branch	LP2-40300	Aquatic Life (Impaired Aquatic Community)
Keg-Weeping Water	Weeping Water Creek	NE1-12800	Aquatic Life (Selenium)
	Weeping Water Creek	NE1-13000	Recreation (Bacteria)

**During the development of this plan, Antelope Creek (LP2-20900) was determined to no longer be impaired due to E. coli (NDEQ, 2018). However, implementation of activities identified in this plan are still a priority for the LPSNRD and City of Lincoln.*

Table 38: Impaired Lakes in the Planning Area

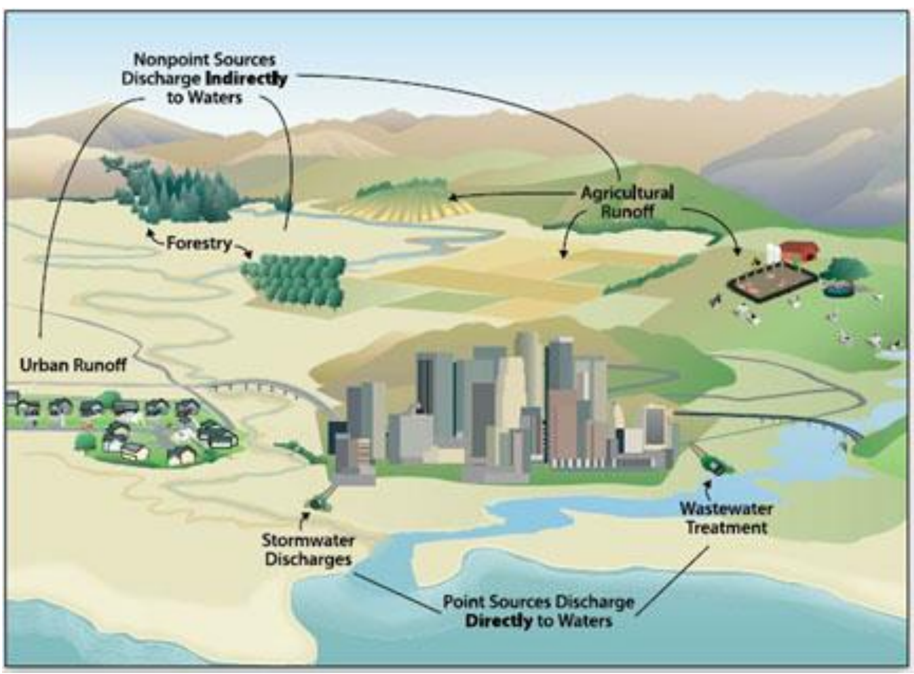
Watershed	Lake Name	Lake ID	Beneficial Use (Pollutant Causing Impairment)
Lower Platte	Jenny Newman	LP1-L0060	Aquatic Life (Nutrients, Chlorophyll-a)
Salt Creek	Wagon Train	LP2-L0030	Aquatic Life (Nutrients, Chlorophyll-a, Diss. Oxygen, Fish Consumption Advisory)
	Holmes	LP2-L0040	Aquatic Life (Nutrients, Chlorophyll-a, pH, Fish Consumption Advisory)
	Stagecoach	LP2-L0050	Aquatic Life (Nutrients, Chlorophyll-a, Fish Consumption Advisory) Aesthetics (Sedimentation)
	Oak	LP2-L0060	Aquatic Life (DO, Chlorides)
	Yankee Hill	LP2-L0090	Aquatic Life (Nutrients, Chlorophyll-a, pH)
	Bowling	LP2-L0100	Aquatic Life (Nutrients, Chlorophyll-a)
	Bluestem Lake	LP2-L0110	Aquatic Life (Nutrients, Chlorophyll-a, Fish Consumption Advisory) Aesthetics (Sedimentation)
	Wildwood Lake	LP2-L0120	Aquatic Life (Nutrients, Chlorophyll-a, Diss. Oxygen, Fish Consumption Advisory)
	Conestoga Lake	LP2-L0130	Aquatic Life (Nutrients, Chlorophyll-a) Aesthetics (Sedimentation)
	Olive Creek Lake	LP2-L0140	Aquatic Life (Nutrients, Chlorophyll-a, pH)
	Branched Oak Lake	LP2-L0150	Aquatic Life (Nutrients, Chlorophyll-a)
	Pawnee Lake	LP2-L0160	Aquatic Life (Nutrients, Chlorophyll-a) Aesthetics (Sedimentation)
	Merganser Lake	LP2-L0170	Aquatic Life (Fish Consumption Advisory)
	Meadowlark Lake	LP2-L0220	Aquatic Life (Nutrients, Chlorophyll-a, Diss. Oxygen)
	East Twin Lake	LP2-L0240	Aquatic Life (Nutrients, Chlorophyll-a)
	West Twin Lake	LP2-L0260	Aquatic Life (Nutrients, Chlorophyll-a, Ammonia)
	Redtail Lake	LP2-L0280	Aquatic Life (Nutrients, Chlorophyll-a)
Keg-Weeping Water	Weeping Water City Lake	NE1-L0020	Aquatic Life (Fish Consumption Advisory)

5.06 POLLUTANTS AND SOURCES

INTRODUCTION

Generally, sources of pollution can be separated into two main categories: point sources and nonpoint sources. A point source is any discernible, confined, and discrete conveyance from which pollutants can be discharged. In other words, to have point source pollution, it must be possible to clearly identify the specific origin and travel path of the pollution. Examples would include any pipe, ditch, tunnel, conduit, well, smokestack, or animal feeding operation that might discharge. The discharge from some point sources is regulated by the National Pollutant Discharge Elimination System (NPDES) permit program. Many agricultural, industrial, and municipal facilities are required to obtain NPDES permit coverage. However, individual homes connected to a municipal or septic system typically do not need coverage under an NPDES permit.

Identifying these permitted facilities is important in developing a watershed plan. While they are assumed to be meeting all their permit requirements, their pollutant load contributions must be accounted for. This allows for nonpoint pollution loads to be clearly separated. Nonpoint sources of pollution may also come from other "facilities", activities, or land uses that do not meet regulatory requirements to be considered point sources. Because these facilities are not regulated, are typically smaller, or otherwise not well defined, they are thus treated as nonpoint sources for management purposes. This is conceptually illustrated below in Figure 55.



Source: Osterberg and Cline, 2014

Figure 55: Examples of Point and Nonpoint Sources of Water Pollution

POLLUTANTS ADDRESSED

Nonpoint source pollution is typically transported from broader areas during precipitation events. However, their origin is often difficult or impossible to identify due to their diffuse and widespread nature. Within the planning area, nonpoint source pollution is considered the major contributor to water quality impairments. While it can be difficult to identify specific nonpoint sources, this plan addresses the following pollutants of concern for priority waterbodies and target areas (as applicable): bacteria, nutrients, sediments, and atrazine. Pollutants, sources, and their impacts are summarized in Table 39. The following sections discusses each pollutant and it's sources in more detail.

Table 39: Summary of Pollutants and Sources

Pollutant & Sources		Possible Impacts on Waterbody Uses
Point Sources (permitted)*	***Nonpoint Sources***	
Pathogens/Bacteria (*E. coli*)		
• WWTFs • Permitted AFOs	• Wildlife and Pets • Unpermitted AFOs & grazing livestock • Underperforming septic systems • Land application of manure • Land application of wastewater/ sludge	• Human health risks • Recreation impairments
Nutrients (Phosphorus and Nitrogen)		
• WWTFs • Permitted AFOs	• Fertilizer application • Wildlife and Pets • Unpermitted AFOs & grazing livestock • Underperforming septic systems • Land application of manure or wastewater • Gully, Rill, and Stream Erosion	• Aquatic life impairments • Human health risks • Drinking water supply impacts • Recreational impacts
Sediment		
• WWTFs • Stormwater systems • Construction Sites	• Agriculture (cropland and pastureland erosion) • Silviculture and timber harvesting (erosion) • Urban Sources, Construction, and Roads • Underperforming septic systems • Gully, Rill, and Stream Erosion	• Aquatic Habitat • Fills reservoirs • Recreational impacts • Human health risks – fish consumption
Atrazine		
• None	• Agriculture (applied primarily to corn)	• Aquatic life • Drinking water supply impacts

**Point sources were initially identified in order to distinguish the level of pollutant loads associated with all sources; however, they were not considered for management recommendations.*

E. coli Bacteria

Many types of bacteria may be present in waterbodies, making it difficult to identify and measure specific pathogenic organisms. Therefore, indicator organisms are used to determine the level of impairment of surface waters. Studies conducted by the EPA to determine the correlation between different bacteria and the occurrence of gastrointestinal illness suggest that *E. coli* is the best indicator of health risk from contact with recreational waters. *E. coli* is a species of fecal coliform bacteria that is commonly found in the fecal matter of warm-blooded animals. Most strains of *E. coli* are harmless; however, certain strains (0157:H7) can cause mild to severe gastrointestinal illness.

In 2005, *E. coli* became the sole parameter for assessing the primary contact recreation use in Nebraska; therefore, identifying the sources of *E. coli* contamination is a priority. Sources of *E. coli* include the waste from wildlife, pets, livestock, and humans (septic systems). Additionally, the spreading of manure and livestock waste or municipal wastewater for agricultural purposes can also be a source. Contamination from manure is most pronounced where animals congregate and/or have direct access to water bodies, or where manure is applied improperly.

Current concentrations of *E. coli* in several of the streams in the planning area exceed water quality standards. This indicates an exposure risk to users to *E. coli* and other pathogenic bacteria originating from fecal contamination which may cause gastrointestinal illness, such as giardia (common referred to as beaver fever).

Nutrients & Sediment

Nutrients such as phosphorus and nitrogen occur naturally in the environment. However, an overabundance of these nutrients poses ecological and human health risks and may lead to impaired water quality. Nutrient enrichment in Nebraska water bodies can stem from both external and internal sources. External sources consist of soil erosion (from the landscape, stream banks, and lake shores); animal, pet, and livestock waste; human waste (on-site wastewater treatment systems [OWTSs] and wastewater treatment facilities [WWTFs]); and fertilizer runoff. Internal sources are those nutrients which originate from an external source that become trapped in waterbodies (particularly in lakes and reservoirs) and are recycled annually.

Excess amounts of nutrients in water bodies leads to excess algae production, which in turn may lead to decreased oxygen levels that disrupt aquatic life. Blue-green algae (cyanobacteria) thrive in nutrient enriched waters and when conditions are right will produce large “blooms”. Blue-green algae produce cyanotoxins which can make humans and animals sick.

While both phosphorus and nitrogen exist in both dissolved and sediment-bound forms, they each have different preferences in how they are transported. Phosphorus has a greater tendency to adhere to soil particles, meaning phosphorus poses a greater threat to surface water bodies via soil erosion and surface runoff. Nitrogen is more readily soluble and poses an increased risk to groundwater contamination through leaching. Nitrogen contamination of groundwater supplies is of particular concern. Elevated levels of nitrate in drinking water are known to cause a disease called methaemoglobinaemia (or “blue baby syndrome”) with infants. The introduction of anthropogenic fertilizers (primarily nitrogen based) for row crops causes an increased risk of contamination from those land uses.

Sediment

Sedimentation and excessive soil erosion also contribute to impaired water quality. Alone, sediment can degrade water clarity (typically measured as turbidity) which is both harmful to aquatic habitat and is aesthetically undesirable. Excessive sedimentation diminishes the suitability of instream and streamside habitat for fish and wildlife. Sediment buries river and reservoir/lake gravel substrate that supports spawning and foraging habitat for benthic and other aquatic organisms. Sedimentation reduces the capacity of reservoirs, which in turn reduces its productivity and ability to attenuate other pollutants.

Pollutants can adhere to sediment, which then acts as a transport mechanism to a waterbody. Sediment associated contaminants such as minerals or organic compounds can be passed on to fish, birds, and mammals from consuming bottom-dwelling fish and organisms in lakes and streams. The EPA has identified sediment pollution as a potential source of contamination for consumable fish, which may pose several health risks to humans. The *Wadeable Streams Assessment* done in 2004-2005 by the EPA reported that increases in nutrients (e.g., nitrogen and phosphorus) and streambed sediments have the highest negative impact on biological conditions (NDEQ, 2015a).

The two primary sources of sedimentation are landscape erosion (sheet, rill, and gully) from upland areas and streambed/bank erosion. The erosion of stream banks is a natural process that can have beneficial impacts on the creation and maintenance of riparian habitat; however, excessive erosion can smother submerged aquatic vegetation, fill in riffle pools, and contribute to increased levels of turbidity and nutrients. Excessive erosion from within streams is largely due to hydromodification, which is the alteration of the natural flow of water through a landscape. In the planning area, this has primarily been due to changes in watershed hydrology (runoff) and the channelization of streams. An additional source of soil erosion, which essentially only impacts lakes, is shoreline erosion. Shoreline erosion rates are determined by soil types, bank height, lake orientation, lake fetch, lake depth, and recreational activities such as power boating (Asplund, 1996).

Erosion and sediment loading happens as a result of two separate processes: precipitation events and baseflows. During precipitation events, water causes erosion and the transport of sediment through surface runoff, causing erosion of uplands. Precipitation also increases stream flows, causing increased streambank and bed erosion. During dry periods, or when there is no precipitation, stream bed and bank erosion still takes place due to the baseflow of the stream; however rates are much lower than during storm events.

Atrazine

Atrazine is one of the most heavily used pesticides in North America (USEPA, 2003a). Atrazine is a potent endocrine disrupter, and even extremely low dose exposure is linked to a number of serious health affects in animals and humans. Fish and amphibians are most vulnerable and it is known to compromise growth, behavior, immune function, and gonadal development.

Atrazine is a triazine herbicide currently registered for use on broadleaf plants and some grassy weeds. Although atrazine can be used for a variety of purposes, its greatest use is on corn and sorghum (USEPA, 2018). Sorghum is not a dominant crop within the planning area; therefore, land used for corn production is presumably where the majority of atrazine is applied and is thus considered the source of atrazine in the planning area.

POLLUTANTS NOT ADDRESSED

For the purposes of this plan, point sources of pollution such as wastewater treatment facilities (WWTF) were assumed to be meeting permitting conditions and not contributing beyond the pollutant limits set by permits. Permitted Animal Feeding Operation (AFO) facilities are designed to contain any runoff that is generated by storm events weaker in intensity than a 25-year storm event. Therefore, management recommendations and associated load reductions were eliminated from further consideration for these point sources. However, initial analysis was necessary in order to distinguish pollutant loads between point and nonpoint sources.

Pollutants that originate from naturally occurring sources (independent of human activity) will not be addressed in this plan. These include iron, chloride, and selenium. Additionally, several other water quality parameters, which are listed as causes of impairments in the 2016 IR, are not directly addressed in this plan. These include dissolved oxygen, ammonia, chlorophyll-a, and pH. For the purposes of this plan, which addresses the management of nonpoint source pollution, these parameters are not considered to be pollutants. These water quality parameters serve as symptoms of pollution, rather than the cause of pollution. Thus, they are expected to show improvements through actions addressing sediment and nutrient pollutants during the implementation of this plan. Additional discussion is provided within Chapter 10, 11, and 12 for target areas with these impairments.

Fish tissue contamination was not addressed in this plan due to the global nature of the sources. Mercury is a naturally occurring substance but can enter the environment from human activities, including atmospheric deposition from air emissions and improper disposal of products containing mercury. When mercury from human activities enters rivers and lakes, it can transform in methyl-mercury and accumulate in fish tissue. Consuming fish that contain mercury is considered a primary path for human exposure. Because the majority of mercury contamination is caused by air emissions, which are not contained by watershed boundaries, it is not a pollutant that can be addressed through typical nonpoint source implementation and will be given no further consideration in this plan.

5.07 POLLUTANT SOURCES

LAND USE

Pollutant loading assessments conducted on target areas were centered on runoff generated from specific nonpoint sources of pollution. In some cases, similar land cover types were grouped to define one source. The area in each land cover category was either determined through the 2016

USDA Cropland Data Layer for landuse/landcover data or estimated from aerial photography. In-lake sources of sediment and nutrients were also evaluated for target areas that included lakes. A description of each source is provided below.

Urban (Developed)

Developed, in this case, does not indicate that the land is being used for crop production. Urban land refers to any areas that have been developed specifically for human habitation. Under this definition, both the smallest villages and the largest cities are considered urban. These lands are also interchangeably described as developed, which only means that they have been altered for humans through the construction of roads, buildings, power lines, sewer systems, buildings, or for any number of other amenities. This landuse category also includes acreages and farmsteads, which are found outside of the corporate limits of communities. Most urban land is considered to be “impervious”, that is nearly all precipitation that falls on these surfaces (parking lots, streets, etc.) runs off and doesn’t infiltrate into soil.

Developed land contributes to nutrient pollution from soil erosion and fertilizer application to lawns. Soil erosion is typically low due to increased impervious surfaces unless construction or land clearing is occurring. Urban wildlife and improper disposal of pet waste are both sources of bacterial and nutrient contamination. While urban areas make up a small portion of the land use, the relative contribution may be much higher due to a lack of natural vegetation and increased runoff when compared to other land use types.

It is worth noting that the *E. coli* concentrations reported in the *Antelope Creek Watershed Basin Management Plan* (EA, 2012) for developed areas are typically 5 to 10 times larger than those report by the National Stormwater Quality Database (http://www.bmpdatabase.org/nsqd.html) for similar urban land use types. The *E. coli* concentrations reported by (EA, 2012) were based upon locally collected stormwater quality data. Therefore, for the purposes of this plan, it was assumed that these concentrations were generally representative for the other developed areas in the planning area. As more water quality data is collected in the planning area, it is recommended that the assumed *E. coli* concentrations for each land use be updated, and the results of this tool revaluated to further asses the feasibility of achieving required load reductions.

Cropland

Most of the cultivation that occurs in the planning area is generally associated with either corn or soybean production. Cropland contributes to nutrient pollution through soil erosion and the application of commercial fertilizer. This land may have increased erosion due to its limited amount of perennial vegetation or groundcover most of the year, leading to increased sediment loss and the formation of rills and gullies. Bacterial pollution from cropland is primarily associated with wildlife and manure applied as fertilizer. Most atrazine originates from land used for corn production. Cropland also includes areas used to produce annual and perennial crops other than corn or soybeans. This category can include oats, rye, sorghum, winter wheat, barren, and idle cropland. Because of the differences in hydrologic function and pollutant source originating from various crop types, these may be split out separately (when appropriate) in the water quality modeling.

Forest

This land cover category is comprised of both deciduous and evergreen forests, as well as areas of thick brush. Forest land found in the planning area is primarily limited to riparian and natural areas. An exception is the bluffs along the Platte and Missouri Rives where the ground is not suitable for large scale crop production. Forests contribute to nutrient and sediment pollution through soil erosion; however, it is often minimal due to the high amount of perennial vegetation and groundcover present. Bacterial pollution from forests is primarily associated with wildlife

Grass/Pasture

This land cover category includes areas with permanent grasses such as: lands enrolled in the Conservation Reserve Program (CRP), pastures, prairies, and developed open space. Developed open space, typically parkland, is a small part of this land use. Most of this land can be used for livestock grazing or the production of hay crops, typically on a perennial cycle. Grass/pasture land uses contribute to nutrient and sediment pollution through soil erosion but is often minimal due to the high amount of perennial vegetation and groundcover present. Bacterial pollution from this land use is primarily associated with wildlife or from when livestock are present during the year.

ANIMAL FEEDING OPERATIONS

Animal feeding operations (AFO) are facilities that confine livestock in a limited feeding space for an extended period of time. The Nebraska Livestock Waste Management Act authorizes the NDEQ to regulate discharge of livestock waste from these operations. Nebraska's Livestock Waste Control Regulations (Title 130) classifies AFOs as small, medium, or large operations based on the number and type of livestock confined in the facility (NDEQ, 2011b). Title 130 also requires inspection of medium and large operations to assess the potential for waste discharge. Depending on the size of the operation and potential to discharge pollutants, the operation may be required to obtain a construction and operating permit for a waste control facility from NDEQ. AFOs confining less than the equivalent of 300 beef cattle are considered administratively exempt from inspection and permitting unless they have a history of discharging or the potential to discharge pollutants to Waters of the State.

For the purposes of this plan, permitted AFOs (typically medium and large operations) are not considered a pollutant source due to regulatory requirements. Non-permitted AFOs (typically small operations) do not have regulatory requirements imposed on them and are thus treated as potential nonpoint sources of pollution for management recommendation purposes.

Permitted Animal Feeding Operations

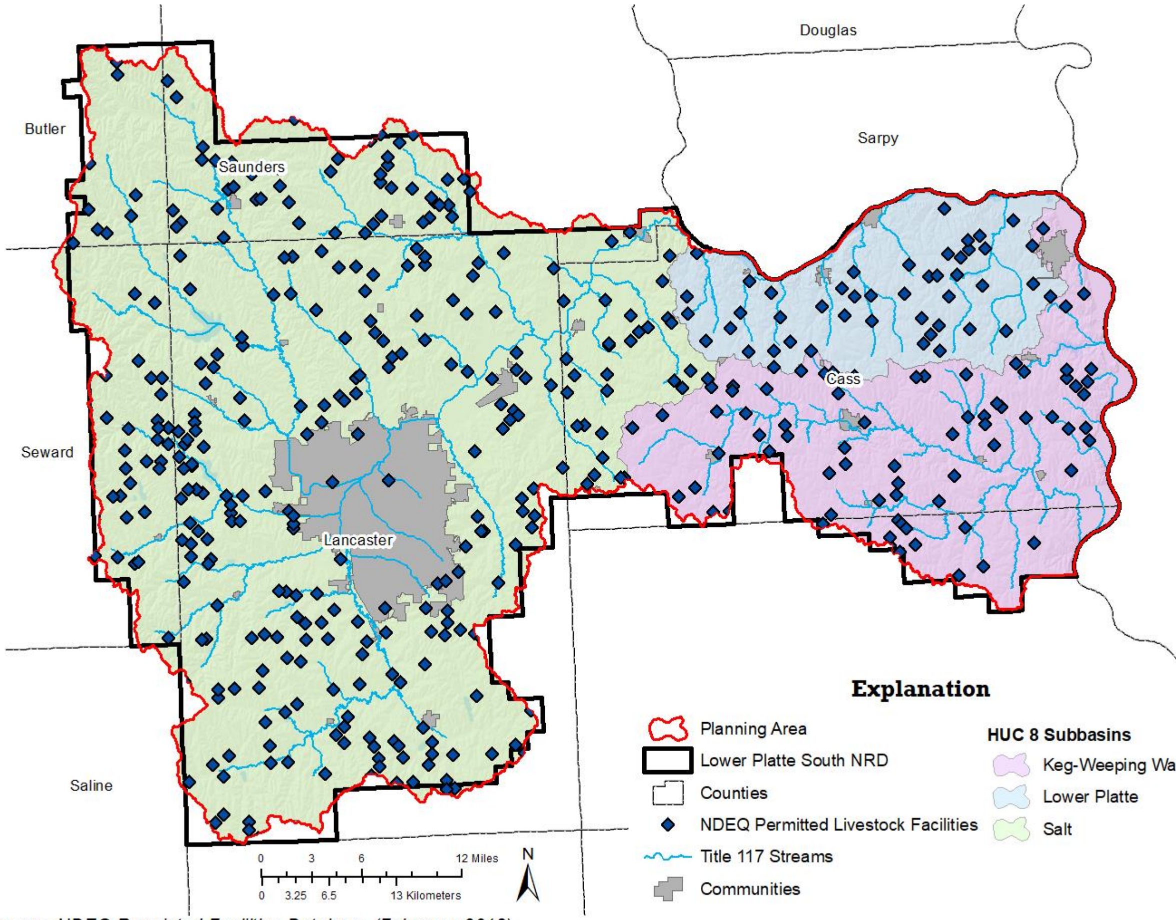
Active animal feeding operations are considered potential sources of *E. coli* bacteria. Figure 56 shows the AFOs within the planning area that have been entered into the NDEQ permitted livestock facilities database. As of February 2018, there were 431 permitted AFOs within the planning area. Table 40 provides the number per HUC 8 subbasin, and a complete list can be found in Appendix G. Each AFO may have more than one livestock waste control facility (LWCF). An operation that has discharged livestock waste to Waters of the State or has been determined by NDEQ that such a discharge is more likely than not to occur is required to obtain a permit issued by the State of Nebraska for construction and operation of a LWCF. These facilities are designed to contain any runoff that is generated by storm events that are less than or equal to a 25-year, 24-hour rainfall event.

Land application of liquid or dry manure from a LWCF is a recognized way of controlling the discharge from these facilities, as well as recycling nutrients from the AFO. Certain controls are required to be in place and must be documented in a nutrient management plan, which NDEQ maintains a copy of. Records and controls for non-permitted AFOs are not required to be kept.

Table 40: Permitted Active AFOs within the Planning Area

HUC 8 Subbasin	Number of Permitted Active AFOs
Salt	407
Keg-Weeping Water	46
Lower Platte	71
Total	**431**

Source: NDEQ Regulated Facilities Database (NDEQ, 2018b). Data is based on registered livestock waste control facilities (LWCF), and mailing addresses for each, which may not always be the same as the physical address of each facility.
Note: this count is based on planning area boundaries, not LPSNRD boundaries



Source: NDEQ Regulated Facilities Database (February, 2018)

Figure 56: Permitted Active Livestock Facilities in the Planning Area

Non-Permitted Animal Feeding Operations

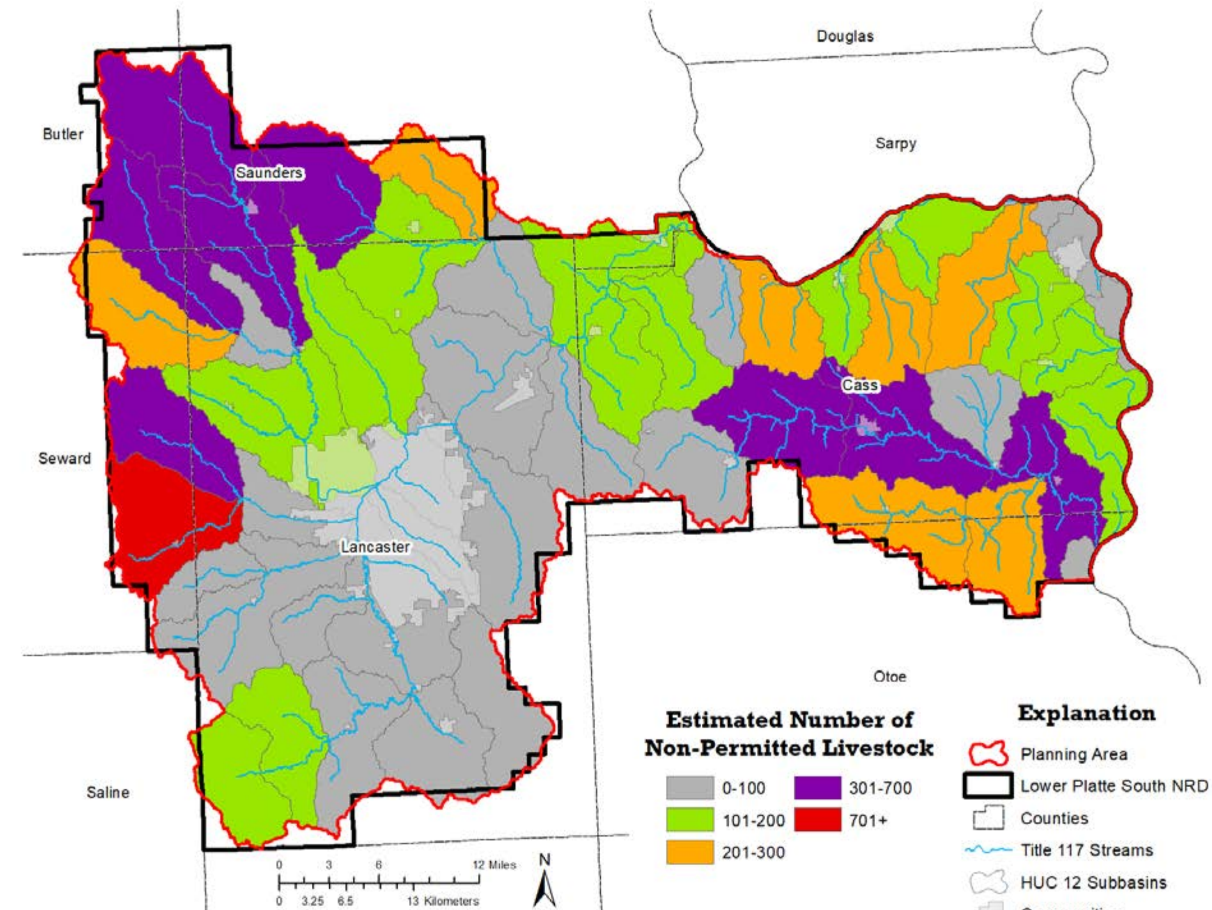
There are approximately 46,500 cattle associated with permitted livestock facilities in the planning area. However, according to the 2007 agricultural census data, there are approximately 54,950 total cattle in the planning area. This means that the remaining cattle are associated with non-permitted AFOs. Cattle manure associated with non-permitted AFOs can be assumed to be found in varying locations depending on the time of year and how a producer might manage their AFO. Cattle and their manure may be found in heavy use areas (i.e. barnyards, stables, wintering areas, and open lots) or found grazing in pastures or other fields. Because of the high amount of grassland in the watershed, it is anticipated a high number of non-permitted cattle spend time in these areas. The exact number and location of non-permitted AFOs in the watershed is not known as their location and other information is not recorded in NDEQ's database of permitted livestock facilities. Non-permitted facilities may include both pasture/grazing based operations and confinement/feed lot based operations; however, due to the lack of data, a distinction cannot be made between them in this plan.

To estimate the distribution of non-permitted livestock, a visual analysis of aerial imagery was completed to identify potential non-permitted AFO facilities. Additional discussion on this analysis can be found in Appendix D. These operations were common throughout the planning area, as can be seen below in Table 41 and Figure 57. Non-permitted AFOs may contribute to bacteria, nutrient, and sediment pollution due to animal waste and vegetation removal from heavy use areas and streambanks with cattle access.

Table 41: Estimated Non-Permitted Livestock within the Planning Area

HUC 8 Subbasin	Estimated # of Non-Permitted Cattle
Salt	1,282
Keg-Weeping Water	4,771
Lower Platte	2,236

Note: this count is based on planning area boundaries, not LPSNRD boundaries



Source: JEO analysis of: USDA Agriculture Census (2012), NDEQ (July, 2017)

Figure 57: Estimated Number of Non-Permitted livestock per Subwatershed

On-site Wastewater Systems (Lagoons/Septic Tanks)

Illicit connections, discharges, combined sewer overflows, sanitary sewer overflows, straight pipes from septic tanks, underperforming septic systems, or other underperforming on-site wastewater systems can also be sources for *E. coli* bacteria. Under Title 124 Chapter 3, NDEQ requires anyone doing work associated with onsite wastewater systems to be certified by the State of Nebraska, and requires systems constructed, reconstructed, altered, or modified to be registered (NDEQ, 2012). As of February 2018, a total of 3,309 onsite wastewater systems have been registered within the planning area (Table 42). Systems installed prior to 2001 were not required to be registered; therefore, the exact number of septic systems or underperforming septic systems is not possible to determine. According to the National Environmental Services Center (NESC), it is estimated that 40% of all septic systems are presently underperforming and about 6% of systems are either repaired or replaced annually (NESC, 2013).

The number of unregistered on-site wastewater treatment systems (OWTS) was estimated using the Spreadsheet Tool for Estimating Pollutant Loads (STEPL) data server (TetraTech, 2013). Septic system data for each HUC 12 subwatershed is based on septic system surveys performed by the National Small Flow Clearing House in 1991 and 1998. There are an estimated 9,864 unregistered OWTS within the planning area (Table 42). Registered OWTS were downloaded and mapped into their respective HUC 12 subwatershed from the NDEQ Interactive Mapping Tool (NDEQ, 2018b). While the load from both registered and non-registered systems was estimated for modeling purposes, only non-registered systems were included in the implementation strategy.

Table 42: Registered and Unregistered On-site Wastewater Facilities within the Planning Area

HUC 8 Subbasin	Registered	Unregistered
Salt	2,585	6,010
Keg-Weeping Water	392	1,565
Lower Platte	332	2,289
Lower Platte	332	2,289

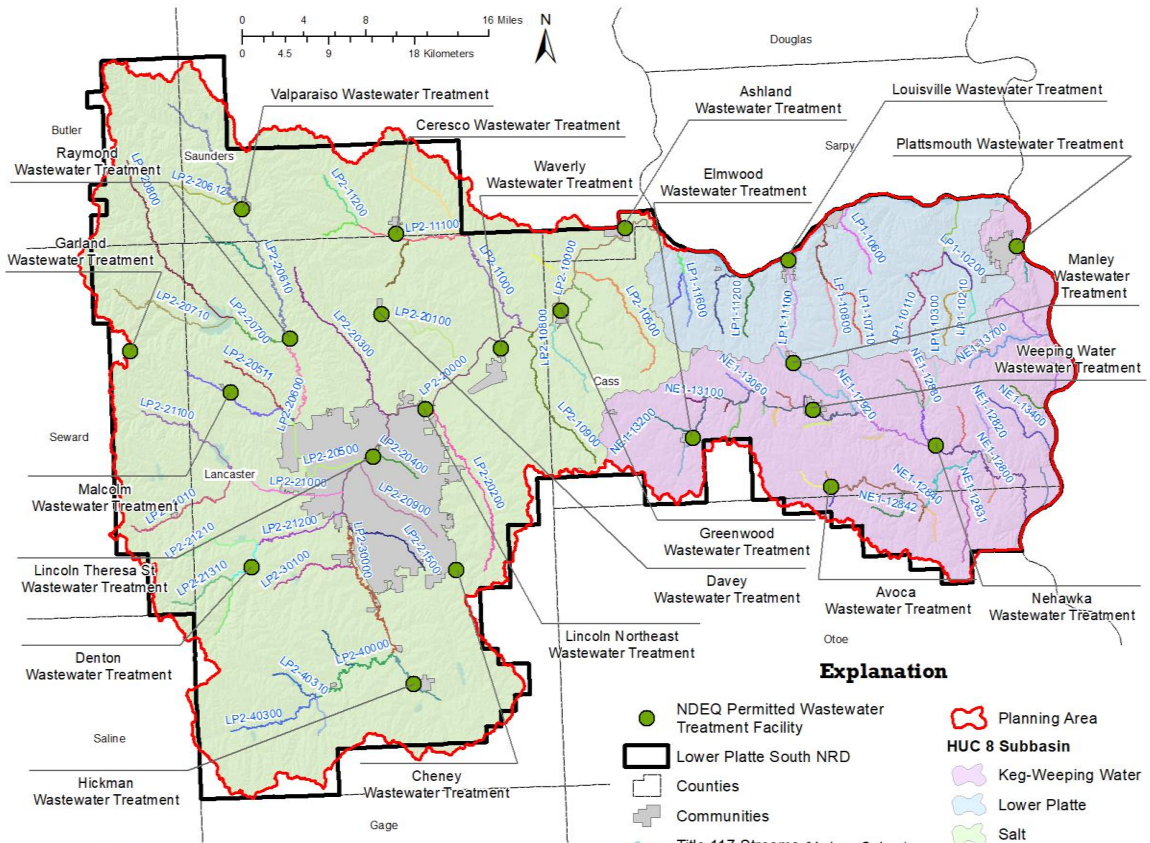
Source: NDEQ, 2018b and TetraTech, 2013

Note: this count is based on planning area boundaries, not LPSNRD boundaries

WASTEWATER TREATMENT FACILITIES

Point sources discharge, or have the potential to discharge, wastewater to Waters of the State in the planning area. Facility types include municipal, commercial, and industrial wastewater treatment facilities (WWTF). Facilities that have been issued a National Pollutant Discharge Elimination System (NPDES) Permit (according to EPA's Enforcement and Compliance History Online) in the planning area are listed in Appendix G and are shown in Figure 58. Under Section 503 of the Clean Water Act, WWTFs may dispose of sewage sludge through land applications. Sludge is land applied after proper stabilization and is incorporated into the soil at agronomic rates. Improper or over-application of sludge may potentially cause bacteria impairment to surface water. Nebraska is not a 503 authorized State; therefore administration of Section 503 of the CWA falls within the authority of the EPA's Bio Solids program.

There are 21 permitted WWTFs with the potential to discharge to the water bodies in the planning area. Annual point source loadings were based on the NDEQ 5-alt analysis, which provides Waste Load Allocations (WLA) for each permitted discharge in the planning area.



Source: NDEQ Regulated Facilities Database (June, 2017)

Figure 58: NPDES Permitted Facilities in the Planning Area

IN-LAKE POLLUTANT SOURCES

Lake Bottom Sediment - The sediment at the bottom of a lake or reservoir plays an important role in the overall nutrient dynamics of shallow lakes, such as those found in the planning area. Internal phosphorus loading originates from a phosphorus pool which accumulates in the sediment. Sediments can release phosphorus into overlying water under certain environmental conditions, which may have a significant impact on water quality.

Bottom Sediment Re-suspension - Phosphorus contained in the bottom sediment can also be introduced into the water column through sediment resuspension. Resuspension is caused by wind and wave action or by some species of fish, which stir up bottom sediments during feeding. Some recreational activities, such as power boating, can also increase sediment and nutrient resuspension.

Shoreline Erosion - As reservoirs age, they lose depth due to sediment deposition from the watershed. Shoreline/bank erosion processes can add additional sediment and pollutants to the reservoir while affecting the depth and habitat diversity of shorelines. Physical factors, such as bank height, prevailing winds, fetch, and the amount of vegetation on the banks and in the water, can dictate the extent of shoreline erosion.

Waterfowl - While lakes provide necessary habitat for aquatic birds, water quality impacts can be felt from a large number of resident and migratory waterfowl. Bird feces can be a significant contributor of nutrients and bacteria to lakes, resulting in increased eutrophication and health risks to recreational users.

5.08 WATER QUALITY MODELING

The resources and information identified in this and other chapters in the plan, along with literature reviews, were used to develop estimates of pollutant source loads within identified target areas using various water quality models. A water quality model allows quantitative predictions about existing pollutant loads, as well as quantifying the effects of implementing various BMPs. Water quality modeling allows managers to evaluate management strategies and show incremental progress towards meeting water quality standards or other goals. Detailed documentation on the approach, inputs, and results of each water quality model can be found in Appendix D.

A simplified modeling approach was developed to meet planning requirements and resource management goals. Figure 59 illustrates the modeling process. This approach was necessary due to the limited amount of water quality monitoring data available over a large geographic area. Various hydrologic and water quality variables for all pollutant sources were utilized to reasonably match existing water quantity and quality data. The watershed yield analysis provided an estimate of annual surface runoff volumes for each HUC 12 by land use, and all models were populated with the most current information and data.

Multiple modeling methodologies were used:

- To model *E. coli* bacteria, a model specific to each HUC 8 subbasin was built in a tabular format in order to identify existing pollutant loads. Modeling results were then provided on a subwatershed (HUC 12) basis. Pollutant load reductions, due to BMP implementation, were only modeled in applicable target areas. *E. coli* loadings from various land use areas were calculated using the Simple Method (Schueler, 1987), which estimates the annual load as a product of the annual runoff volume and associated concentration of *E. coli* in the runoff.

- To model nutrient and sediment, three models were used together: Statistical Tool for the Estimation of Pollutant Load (STEPL) (TetraTech, 2007), Canfield-Bachmann Loading Regression Equation (Canfield and Bachmann, 1981), and Sediment Phosphorus Release Regression Equation (Dzialowski and Carter, 2012). These were only used in target areas.
- Atrazine was evaluated using analytical methods to determine loading capacities and associated load reductions based on water quality sampling data, similar to the methodologies used by NDEQ (NDEQ, 2007a)

Future plan updates will allow additional water quality data and implementation strategies to be evaluated. Model estimates, in conjunction with future plan reviews and monitoring, will be used to show incremental progress towards meeting plan goals.

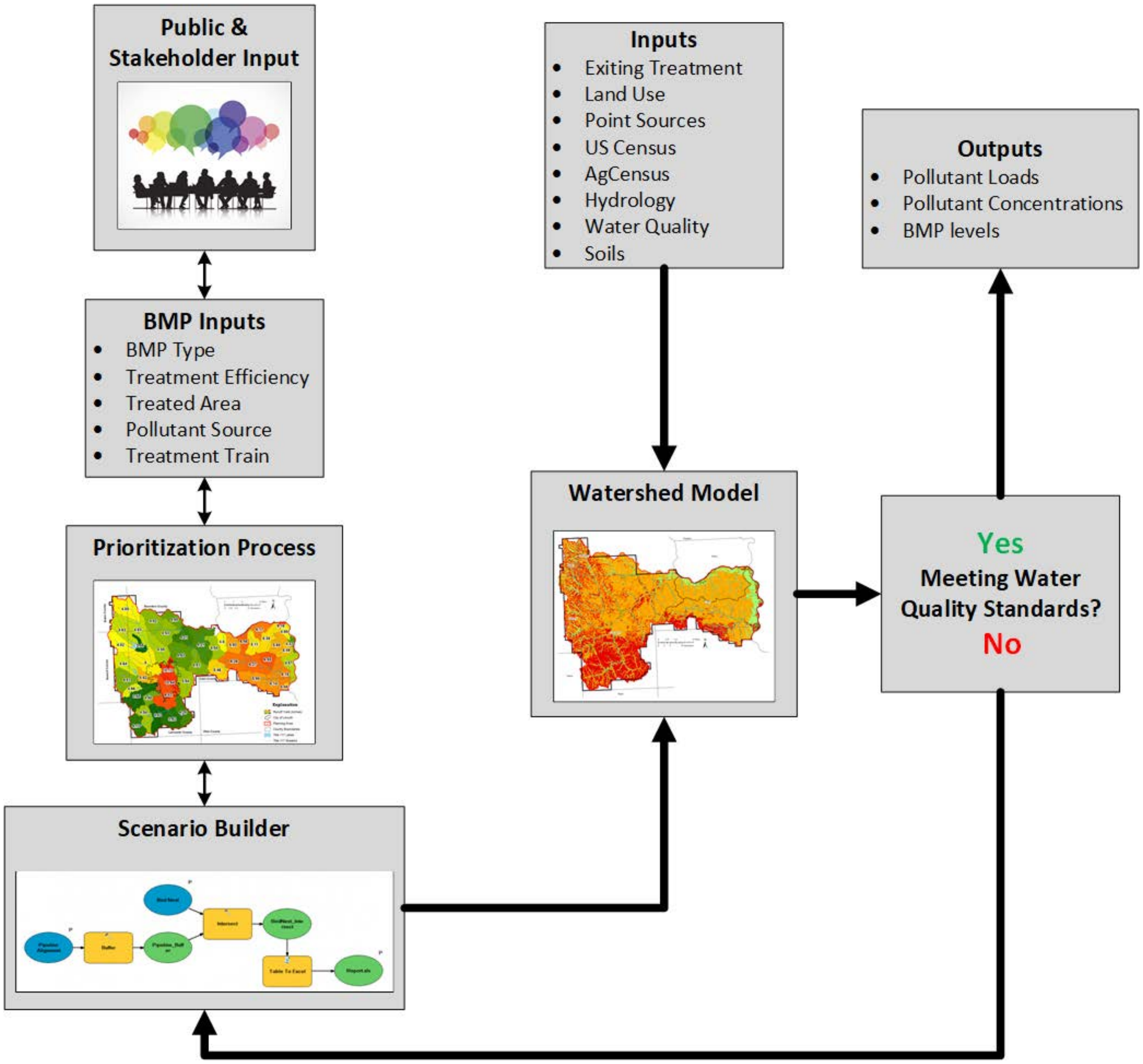


Figure 59: Illustration of water Quality Modeling Process

THIS PAGE LEFT INTENTIONALLY BLANK

CHAPTER 6. COMMUNICATION AND OUTREACH

6.01 INTRODUCTION

Effective communication by project sponsors is critical to faciliate behavioral changes in those responsible for land management decisions. Outreach and education to key stakeholders (i.e. producers, farm mangers, propery owners, land managers, and water users) is vital to achieve plan goals. The success of this plan hinges on the voluntary efforts of landowners and producers. Because this plan is not regulatory, participants must be involved and educated throughout the process to understand and value the benefits of improved water quality. Public involvement is needed for both the initial implementation of the plan and for long term protection and maintenance of BMPs within the watershed.

The intent of this chapter is to discuss the components of an effective communication and outreach program, provide recommendations to enhance existing programs, and use this framework to lay out a general approach to developing Information & Education (I&E) strategies which will support the successful implementation of this plan.

Detailed I&E strategies for each target area are found within the subbasin chapters (Chapters 10, 11, and 12). As projects move forward, additional project level strategies, specific activities, events, and other elements of an I&E program will be developed on a case by case basis. These will be developed as part of a Project Implementation Plan (as necessary). I&E activities will be ongoing and adapt to changes in the planning area in order to meet the needs of specific target audiences. They will support the adoption and implementation of BMPs that address goals and objectives outlined in this plan.

The overarching strategy discussed in this chapter was developed with stakeholder input and by following principles outlined in *The Social Indicator Planning & Evaluation System (SIPES) for Nonpoint Source Management: A Handbook for Watershed Projects* (Genskow and Prokopy, 2011). The SIPES Handbook describes a step-by-step system for using social indicators to help managers plan, implement, and evaluate watershed management projects. The SIPES Handbook provides valuable information and is recommended for use by the *2015 State Nonpoint Source Management Plan*. Additional information about SIPES can be found online at: http://greatlakeswater.uwex.edu/social-indicators.

6.02 STRATEGY DEVELOPMENT

TARGET AUDIENCES

Target audiences can include a specific group of stakeholders, such as solely agricultural producers, or a collective group of stakeholders, such as everyone with water quality interests within a priority area. Stakeholder diversity in both interest and experience is key to making a successful public involvement strategy to relay the message across a wide spectrum. Natural resources managers will be expected to work with community leaders and key individuals to create and deliver the message. The list below identifies key groups to be included as potential target audiences. Note that not all will be targeted for every project, and there may be additional groups identified in the future.

- Recreational water users within each target area
- Land managers, residents, and property owners within each target area
- Producers who utilize cover crops, no-till, grassed waterways, or those with the potential to implement similar type practices
- LPSNRD Board of Directors and staff
- County government staff and elected officials
- City and Village government staff and elected officials
- Saline Wetland Conservation Partnership
- Rural homeowners with private wells and septic systems
- Absentee landowners (local and distant)
- Agricultural retailers
- Civic leaders (Service organizations, non-profits, etc.)
- Youth (FFA, 4-H, ag students, science classes, etc.)
- Beginning/Young Farmers
  - These are important, as sometimes change can only be affected through generational changes

STRATEGIES AND OUTCOMES

There are four strategies within the communication and outreach program objectives: awareness change, knowledge change, behavior change, and generational change. As the I&E activities are implemented, target audiences will be made aware, gain knowledge about, and collectively improve or maintain water quality throughout the plan area and specifically within target areas.

Awareness Strategy

The purpose of an awareness change strategy is to make property owners, agricultural producers, residents, and other key stakeholders aware that water quality issues are present and what actions will be taken to improve water quality. The general awareness strategy includes:

- Build a unifying logo, tagline, and message to create a sense of place and value. The level of implementation (target area verses district-wide), and resources available may dictate how this is accomplished. This would be included on signage and other documents.
- Develop signage to be used at project demonstration sites, key watershed entrances or landmarks, and other highly visible areas.
- Promote the plan through newsletters, flyers, press releases, websites, and key events.
- Recognize, record, acknowledge, and share existing and previous conservation efforts completed by landowners through outreach methods.

Knowledge Strategy

The purpose of a knowledge strategy is to increase knowledge and understanding of: 1) water resource issues across a wide variety of stakeholders, 2) recommended practices or projects, and the 3) plan purpose and goals.

- Identify other groups within the watershed already conducting environmental or conservation education. Partnerships with these groups will be pursued.
- Develop a reporting system to identify successes and failures of projects to the public.
- Provide updates on plan progress and monitoring results through newsletters, flyers, press releases, and websites.
- Provide educational opportunities that focus on specific issues, solutions, and funding opportunities through public meetings, handouts, field days, and classroom activities.
- Stress *why* this plan and the issues in it are important to local landowners and citizens in all I&E activities to help them understand how they are affected locally.
- Develop and organize demonstration sites, tours, and field days.

Behavior Change Strategy

The purpose of a behavior change strategy is to target I&E activities that lead to changes in behavior, acceptance, and adoption of BMPs

- Provide information directly to target audiences on the benefits of BMPs, as well as programs available to assist in their implementation (technical and funding).
- Provide information directly to farm consultants, ag-retailers, and other audiences that have a high degree of influence on landowner and producer decisions.
- Identify and work with a local school to develop a water quality monitoring program, with information derived that benefits students and parents.
- Hold targeted coffee shop meetings, tailgate sessions, and other informal/casual informational exchanges to build relationships and to learn more about the constraints and hurdles to adoption.
- Empower and encourage landowners to promote adoption of new practices through technical and financial assistance.

Generational Change Strategy

The purpose of this strategy is to educate and motivate action from future land managers, producers, residents, and decision makers (i.e., the youth) about the implications of land management on water quality, natural resources, and soil health benefits.

- Include youth activities into project plans, such as a field tour of project sites.
- Provide information to FFA and other similar organizations on water quality, benefits of BMPs, etc.

- Provide targeted information for younger generations at regularly used recreation areas (beaches or picnic shelters) on the importance of watershed management and its relation to water quality within the specific lake where the information is posted.

OUTREACH DELIVERY METHODS

Outreach methods will be customized to the target audience. During the planning process, the more well attended meetings were a result of direct mailings to property owners within priority watersheds. A diverse outreach campaign should be considered using a combination of techniques. Specific outreach methods used in a multi-media communication campaign for information and education may include:

- One-on-one contact – meetings on site to discuss placement of projects or to answer questions on available programs and project opportunities. This is recommended when siting projects within target areas.
- Direct mailing – postcard invites to each property owner within the target area is recommended to improve attendance of public meetings.
- Mass media – radio, newspaper, farm magazines, outdoor magazines is recommended to announce available conservation incentives.
- Electronic media and social media – websites, Facebook, Twitter, Instagram, etc. Recommended in addition to traditional outreach methods.
- Signage – billboards, cooperator recognition signs, traveling displays, demonstration signs are recommended to be put in high traffic areas such as: major intersections, public beaches, entrances to state and local recreation areas, or boat ramps.
- Events – training and demonstration field days and recognition picnics. This is recommended to be held in conjunction with existing events, such as county fairs, nitrogen certification training events, etc.
- Clinics – outdoor recreation (kayaking, fishing, etc.), equipment calibration, BMP maintenance inspection, record keeping.
- On-site project demonstrations – water quality monitoring, BMP installation, and maintenance.
- Curriculum – lesson plans and materials for formal and informal youth education.
- Educators – these may be utilized to initially develop materials or to assist in facilitating information exchange as educators are typically perceived as a neutral party.

EVALUATION

A strategy to evaluate the success of I&E activities should be outlined in each future Project Implementation Plan. Evaluation tools that may be used for evaluation include, but are not limited to:

- Utilize sign-in sheets to record attendance at events over time.

- Evaluation forms that allow participants to self-evaluate awareness-level changes, attitude changes, and intended behavior changes.
- Pre- and post-surveys to evaluate knowledge gained, anticipated behavior changes, need for further learning, etc.
- Evaluation forms which assess I&E activity content, presenters, usefulness of information, etc.
- Follow-up interviews or surveys (one-on-one contacts, phone calls, e-mails, surveys) with I&E activity participants.
- "Market viability tests" for conservation practices to help further understanding of what is acceptable and why that is to landowners.
- Documentation through pictures at public events and meetings.

Evaluation data should be summarized on a project-by-project basis and accumulated to measure achievement of the desired outcomes and to evaluate the program's contribution to specific projects as well as achieving the long-term goals and objectives of the plan.

6.03 ENHANCING EXISTING PROGRAMS

INFORMATION AND EDUCATION COORDINATOR

The LPSNRD has a dedicated Information and Education (I&E) Coordinator on staff that works to inform and educate the public about a variety of environmentally focused topics, including water quality. Having a professional staff member in this capacity puts the LPSNRD in a better position to develop a cohesive I&E strategy for implementing this plan. The I&E strategy in this plan will focus on a coordinated multi-media communication campaign, direct contact outreach methods, coordination with partner agencies, and other actions that will target voluntary changes in behavior.

EXISTING PROGRAMS

The LPSNRD has a variety of existing programs intended to improve soil health, support healthy watersheds, and to encourage property owners to engage in conservation. These programs are summarized below with a strategy to increase use of these programs in target areas.

LPSNRD Cover Crop Program

In 2018, the LPSNRD started a cover-crop program to encourage producers to plant cover crops help landowners plan cover crops that help control erosion and make the soil more productive. This new program is available in select areas. Additional information can be found on the LPSNRD website: https://www.lpsnrd.org/programs/landowner-cost-share/land-treatment

- *Awareness Change*: Producers are encouraged to participate in cover crop workshops that are shared via advertising.

- *Knowledge Change*: Cover crop producers increase their knowledge about the effects and implications of cover crop practices through attendance of LPSNRD, NRCS, or other stakeholder sponsored and promoted workshops.
- *Behavior Change*: Cover crop producers improve production techniques in the district through improved soil health.

LPSNRD BMP Cost-sharing Program

The LPSNRD assists approximately 250 property owners annually with the cost of improvements such as terraces, buffer strips, and filter strips (LPSNRD, 2018). The cost-sharing program is coordinated with other resource agencies such as NRCS and NeDNR. Additional information can be found on the LPSNRD website: https://www.lpsnrd.org/programs/landowner-cost-share/land-treatment.

- *Awareness Change*: Producers in target areas should receive post cards notifying them of the LPSNRD cost-share program.
- *Knowledge Change*: Producers will be informed of the benefits (profitability) to their operation in addition to the water quality goals within target areas, and how their actions can help achieve those goals.
- *Behavior Change*: By understanding the long-term benefits conservation practices can have to their own operations, implementation of practices should increase.

WILD Nebraska

WILD Nebraska is a partnership program between LPSNRD and NGPC that encourages cooperators to re-establish and enhance wildlife habitats on private lands through cost-sharing. The program is divided into grasslands, wetlands, woodlands, and general activities (LPSNRD, 2018).

- *Awareness Change*: Property owners in the district, especially within target areas, are encouraged to participate in WILD Nebraska by increasing advertising of the program.
- *Knowledge Change*: Property owners will learn that their projects can have a collective benefit to improving the health of a watershed.
- *Behavior Change*: Property owners will learn that projects, both large and small, that re-establish and enhance wildlife habitat will also protect water resources leading to increased implementation of the project.

Saline Wetlands Conservation Partnership

The City of Lincoln and LPSNRD are leading an effort to address saline wetland conservation needs, as part of the Saline Wetlands Conservation Partnership (SWCP). This group, led by a coordinator, works with private landowners to encourage wetland protection and provides outreach, feedback, planning, and coordination.

- *Awareness Change*: The SWCP will consider an outreach campaign to educate property owners on the benefits of streambank stabilization and riparian buffers within the Upper Little Salt Creek subwatershed.
- *Knowledge Change*: Property owners understand the value of this unique resource and learn about financial assistance opportunities to improve their own property, thus protecting downstream wetlands.
- *Behavior Change*: Using financial assistance incentives, property owners will consider installing and maintaining healthy riparian buffers to reduce downstream sedimentation.

6.04 PROJECT IMPLEMENTATION

Targeted communication and outreach will be necessary for achieve BMP implementation in a comprehensive manner at identified target areas. Chapters 10 -12 identify specific audiences and strategies for project level communication and outreach. As projects are developed for each of those target areas, the following information will need to be clearly identified and included in a Project Implementation Plan (as applicable). This information should be tailored to the target audience within each target area:

- Communication priorities – urgent needs vs. general needs
- What level of detail do they need to know?
- What subject area is most appropriate for which audience?
- How do audiences best receive and process information?
- What is the expected outcome of I&E programming? (i.e., awareness, knowledge, attitude/behavior change, action)
- What are the obstacles for this target audience?
- How do you measure the effectiveness of I&E programming with the specific target audience (evaluation)?

THIS PAGE LEFT INTENTIONALLY BLANK

CHAPTER 7. MANAGEMENT PRACTICES

7.01 INTRODUCTION

An important step in finding solutions to address nonpoint source pollution is to create a toolbox of practical management alternatives that can be utilized by landowners, producers, resource managers, and others. A variety of proven and modern management measures for upland, stream, lake, and groundwater resources are currently available to achieve improved and protected water quality. This chapter describes structural and non-structural measures that have been identified for their capability to address the primary pollutants degrading water quality in the basin: total nitrogen, total phosphorus, sediment, bacteria, and atrazine.

The suitability and performance of management techniques can vary significantly based on site conditions (e.g. soils, slope). While the focus of the plan is centered on target areas, this list is intended to be general in nature and can be used for applications throughout the entire planning area. Site specific BMP recommendations for each target area, along with pollutant reduction estimates, are described later within individual HUC 8 subbasin chapters.

NOTE TO READERS

The BMP examples and references included in this plan are not intended to be comprehensive - this list does not preclude the LPSNRD or its partners from using other technically sound practices.

Due to the large number of practices available to improve water quality, detailed reviews for each practice was not possible within this plan. The USDA currently lists more than 1,100 practices that are eligible under the Environmental Quality Incentives Program (EQIP) program. Details on the magnitude, cost, water quality benefits, and maintenance of specific practices can be provided by appropriate experts or found in technical documents such as the *NRCS Field Office Technical Guide* and the *Agricultural BMP Handbook for Minnesota* (MDA, 2012).

Selection of various management practices or actions should consider not only the watershed or field level characteristics, but also the management goals and technical and financial resources available. Additionally, political and social and political realities will need to be considered. Support from the LPSNRD Board of Directors will be necessary to approving cost-share applications or implementing new programs. Finally, because this is a voluntary plan, most projects will need willing landowner participation. Projects can be implemented much more effectively and successfully when public and landowner buy-in is garnered through active involvement during the planning process.

A small list of priority practices has been identified based upon stakeholder feedback during the development of this plan and available modeling or BMP siting tools. These were identified to focus the planning efforts on the likely actions to be implemented. Information on treatment efficiency and how the priority practices were utilized in the water quality model is also presented.

Water quality modeling was used to assist in developing an implementation plan, which identifies where and at what level management practices and monitoring will be implemented within target areas. Implementation strategies have been developed for target areas and outlined in Chapters 10 - 12.

By implementing the LPSNRD District-wide WQMP it is expected the impaired waterbodies will meet water quality standards quicker than pursuing the development of a TMDL due to active stakeholder interest and investment in implementing BMPs in areas that have been identified in Chapters 10 - 12 to be contributing the highest pollutant loads.

7.02 PRACTICE CLASSIFICATION

Water quality management practices have many names. For example, NDEQ refers to management practices as *conservation practices* (CP) in the State Nonpoint Source Management Plan (NDEQ, 2015b). However, they are more commonly identified as *best management practices* (BMPs); therefore, BMP will be used throughout this plan. Many BMPs will help reduce loads from multiple pollutants, while other practices are designed for a single pollutant. Most BMPs offer site-specific control of nonpoint source pollution. Classification of BMPs is based upon the primary construction/implementation requirements. Practices are generally divided into two types: structural and non-structural, as described below.

STRUCTURAL BMPS

Structural practices typically consist of the construction of physical barriers that intercept, trap, treat, or remove pollutants from runoff or that prevent pollutants from entering runoff. Examples include terraces, dams, and grassed waterways. Structural techniques tend to be more durable, although they do require periodic maintenance. These techniques are more effective when used in tandem with non-structural practices. In most cases, structural practices require a greater level of cooperation from the landowners, as they may be more invasive or the benefits might impact their day-to-day operation. This can lead to structural practices being more expensive to implement and maintain than non-structural practices; however, they also typically provide longer term benefits.

NON-STRUCTURAL BMPS

Non-structural practices rely on in-field management actions to control and treat pollution. The goal of these practices is to avoid or lessen the severity of degradation at the source. Examples of non-structural practices include: no-till farming, irrigation management, cover crops, chemigation, and other nutrient management practices. Implementation of these practices typically only requires a decision by the landowner or operator to adjust their existing operational practices. A benefit of these practices is that they typically allow land to stay into agricultural production. A challenge with the implementation of non-structural BMPs is that they are much less permanent in nature and must be spread throughout the watershed to be effective. This can provide challenges in documenting the level of BMP treatment across a watershed. These practices are most effective when they are fully integrated into a producer's operations and management.

7.03 SYSTEMS APPROACH TO MANAGEMENT

Management of nonpoint source pollution is most effective when a multi-practice systematic approach is taken to eliminating pollutants at the source, rather than mitigating them at their point of delivery. This is also known as a "treatment train." BMPs that work cohesively deliver more effective pollutant control than a single practice can provide. The NRCS has identified this system through the acronym "ACT" (Avoid, Control, Trap) and NDEQ describes these actions as follows (NDEQ, 2015c):

> **Avoid (A).** It is sometimes feasible to eliminate contamination at the source by discontinuing a potentially harmful activity or use of a particular product. Discontinuing the use of a pesticide, for example, would completely eliminate that product from the runoff stream. When discontinuing an activity or product is not feasible, altering the activity or application of a product may significantly reduce, but not eliminate, contamination from that source. For example, limiting livestock access to a stream or changing the rate and timing of chemical application can reduce contaminant runoff. Where complete avoidance is not feasible or acceptable, it is important to employ additional complementary BMPs to further reduce contaminant runoff.
>
> **Control (C).** Practices that control the direction and rate of runoff can provide additional reduction of contaminants during precipitation events. These practices allow precipitation, infiltration, absorption or attenuation of contaminants before they reach a receiving water. Filter strips and porous pavement, for example, facilitate infiltration of runoff water into the soil where natural processes degrade and absorb contaminants.
>
> **Trap (T).** When avoidance and control of pollutant runoff is unfeasible or inadequate, trapping contaminants before they can discharge into receiving waters may be a necessary last line of defense. The distinction between practices that control contaminants and those that trap contaminants, however, is somewhat ambiguous, as the practices function in much the same way: precipitation, infiltration, absorption, or attenuation of contaminants. Many BMPs provide both functions. A sediment basin or constructed wetland designed to intercept flow and remove contaminants before discharging to a receiving water are the clearest examples of practices employed to trap contaminants.

7.04 COMMON BMPS

Many BMPs have proven effective in reducing nonpoint source pollution and are commonly employed in Nebraska. These actions have been identified in the *2015 Nebraska State Nonpoint Source Management Plan* (NDEQ, 2015b) and are displayed in Table 43. BMPs are loosely grouped together based on the type of landscape or by the pollutant they are used to address. However, many of them can be used in a variety of settings as well as in tandem with other practices. Practices effective in restoring or protecting groundwater resources from the impacts of nonpoint source pollution are also included in the table. For simplicity, practices that are effective at treating Atrazine are provided separately in Table 44. Descriptions of more commonly used practices are located in Appendix E.

The table below is intended to provide examples of the most commonly accepted practices in Nebraska. However, it is not meant to preclude other innovative practices that may be appropriate to specific projects or site conditions. While this list provides a look inside the "tool box" that managers have, a smaller list of priority practices was selected to be the focus in this plan.

Table 43: Common Conservation Practices

Practice	Practice Mode of Action			Pollutants Addressed		
	Avoid	Control	Trap	*E. coli*	Sediment	Nutrients
Cropland						
Filter/buffer strip		x	x	x	x	x
Contour farming		x	x		x	x
Integrated pest management	x	x				
Underground outlet/grass waterway		x	x		x	x
Crop to grass/habitat/CRP conversion	x				x	x
Irrigation management	x	x			x	x
No-till		x	x		x	x
Soil sampling*	x					x
Terraces/diversions		x	x		x	x
Retention basin		x	x	x	x	x
Detention basin*		x	x	x	x	x
Sediment control basin		x	x	x	x	x
Non-Permitted Livestock						
Alternate water supply	x			x	x	x
Manure management at AFO Facilities	x	x		x		x
Reduced nutrients in feed*	x					x

Practice	Practice Mode of Action			Pollutants Addressed		
	Avoid	Control	Trap	*E. coli*	Sediment	Nutrients
Pasture management/Prescribed grazing	x	x		x	x	x
Exclusion fencing	x			x	x	x
Urban						
Pet waste management	x			x		x
Porous pavement		x	x	x		x
Bioswale		x	x	x	x	x
Soil amendments	x	x	x		x	x
Rain garden		x	x	x	x	x
Rain water harvesting	x	x		x	x	x
Low-impact landscaping	x				x	x
Low or No-phosphorus Fertilizer*	x					x
Low impact development (LID)						
In-Stream or Riparian Corridor						
Remeandering	x		x	x	x	x
Oxbow reconnection	x	x	x	x	x	x
Floodplain construction/reconnection		x	x	x	x	x
Streambank stabilization		x		x	x	x
Grade stabilization structure		x			x	
In-stream/constructed wetland		x	x	x	x	x
Riparian zone renovation	x	x	x	x	x	x
In-Lake						
Sediment removal		x			x	x
In-Lake forebays*	x		x	x	x	x
Alum application		x	x			x
Lake aeration*		x				x
Shoreline stabilization		x			x	x
Fish renovation*	x					x
Aquatic habitat development	x	x		x	x	x
In-Wetland						
Constructed wetland		x	x	x	x	x
Wetland renovation*		x	x	x	x	x
Groundwater						
Well sealing	x			x		x

Practice	Practice Mode of Action			Pollutants Addressed		
	Avoid	Control	Trap	*E. coli*	Sediment	Nutrients
On-site Wastewater Treatment System (OWTS) Upgrade Practice*						
Irrigation management*	x				x	x
Nutrient management	x	x				x
Cover crop	x	x			x	x
Conservation Practice Facilitation						
Conservation consultant	N/A	N/A	N/A	N/A	N/A	N/A
Watershed coordinator	N/A	N/A	N/A	N/A	N/A	N/A
Crop production deferment	N/A	N/A	N/A	N/A	N/A	N/A

Source: NDEQ, 2015b

**denotes practices that have been added based on previous experience and knowledge*

Table 44: Common BMPs That Treat Atrazine

Practice	Practice Mode of Action			Rank*
	Avoid	Control	Trap	
General Pesticide Management BMPs (for reducing pesticide availability in the field)				
Follow integrated pest management (IPM) principles	X	X		2
Follow label requirements for application rates, mixing, loading, and proper disposal of rinsate and containers	X			2
Pesticide rotation/alternative pesticides	X			3
Avoid application if rainstorms are pending within 48 hours	X			2
Delay application on saturated, or wet soil	X			3
Follow mandatory and precautionary, label statements for protecting water resources	X			2
Change in application timing or banding	X	X		2-3
General Cropland Management BMPs (for reducing water and sediment runoff)				
Crop rotation (including using cover crops)	X			2
Crop rotation with 50% legumes, small grains, or grasses	X	X	X	3
Filter strips (along wetlands, streams, rivers, and impoundments)		X	X	1
Grassed waterways (functional)		X	X	1
Terraces (functional) and other earthen structures		X	X	1
Irrigation water management (timing and amount)		X		1

Source: USDA, 2016

**Practices ranked by how effective atrazine runoff is reduced: 3 = highly, 2 = moderately, 1 = slightly*

7.05 ALTERNATIVE & INNOVATIVE MANAGEMENT PRACTICES

In addition to the common conservation practices previously discussed, additional management actions were also identified. These could include actions that may not correlate directly into "quantifiable" loading reductions but assist in plan implementation, or actions that modify a waterbody directly to improve its water quality. These management strategies may also allow stakeholders to achieve additional goals identified in the plan. The following alternative management strategies were identified:

- **Information and Education.** Information and education programs will be ongoing throughout the life of this plan, which may also include conservation practice demonstration sites. Outreach programs build awareness and promote behavioral changes that will improve the success rate of projects and enhance load reductions. Additional discussion can be found in Chapter 6.
- **City of Lincoln Urban BMP Guidelines**. The City of Lincoln has developed comprehensive guidance on a number of urban stormwater BMPs (City of Lincoln and others, 2006). The report provides guidance on selection and design of both BMPs and Low Impact Development (LID) approaches. Many of these BMPs were considered in this plan and will continue to be referenced by project sponsors.
- **Recognize Past and Current Conservation Efforts**. There has been ongoing conservation work within the planning area for a number of years. Recognizing these successful practices and the landowners who have implemented them is useful for outreach efforts and in highlighting success stories. Cataloging this information also helps future estimates of existing treatment levels. Additionally, rehabilitating structures or expanding existing BMP programs may be a way to both reward past conservation efforts of landowners, and increase awareness and the effectiveness of existing treatment options economically. The NRCS's Conservation Stewardship Program (CSP) is a good example of this type of program.
- **Wellhead Protection (WHP) Area Planning**. Each WHP Area (also referred to as CWSPAs in the LPSNRD) has been identified as a special resource area due to the influence it has on the source water aquifers and associated public drinking water systems. Developing and implementing either a wellhead protection plan or a drinking water protection and management plan for each WHP area in the planning area will be promoted. Many of the management recommendations for WHP areas will also contribute to the reduction of pollutants entering surface waters.
- **Water Quality Monitoring**. There are existing limitations in the available water quality data within the planning area. To combat these limitations and benefit future water quality improvement projects, more frequent water quality monitoring at expanded sampling locations, particularly pre- and post-project status, should be used. Additional discussion regarding water quality monitoring is located in Chapter 4.
- **District-wide Initiatives**. In addition to priority BMPs for target areas, there are also multiple practices that should be implemented district-wide. This may include practices

that: don't inherently fit into target areas; enhance landowner involvement; provide information and education; or are opportunities for demonstration sites. Ultimately these programs build awareness and promote behavioral changes to improve the success rates within target areas and enhance load reductions.

7.06 PRACTICE SUITES

In the context of watershed planning, there are instances where numerous BMPs all have the potential to address a certain pollutant source. However, as this plan relies on voluntary landowner and producer involvement, it will be necessary to contact these participants in order to determine which BMPs will meet their specific needs. Coordinating between landowners, producers, and the project sponsor will produce a plan with identified practices that are feasible. For the purpose of this planning effort, some BMP practices have been grouped together into "suites" (which allows for better stakeholder communication, estimating load reductions, costs, etc.). Each practice suite is discussed below.

NON-STRUCTURAL AND AVOIDANCE BMPS

This practice suite will typically be implemented through education and technical assistance and be targeted towards cropland, manure application sites, and all permitted and non-permitted AFOs. Nutrients, *E. coli* bacteria, and atrazine are all addressed. This suite consists of non-structural and management-based BMPs targeted at nutrient, manure, and pesticide management. Specific BMPs will only be determined once a project sponsor meets with a landowner or producer. However, potential BMP actions may include, but are not limited to, the following:

- Planning
- Modified application timing, rates, or placement
- Nitrogen inhibitors
- Changing sources
- Various types of sampling
- The 4Rs of nutrient management (right source, right rate, right time, right place)
- Integrated pest management

GRAZING LANDS MANAGEMENT BMPS

This practice suite will typically be implemented through education and technical assistance; however, conservation payments may assist in some cases. BMPs are targeted at pasture land and address nutrients, sediment, and *E. coli* bacteria. This suite consists of both structural and non-structural BMPs. Specific BMPs will only be determined once a project sponsor meets with a landowner or producer. However, potential BMP actions may include, but are not limited to, the following:

- Exclusion or cross fencing

- Alternative water sources
- Grazing management plans
- Stream crossings

NON-PERMITTED AFO FACILITY BMPS

This practice suite will primarily be implemented with conservation payment assistance; however, technical assistance will also be an important factor. BMPs are targeted at non-permitted AFOs and will address nutrients, sediments, and *E. coli* bacteria. This suite consists of both structural and non-structural BMPs. Specific BMPs will only be determined once a project sponsor meets with a landowner or producer. However, potential BMP actions may include, but are not limited to, the following:

- Animal waste/manure storage systems
- Clean water diversion systems
- Vegetative treatment systems (VTS)
- Terraces
- Containment
- Evaporation ponds
- Open lot runoff management
- Heavy use area protection
- Feed management practices

7.07 ACPF TOOL

In order to identify potential locations and the quantify BMPs recommended in this plan, the planning team utilized a tool developed by the USDA. The Agriculture Conservation Planning Framework (ACPF) tool is used extensively across the Midwest to assist in watershed planning activities. The ACPF tool utilizes modern, high-resolution geo-spatial datasets within the ArcGIS environment and LiDAR data to analyze soils and land use. This analysis assists in identifying a broad range of opportunities to install conservation practices in fields and watersheds. These opportunities can then inform a non-prescriptive approach to encourage farmers and landowners to become engaged in local watershed improvement.

Conceptually, the ACPF tool is based on a “Conservation Pyramid” (Figure 60), which emphasizes soil conservation as the foundation to agricultural watershed management. Well-managed soils lose less water to runoff and leaching, which improves production, and enables additional BMPs to effectively treat any losses that still may occur. These additional BMPs control water flows and trap/treat nutrient losses in fields, at field edges, and in riparian zones. The ACPF tool identifies locations where specific landscape attributes are favorable for installation of each type of BMP and prioritizes these locations according to susceptibility to runoff and erosion losses. The ACPF tool provides an inventory of BMP alternatives which can be considered at field level. Prescriptions and recommendations are left as local decisions. The planning team utilized this tool in each of the agricultural target areas. Individual maps and atlases of the results can be found in Appendix F. Additional details on how this data was incorporated into each of the target area implementation plans can be found in Chapters 10 - 12.

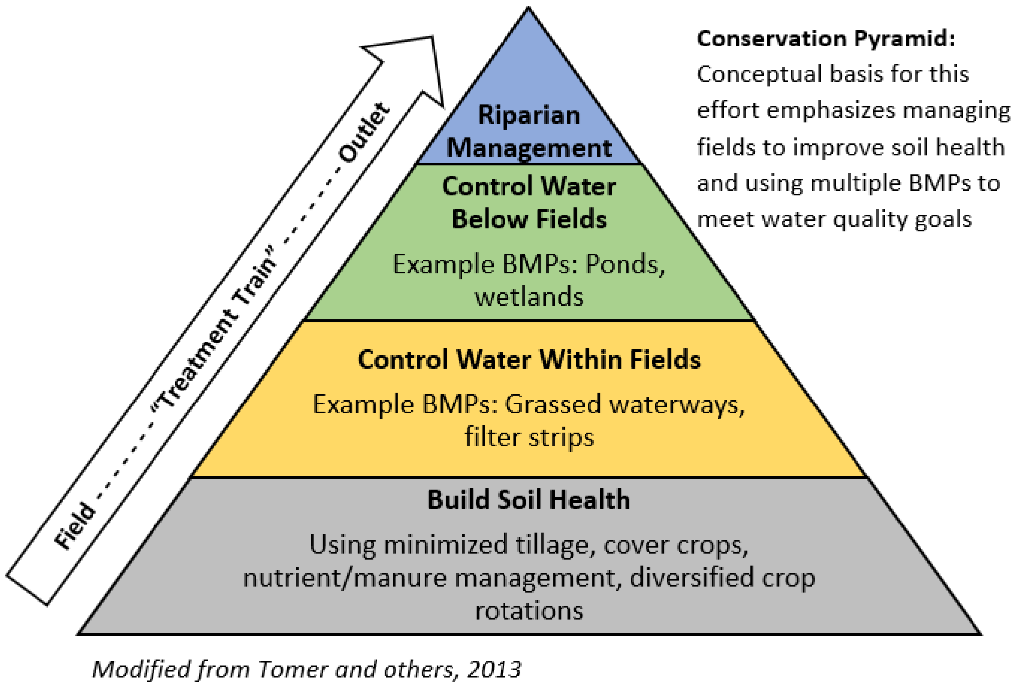


Figure 60: Conservation Pyramid

7.08 PRIORITY PRACTICES

SELECTION

This chapter has identified various types of management practices that could be considered for implementation in the planning area. While these should all be considered viable options for use, it is not practical to evaluate every conservation practice or implementation scenario. In order to develop that list, the following tools/techniques were utilized:

- Agricultural Conservation Planning Framework (ACPF) tool
- Technical Advisory Committee (TAC) input
- Citizen Advisory Committee (CAC) input
- Public review

BMPs and treatment scenarios were reviewed and evaluated through the community-based watershed planning process. BMPs believed to have the biggest impact on water quality and were preferred by landowners were identified as "priority practices." The ACPF tool identified opportunities for structural BMPs; and the TAC and CAC provided input on non-structural BMPs. Additionally, a review of the *Antelope Creek Watershed Basin Management Plan* (EA, 2012) provided additional BMP data for the urban landscape. Priority BMPs were also evaluated on their efficiency in addressing pollutants of concern. Additional consideration was given to those practices which helped to meet additional goals, such as education/public involvement. Table 45 summarizes the priority practices and their treatment efficiencies.

POLLUTANT TREATMENT EFFICIENCIES

The treatment efficiencies shown in Table 45 are used for planning purposes; however, actual performance may be different than documented in the literature. When feasible, it is recommended that pollutant load reductions be calculated from BMPs within the region with statistically based influent and effluent monitoring results. This data may be available in the future if pre-and post-BMP monitoring is implemented. As previously discussed, treatment efficiencies for practice suites are estimated based on the efficiency of each type of BMP in that suite.

Guidance from the literature was used to estimate treatment efficiencies and to assist in identifying where BMPs would be implemented. Detailed descriptions of each practice, efficiencies, modeled implementation levels, and other key assumptions can be found in the water quality modeling reports located in Appendix D. Additional details on locations, total amounts, and load reductions are provided in the respective water quality modeling reports and the ACPF Atlases (Appendix F), as well as summarized in the implementation plans for each subbasin (Chapters 10 - 12).

Table 45: Summary of Priority Practices and Estimated Treatment Efficiencies Summary

Management Practice	Estimated Treatment Efficiency				
	E. coli	**TN**	**TP**	**TSS (Sediment)**	**Atrazine**
Education and Information	10%	10%	10%	10%	10%
OWTS Upgrade Practice	Changes to failure rate in model				
Pet Waste Management	20%	0%	0%	0%	0%
Non-structural & Avoidance BMPs (Working Lands Management)	10%	20%	35%	0%	40%
Grazing Lands Management BMPs	40%	15%	15%	15%	0%
Cover Crops	40%	60%	15%	20%	0%
Riparian Buffers	70%	50%	60%	65%	30%
No-Till Farming	0%	55%	45%	75%	0%
Contour Buffer (filter) Strips	70%	50%	60%	65%	30%
Non-permitted AFO Facility BMPs	75%	60%	80%	70%	0%
Wetlands/Farm Ponds/Sediment Basins	70%	55%	70%	85%	0%
Stream Restoration	35%	77%	77%	77%	0%
Terraces	70%	20%	70%	85%	30%

Water and Sediment Control Basins (WASCOBS)	70%	55%	68%	86%	30%
Grassed Waterways	70%	10%	25%	65%	30%
Urban Stormwater BMPs	30%	40%	43%	78%	0%

Source: Water Quality Modeling
Note: Grassed waterways, and their conceptual locations, were also identified as a priority BMP, however they were grouped with wetlands in the water quality modeling, due to technical limitations.

7.09 EXISTING TREATMENT

Estimating currently treated areas is an important step in the planning process. This knowledge helps to identify possibly priority BMP acceptance and is necessary for water quality modeling calibration. These estimates are also used to determine potential pollutant load reductions that additional treatment could have in the watershed. Unfortunately, no central listing or full inventory exists for this information. The NRCS works with many producers through EQIP and other programs; however, that information is subject to privacy laws. Additionally, many landowners implement BMPs on their own without government assistance.

To estimate the existing level of treatment in the watershed, multiple resources were reviewed and documented in a technical memorandum, located in Appendix C. Table 46 displays estimates for existing treatment levels. The planning team assumed that these levels represented the average across the entire planning area. It is likely that these levels may vary amongst locations in the planning area, and it is recommended that detailed estimates be conducted for inclusion in future updates to this plan.

Table 46: Existing BMP Treatment Levels Across the Planning Area

Management Practice	Estimated Existing Treatment Level
Education and Information	N/A
OWTS Upgrade Practice	N/A
Pet Waste Management	City of Lincoln only
Non-structural & avoidance BMPs	30%
Grazing Lands Management BMPs	50%
Cover Crops	20%
Riparian Buffers	N/A
No-Till Farming	85%
Contour Buffer (filter) Strips	30%
Non-permitted AFO Facility BMPs	N/A
Wetlands/Farm Ponds/Sediment Basins	N/A
Stream Restoration	N/A
Terraces	50%
WASCOBS	25%

Grassed Waterways	40%
Urban Stormwater BMPs	N/A

N/A – Estimate was not available or was unable to be calculated at planning area scale

Existing BMPs were assumed to be evenly distributed across the watershed. Treatment levels varied from 20% to 85%. Currently the planning area has multiple pollutant reducing BMPs in place throughout the watershed, all of which are found in the target areas determined to be contributing the highest *E. coli* loads.

7.10 CONSIDERATIONS FOR BMP IMPLEMENTATION

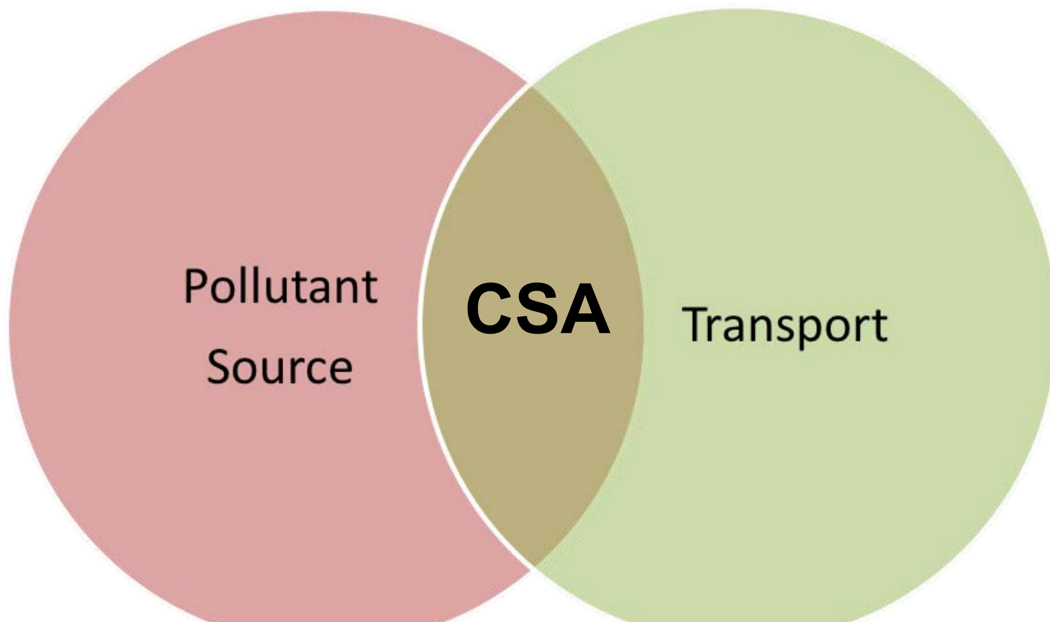
There is great variation in management practices which can be utilized to improve soil health, water quality, and habitat. When implementing this plan, flexibility in practice selection must be considered as there are differences for planning purposes versus real life application. Each target area is unique, and implementation will need to be flexible in order to be tailored to the field level and landowner preferences. Efforts were made to identify effective BMPs that can be voluntarily adopted by landowners. This plan does not assume non-priority practices have little to no benefit, rather there is a limit of how many BMPs can be reasonably modeled within the scope of this planning effort. Project sponsors will encourage the use of a multi-faceted systems approach when implementing this plan.

The effectiveness of individual management practices in reducing nonpoint source pollution loads can be highly variable based on several site-specific factors, especially producer acceptance. Additionally, the installation or use of one practice is rarely sufficient to completely control the pollutant of concern. Using a combination of practices that control the same pollutant are generally more effective. To most effectively control nonpoint source pollution, management systems should be designed based on the following factors:

- Pollutant type, source, and cause;
- Agricultural, climatic, and environmental conditions;
- Farm operator's economic situation;
- System designer's experience; and
- Acceptability by the producer of the BMP components.

CRITICAL SOURCE AREA TARGETING

Even properly designed management systems constitute only one part of an effective land treatment strategy. For a truly effective land treatment strategy, properly designed systems must be placed in the correct locations in the watershed (i.e., critical source areas), and the extent of land treatment must be sufficient to achieve water quality improvements. The EPA defines a critical source area (CSA) as those areas within a watershed that contribute a disproportionately large amount of pollutants of concern to the identified water quality problems. They are generally considered to be places where high-level pollutant sources overlap or interact with high pollutant transport potential (Dressing, 2018), as shown conceptually in Figure 61.



Adopted from Meals and others, 2012

Figure 61: Concept of Critical Source Areas

Due to the importance of CSAs, it is essential that these landscapes be identified and BMPs are specifically targeted to these areas. This will allow an overall implementation strategy to be more cost-effective. Generally, 75% of the critical area must be treated with the appropriate BMP systems. In comparison, if the problem derives from livestock, 100% of the critical area within the watershed must be treated with BMP systems (Meals, 1993). The implementation strategies found in Chapters 10 - 12 of this plan include identification of CSAs utilizing the ACPF tool; however, all producers and landowners should be encouraged to develop operation specific conservation plans. These plans incorporate specific tools that can be used to achieve operation and resource goals.

CHAPTER 8. TECHNICAL AND FINANCIAL RESOURCES

8.01 OVERVIEW

By sponsoring this plan, the LPSNRD will also assume the role of spearheading its goals and objectives. The intent of this chapter is to summarize the technical and financial resources available to support the LPSNRD in plan implementation, including a listing of the primary agencies and the most widely available funding sources. Specific cost estimates needed to implement the plan are described later in subbasin specific chapters (Chapters 10 – 12). The LPSNRD should consider five primary categories when establishing detailed cost estimates for future projects as described below:

- **Project Development** – efforts include assessment of data, preparation of project implementation plans, monitoring plans, and development of funding strategies and applications.
- **Land Conservation Measures (BMPs)** – the LPSNRD has multiple programs that provide funding or enhance existing conservation funding from other agencies to incentivize the implementation of BMPs. Additional programs or program enhancements may be necessary to achieve target and special priority areas goals.
- **Cost of Targeted Projects and Actions** – the LPSNRD annually plans and budgets for site specific projects which includes annual interlocal agreements with partners. Target projects include water quality, flood control, streambank improvements, wetland enhancements, and many others. Specific costs often include surveys, engineering design, permitting, construction, and operation and maintenance.
- **Monitoring Cost** – the LPSNRD's monitoring efforts vary and are more focused on groundwater quality and quantity. Monitoring projects implemented in relation to this plan are important and these costs should be incorporated into project implementation plans.
- **Staffing** – the LPSNRD currently has staff that are responsible for overseeing planning and implementation of watershed-based projects. The LPSNRD regularly evaluates staffing needs and workloads, and often addresses varying workloads with seasonal help. Additional staff should be considered to assist with any of the following responsibilities: watershed implementation; coordination with partner agencies; monitoring and assessment; project tracking and reporting; and public education and outreach efforts.

While NRDs are taxing authorities, they rely on a variety of local, state, and federal funding to leverage available funding resources. All available monetary and technical resources will need to be explored and utilized if possible to achieve the plan goals. Agencies and other groups that have resources that may be useful in addressing nonpoint source pollution in the watershed have been identified. Many of these primary organizations are identified in the *Nebraska Nonpoint Source Management Plan* (NDEQ, 2015b) and are summarized in Table 47, followed by others that have been highlighted specifically for this planning area. During the implementation process, other agencies or funding opportunities may be identified and should be considered. Participation will depend on the agency/organization's program capabilities and priorities.

Table 47: Summary of Financial & Technical Resources

Organization/Program	Acronym	Technical Assistance	Funding Assistance
Nebraska Environmental Trust (NET) www.environmentaltrust.org/			
Nebraska Environmental Trust Fund	NET	-	X
United States Bureau of Reclamation (USBR) https://www.usbr.gov/			
WaterSMART Grant	-	-	X
Drought Response Program	-	-	X
United States Geological Survey (USGS) – Nebraska Water Science Center http://ne.water.usgs.gov/			
Monitoring Data and Project/Study Partnership Opportunities	-	X	X
Cooperative Water Program	CWP	X	X
Federal Highway Administration (FHWA) and Nebraska Department of Roads (NDOT) https://dot.nebraska.gov/			
Various Programs and Technical Support	-	X	X
County Bridge Match Program	-	-	X
US Army Corps of Engineers (USACE) www.usace.army.mil/			
Section 14 Emergency Streambank and Shoreline Protection	-	X	X
Section 206 Aquatic Ecosystem Restoration	-	X	X
US Department of Health and Human Services (DHSS) www.hhs.gov/			
Various Safe Water and Wastewater Treatment Programs	-	X	X
National Park Service www.nps.gov/			
Various Recreational Facilities Programs	-	X	X
US Department of Agriculture (USDA) and Natural Resources Conservation Service (NRCS) http://www.nrcs.usda.gov/			
Environmental Quality Incentives Program	EQIP	X	X
Conservation Stewardship Program	CSP	X	X
Conservation Reserve Program	CRP	X	X
National Water Quality Initiative	NWQI	X	X
Agricultural Conservation Easement Program	ACEP	X	
Conservation Innovation Grants	CIG	X	X
Healthy Forests Reserve Program	HFRP	X	X
Regional Conservation Partnership Program	RCPP	X	X

Organization/Program	Acronym	Technical Assistance	Funding Assistance
US Forest Service (USFS) or Nebraska Forest Service (NFS) http://nfs.unl.edu/			
Various Forestry Programs	-	X	X
Nebraska Department of Natural Resources (NeDNR) http://www.dnr.nebraska.gov/			
Small Watersheds Flood Control Fund	-	-	X
Natural Resources Water Quality Fund	NRWQF	-	X
Water Well Decommissioning Fund	-	-	X
Soil and Water Conservation Fund	-	-	X
Nebraska Department of Environmental Quality (NDEQ) http://www.deq.state.ne.us/			
Nonpoint Source Pollution Management Program	319	X	X
Wetlands Program Development Grants	WPDG	-	X
Linked Deposit Program through the Clean Water State Revolving Fund	-	-	X
Community Lakes Enhancement and Restoration Program	CLEAR	X	X
Underground Storage Tank Program	-	X	X
State Revolving Fund	SRF	-	X
Nebraska Game and Parks Commission (NGPC) outdoornebraska.ne.gov/			
State Wildlife Grant Program	SWG	-	X
Land and Water Conservation Fund	LWCF	-	X
Recreational Trail Program	RTP	-	X
Nebraska Wildlife Conservation Fund	-	-	X
Aquatic Habitat Improvement Program	-	X	X
Sport Fish Restoration Program	SFR	X	X
Open Fields and Waters Access Program	-	X	X
WILD Nebraska Program	-	X	X
Nebraska Natural Heritage Program	-	X	X
Nebraska Department of Agriculture www.nda.nebraska.gov/			
Nebraska State Buffer Strip Program	-	-	X
Saline Wetland Conservation Partnership		X	X
Property owner outreach, fundraising, project implementation	-	-	-
Groundwater Foundation www.groundwater.org/			
Education and Community-based action programs	-	X	-

Organization/Program	Acronym	Technical Assistance	Funding Assistance
University of Nebraska Extension extension.unl.edu			
Information and Various Outreach Programs	-	X	-
Pheasants Forever www.pheasantsforever.org/			
Corners for Wildlife Program	-	-	X
Local PF Chapters - Various conservation programs	-	X	X
Ducks Unlimited www.ducks.org/			
Various Conservation Programs	-	X	X

8.02 PLANNING AREA SPECIFIC RESOURCES

Beyond internal BMP funding programs, there are several key funding sources provided by other agencies that are commonly utilized by NRDs or other project sponsors for water quality-based improvement projects within Nebraska. It is common for the LPSNRD to pool funding and technical resources with other agencies. It is likely the LPSNRD will partner with or utilize support from the following programs during the implementation of this plan.

CLEAN WATER ACT SECTION 319 PROGRAM

The EPA awards funds through the Section 319 Program to states, territories, and tribes to reduce and mitigate nonpoint source pollution and improve water quality. Nonpoint source programs may include technical and financial assistance for education, training, demonstration projects, and BMP implementation. Funds are awarded annually to states in accordance with a state-by-state allocation formula developed by the EPA. In Nebraska, NDEQ administers these funds through a competitive application process with applications due the Tuesday following Labor Day. Funding from the 319 program will be pursued to assist in the implementation of this plan. It is anticipated that additional funding sources will be utilized to assist in implementing activities that 319 funding does not target.

In several places, the plan mentions maintaining (digging out, renovating, etc.) several existing WASCOBs/wetlands installed under previous projects. Given the significant 319 work in the District, it’s possible that some of these structures were originally funded with federal dollars (either EPA or NRCS). Via the terms and conditions of the 319 grant and the NDEQ contracts, the structures were to be operated and maintained for their full designed life span. Likewise, NRCS has operation and maintenance requirements for each practice in its Technical Manual. Before putting 319 dollars towards these structures, project sponsors should make reasonable efforts to ensure maintenance was completed as it should have been throughout the life of the structure. This is intended to ensure that stewardship of previous federal dollars is confirmed before awarding more to the same practice and operator.

NEBRASKA ENVIRONMENTAL TRUST

The Nebraska Environmental Trust (NET) was established in 1992 to conserve, enhance, and restore the natural environment of Nebraska. The NET especially seeks projects that bring public and private partners together to implement high-quality, cost-effective projects. Applicants for NET grants must meet specific eligibility criteria that ensure public benefit and substantial environmental gains. Annual applications are due the Tuesday following Labor Day. Although NET grants have no match requirement, a local match is recommended.

NGPC – AQUATIC HABITAT PROGRAM

The Nebraska Game and Parks Commission (NGPC) routinely leads significant aquatic habitat renovations across

the state through the Aquatic Habitat Program. Funding is made available by purchasing an Aquatic Habitat Stamp annually, which are available when obtaining a Nebraska fishing license. It is common for LPSNRD and NGPC to partner on aquatic habitat enhancement projects.

SALINE WETLANDS CONSERVATION PARTNERHSIP

In 2003 a group was formed of local, state, and federal agencies to establish an implementation plan for preservation of one the Eastern Saline Wetlands. The group was initially supported solely by the NET but in 2008 an interlocal agreement was created between the City of Lincoln, Lancaster County, LPSNRD, NGPC, and The Nature Conservancy to formalize the Saline Wetlands Conservation Partnership (Partnership). Since that time the Partnership has forged working relationships with property owners, conservation interests, and government agencies to sustain existing resources and restore degraded saline wetland resources. The Partnership continues to plan and implement a variety of wetland restoration efforts.

PROPERTY OWNERS

Landowners/operators will contribute both time and resources for implementing conservation measures. The landowners/operator’s cost to implement conservation measures will vary by practice type and extent of funding received from other sources. Financial assistance through incentives are necessary for many conservation measures, particularly for smaller producers that may not be able to afford to install more costly measures.

8.03 ALTERNATIVE FUNDING OPTIONS

Successfully implementing this plan will require creative approaches to project funding. A broad range of funding opportunities will create opportunities for additional implementation options. Alternative funding sources can sometimes be found at regional or local levels through partnerships with private sector businesses, private foundations, and other non-governmental organizations.

The following alternative funding sources and techniques have been employed in other communities. This approach is not as straight-forward as applying for grants. Rather, it involves engaging a broad spectrum of stakeholders and employing a combination of funding sources to solve formidable issues. However, the reality is that significant increases in government funding to address nonpoint source pollution efforts are not on the immediate horizon and the LPSNRD will need to be creative, cooperative, and proactive to produce meaningful implementation.

Local Options

- Capital Improvement Funds
- Permits and Fees
- In-Kind Services
- Developers/Property Owners

Private Foundations or non-profits

- Farm Bureau
- Nebraska Cattlemen Association
- Corn Growers Association
- Soybean Association

CHAPTER 9. PRIORITIZATION PROCESS

9.01 OVERVIEW AND DEFINITIONS

This purpose of this chapter is to describe the process used to formally define priorities identified through stakeholder and public involvement process. The focus is on identifying implementation priorities for the initial five-year increment of plan implementation.

During the process of establishing a methodology, several standard terms were defined to ensure all stakeholders involved in the process were using consistent terminology throughout discussions. These terms are generally described below:

Priority Water Bodies - The actual resource you want to protect or restore. These are typically identified as specific lakes, streams, wetlands, or other unique water resources identified through stakeholder input and existing plans/documents such as: Title 117 State Resource Waters; 303(d) list of impaired waters; areas identified in the State Nonpoint Source Management Plan; Wellhead Protection Areas; Nebraska Game and Park Commission's (NGPC's) Aquatic Habitat Plan; wetland complexes identified by NGPC; and others. These may include areas most susceptible or sensitive to nonpoint source pollution.

Target Areas - The defined areas within a watershed where implementation of BMPs will be focused to improve or protect the water quality of priority water bodies. These are typically based on designated drainage areas or stream corridors, but they are not required to be based on HUC 12 boundaries. The *2015 State Nonpoint Source Management Plan* (NDEQ, 2015b) specifies that target areas may only make up a maximum of 20% of a HUC 8 subbasin area. Target areas are often customized to specific drainage areas using GIS analysis, water quality modeling, or other tools. Selection of these areas can be based on varying factors such as pollutant load, pollutant source, achievable results, landowner interest, etc.

Critical Source Areas (CSA) – These are a relatively small fraction of a watershed that generates a disproportionate amount of pollutant load (Meals and others, 2012). Identifying these areas allows better targeting of BMPs to most effectively use financial and technical resources. CSAs occur where a pollutant source in the landscape coincides with an active hydrologic transport mechanism; therefore, identifying the pollutant of concern, it's source, and understanding hydrology are the first steps in CSA identification**.** These are identified within target areas, which often requires detailed assessments, modeling, GIS analysis, or in-field work to identify and define. Additional details on CSAs can be found in Chapter 7 and the individual subbasin chapters (Chapters 10 - 12).

Special Priority Areas – Areas determined to have specific, limited, and timely needs that may lie outside of a target area. These areas do not count towards the 20% Rule. Practices are restricted to those necessary to address the specific needs of the special priority area. Examples of these areas are wellhead protection areas or unique landscapes, such as the Eastern Saline Wetlands.

Priority Practices - BMPs identified by the project partners that are key to achieving goals in both the target areas and special priority areas. These are typically screened down from a suite of practices based on agency and public input, such as pollutant treatment efficiency and landowner acceptance. These are typically the BMPs that are included in the water quality modeling efforts and can consist of structural or non-structural practices (see Chapter 7).

Monitoring Priorities - Monitoring is necessary for baseline data, filling in data gaps, and for tracking plan progress. Monitoring priorities may vary, but could include water quality, water quantity, social indicators of change, and BMP tracking over time.

Education & Information Priorities – Each target area has an education and outreach component; however, there can also be stand-alone education and information priorities especially as it relates to specific issues identified by stakeholders, such as source water protection.

9.02 METHODOLOGY

The plan covers a large geographic area, includes multiple HUC 8 subbasins, and has many competing priorities. In order to narrow down the focus of this plan to a scope that is manageable for the LPSNRD to address in the near future, priority water bodies were identified. This process had to recognize the inherent differences in the sources of pollutants for each water body, the scale of contributing areas, and the resources and effort required to address them. The water bodies selected are the focus of the first five-years for plan implementation efforts. The initial list of possible priority water bodies was limited to the following criteria:

- Identified as impaired in the 2016 Integrated Report (NDEQ, 2016b)
- Designated as a high quality or unique resource within the State NPS Plan (NDEQ, 2015b)
- Identified by NGPC as priority wetland areas or regional wetland complexes (LaGrange, 2005)

Water bodies where naturally occurring materials have led to water quality impairments (selenium, chloride, etc.) or where impairments are not caused by nonpoint source pollution (e.g. mercury) were not considered within the prioritization process.

To facilitate the selection of a final list of priority water bodies, a screening process unique to the LPSNRD was utilized. A similar process has been used successfully on comparable plans in Nebraska. The screening process was based on a points system representing various agency and stakeholder interests. There is equal weighting assigned for each criterion because of the inherent subjectivity of each category. Figure 62 outlines this screening process. Additional details are provided in Appendix C. Finally, water quality modeling and input from stakeholders and the public were all considered in the final selection of priority water bodies by the LPSNRD.

Once the final priority water bodies were identified, implementation strategies were developed for each impaired resource (see Chapters 10 - 12). These implementation strategies include target areas for treatment, BMPs, quantified pollutant load reductions, and other components. Detailed implementation strategies were only developed for the final list of priority water bodies and special priority areas, as other areas are not anticipated to implement projects in the first five-year increment of the plan.

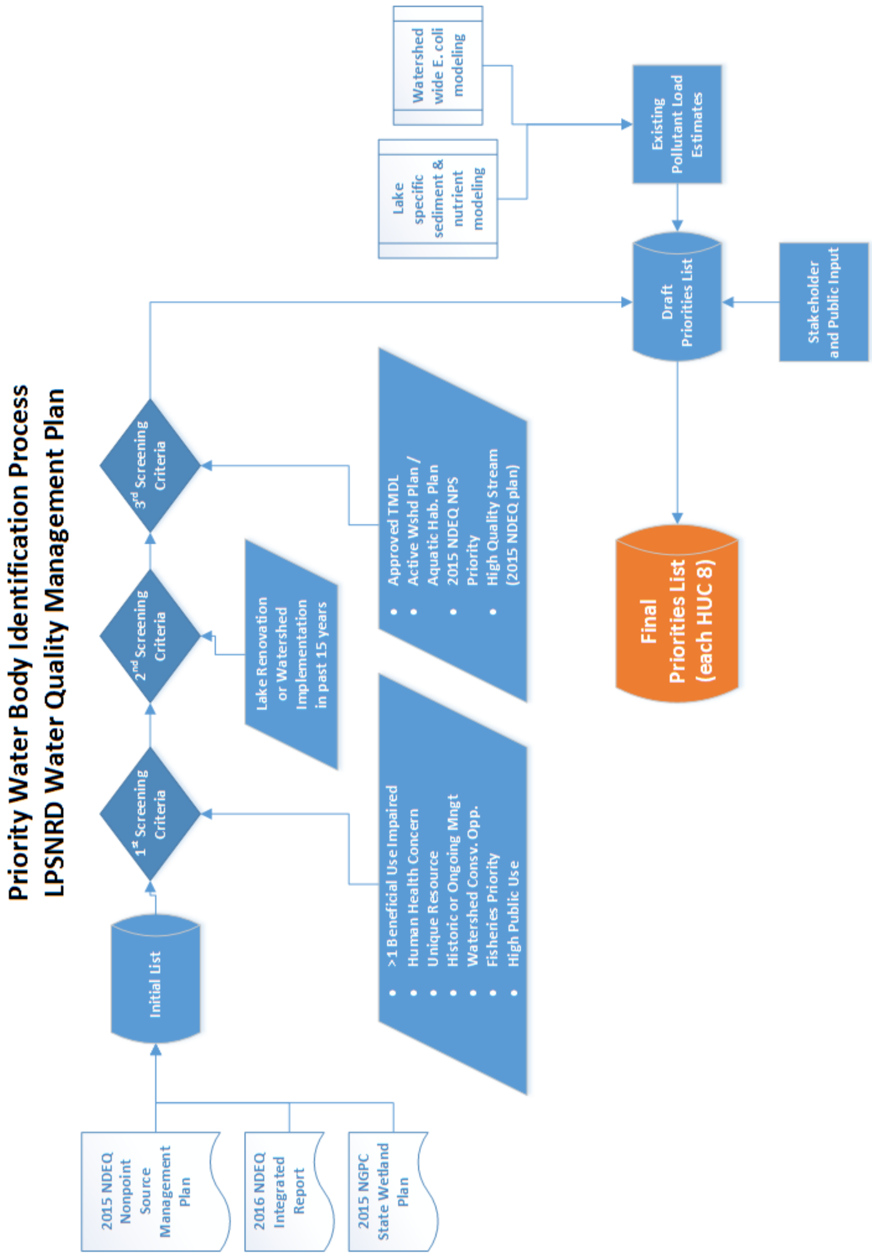


Figure 62: Flow Chart of Water Body Prioritization Process

9.03 PRIORITY WATER BODIES AND TARGET AREAS

After the final screening was completed, five priority water bodies were identified: Pawnee Reservoir and Middle Creek near Malcolm; East and West Twin Reservoirs near Pleasant Dale; Decker Creek near Platte River State Park; and Antelope Creek in Lincoln. A special priority area, the Eastern Saline Wetlands, was also included as it is located primarily within the Upper Little Salt Creek subwatershed. No priority water bodies were identified in the Keg-Weeping Water HUC 8. These priority water bodies are shown in Figure 63, along with their associated target area. Table 48 displays contribution of the target areas towards the 20% rule. The identified target areas are consistent with NDEQ's requirements that less than 20% of an HUC 8 be identified as a target area.

PAWNEE RESERVOIR AND MIDDLE CREEK

Pawnee Reservoir is on the list of upcoming lake renovations and experiences significant blue-green algae blooms on a regular basis, often resulting in beach closings. This is a high-use recreation site near Lincoln. Additionally, Middle Creek (above Pawnee Lake) is impaired for atrazine. It is recommended that the remaining portion of the HUC 12 subwatershed, which doesn't drain to Pawnee Lake also be targeted to round out the project area.

EAST TWIN AND WEST TWIN LAKES

East Twin Lake, which is significantly larger than its twin to the west, is also subject to a future full lake renovation by NGPC. West Twin Lake is essentially a sediment basin to East Twin Lake. This area is a target for a fishery renovation.

DECKER CREEK

Decker Creek was identified as a priority area due to extremely high levels of *E. coli* bacteria present within the stream. Additionally, it presents an opportunity to address a rural *E. coli* bacteria problem versus an urban area (i.e. Antelope Creek). Decker Creek flows to the Platte River and with its confluence near Platte River State Park.

ANTELOPE CREEK

Antelope Creek is located in the heart of Lincoln and has numerous public spaces along the stream corridor including: Holmes Lake; the Lincoln Children's Zoo; University of Nebraska-Lincoln's City Campus; Innovation Campus (formerly State Fair Grounds); multiple parks; and a fully developed bicycle trail system. The stream is impaired due to *E. coli* bacteria and multiple projects have been completed in recent years following the development of a water quality plan (EA, 2012). The City of Lincoln and LPSNRD both intend to continue implementing projects identified in that plan.

UPPER LITTLE SALT CREEK WATERSHED (EASTERN SALINE WETLANDS)

This target area will leverage the existing *Upper Little Salt Creek Saline Wetlands Plan* (Lincoln Parks and Recreation, 2015) which has identified several actions to restore wetlands. The focus within this plan will be conservation work within the watershed that will limit further degradation of this unique resource by reducing sedimentation to the wetland areas from the watershed.

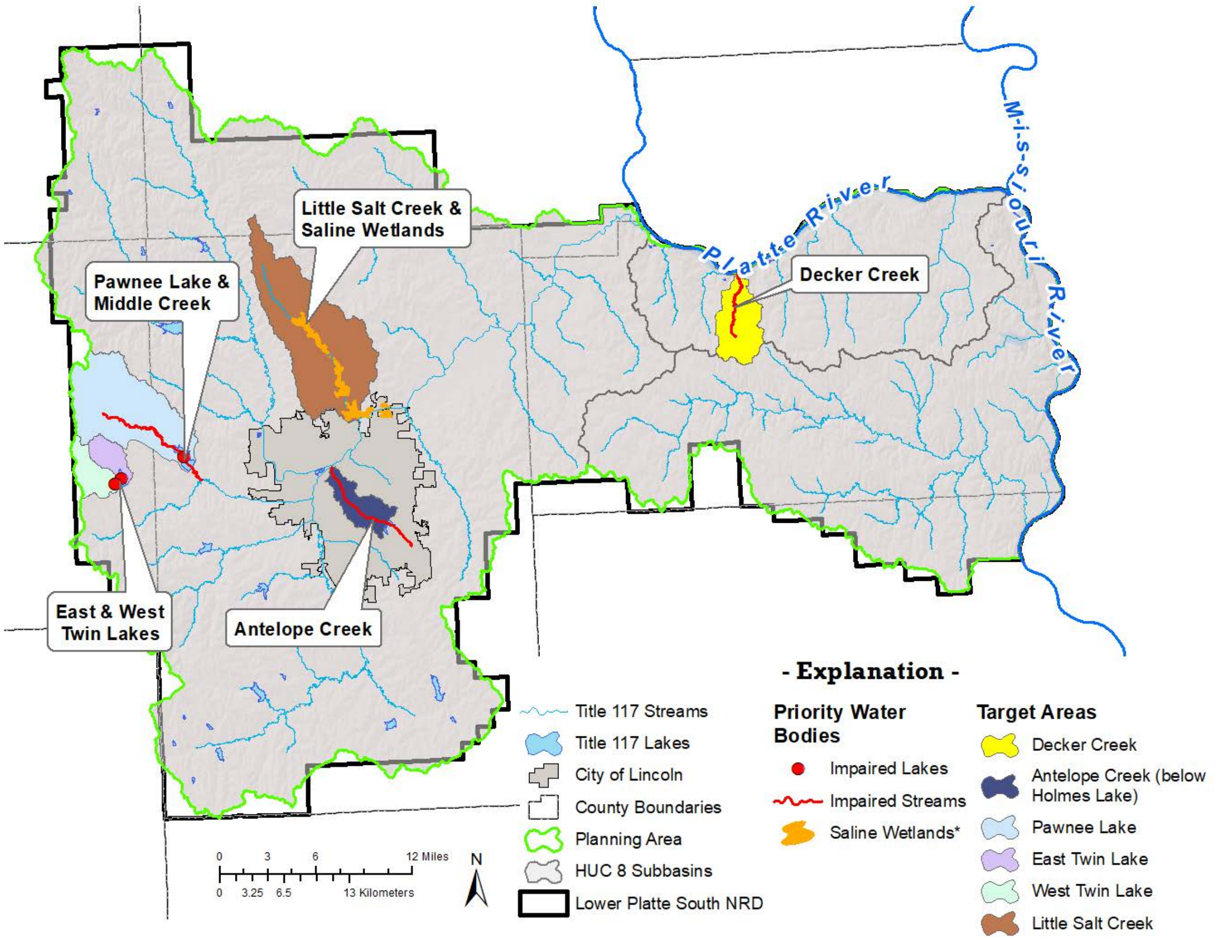


Figure 63: Priority Water Body Locations and Target Areas

Table 48: Priority Water Bodies, Target Areas, and the 20% Rule

HUC 8	Priority Water Body	Target Area & HUC 12 Code	Acres	% of HUC 8
Salt	Pawnee Lake	Pawnee Lake - Middle Creek HUC 12 102002030202	20,963	3%
	Middle Creek			
	East & West Twin Lakes	South Branch - Middle Creek HUC 12 102002030201	6,835	1%
	Antelope Creek*	Antelope Creek 102002030304	4,931	1%
	Eastern Saline Wetlands	Little Salt Creek 102002030901	29,326	4%
Salt Creek HUC 8 Total Targeted Area			**62,055**	**9%**
Lower Platte	Decker Creek	Deck Creek-Platte River 102002020203	7,621	7%
Lower Platte HUC 8 Total Targeted Area			7,621	7%
Keg-Weeping Water	None	None	n/a	n/a
Keg-Weeping Water HUC 8 Total Targeted Area			**0**	**0%**

**During the development of this plan, Antelope Creek (LP2-20900) was determined to no longer be impaired due to E. coli (NDEQ, 2018). However, implementation of activities identified in this plan are still a priority for the LPSNRD and City of Lincoln.*

9.04 SECONDARY PRIORITY WATERBODIES

Towards the end of the prioritization process, stakeholders identified one waterbody: Dead Man's Run stream (LP2-20400) that could be considered a secondary priority. Dead Man's Run is impaired due to *E. coli*. This waterbody, and associated HUC (102002030903), is the focus of a large USACE Section 205 flood risk reduction project, where both the City of Lincoln and the LPSNRD are also involved. While water quality management is not the focus of these efforts, there may be opportunities for joint projects. Detailed implementation strategies (within this plan) are not developed and implementation work related to these waterbodies will not be eligible to receive Section 319 funding; however, nonfederal funds utilized for water quality projects on secondary priority waterbodies may count towards matching dollars for Section 319 projects within the target areas of priority waterbodies.

9.05 OTHER PRIORITIES IDENTIFIED

In addition to target areas, which are focused on on-the-ground implementation of BMPs, the project team also identified other priorities. These include special priority areas, monitoring/data collection priorities, and information and education (I&E) priorities. Some of these are specific to HUC 8 subbasins, while others would apply across the LPSNRD (district-wide). Special priority areas provide flexibility to address small-scale areas identified with specific, limited, and timely needs that lie outside of the target areas. Monitoring and I&E priorities include activities which would take place separate from pre/post project activities and, at times, outside of target areas. It should be noted that even when these activities are outside of target areas, they may still be in support of other implementation actions. These other prioritized activities are excellent candidates for partnering opportunities.

PRIORITIES SPECIFIC TO HUC 8 SUBBASINS

The following priorities were identified for each HUC 8 subbasin (Table 49). Additional discussion on each is located in the relevant subbasin chapter (Chapters 10 - 12).

Table 49: Priorities that are specific to HUC 8 Subbasins

HUC 8 Subwatershed	Special Priority Areas	Monitoring Priorities	I&E Priorities
Salt Creek	• Saline wetlands • Salt Valley Greenway • Existing sediment retention structures • Antelope Commons (The Preserve)	• Stevens Creek • Impaired aquatic communities • Bathymetric Surveys	• Home Owners Associations
Lower Platte River	• None	• Jenny Newman Lake • Decker Creek	• None
Keg-Weeping Water	• None	• None	• Beaver Lake

DISTRICT-WIDE PRIORITIES

Additional priorities, which are applicable to the entire LPSNRD (district-wide), were identified. Each is discussed below.

Special Priority Areas

- **Wellhead Protection Areas**
  - NDEQ's Wellhead Protection Program is a voluntary program that helps community water systems protect groundwater through a series of steps including delineation and mapping of the Wellhead Protection (WHP) Areas. This plan recognizes WHP Areas (also referred to as CWSPAs in the LPSNRD) as special priority areas due to the influence a WHP Area has on the management needs of source water aquifers and associated public drinking water systems. WHP areas within the planning area are identified in Chapter 3. Completion of WHP plans and implementing BMPs targeting groundwater quality are priorities.
  - Pollutant management in WHP areas typically focuses on nitrate-nitrate (nitrate) contamination of groundwater. Nitrates are known to cause a disease called methaemoglobinaemia (or "blue baby syndrome") with infants. Carcinogenic compounds have also been known to become more prevalent when there are high levels of nitrates in drinking water. While low levels of nitrates in groundwater can occur naturally, the major source of nitrates in agriculturally dominated areas, such as this subbasin, are nitrogen fertilizers. Completion of WHP plans for each area is a priority, as well as any BMPs which target groundwater quality. These would include but are not limited to: Fertilizer at Agronomic Rates, Irrigation Water Management, and Cover Crops.
  - The LPSNRD does already offer cost share for WHPs in the form of the Spring Nitrogen Application Program, fertilizer meter, and soil sampling. The LPSNRD also require Nitrogen Certification in some areas that are in Phase II or Phase III
- **On-site Wastewater Treatment Systems**
  - Illicit connections, discharges, sanitary sewer overflows, straight pipes from septic tanks, failing septic systems, or other failing on-site wastewater treatment systems (OWTS) can be sources of *E. coli* bacteria and nutrients contamination. Under Title 124 Chapter 3, NDEQ requires individuals doing work associated with OWTSs to be certified by the State of Nebraska, and requires that all systems constructed, reconstructed, altered, or modified to be registered (NDEQ, 2012). Registration requirements did not exist for systems installed prior to 2001; therefore, the precise number of septic systems, including failing systems, is not possible to determine.
  - In 2004 the adoption of new regulations and design standards for on-site wastewater systems offered an opportunity to address potential sources of bacterial and nutrient contamination in waterbodies. The On-site Wastewater System Upgrade practice for Section 319 projects was created to support pumping

and inspection of on-site wastewater systems and to replace systems installed before 2004.

- **Non-permitted livestock facilities**
    - Almost all livestock operations have the potential to adversely affect water quality; however, AFOs confining less than the equivalent of 300 beef cattle are considered administratively exempt from inspection and permitting unless they have a history of discharging or the potential to discharge pollutants to Waters of the State. Non-permitted (typically small) AFOs do not have regulatory requirements imposed on them and are thus treated as potential nonpoint sources of pollution for management recommendation purposes. Non-permitted AFOs may contribute to bacteria, nutrient, and sediment pollution due to runoff from areas with a high density of livestock and minimal perennial vegetation or groundcover.
    - Non-permitted livestock facilities are identified as a special priority area to provide a pro-active approach to livestock waste treatment while demonstrating appropriate treatment technologies and BMPs. Only operations that are exempted by regulations or are deemed exempt by NDEQ are included.
    - BMPs include all of those identified under the “Non-permitted AFO Facility BMPs” practice suite (Chapter 7):
        - Animal waste/manure storage systems
        - Clean water diversion systems
        - Vegetative treatment systems (VTS)
        - Terraces
        - Containment
        - Evaporation ponds
        - Open lot runoff management
        - Heavy use area protection
        - Feed management practices

Monitoring Priorities

- **Existing BMP Treatment Levels** –Additional site-specific information on the level of BMP implementation is needed across the planning area. This would ideally include an inventory of existing structural BMPs identified via aerial imagery and/or LiDAR data; and non-structural BMPs, likely identified through surveys.
- **Pre-project Monitoring** – Several years before a project is put into place, pre-project data should be collected in order to enable evaluation of changing conditions during and after project implementation.
- **Impaired Aquatic Communities** – Several stretches of streams in the planning area have impaired aquatic communities from unknown causes. It is likely that these causes are related to habitat conditions, however assessments need to be made to confirm this. The LPSNRD will coordinate with NDEQ and other agencies to conduct in-stream biological assessments to identify the cause of the impaired aquatic communities.

Information & Education Priorities

- **LPSNRD Board of Directors** – The NRD's Board would benefit from additional education outreach regarding the various water quality issues and priorities identified in this plan. Fully understanding the scope of activities and requirements for implementation will be crucial to making this plan an effective management tool.
- **Rural Water Districts** – These organizations are responsible for providing safe drinking water to many rural citizens outside the purview of municipal or county government structures. The planning team will work with the board members and/or system operators through targeted I&E efforts related to nonpoint source pollution and source water management.
- **County Commissioners/Supervisors** – These decision makers are responsible for approving funds and projects within their specific county. These entities must fully understand what is in this plan if they are expected to take action on the implementation activities within it.
- **Village/city governments with WHP areas** - These decision makers are responsible for approving funds and projects within their specific jurisdiction. Additionally, they are responsible for making decisions on zoning. The planning team will work with them through targeted I&E efforts related to nonpoint source pollution and source water management.

CHAPTER 10. SALT CREEK HUC 8 SUBBASIN

10.01 SUBBASIN BACKGROUND

The Salt Creek Subbasin (HUC 8: 10200203) is the largest of the three subbasins addressed in this plan. The subbasin is 722,994 acres (entire planning area is 1,048,774 acres) and consists primarily of Lancaster County (Figure 113). This subbasin is the most diverse in land use/land cover compared to the rest of the planning area. A large urbanized area (Lincoln, NE) and many smaller communities and acreages are located within the subbasin. Lincoln's perimeter includes several small towns and acreages which contributes to the area's growing population and expanding urban footprint. Row crop (corn/soybean) production is the dominant agriculture land use (50%), however the western portion of the subbasin includes high amounts of grass/pasture lands (27%). There are many large reservoirs (constructed for flood control) located in the subbasin, most of which are also utilized for recreational purposes. Finally, as discussed in Chapter 3, the majority of Nebraska's saline wetlands are located within this subbasin. All these elements make for unique resource concerns and opportunities within Nebraska and this planning area.

This chapter is intended to focus primarily on the target areas and special priority areas identified within the Salt Creek HUC 8 Subbasin. Little discussion is given to the rest of the subbasin here, as much of that information can be found throughout the rest of this plan. Information on an inventory of subbasin characteristics is found in the following chapters/section within this plan:

- Land Use: Chapter 3.02
- Existing land treatment (BMPs): Chapter 7.09
- Irrigation: Chapter 3.06
- Permitted facilities: Chapter 5.07
- Water resources: Chapter 3.03
- Existing resource conditions: Chapter 5

A general discussion of the types and sources of pollutants addressed in this chapter can be found in Chapter 5. This subbasin specific chapter provides information for the contribution of pollutant by source within each target area. Additionally, this chapter provides the following information for each target area:

- Pollutant sources and loads;
- Pollutant load reductions needed to meet water quality standards (load reduction goals);
- Pollutant load reductions as a result of BMP implementation;
- Communication and outreach;
- Schedule and milestones;
- Monitoring; and
- Costs.

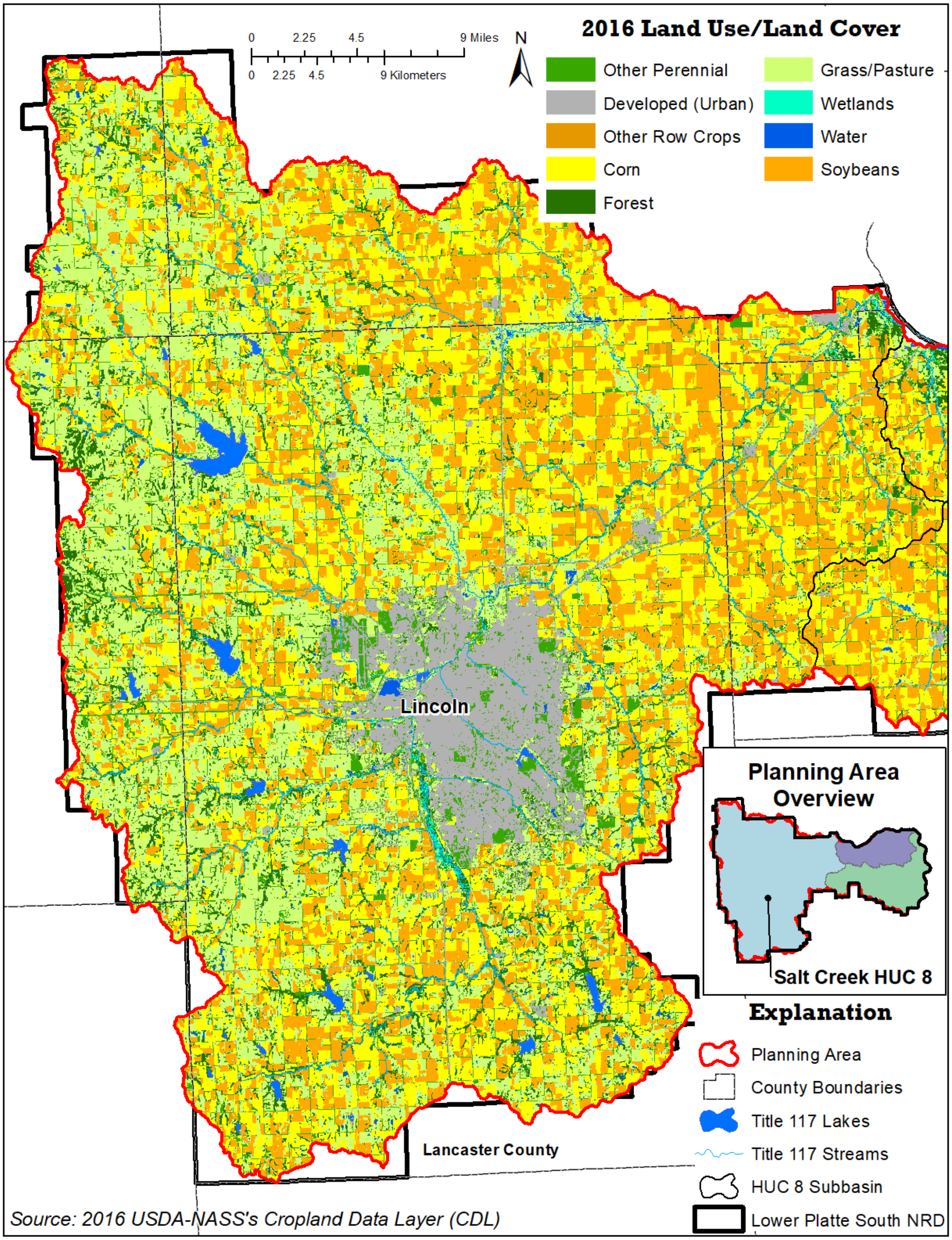


Figure 64: Land Use/Land Cover within the Salt Creek HUC 8 Subbasin

10.02 OVERVIEW OF PRIORITIES

As discussed in Chapter 9, target areas and special priority areas were selected through a review of water quality data and stakeholder input. As shown in Figure 65 and Table 50, the following areas within this subbasin have been selected for focused implementation efforts:

Target Areas

- Pawnee Lake and Middle Creek
- East and West Twin Lakes
- Antelope Creek (below Holmes Lake)
- Little Salt Creek

Special Priority Areas

- On-site Wastewater Treatment Systems (OWTS)
- Non-permitted animal feeding operations (AFOs)
- Wellhead protection areas (WHP areas) (also referred to as CWSPAs in the LPSNRD)
- Saline Wetlands
- Lincoln-Lancaster Salt Valley Greenway
- Existing sediment retention structures
- Antelope Commons (The Preserve)

As part of the prioritization process in the development of this plan (Chapter 9), target areas were identified based on the contributing area to each priority waterbody identified. The total size of each target area was calculated through GIS analysis to ensure the sum of the targeted areas equaled less than 20% of the total HUC 8 area which satisfied the NDEQ guidance (NDEQ, 2015a). Within the Salt Creek HUC 8 Subbasin, 62,055 acres are targeted for implementation work, approximately 9% of the HUC 8 area (Table 50). The following sections of this chapter provide information on the implementation strategy for each target area, with additional details and supporting technical information located in Appendix D.

Table 50: Priority Waterbodies and Associated Target Areas within the Salt Creek HUC 8 Subbasin

Priority Water Body Addressed (Water Body ID)	HUC 12 Subwatershed	Target Area Size (acres)	% of Total HUC 8 Size	Pollutants/Impairments Addressed
Pawnee Lake (LP2-L0160)	102002030202	20,972	3%	Sediment, nutrients, and algal biomass
Middle Creek (above Pawnee Lake) (LP2-21100)	102002030202	20,963*	*	Atrazine
East Twin Lake (LP2-L0240)	102002030201	2,983	<1%	Sediment and nutrients
West Twin Lake (LP2-L0260)	102002030201	3,852	1%	Sediment and nutrients
Antelope Creek, below Holmes Lake (LP2-20900)**	102002030307	4,931	1%	*E. coli* bacteria
Little Salt Creek (LP2-20300)	102002030901	29,326	4%	*E. coli* bacteria, and sediment
Total	**n/a**	**62,055**	**9%**	**n/a**

**Same drainage area as Pawnee Lake, therefore not included in Total Area*

***During the development of this plan, Antelope Creek (LP2-20900) was determined to no longer be impaired due to E. coli (NDEQ, 2018). However, implementation of activities identified in this plan are still a priority for the LPSNRD and City of Lincoln.*

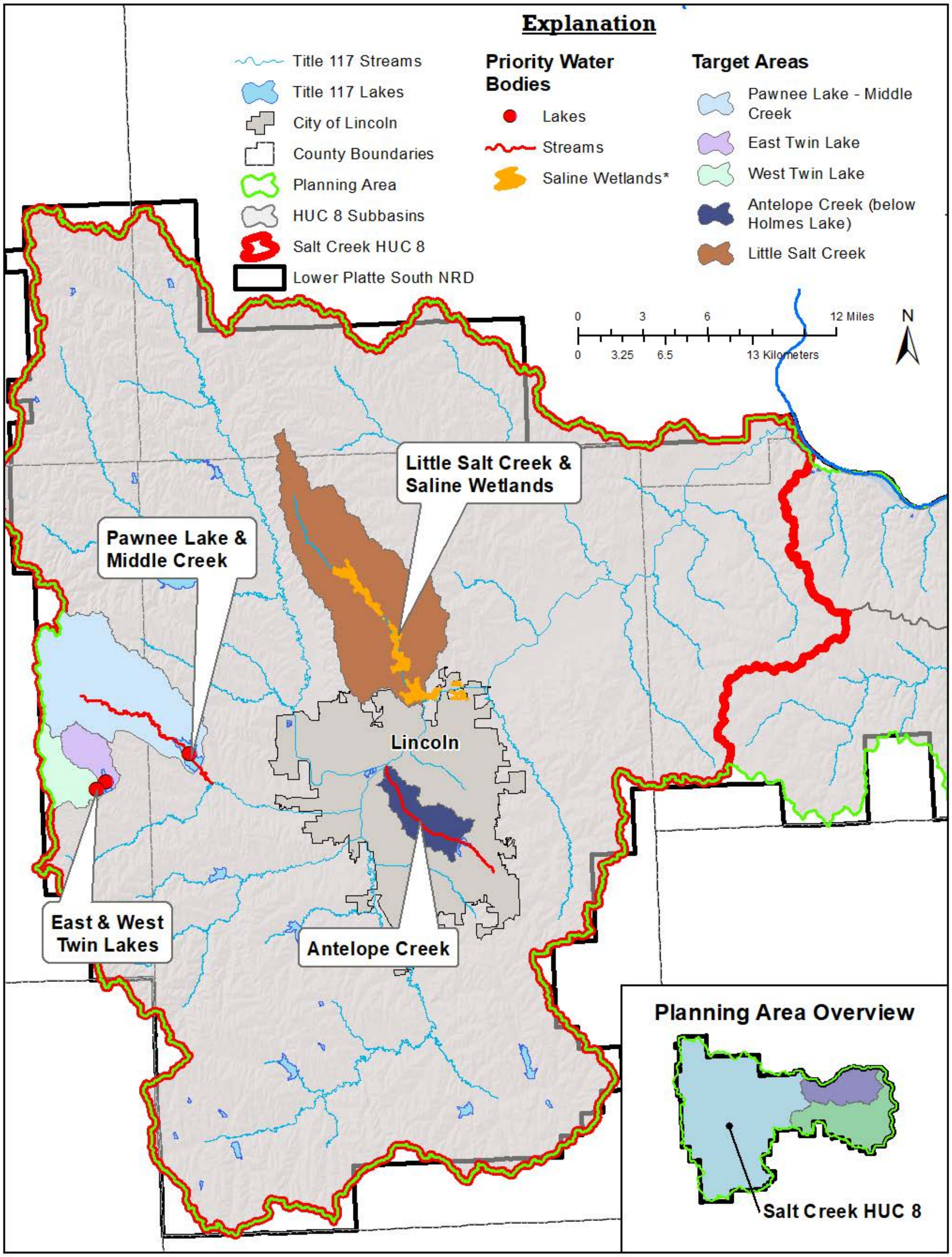


Figure 65: Target Areas and Special Priority Areas within the Salt Creek HUC 8 Subbasin

10.03 PAWNEE LAKE AND MIDDLE CREEK TARGET AREA

INTRODUCTION

NOTE TO READERS

Information in this section is summarized from the *Pollutant Modeling and BMP Implementation Recommendations Summary Report for Pawnee Lake and Middle Creek Subwatershed* (Laketech, 2018a), a copy of which is also provided in Appendix D. Unless otherwise noted, additional details and background information can be found in that comprehensive document.

The Middle Creek HUC 12 subwatershed (102002030202) is a tributary of Salt Creek located in Seward and Lancaster counties (Figure 66). Middle Creek is made up of three designated segments: "South Branch Middle Creek" (LP2-21010), which flows through Denton; Middle Creek – Headwaters to South Branch" (LP2-2110), which flows from above Pawnee Lake to the confluence with South Branch; and "Middle Creek to Salt Creek" (LP2-21000), which flows from the confluence of those tributaries until it joins Salt Creek.

Middle Creek's assigned beneficial uses include: Aquatic Life; Aesthetics; and Agricultural Water Supplies (NDEQ, 2014). The lower portion is fully supporting the assigned beneficial uses, whereas the South Branch Middle Creek has not been assessed. The headwaters of Middle Creek (LP2-21100) above Pawnee Lake is listed as impaired (Aquatic Life use) due to atrazine (NDEQ, 2016b). The Middle Creek drainage area above Pawnee Lake is 20,972 acres.

Pawnee Lake was constructed on Middle Creek in 1966 (USACE, 2018). The lake is located only a few miles from the city limits of Lincoln in Lancaster County. As-built records indicate the lake comprised 734 surface acres and had a conservation pool volume of 8,695 acre-feet. The dam was constructed by the U.S. Army Corp of Engineers (USACE) for the primary purpose of flood control, with recreation as a secondary benefit. Recreational activities are managed by the Nebraska Game and Parks Commission (NGPC). Pawnee Lake, which has a State Park designation, is the second largest lake in the Salt Valley system. The lake has two swimming beaches and is used extensively for all types of passive and active recreation. The lake and park area accommodated 327,727 visitors in 2017 (NGPC, personal communication, April 4, 2018).

Pawnee Lake's assigned beneficial uses include: Primary Contact Recreation, Aquatic Life, Aesthetics, and Agricultural Water Supplies (NDEQ, 2014). Pawnee Lake is listed as impaired from sediment (Aesthetics use), nutrients (Aquatic Life use), and algae density (Aquatic Life use) in the 2016 Integrated Report.

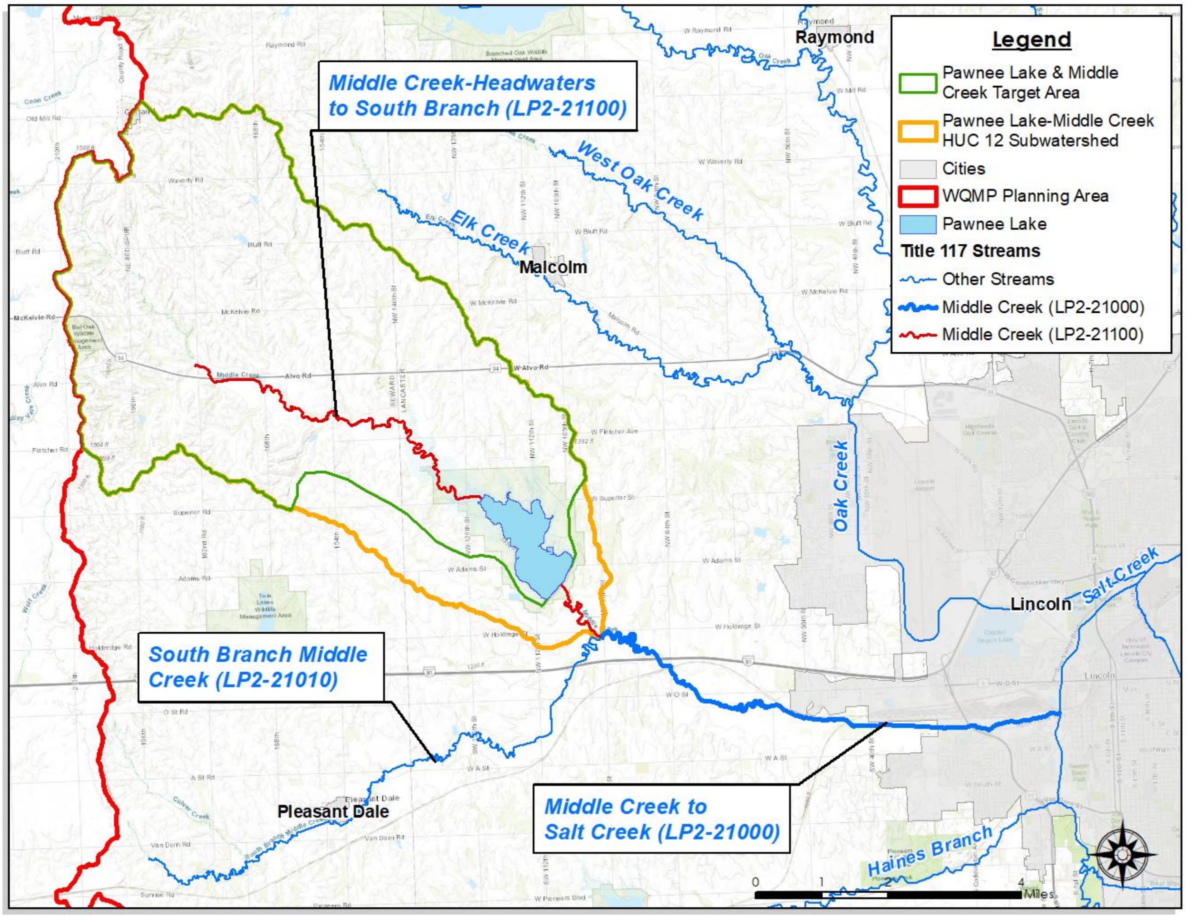


Figure 66: Location of the Pawnee Lake and Middle Creek Target Area

IMPAIRMENTS

Middle Creek – Atrazine

Middle Creek (LP2-21100) was first listed as impaired for atrazine in the 2006 IR and carries the same listing in the 2016 IR (NDEQ, 2016b). In 2007, NDEQ developed a Total Maximum Daily Load (TMDL) to address this concern (NDEQ, 2007a). Atrazine data used to develop the TMDL (2002-2004) and post-TMDL atrazine data (2007-2008) were collected as part of the Salt Valley Lakes Runoff Monitoring program coordinated by NDEQ. All samples were collected from a single station (SLP2MDCLR203) located approximately 1.5 miles above Pawnee Lake.

The 2007 atrazine TMDL was based on runoff data collected from Middle Creek during the months of May and June from 2002 through 2004. Of the seven runoff samples collected during this time period, five exceeded the chronic water quality standard of 12.00 µg/L. No samples exceeded the acute atrazine criteria of 330 µg/L. Three May-June samples collected by NDEQ in 2007 and 2008 were added to the sample pool. Of the ten total atrazine samples collected, six exceeded the chronic water quality standard (Figure 67). Based on NDEQ assessment procedures, a sample size of ten only allows for two deviations from the chronic water quality standard, with three being the threshold for impairment. While the data is not current, it does support the stream impairment listing for atrazine.

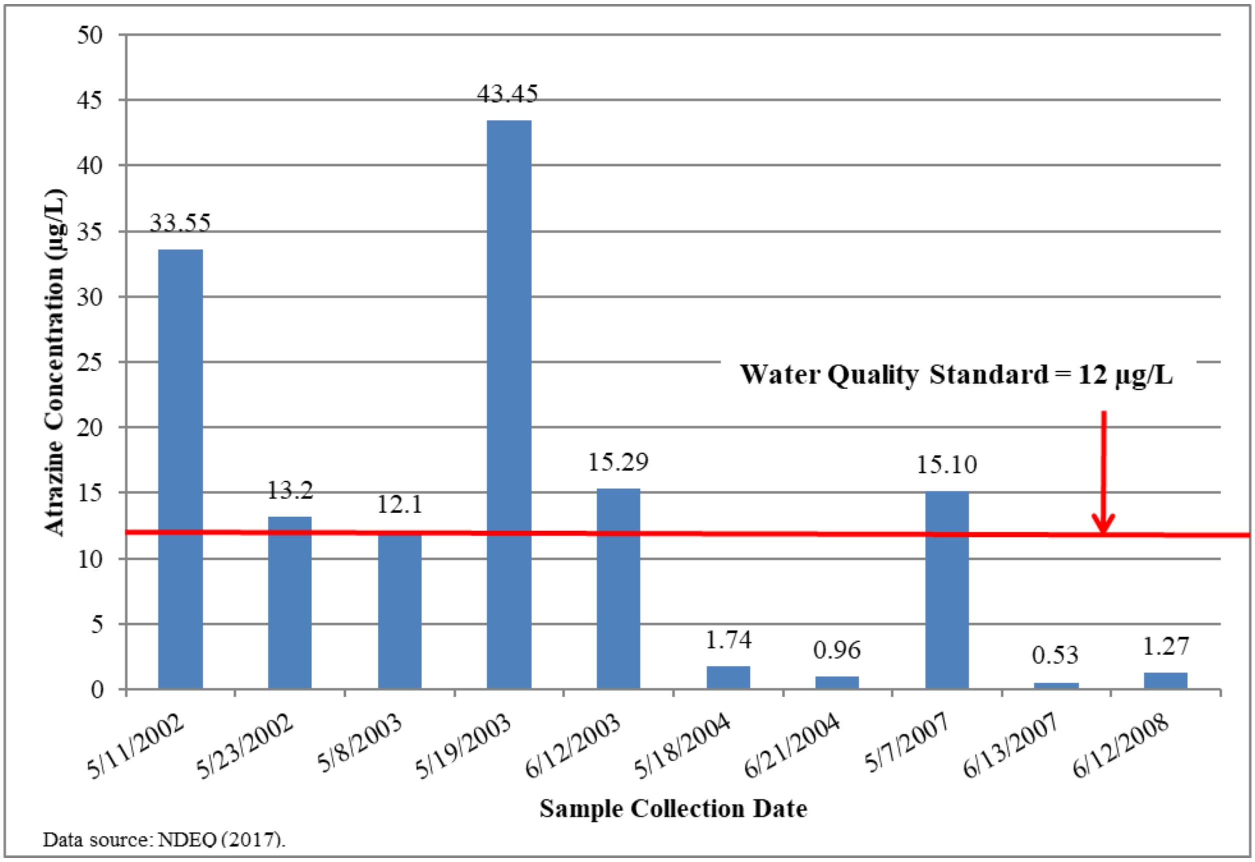


Figure 67: Atrazine Concentrations in Middle Creek (LP2-21100) under runoff conditions

Pawnee Lake – Nutrients and Algae Density

The Aquatic Life use in Pawnee Lake is currently impaired due to high concentrations of total phosphorus and total nitrogen, as well as excessive algae growth (NDEQ, 2016b). Current nutrient concentrations and algae biomass (chlorophyll-*a*) were determined from water quality sampling conducted by the USACE from 2012 through 2016 (USACE, 2017). Mean growing season (May-September) total nitrogen and total phosphorus concentrations, in addition to algae biomass; lead to the 2016 IR impairment designation for Aquatic Life use (Table 51).

Table 51: Pawnee Lake Nutrient Concentrations and Algae Biomass

Parameter	Data Period	N	Growing Season Mean	Water Quality Standard
Total Phosphorus (µg/L)	2012-2016	25	138.8	50.0
Total Nitrogen (µg/L)	2012-2016	25	1,555	1,000
Chlorophyll-*a* (mg/m3)	2012-2016	25	48	10

Source: USACE, 2017

Pawnee Lake – Sediment

Pawnee Lake's aesthetics use is currently impaired due to the amount of conservation pool storage volume the lake has lost since construction (NDEQ, 2016b). The as-built conservation pool volume for Pawnee Lake was estimated to be 8,695 ac-ft. As of 2016, Pawnee Lake has lost an estimated 28.3% of that volume, which is slightly above the NDEQ sedimentation assessment criterion of 25% (Table 52).

The current average annual sedimentation rate to the conservation pool is estimated to be 49.2 ac-ft/year. This results in an average conservation pool volume loss of 0.57% per year, which falls below NDEQ assessment criteria of 0.75% per year (USACE, 2018).

Table 52: Estimated Conservation Pool Volume Loss due to Sedimentation for Pawnee Lake

Pawnee Lake	#
Volume (ac-ft.)	
Original (1966)	8,695
Estimated (2016)	6,235
Total conservation pool loss (difference)	2,640
Percentage (%)	
Total conservation pool loss	28.3
Criterion (%)	
NDEQ assessment criterion	25.0

Source: USACE, 2018

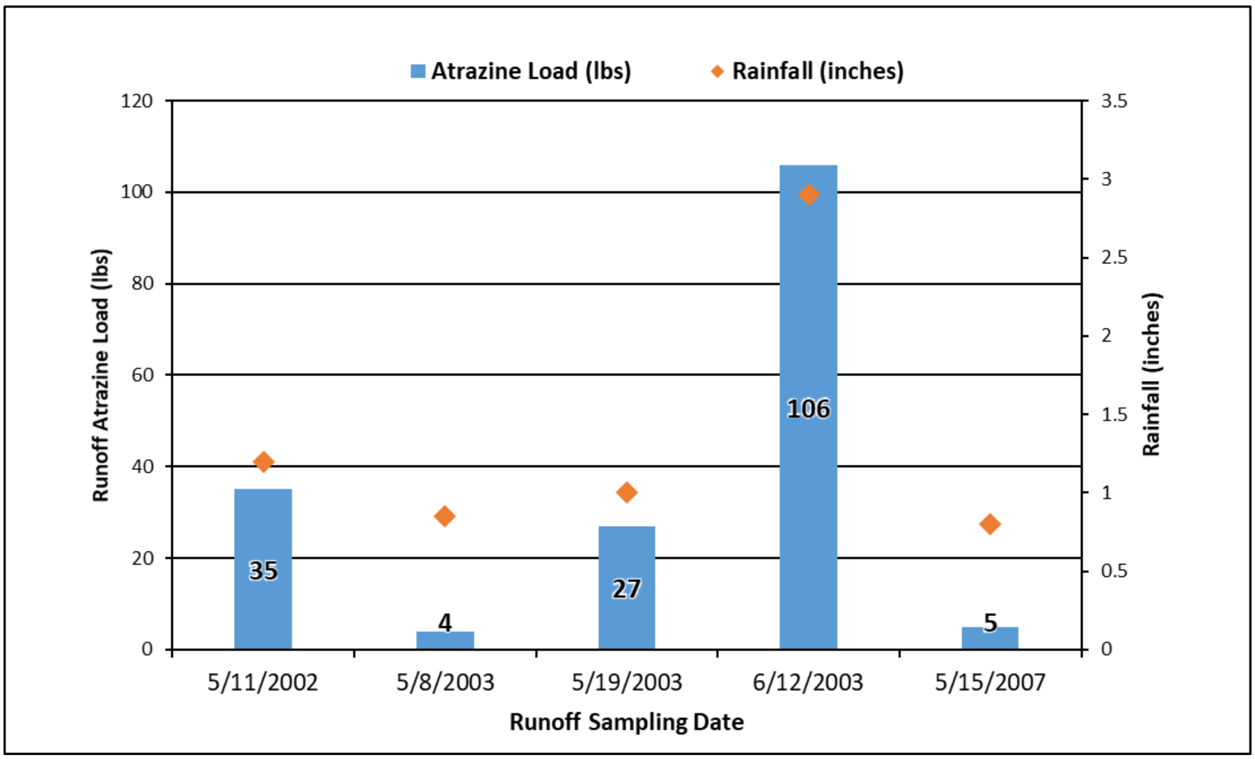
POLLUTANT SOURCES AND LOADS

Pollutant loads and source contributions were estimated using multiple methods, including a combination of mathematical calculations and water quality modeling. Additional details such as a summary of data, data sources, and methods can be found in the modeling/implementation report in Appendix D.

Middle Creek – Atrazine

Atrazine is a triazine herbicide currently registered for use on broadleaf and grassy weeds. Although atrazine can be used for a variety of purposes, it is primarily used on corn and sorghum (USEPA, 2018). As sorghum was only grown on 3.1 acres (<1%) of the Middle Creek drainage above Pawnee Lake in 2016, the majority of atrazine was presumed to be used on land with corn production. For the purpose of this plan, the entire atrazine load to upper Middle Creek (LP2-21100) has been allocated to land used for corn production (2,256 acres in 2016).

Due to the influence of Pawnee Lake dam on downstream transport of pollutants, as well as the current full support status for all beneficial uses, the lower portion of the Middle Creek (i.e. below Pawnee Lake dam) was not included in the atrazine loading assessment. To remain consistent with the 2007 TMDL, only samples collected in the months of May and June that exceeded the standard were assessed. To calculate total atrazine loads, measured atrazine concentrations and storm event water yield estimates from the drainage area above Pawnee Lake were used (Figure 68). For the five storm events assessed, atrazine loads ranged from 4.4 pounds (May 8, 2003) to 105.8 pounds during the May 19, 2003 runoff event.



Source: NDEQ, 2017a

Figure 68: Precipitation and Atrazine Runoff Loads to Middle Creek (LP2-21100)

Pawnee Lake

To fully account for pollutant sources, contributions from external and internal sources were quantified. External sources of nutrients to Pawnee Lake include runoff from the drainage area and atmospheric deposition through precipitation directly on the lake. While internal loads of phosphorus were estimated, the lack of literature and data prevented an estimation of internal nitrogen loads. The annual phosphorus load from bottom sediment release, bottom sediment re-suspension, and waterfowl waste were estimated. Due to a lack of data, re-suspension and waterfowl waste inputs were amassed as one load. Although waterfowl use numbers were unavailable for Pawnee Lake, it is assumed they contribute a small portion of the phosphorus load, relative to other sources.

Pawnee Lake – Phosphorus

The total gross phosphorus load to Pawnee Lake is estimated to be 29,483 lbs/yr. (Figure 69Table 53). Approximately 60% of the total load stems from external phosphorus sources, with the remaining 40% of the load contributed from internal sources. The largest contributor of phosphorus to Pawnee Lake is from lake bottom sediment resuspension/waterfowl waste, which constitutes 35% of the total load. Runoff from uncontrolled non-permitted open lots used for animal feeding and holding contributes 19% of the total load to the lake, whereas ground used for corn and soybean production contributes 16% of the total load. Figure 69 shows the remaining phosphorus load sources and amounts.

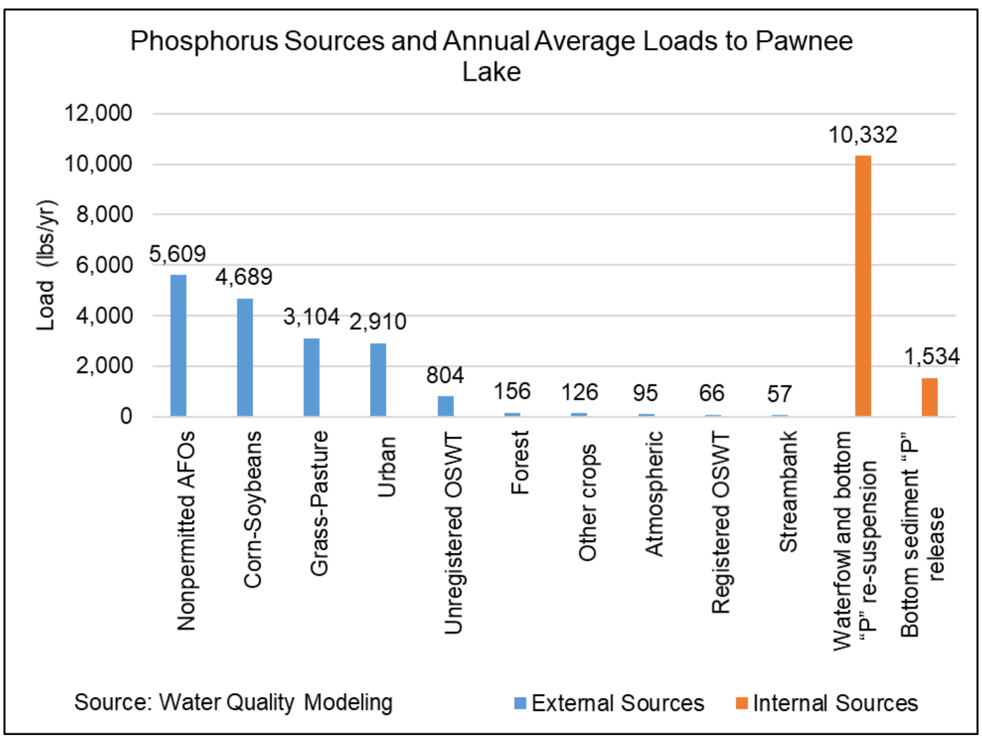


Figure 69: Phosphorus Sources and Annual Average Loads to Pawnee Lake

Pawnee Lake – Nitrogen

The total gross nitrogen load to Pawnee Lake is estimated to be 69,817 lbs/yr. This estimate only accounts for external sources of nitrogen, which includes drainage area runoff and nitrogen contributed through precipitation falling directly on the lake surface. The largest external source of nitrogen to Pawnee Lake is non-permitted AFOs, which account for approximately 40% of the load (Figure 70). The second highest load is grass/pasture, note this source does not include any load from cattle, only from soil erosion and wildlife.

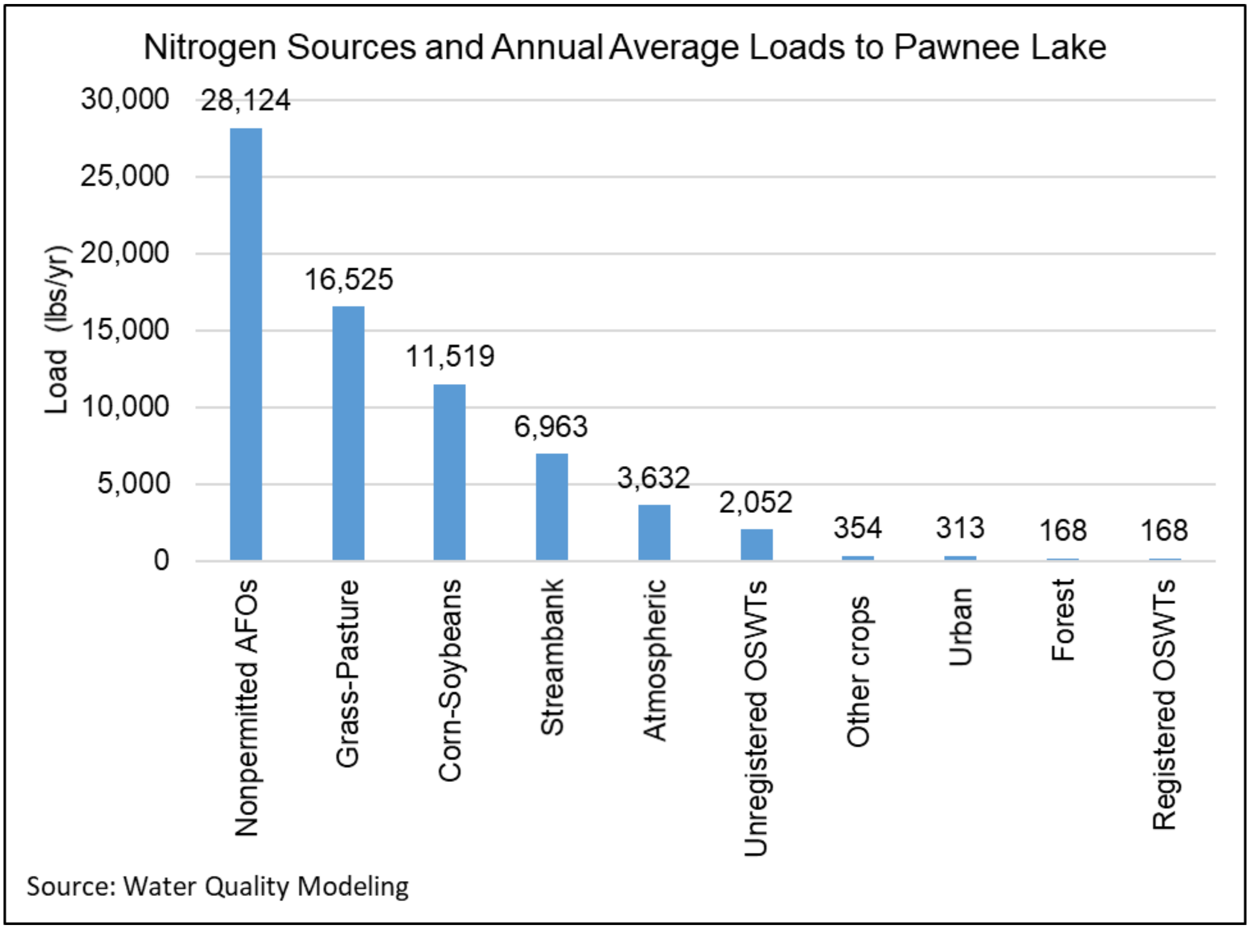


Figure 70: Nitrogen Sources and Annual Average Loads to Pawnee Lake

Pawnee Lake – Sediment

The total sediment load to Pawnee Lake is estimated to be 7,714 tons/yr. Of this amount, watershed runoff (external sources) contributes approximately 84%, while shoreline erosion (internal source) contributes the remaining 16%. The largest source of sediment to Pawnee Lake is from land used for corn and soybean production, contributing 2,624 tons/yr. or 34% of the sediment load (Figure 71). Approximately 39% of the total sediment load to Pawnee Lake stems from streambank and lake shoreline erosion. Only those sources with contributing loads are shown on the figure.

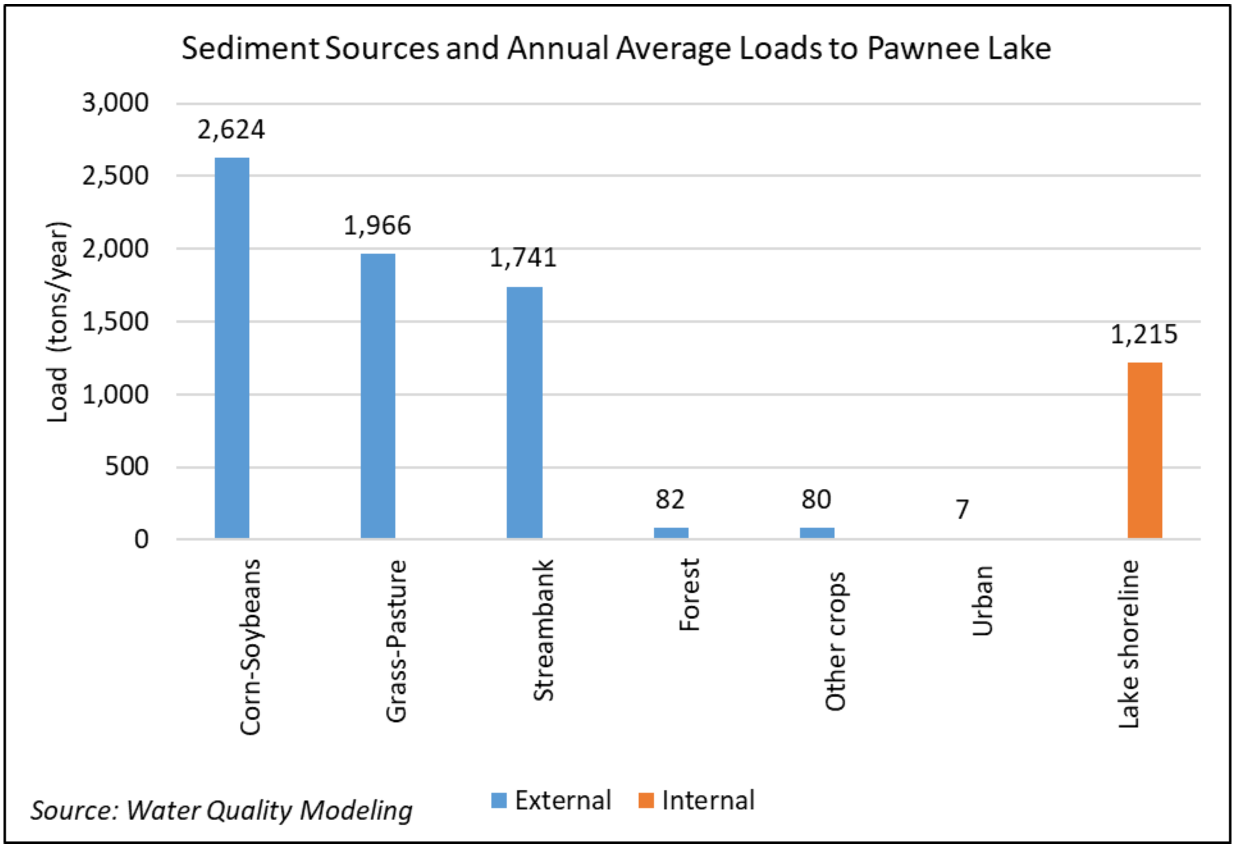


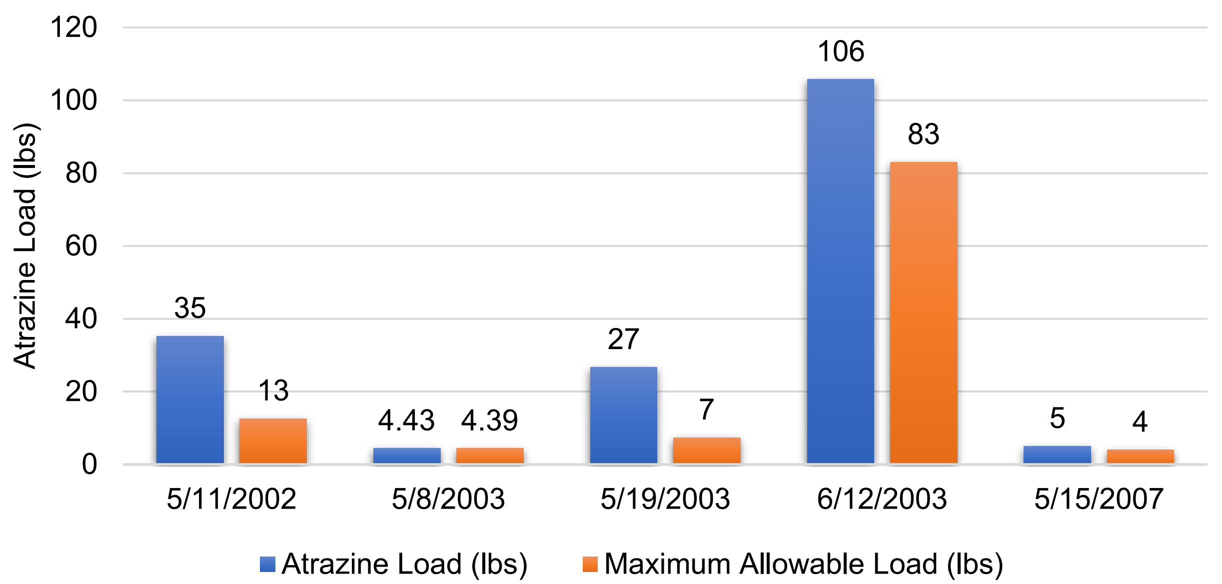
Figure 71: Sediment Sources and Annual Average Loads to Pawnee Lake

REQUIRED POLLUTANT LOAD REDUCTIONS

Middle Creek – Atrazine

The 2007 Atrazine TMDL was based on reducing in-stream atrazine concentrations, rather than the total atrazine load (mass per unit time). In order to provide the maximum protection to the stream, the TMDL targeted the highest measured concentration between 2002 and 2004 as the basis for determining reductions. The maximum measured concentration of 44 µg/L (May 19, 2003) requires a 73% reduction to meet the chronic standard of 12 µg/L.

In order to develop an atrazine load reduction target, loading capacities and associated reductions were determined for sampling dates that exhibited atrazine concentrations above the chronic standard of 12 µg/L (Figure 72). The May 23, 2002 storm event did not produce runoff; therefore, this event was not included. The May 19, 2003 runoff event that was targeted for the TMDL produced an atrazine load of 27 lbs., which would need to be reduced to approximately seven pounds to meet the chronic water quality standard.



Source: Water Quality Modeling

Figure 72: Upper Middle Creek (LP2-21100) Atrazine loads and loading capacities.

Pawnee Lake – Phosphorus and Nitrogen

The total phosphorus loading capacity for Pawnee Lake was determined from the Canfield-Bachmann lake loading regression equation (Canfield & Bachmann, 1981). The current in-lake phosphorus concentration of 139 µg/L will need to be reduced by 64% to meet the water quality standard of 50 µg/L (Table 53). The phosphorus load capacity associated with an in-lake concentration of 50 µg/L is approximately 3,892 lbs/yr. To meet the water quality standard, the current annual phosphorus load of 29,483 lbs. will need to be reduced by 25,591 lbs/yr. or 87%.

The load reduction target for total nitrogen was based on the required in-lake concentration reduction of 36%. Applying a 36% reduction to the current load of 69,817 lbs/yr. would result in an annual loading target of 44,683 lbs/yr (Table 54). In order to determine the extent of load reductions that can be achieved from controlling anthropogenic sources of pollutants, natural background loads of phosphorus and nitrogen were determined for the Pawnee Lake drainage area. Estimated annual natural background loads constitute approximately 76% of the phosphorus loading capacity and 87% of the annual nitrogen loading target. These numbers indicate an aggressive nutrient reduction strategy will need to be implemented in order for Pawnee Lake to meet phosphorus and nitrogen targets.

Table 53: Phosphorus Reduction Targets for Pawnee Lake

Phosphorus Levels and Targets	
Concentration	
Current in-lake phosphorus (µg/L)	138.8
Target in-lake phosphorus (µg/L)	50.0
Target reduction (µg/L)	88.8
Target reduction (%)	64%
Sum of External and Internal Loads	
Current gross load (lbs/yr.)	29,483
Load capacity (lbs/yr.)	3,892
Target reduction (lbs/yr.)	25,591
Target reduction (%)	87%

Source: Water Quality Modeling

Table 54: Nitrogen Reduction Targets for Pawnee Lake

Nitrogen Levels and Targets	
Concentration	
Current in-lake nitrogen (µg/L)	1,555
Target in-lake nitrogen (µg/L)	1,000
Target reduction (µg/L)	555
Target reduction (%)	36%
Sum of External and Internal Loads	
Current gross load (lbs/yr.)	69,817
Target load (lbs/yr.)	44,683
Target reduction (lbs/yr.)	25,134
Target reduction (%)	36%

Source: Water Quality Modeling

Pawnee Lake – Sediment

The most current bathymetric survey of Pawnee Lake was completed by the NGPC in 2002 (NGPC, 2017b). The conservation pool storage capacity (measured in 2002) and current sedimentation rates were used to determine current conservation pool storage volume (USACE, 2018). Pawnee Lake is currently losing 0.57% of the original conservation pool volume annually, well below the 0.75% criterion used by NDEQ to determine impairment (Table 55). Although the annual rate of sedimentation is below NDEQ assessment criterion, the lake has lost approximately 28.3% of its original conservation pool volume. This loss is slightly above the NDEQ assessment criterion of 25%. A 3.3% increase in conservation pool volume (or 287 ac-ft) would be needed to meet criterion; whereas an increase of 2,460 ac-ft. would be needed to fully reclaim the as-built conservation pool storage of 8,695 ac-ft.

Table 55: Sedimentation Rates and Volume Loss for Pawnee Lake (1966-2016)

Pawnee Lake	#	NDEQ Criteria
Conservation Pool Storage Volume (ac-ft.)		
Original storage volume (1966)	8,695	
2002 Storage Volume	6,924	
Estimated current storage volume (2016) [1]	6,235	
Total conservation pool storage volume loss (1966-2016)	2,460	
Conservation Pool Storage Volume Loss		
Total conservation pool loss (%)	28.3	25
Average annual conservation pool loss (%/yr.)	0.57	0.75
Necessary Storage Volume Increase		
Storage capacity increase needed to meet 25% (ac-ft.)	287	

Source: USACE, 2018

[1]*Based on 2002 bathymetric data.*

IMPLEMENTATION STRATEGY

A VOLUNTARY PLAN

The implementation of this plan is based entirely on the voluntary actions of landowners and citizens. Individuals must decide if it is an advantage to participate, and it is the responsibility of the LPSNRD and other stakeholders to find ways to make participation advantageous.

The implementation strategy for the drainage area above Pawnee Lake includes multiple practices that target pollutant sources through the ACT approach (avoid, control, trap), also known as a "treatment train". All pollutant sources will be addressed with the exception of atmospheric loading, as this plan only address nonpoint source pollution from surface water runoff. The identification of management practices, suites of practices, and best suited locations were determined from the ACPF Toolbox software, which provides field level recommendations of conservation opportunities (possible sites for BMPs) to inform local watershed planning efforts. Additional opportunities were found through analysis of aerial photography to identify nonpermitted AFOs and rural residences that may have unregistered OWTSs. It is assumed that these facilities are meeting all legal requirements; however, they are also possible sources of pollutant loads. In all cases, only willing landowners will be included in this voluntary implementation strategy.

The implementation strategy presented in this plan should be used as a guide for practice implementation and may be subject to revision as new information becomes available and as willing landowners are identified. Although avoidance practices are not part of the ACPF, they are an important part of the pollutant reduction strategy for Pawnee Lake. A multitude of avoidance practices apply to the Pawnee Lake drainage. For a detailed description of these and other practices provided below, refer to Chapter 7 of the WQMP.

Water quality assessments indicate Pawnee Lake exhibits a significant load of sediment and nutrients from internal sources. Given the size of the lake and extent of in-lake work required, only a general accounting of appropriate measures and costs is provided here. Specific measures and accurate costs should be determined through a feasibility/design study with results included in a future revision of this plan.

To provide an accurate load reduction estimate from practice implementation, recommended practices were used to develop a "treatment train" (following ACT methodology) that follows the flow of pollutants from the source to the receiving waterbody (Figure 73). The drainage area treatment train is comprised of seven levels of treatment, beginning with education/outreach and avoidance practices, and ending with in-lake management measures.

Figure 73: Implementation of Priority BMPs through a "Treatment Train" Approach

BMP TARGETING

Drainage Area Treatment

A suite of structural and non-structural management practices was selected based on stakeholder input and the results of technical analysis. In addition to structural practices, education/outreach and avoidance practices were added to the suite of recommendations for the Pawnee Lake drainage (Table 56). Ground used for corn and soybean production is targeted for the largest number of practices. All land cover types and pollutant sources were targeted for education and outreach activities except for water and wetlands, which were not classified as pollutant sources. Figure 74 and Figure 75 provide an overview of conceptual locations where BMPs could be placed. These maps are not "planned" locations, but instead provide a starting point for discussions with willing landowners and enable managers methods to develop this WQMP. Detailed map books can be found in Appendix F of the WQMP.

Table 56: Priority BMPs and Targeted Pollutant Sources

Land Cover Type/ Pollutant Sources	Current Acres	BMP	Acres Targeted
All	20,159[a]	Education & Outreach	20,159
Corn-Beans	4,547	Avoidance	3,183
		Terraces - cover crops - no till	214
		Contour buffer - cover crop - no till	468
		Cover crops-contour buffer	640
		Cover crops	2,316
		WASCOBS	580
		Wetlands	2,107
		Riparian buffers	678
Non-permitted AFOs	187	Avoidance	187
		WASCOBS	70
Pasture	11,619	Grazing management	5,903
		WASCOBS	1,002
		Wetlands	7,631
Other Crops	320	WASCOBS	31
		Wetlands	320
Forest	3,263	WASCOBS	198
		Wetlands	2,085
Urban	223	Wetlands	128
Streambank Stabilization (miles)	15	Bank stabilization (miles)	8.9
OWT Systems	270	Unregistered system upgrade (#)	57

Note: Grassed waterways, and their conceptual locations, were also identified as a priority BMP, however they were grouped with wetlands in the water quality modeling, due to technical limitations.

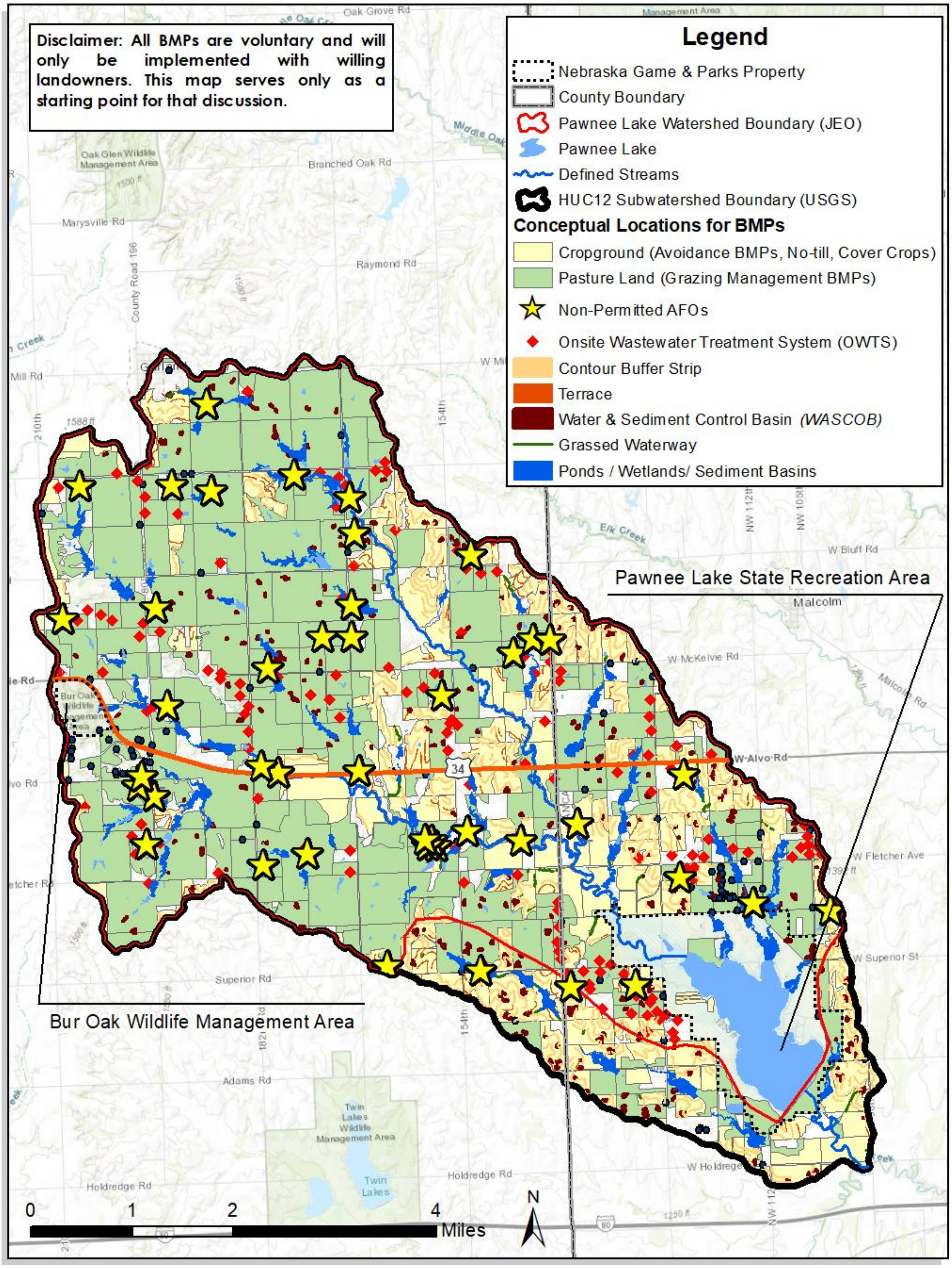


Figure 74: Conceptual locations of in-field and edge-of-field BMPs

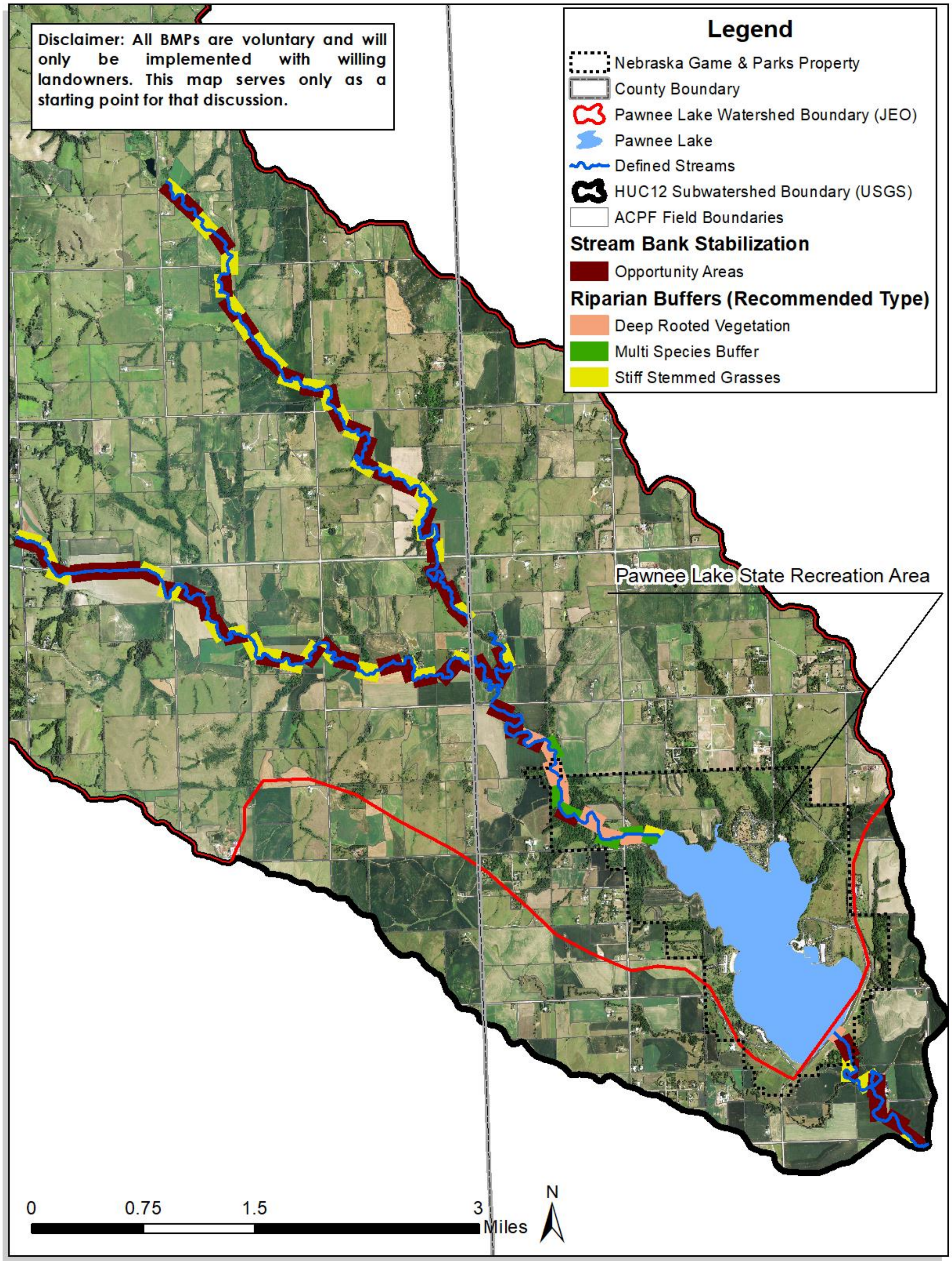


Figure 75: Conceptual locations of in-stream and riparian BMPs

In-lake Management Measures

The proposed implementation strategy for the Pawnee Lake drainage area will achieve the nitrogen load reduction target of 36%. In contrast, it does not achieve the phosphorus loading reduction target of 87% because of the large contribution (i.e., 40%) from in-lake sources. Therefore, in-lake management practices will be required to achieve load reduction goals. Additionally, sediment removal from the lake will be required to address the current aesthetics impairment. Several in-lake management measures are recommended to reduce internal pollutant loads. Although conceptual locations for each practice have been identified (Figure 76), it is recommended that all in-lake management measures be further evaluated to facilitate development of conceptual designs and accurate cost estimates. The following management measures were identified:

1) SEDIMENT REMOVAL

Sediment removal from the Pawnee Lake will reduce bottom sediment re-suspension and increase the reservoirs ability to attenuate nutrients. In order for Pawnee Lake to achieve a full support for the Aesthetics beneficial use, the conservation pool storage volume will need to be increased by 3.3% (or 287 ac-ft.). Returning the lakes conservation pool to the as-built volume requires an increase of 28.3% (or 2,460 ac-ft.). In order to meet the water quality standard for lake phosphorus, the conservation pool storage volume would need to be returned to as-built conditions.

2) IN-LAKE SEDIMENT BASIN

Water quality basins are an important component of reservoir sedimentation management, primarily through decreasing sediment and nutrient impacts to Pawnee Lake. Three in-lake basins have been identified to address pollutant loads from four tributaries contributing the greatest pollutant loads.

3) LAKE SHORE (BANK) STABILIZATION

Shoreline erosion and sediment/nutrient resuspension are significant contributors to the water quality issues at Pawnee Lake. Shoreline erosion accounts for 16% of the total sediment load to Pawnee Lake while bottom sediment resuspension accounts for 35% of the total phosphorus load. Problems are associated with soil types, bank height, lake orientation, lake fetch, lake depth, and recreational activities such as power boating. The sediment basins could be configured to address most of this shoreline area, with the remaining erosion prone areas addressed with offshore breakwaters. A combination of vegetation and hard armoring will be used.

4) NUTRIENT INACTIVATION

Based on the phosphorus load assessment and estimated benefits of proposed management measures for Pawnee Lake, nutrient inactivation may be required to meet the in-lake standard of 50 µg/L. Nutrient inactivation should only be used after external pollutant load reduction targets have been achieved and in-lake monitoring data suggests that additional reductions are necessary.

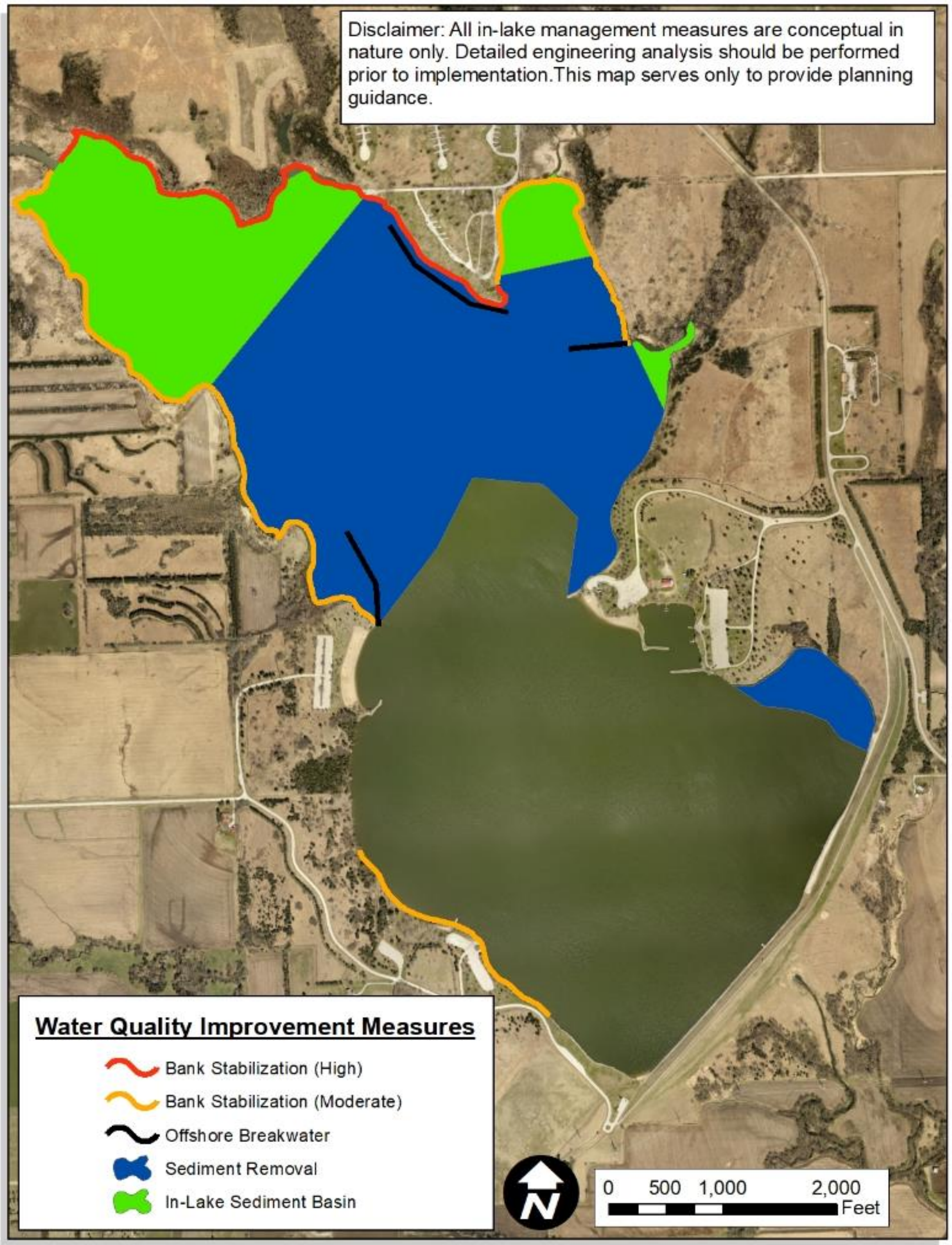


Figure 76: Conceptual locations for in-lake management measures at Pawnee Lake

CRITICAL SOURCE AREAS

Critical Source Areas (CSA) are a relatively small fraction of a watershed that generates a disproportionate amount of pollutant load (Meals, 2012). As discussed in Chapter 7, CSAs occur where a pollutant source in the landscape coincides with an active hydrologic transport mechanism. Identifying CSAs allows for the prioritization of fields where BMPs are likely most needed and allows for financial and technical resources to be used most efficiently.

CSAs in the Pawnee Lake and Middle Creek Target Area were identified using the field runoff risk assessment in the ACPF Toolbox. This assessment provides a relative risk rating (not an absolute risk rating) and is based on a cross-reference of two factors:

- Slope steepness – Steeper fields have a higher risk of generating runoff
- Distance to stream – The closer a field is to a waterbody, the higher the risk a pollutant will be delivered to waterbody

Once the assessment is complete, each field receives a relative classification, ranging from A (highest risk – most critical), to B (very high), C (high), and other (‘present’). One limitation of this tool is that only agriculture land uses (cropland or pasture land) are included. These other land uses (typically rural residences or other natural areas) are identified as “unknown” in the assessment. “Unknown” areas may still have an elevated runoff risk (especially for pollutants such as manure application or failing OWTS’s). A “present” or “unknown” classification does not mean that a BMP would not provide benefits to a given field, but rather indicates that other fields have a greater potential to deliver pollutants to a waterbody via surface runoff. In future updates to this plan, an assessment of all fields for runoff risk is recommended.

For the purposes of this plan, areas identified as A or B through the runoff risk assessment have been identified as CSAs. In the Pawnee Lake and Middle Creek Target Area (Figure 77), there are 3,115 acres of CSAs (13% of the Target Area), which are broken down as follows:

- Highest Risk CSA: 1,030 acres
- Very High Risk CSA: 2,085 acres

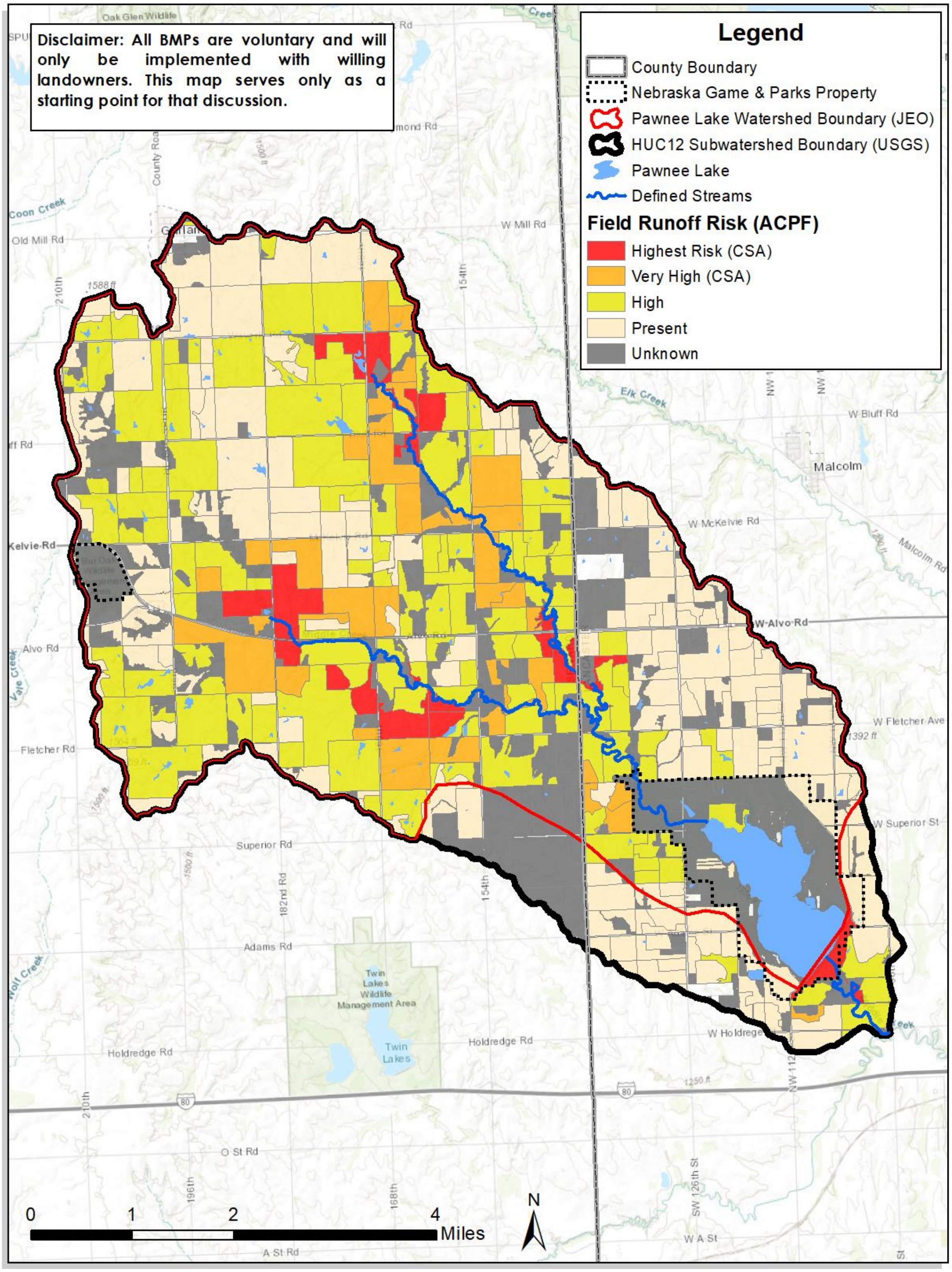


Figure 77: Critical Source Areas at Pawnee Lake as identified with the ACPF Tool

MEETING WATER QUALITY STANDARDS

Pawnee Lake – Sediment and Nutrients

Implementing a comprehensive strategy for Pawnee Lake that includes management practices for both external and internal pollution control measures will result in the lake meeting water quality standards for in-lake phosphorus and nitrogen loads (Table 57 and *Source: Water Quality Modeling*

Table 58). It is assumed that if lake nutrient concentrations meet the water quality standard, algae biomass will also meet the standard. Additionally, a full support status will be achieved for the aesthetics use by increasing lake storage capacity. Reduction targets for phosphorus and nitrogen will be attained. No load reduction target for sediment was required. Additional details can be found in the summary report located in Appendix D.

Table 57: Estimated Phosphorus Reductions and Water Quality Targets for Pawnee Lake

Phosphorus Amount	Load (lbs/yr.)	In-Lake Concentration (µg/L)
Beginning total phosphorus load	29,483	138.8
External total phosphorus reductions	12,947	29.8
Internal load reductions/improvements	13,882	59.7
Total phosphorus reductions	26,829	89.5
Expected conditions	2,654	49.3
Phosphorus loading capacity & water quality standard	3,892	50.0

Source: Water Quality Modeling

Table 58: Estimated Nitrogen Reductions and Water Quality Targets for Pawnee Lake

Nitrogen Amount	Load (lbs/yr.)	In-Lake Concentration (µg/L)
Beginning total nitrogen load	69,817	1,555
External total nitrogen reductions	43,141	960
Internal load reductions/improvements	14,672	282
Total nitrogen reductions	57,813	1,242
Expected conditions	12,004	311
Nitrogen loading capacity & water quality standard	44,683	1,000

Source: Water Quality Modeling

Although nutrient reduction benefits for implementing external and internal management practices have been estimated and provide a path to meeting water quality standards, cumulative benefits of implementing a comprehensive plan are difficult to accurately project. Thus, a sound monitoring and data collection network will be critical to adaptively manage Pawnee Lake.

Middle Creek – Atrazine

Several management practices targeted for reducing sediment and nutrient loss from corn ground will reduce atrazine loads carried to receiving streams as runoff. Those practices in addition to BMP's developed specifically for Nebraska (Franti and others, 2003), were used to develop a treatment train specific for atrazine.

Avoidance practices, such as reducing application rates and using crop rotations, will result in the largest atrazine load reduction to Middle Creek (Table 59). Atrazine load reductions associated with using the treatment train approach will reduce in-stream concentrations by approximately 92%, exceeding the load reduction target of 78%. The May 19, 2003 storm event produced an atrazine concentration of 43.45 µg/L. If the benefits from the proposed management measures were applied to that concentration, the expected concentration would be 9.76 µg/L, far below the chronic standard of 12.00 µg/L. Additional details can be found in the summary report located in Appendix D.

Table 59: Expected Atrazine Reductions and Water Quality Targets in Middle Creek

Beginning Atrazine Conditions (5/19/2003 Runoff Event)	Practice Efficiency (%)	Acres Applied	Load (lbs)	Concentration Reduction (µg/L)
Atrazine Load/Concentration	-	-	26.71	43.45
Reduction due to BMP Train				
Level 1 - Reduced application rates/timing	69	2,256	18.43	29.98
Level 2 - Soil incorporation-band application	67	2,256	5.55	9.02
Level 3 - Contour buffers	30	1,108	0.40	0.65
Level 3 - Terraces	40	214	0.09	0.14
Level 4 - Water/Sediment control basins	30	580	0.17	0.28
Expected Conditions				
Total reduction	-	-	24.64	40.07
Final load/expected concentration	-	-	2.07	3.38
Loading capacity/chronic standard	-	-	7.38	12.00

Source: [1] Franti and others, (2003); [2] Nebraska Department of Agriculture (NDA), 2016

MONITORING

The LPSNRD will follow the established protocol and procedures to: develop sound, defensible monitoring strategies and networks; properly manage data; and disseminate information to decision makers and other stakeholders. Monitoring goals can only be achieved through partnerships with other resource agencies such as NDEQ and NGPC. Steps will be taken to ensure collection of scientifically valid data, which may include the development of Quality Assurance Project Plans (QAPP) for state and federal review. Additional guidance and references are located in Chapter 4 of the WQMP.

To adequately design monitoring networks that facilitate water resource management, it is critical to use data for its intended purposes. Thus, it is necessary to establish specific monitoring goals and objectives. A set of monitoring goals and objectives has been developed for Middle Creek and Pawnee Lake. Targeted parameters, monitoring sites, and monitoring frequency have been defined to meet each objective. Monitoring goals and objectives provided below in *italics* may require expanded or new monitoring efforts, whereas objectives and parameters in plain text are currently being addressed. Detailed monitoring actions for each objective are located in the summary report located in Appendix D.

Monitoring Goal 1: Evaluate the water quality condition of Pawnee Lake.

- Assess the suitability of Pawnee Lake for primary contact recreation.
- Evaluate beneficial use support and water quality trends for Pawnee Lake.
- *Document current atrazine concentrations in Middle Creek.*

Monitoring Goal 2: Estimate pollutant loads and source contribution to Middle Creek and Pawnee Lake.

- Quantify sediment, nutrient, and atrazine runoff loads for the drainage area above Pawnee Lake.
- *Estimate sediment, nutrient, and atrazine runoff loads from catchments above Pawnee Lake.*
- *Quantify external phosphorus, nitrogen, and sediment loads to Middle Creek and Pawnee Lake from specific land cover types.*
- *Verify sediment and nutrient loads stemming from streambank erosion.*
- *Quantify internal phosphorus, nitrogen, and sediment loads to Pawnee Lake from specific sources.*
- *Estimate the current lake conservation pool storage volume.*
- *Quantify annual lake retention of phosphorus, nitrogen, and sediment.*

Monitoring Goal 3. Gather data needed to complete pre-implementation planning.

- *Evaluate spatial sediment deposition in Pawnee Lake.*

COMMUNICATION AND OUTREACH

Chapter 6 of this plan provides a broad, programmatic approach that the LPSNRD and its partners will take to address nonpoint source pollution through communication and outreach activities. Specifically, within a target area there are certain pieces of information necessary for successful communication and outreach efforts which will, in turn, support the implementation of BMPs. Those items specific to the Pawnee Lake and Middle Creek Target Area were identified via stakeholder and public input, and are as follows:

- Identified Target Audiences
    - Recreational water users of Pawnee Reservoir
    - Land managers, residents, and property owners within Pawnee Reservoir drainage area
    - Producers with existing BMPs who may be interested in implementing more
    - Rural homeowners on private wells and septic systems
- Methods
    - Utilize parcel ownership information, along with the detailed BMP location maps created with the ACPF Tool, to contact specific landowners about BMPs applicable to their properties
        - A postcard mass mailing followed up by phone calls will help start initial implementation efforts and/or increase attendance at public meetings
    - Work with NDEQ and NGPC to develop targeted blue-green algae information kiosks at highly visible locations at Pawnee Lake (i.e. public beaches, entrances to Pawnee lake, or boat ramps)
    - Build a unifying logo, tagline, or message around protecting and restoring Pawnee Lake. This would be included on signage and other documents
    - Develop signage to be used at project demonstration sites, key watershed entrances or landmarks, and other highly visible areas
    - Utilize locations within the Village of Malcolm for the following:
        - Post flyers, distribute press releases, and advertise at local events
        - Hold targeted coffee shop meetings, tailgate sessions, and other informal/casual informational exchanges to build relationships and to learn more about the constraints and hurdles to BMP adoption
    - Piggyback on existing events - Training and demonstration field days, information booths, recognition picnics, etc.
        - Such as the BBQ and Blues Fest held annually in Malcolm, nitrogen certification training events, etc.
    - Hold an outdoor recreation clinic (kayaking, fishing, etc.) at Pawnee Lake

Plan and project sponsors will utilize these target audiences and outreach methods when building project level communication and outreach plans, typically as part of a Project Implementation Plan (PIP). The PIP will identify the specific and tailored actions for each target audience, as discussed in Chapter 6.

SCHEDULE

The timeframe for implementing general actions is provided in Table 60. Actions are subject to approval by the LPSNRD Board of Directors, USACE, and NGPC, and may change as the plan is implemented. Phase I activities will include the initiation of external management practice implementation and the evaluation of in-lake measures. Phase II will begin upon the five-year revision of this plan. A summary of progress achieved during Phase I will be included in the plan revision.

Table 60: Schedule for Implementing Pawnee Lake and Middle Creek Target Area

Activity	Phase I						Phase II
	2019	2020	2021	2022	2023	2024	2025-2029
LPSNRD Board of Directors approval of plan	■						
EPA approval of the plan	■						
Monitoring (ongoing)	■	■	■	■	■		
Develop PIP for Watershed BMPs		■					
Organize stakeholder group		■					
Watershed BMP implementation		■	■	■	■	■	
Project evaluation						■	
Final reporting						■	
In-lake BMP feasibility study					■	■	
Update HUC8 watershed plan							■
Continue watershed BMP Implementation							■
Initiate in-lake BMP implementation							■

MILESTONES

Major milestones that pertain to monitoring, planning, and management practice implementation are provided in Table 61. Milestones will be used to gauge progress in meeting the desired project schedule. As the implementation of this plan is initiated, milestones will be adjusted accordingly to address changes in the schedule.

Table 61: Implementation Milestones for Pawnee Lake and Middle Creek Target Areas

Activity		Phase I						Phase II
		2019	2020	2021	2022	2023	2024	2025-2029
Monitoring	Coordinate with NDEQ	■	■	■	■	■		
	Finalize strategies and QAPPs		■					
	Assess data (annually)	■	■	■	■	■		
Planning	Develop PIP for BMP implementation		■					
	Apply for funding assistance grants		■					■
	Evaluate progress in meeting goals						■	
	Identify additional BMP needs						■	
	Prepare final report(s)						■	
	RFP for In-lake BMP feasibility study					■		
	Complete in-lake feasibility study						■	
	Revise watershed plan as needed							■
Information /Education	Develop stakeholder group		■					
	Work one-on-one with producers		■	■	■	■	■	
Implementation	Initiate BMP implementation		■					
	Complete Phase I BMP implementation						■	

COST

The preliminary opinion of total cost for implementing the nonpoint source pollution control strategy for Pawnee Lake and Middle Creek is estimated to be $47,064,689 (Table 62). This does not include costs for bathymetric surveys or final designs as these costs may be included through existing staff or agency budgets or would be contingent on project scoping. When possible, costs were determined from the 2018 USDA-NRCS EQIP practice payment schedule (USDA, 2018). Costs estimated for in-lake measures were based on average unit prices from a wide range of past project costs and should only be used for general planning purposes. These cost estimates are subject to change based on final design of the rehabilitation, inflation, bidding climate at the time of construction, project size, and/or complexity.

Table 62: Implementation Costs for the Pawnee Lake and Middle Creek Target Area

Practice	Units	Units Targeted	Unit Cost	Total Cost
Education/Information*	Years	5	$10,000	$50,000
Avoidance practices*	Acres	3,183	$108	$343,764
Contour (filter) buffers	Acres	110	$500	$55,000
Terraces	Feet	62,083	$4	$248,332
Cover crops	Acres	3,638	$133	$483,854
No-till	Acres	682	$20	$13,640
Water and Sediment Control Basins (WASCOB)	Feet	54,600	$4	$218,400
Wetlands	#	80	$35,000	$2,800,000
Riparian buffers	Acres	279	$1,650	$460,350
Grazing management	Acres	5,903	$42	$247,926
OWTS Upgrade Practice	#	57	$5,500	$313,500
Non-Permitted AFO Facility BMP	Units	31	$20,000	$620,000
Grassed Waterways	Acres	8	$6,575	$49,313
Sub-Total (Watershed Treatment)				**$5,904,079**
Streambank/Channel Stabilization & Restoration	Feet	93,625	$150	$14,043,750
Sub-Total (In-Stream Work)				**$14,043,750**
Lake deepening/Sediment removal**	Acre-feet	2,460	$8,000	$19,680,000
Shoreline Stabilization	Linear-feet	2,316	$110	$254,760
Jetties and Breakwaters	Linear-feet	6,043	$500	$3,021,500
In-lake Sediment Basins	Acres	90	$30,000	$2,700,000
Nutrient Inactivation	Acres	623	$2,200	$1,370,600
In-lake Feasibility/Design Study	Each	1	$40,000	$40,000
Sub-Total (In-Lake Work)				**$27,066,860**
Updates to Watershed Plan	Each	0	$-	$-
Additional Monitoring	Years	5	$10,000	$50,000
Sub-Total (Planning/Monitoring)				**$50,000**
Total				**$47,064,689**

**Based on estimated costs during the first 5-year increment only*

***Based on returning the lake to originally constructed conservation pool volume*

10.04 EAST & WEST TWIN LAKES TARGET AREA

INTRODUCTION

NOTE TO READERS

Information in this section is summarized from the *Pollutant Modeling and BMP Implementation Recommendations Summary Report for Twin Lakes* (Laketech, 2018b), a copy of which is also provided in Appendix D. Unless otherwise noted, additional details and background information can be found in that comprehensive document.

East and West Twin lakes, collectively known as Twin Lakes, are located in Seward County (Figure 78). The lakes lie on unnamed tributaries of the South Branch Middle Creek (LP2-21010) and are connected at conservation pool elevation by a narrow, shallow channel extending approximately 0.25 miles (Figure 79). Given this connection and the lack of an outflow structure at West Twin, the U.S. Army Corp of Engineers (USACE) operates and refers to these lakes as the singular 'Twin Lakes' system (USACE, 2018). As-built conditions from 1966 indicate that Twin Lakes comprised 245 surface acres and had a conservation pool volume of 2,561 acre-feet (Table 63). The dam was constructed for the primary purpose of flood control, with recreation as a secondary benefit. The lakes and park area are designated as a Wildlife Management Area (WMA) by the Nebraska Game and Parks Commission (NGPC). Both lakes and their drainages comprise approximately 26% of the South Branch Middle Creek HUC12 subwatershed (102002030201).

Current records indicate that East Twin Lake (LP2-L0240) encompasses 149 surface acres (NDEQ, 2016b). Approximately 2,986 acres drain directly to East Twin Lake with the northern border of the drainage adjacent to the Pawnee Lake drainage. East Twin Lake is managed as a no-wake lake, limiting watercraft to five miles per hour (mph).

Current records indicate that West Twin Lake (LP2-L0260) encompasses approximately 45 surface acres (NDEQ, 2016b). While West Twin Lake is significantly smaller than East Twin Lake, it has a larger drainage area consisting of 3,836 acres. The drainage area to lake area ratio for East Twin Lake is approximately 20:1, while West Twin Lake's ratio is 107:1. The lake and surrounding park serve as a more primitive area, with no vehicle access or recreational facilities permitted. In 2002, West Twin Lake had a maximum depth of only four feet at times and the lake has been completely dry as recently as 2007.

Beneficial uses assigned to both lakes include Primary Contact Recreation, Aquatic Life, Aesthetics, and Agricultural Water Supplies (NDEQ, 2014). The 2016 Integrated Report (2016 IR) lists East Twin Lake as being impaired from total phosphorus, total nitrogen, and algae biomass (NDEQ, 2016b). Although West Twin Lake is currently identified as impaired from total phosphorus, total nitrogen, ammonia, and algae biomass, it has not been sampled since 2005. The South Branch Middle Creek has no impaired beneficial uses.

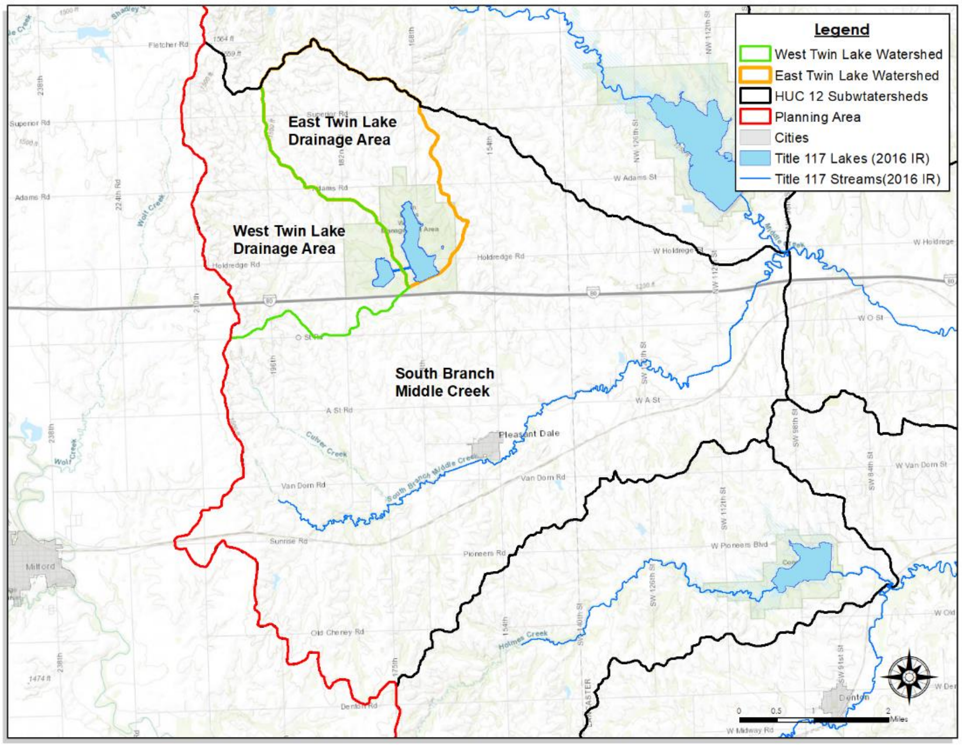


Figure 78: Location of Twin Lakes

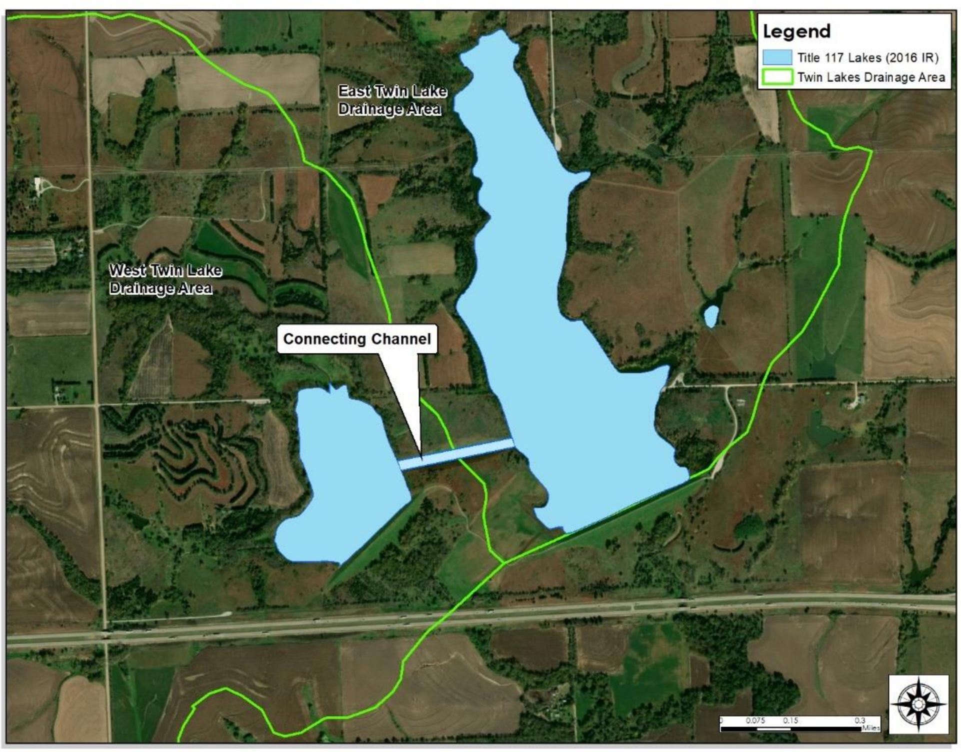


Figure 79: Channel Connecting West Twin and East Twin Lakes

Table 63: Background Information for Twin Lakes

Variable	Twin Lakes
General	
Dammed stream	South Branch Middle Creek
Conservation pool elevation (top)	1,341.0 feet-mean sea level (ft-msl)
Date of dam closure	26-Sep-1965
Drainage area[1]	6,820 ac.
Drainage area to lake area ratio	28:1
"As-Built" Conditions	1966
Lowest reservoir bottom elevation	1,316 ft-msl
Surface area at top of conservation pool (1966)	245 ac
Capacity of conservation pool (1966)	2,561 ac-ft
Mean depth at top of conservation pool (1966)	10.5 ft
Operational Details	(1968-2016)
Maximum recorded pool elevation	1,346.9 ft-msl
Minimum recorded pool elevation	1,332.1 ft-msl
Average annual pool elevation	1,339.4 ft-msl
Current inflow (2012-2016)	2,417 ac-ft
Outlet Works	
Ungated outlets	2; 24" x 63" 1,341.0 ft-msl
Gated outlets (low-level)	1; 42" x 54" 1,333.0 ft-msl

Source: USACE, 2017 [1] = USDA, 2017a

IMPAIRMENTS

Nutrients and Algae Density

East Twin and West Twin lakes are both listed in the 2016 Integrated Report (IR) as having Aquatic Life impairments due to excessive phosphorus, nitrogen, and algal biomass as measured from chlorophyll *a* (NDEQ, 2016b). Although current data was available for East Twin Lake (2012-2016), the most current period of record for West Twin Lake data is from 2002-2005. Mean growing season (May-September) total nitrogen and total phosphorus concentrations, as well as algae biomass, support the 2016 IR impairment designation for the Aquatic Life use (Table 64 and Table 65).

Table 64: East Twin Lake Nutrient Concentrations and Algae Biomass

Parameter	Data Period	N	Growing Season Mean	Water Quality Standard
Total Phosphorus (µg/L)	2012-2016	25	99	50
Total Nitrogen (µg/L)	2012-2016	25	1,509	1,000
Chlorophyll *a* (mg/m3)	2012-2016	25	32	10

Source: USACE, 2017

Table 65: West Twin Lake Nutrient Concentrations and Algae Biomass

Parameter	Data Period	N	Growing Season Mean	Water Quality Standard
Total Phosphorus (µg/L)	2002-2005	18	361	50
Total Nitrogen (µg/L)	2002-2005	10	3,727	1,000
Chlorophyll *a* (mg/m3)	2002-2005	17	43	10

Source: USACE, 2017

The Aquatic Life use for West Twin Lake is also listed as being impaired from ammonia. Fourteen total ammonia samples were collected from West Twin Lake from 2003-2005. Samples were collected from two depths on two of the days sampled (5/18/2004 and 7/1/2004). Samples values, water temperature, and pH measurements were averaged for each of these dates.

While it is unknown how the data set was used for the impairment listing, three of the 12 ammonia concentrations assessed were equal to or above the chronic water quality standard, with two of those violations occurring in 2005 (Figure 80). Due to the age of the data age and the current physical condition of West Twin Lake, ammonia will not be a priority in this Plan.

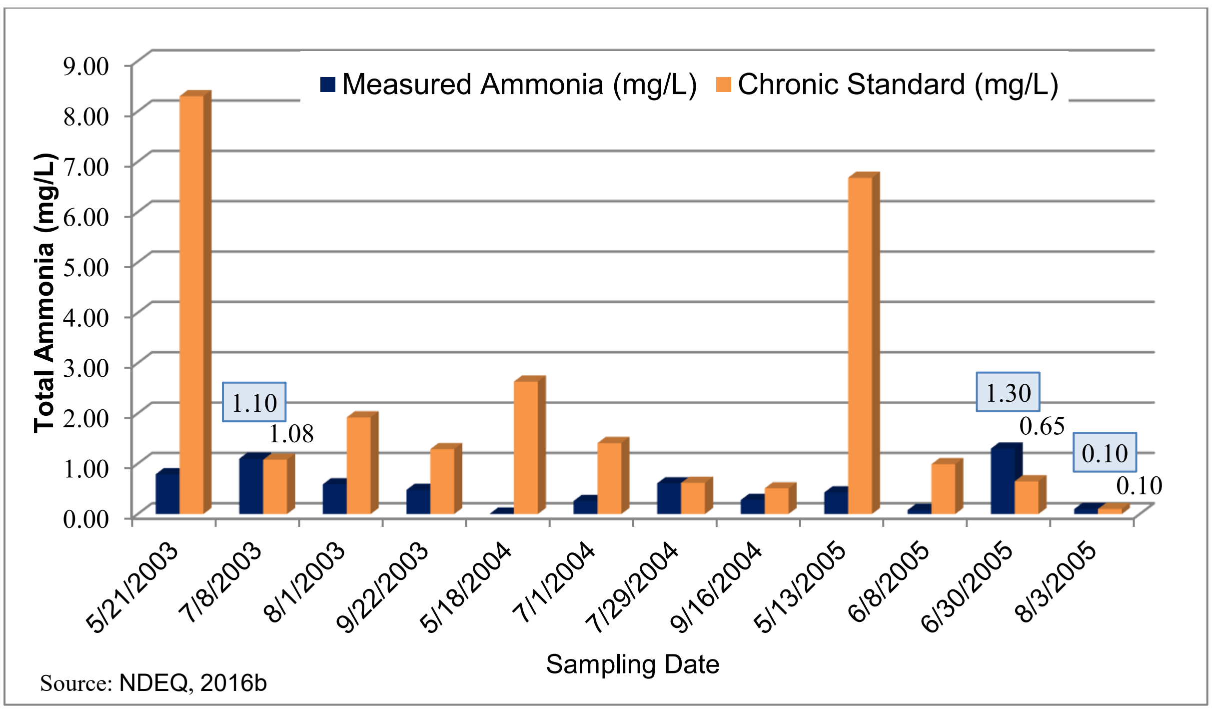


Figure 80: Total Ammonia Concentrations in West Twin Lake

Sediment

Neither East Twin Lake or West Twin Lake are listed as impaired from sediment; however, conservation pool volume loss as estimated by the USACE in 2016 indicate that impairment may exist. The most current bathymetric survey completed on Twin Lakes was in 2002 and was conducted by NDEQ and the United States Geological Survey (USGS). The USACE utilized the results of this survey, as well as an earlier survey they completed in 1994, to provide a range for conservation pool storage capacity loss and sedimentation rates. As reported, Twin Lakes is losing between 0.56% to 0.82% of the original conservation pool volume annually (USACE, 2018). The high end of this range falls slightly above the 0.75% volume loss criteria used by NDEQ to determine impairment. The total loss of volume in the Twin Lakes conservation pool since construction is estimated between 28% and 41%. The low end of this range falls above NDEQ assessment criteria of 25% indicating impairment. Current data is needed to verify lake storage volumes.

Atrazine

Although there are no stream impairments due to atrazine, high concentrations have been measured at the runoff monitoring locations above each lake (Figure 81). Atrazine concentrations exceeded the chronic water quality standard in 45% of the samples collected above East Twin Lake and 43% of the samples collected above West Twin Lake from 2002-2008 (Table 66).

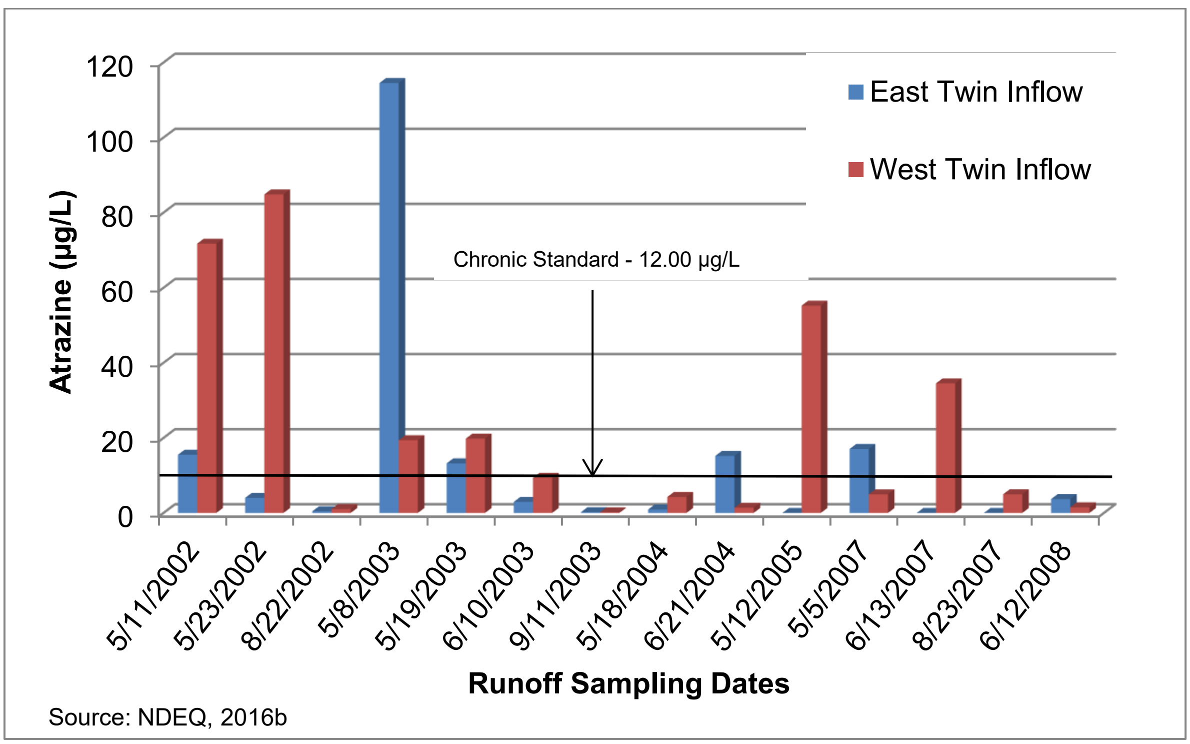


Figure 81: Atrazine Concentrations in Runoff Samples from Twin Lakes Tributaries

Table 66: Summary of Atrazine Samples Collected Above East and West Twin Lakes

Data Period	East Twin	West Twin
Number of runoff samples	11	14
Number >12.00 µg/L	5	6
% > 12.00 µg/L allowed	45	43
Mean concentration (µg/L)	17.06	22.36
Median concentration (µg/L)	4.00	7.16

POLLUTANT SOURCES AND LOADS

Pollutant loads to East and West Twin lakes were estimated for the following parameters of concern: phosphorus, nitrogen, and sediment. Pollutant loads and the contribution from primary sources were estimated from the Statistical Tool for Estimating Pollutant Load (STEPL) model (TetraTech, 2007), Sediment Phosphorus Release Regression Equation (Dzialowski & Carter, 2012), and data calculations. A summary of data, data sources, and assessment methods can be found in the modeling/implementation report in Appendix D.

To fully account for pollutant sources, contributions from external and internal sources were quantified to the extent possible. Due the lack of lake depth and excessively high nutrient concentrations in West Twin Lake, lake response models were not applicable to estimate loads from internal sources. While internal loads of phosphorus were estimated for East Twin Lake, the lack of literature and data prevented the estimation of internal nitrogen loads. Due to lack of data, internal phosphorus loads to East Twin Lake from three sources—waterfowl waste, bottom re-suspension, and phosphorus transferred from West Twin Lake—were reported as one load. External sources of nutrients to each lake include runoff from the drainage area, as well as atmospheric deposition through precipitation directly on the lake.

Phosphorus Loads

The current average annual phosphorus load to West Twin Lake is estimated at 6,609 lbs/yr (Table 67). Land used for corn and soybean production, the largest phosphorus load contributor, contributes approximately 46% of the total (Figure 82). Although land in permanent grass contributes 20% of the phosphorus load, it comprises 52% of the drainage area. Because West Twin Lake has no outflow structure, loads are either retained or transferred to East Twin Lake.

Table 67: Phosphorus Sources and Average Annual Loads to West Twin Lake

Sources	Area	Phosphorus Load	Total
External			
Grass-pasture	1,989	1,481	20
Corn-soybeans	1,131	2,818	46
Forest	500	38	1
Other crops	74	83	1
Urban	64	21	<1
Open lots-Animal feeding/holding[1]	16	693	10
Streambank erosion (miles)	6.1	1,304	20
Registered on-site wastewater (#)	6	4	<1
Unregistered on-site wastewater (#)	33	161	2
Atmospheric deposition (lake area)	45	7	<1
Internal			
Lake shoreline (area loss per year)	-	NE	-
Bottom sediment "P" release	-	NE	-
Waterfowl and bottom "P" re-suspension	-	NE	-
Total Gross Load		6,609	100

Source: Water Quality Modeling

Note. NE = Not estimated. [1]Pertains to non-permitted animal feeding operations.

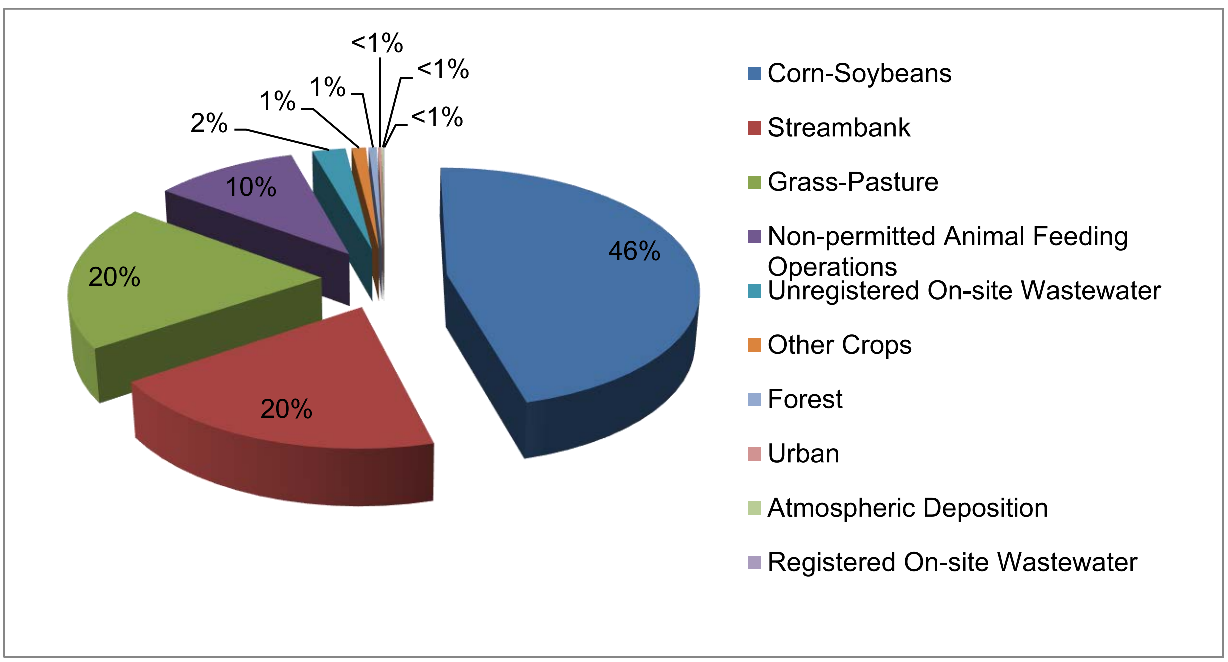


Figure 82: Source Contributions of Phosphorus to West Twin Lake

The current average annual gross phosphorus load to East Twin Lake is estimated at 5,111 lbs/yr. (Table 68). Of this amount, external sources account for approximately 3,886 lbs (or 76%) of the total load. Streambank erosion, which comprises 23% of the overall load, contributes 1,151 pounds of phosphorus to the lake annually (Figure 83). Approximately 17% of the phosphorus load stems from waterfowl waste, bottom sediment re-suspension, and transfer from West Twin Lake.

Table 68: Phosphorus Sources and Average Annual Loads to East Twin Lake

Sources	Area (acres)	Phosphorus Load (lbs/yr)	Total (%)
External			
Grass-pasture	1,541	460	9
Corn-soybeans	828	1,634	32
Other crops	203	16	0
Forest	220	100	2
Urban	8	439	9
Open lots-Animal feeding/holding[1]	12.6	3	0
Streambank erosion (miles)	3.58	1,151	23
Registered on-site wastewater (#)	2	1	0
Unregistered on-site wastewater (#)	12	58	1
Atmospheric deposition (lake area)	149	23	0
Internal			
Lake shoreline (area loss per year)	149	NE	-
Bottom sediment "P" release	149	339	7
Transfer from West Twin, waterfowl, and bottom "P" re-suspension	149	886	17
Total Gross Load		**5,111**	**100**

Source: Water Quality Modeling

Note. NE = Not estimated. [1]Pertains to non-permitted animal feeding operations.

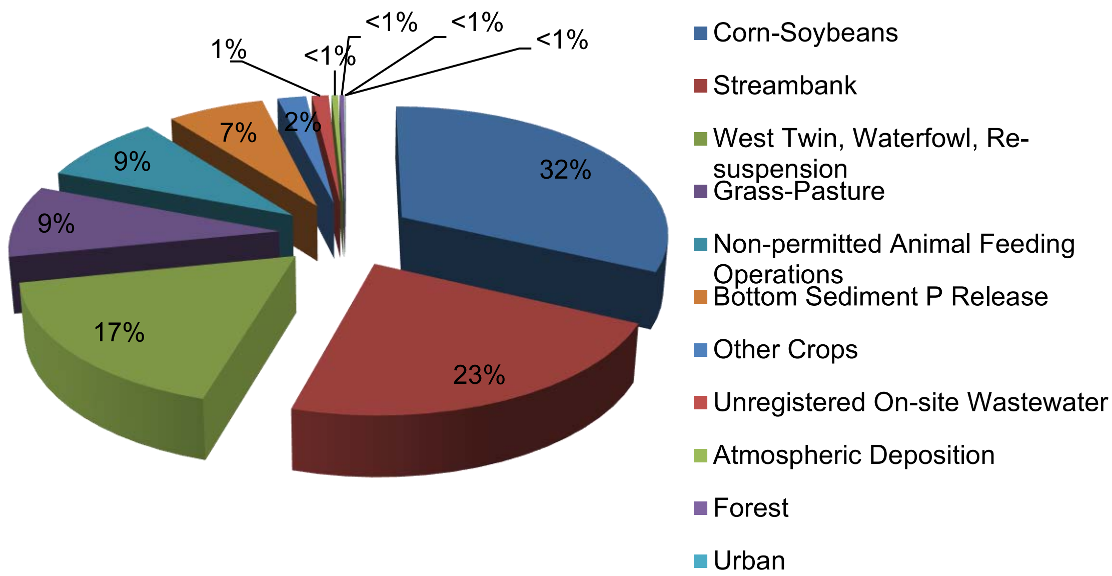


Figure 83: Source Contribution of Phosphorus to East Twin Lake

Nitrogen Loads

The total gross nitrogen load to West Twin Lake is approximately 31,085 lbs/yr. (Table 69). This estimate was determined as the sum of the drainage area runoff load (30,823 lbs/yr.) and nitrogen contributed through precipitation falling directly on the lake surface (262 lbs/yr.). Land used for corn and soybean production contributes the largest nitrogen load to the lake at 42%.

Because West Twin Lake has no outflow structure, loads are either retained or transferred to East Twin Lake. The current average annual external nitrogen load to East Twin is 21,212 lbs/yr. (Table 70). This estimate was determined as the sum of the drainage area runoff load (20,343 lbs/yr.) and nitrogen contributed through precipitation falling directly on the lake surface (869 lbs/yr.).The largest contributor of nitrogen is from land used for corn and soybean production (Figure 84).

Table 69: Nitrogen Sources and Average Annual Loads to West Twin Lake

Sources	Area	Nitrogen Load	Total
External			
Grass-pasture	1,989	10,398	33
Corn-soybeans	1,131	12,952	42
Other crops	500	41	<1
Forest	74	332	1
Urban	64	96	<1
Open lots-Animal feeding/holding[1]	16	3,465	11
Streambank erosion (miles)	6.1	3,120	10
Registered on-site wastewater (#)	6	9	<1
Unregistered on-site wastewater (#)	33	410	1
Atmospheric deposition (lake area)	45	262	1
Internal			
Lake shoreline (area loss per year)	-	NE	-
Bottom sediment release	45	NE	-
Waterfowl and bottom re-suspension	45	NE	-
Total Gross Load		**31,085**	**100**

Source: Water Quality Modeling

Note. NE = Not estimated. [1]Pertains to non-permitted animal feeding operations.

Table 70: Nitrogen Sources and Average Annual Loads to East Twin Lake

Sources	Area (acres)	Nitrogen Load (lbs/yr)	Total (%)
External			
Grass-pasture	1,541	7,051	33
Corn-soybeans	828	7,598	36
Other crops	203	31	<1
Forest	220	542	3
Urban	8	2,197	10
Open lots-Animal feeding/holding[1]	12.6	17	<1
Streambank erosion (miles)	3.58	2,755	13
Registered on-site wastewater (#)	2	3	<1
Unregistered on-site wastewater (#)	12	149	1
Atmospheric deposition (lake area)	149	869	4
Internal			
Lake shoreline (area loss per year)	149	NE	-
Bottom sediment release	149	NE	-
Transfer from West Twin, waterfowl, and bottom re-suspension	149	NE	-
Total Gross Load	**-**	**21,212**	**100**

Source: Water Quality Modeling

Note. NE = Not estimated. [1]Pertains to non-permitted animal feeding operations.

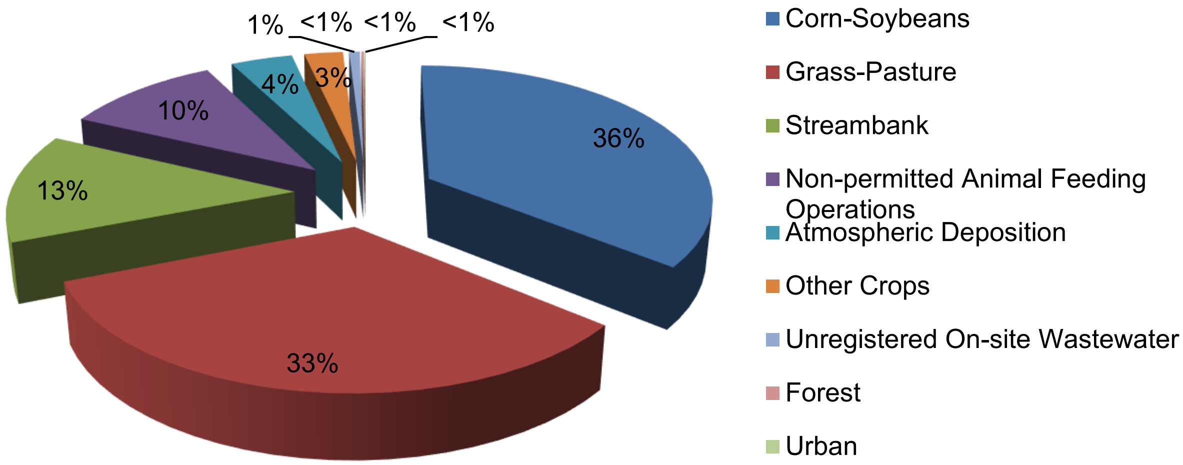


Figure 84: Source Contribution of Nitrogen to East Twin Lake

Sediment Loads

Sources of sediment to Twin Lakes include watershed runoff (external) and shoreline erosion (internal). Shoreline erosion at West Twin Lakes was not estimated due to the lack of historical data. The total gross sediment load to West Twin Lake is estimated to be 2,309 t/yr. (Table 71). The largest source of sediment to the lake is from land used for corn and soybean production, which contributes 43% of the total sediment load. Streambank erosion is the second largest contributor of sediment to the lake and delivers 34% of the total load.

The largest source of sediment to East Twin Lake is from streambank erosion, which contributes 689 t/yr (or 42%) of the total sediment load (Table 72). Lake shoreline erosion contributes the second largest sediment load, accounting for 32% of the total load.

Table 71: Sediment Sources and Average Annual Loads to West Twin Lake

Sources	Area (acres)	Sediment (tons/year)	Total (%)
External			
Grass-pasture	1,989	489	21
Corn-soybeans	1,131	992	43
Forest	500	18	1
Other crops (e.g., rye, alfalfa, oats, winter wheat)	74	28	1
Urban	64	2	<1
Open lots-Animal feeding/holding	16	0	0
Streambank (miles)	6.1	780	34
Registered on-site wastewater (#)	6	0	0
Unregistered on-site wastewater (#)	33	0	0

Atmospheric deposition (lake area)	45	0	0
Internal			
Lake shoreline (area loss per year)	45	NE	-
Bottom sediment release	45	NE	-
Waterfowl and bottom sediment re-suspension	45	NE	-
Total Gross Load		**2,309**	**100**

Source: Water Quality Modeling

Note. NE = Not estimated.

Table 72: Sediment Sources and Average Annual Loads to East Twin Lake

Sources	Area (acres)	Sediment (t/yr)	Total (%)
External			
Grass-pasture	1,541	130	8
Corn-soybeans	828	250	15
Forest	220	3	0
Other crops (e.g., rye, alfalfa, oats, winter wheat)	203	26	2
Feedlots	12.6	0	0
Urban	8	0.4	<1
Streambank (miles)	3.58	689	42
Registered on-site wastewater systems: 5% failure (#)	2	0	0
Unregistered on-site wastewater systems: 40% failure (#)	12	0	0
Atmospheric deposition (lake area)	148	0	0
Internal			
Lake shoreline (area loss per year)	148	524	32%
Bottom sediment release	148	-	-
Transfer from West Twin, waterfowl, and bottom re-suspension	148	-	-
Total Gross Load	**-**	**1,622**	**100**

Source: Water Quality Modeling

REQUIRED POLLUTANT LOAD REDUCTIONS

Phosphorus and Nitrogen

No loading capacities were determined for West Twin Lake because it lacks an outflow and is connected to East Twin Lake at conservation pool elevation. The total phosphorus loading capacity for East Twin Lake was determined from the Canfield-Bachmann lake loading regression equation (Canfield & Bachmann, 1981).

Based on the Canfield-Bachmann results, the current in-lake phosphorus concentration of 98.8 µg/L will need to be reduced by 49% to meet the water quality standard of 50 µg/L (Table 73). The gross phosphorus load capacity associated with an in-lake concentration of 50 µg/L is approximately 1,572 lbs/yr. In order to meet this water quality standard, the current annual phosphorus load of 5,111 lbs/yr will need to be reduced by 3,539 lbs/yr (69%).

The current in-lake nitrogen concentration of 1,509 µg/L will need to be reduced by 34% to meet the water quality standard of 1,000 µg/L. This in-lake reduction was used as the nitrogen load reduction target. Applying a 34% reduction to the current load of 21,212 lbs/yr would result in a reduction target of 14,057 lbs/yr.

In order to determine the extent of load reductions that can be achieved from controlling anthropogenic sources of pollutants, natural background loads of phosphorus and nitrogen were determined for the Twin Lakes drainage area. Estimated annual natural background loads constitute approximately 69% of the phosphorus loading capacity and 84% of the annual nitrogen loading target. These numbers indicate an aggressive nutrient reduction strategy will need to be implemented in order for East Twin Lake to meet phosphorus and nitrogen targets.

Table 73: Phosphorus and Nitrogen Reduction Targets for East Twin Lake

Targets	Phosphorus	Nitrogen
Amount		
Current in-lake phosphorus (µg/L)	98.8	1,509
Target in-lake phosphorus (µg/L)	50.0	1,000
Target reduction (µg/L)	48.8	509
Target reduction (%)	49	34
Sum of External and Internal Load		
Current load (lbs/yr)	5,111	21,212
Load capacity (lbs/yr)	1,572	7,155
Target reduction (lbs/yr)	3,539	34
Target reduction (%)	69	14,057

Source: Water Quality Modeling

Sediment

Bathymetric surveys of Twin Lakes were completed in 1992 and 2002 (USACE, 2017). Sedimentation rates from historic surveys were used to estimate the current storage capacity of the conservation pool of 1,861 ac-ft. (Table 74). As reported, Twin Lakes is losing 0.56% to 0.82% of the original conservation pool volume annually. The high end of this range falls slightly above the 0.75% criterion used to determine impairment. Because the mid-point of the reported range (0.69%) falls below the NDEQ sedimentation assessment criterion, no load reduction targets were established. However, the implementation strategy targeted for phosphorus and nitrogen load reductions will also result in significant reductions to current sediment loads. Collection of current reservoir volume information should be conducted to solidify volume loss and annual sedimentation estimates.

Based on an as-built conservation pool volume of 2,561 ac-ft. and a current volume of 1,861 ac-ft., the loss to the conservation pool is estimated to be 700 ac-ft. or 27.3%. However, the USACE assessment indicates that volume loss could be as high as 41%. The low end of this range falls above the NDEQ assessment criterion of 25%. For planning purposes, the mid-point of the reported range (33.7%) will be used. Based on this loss, approximately 223 acre-feet of conservation pool storage or 8.7% will need to be reclaimed to meet the loss criterion. Although individual lake volumes are not available, observations indicate that West Twin Lake has lost nearly 100% of its conservation pool storage capacity.

Table 74: Sedimentation Rates and Conservation Pool Storage Volume Loss for Twin Lakes

Twin Lakes	Range (Midpoint)	NDEQ
Conservation Pool Storage Volume (ac-ft.)		
Original storage volume (1966)	2,561	
Current storage volume	1,861	
Conservation pool storage volume loss (difference)	700	
Conservation Pool Storage Volume Loss		
Conservation pool loss (ac-ft/yr.)	14.3-20.9	
Average annual conservation pool loss (%/yr.)	0.56-0.82	0.75
Total conservation pool loss (%)	27.3-41.0: Mid-point	25
Necessary Storage Volume Increase		
Storage capacity increase needed to meet 25% (ac-	223	

Source: USACE, 2018

IMPLEMENTATION STRATEGY

The implementation strategy for the drainage area above Pawnee Lake includes multiple practices that target pollutant sources through the ACT approach (avoid, control, trap), also known as a “treatment train”. All pollutant sources will be addressed, except for atmospheric loading, as this plan only addresses nonpoint source pollution from surface water runoff.

A VOLUNTARY PLAN

The implementation of this plan is based entirely on the voluntary actions of landowners and citizens. Individuals must decide if it is an advantage to participate, and it is the responsibility of the LPSNRD and other stakeholders to find ways to make participation advantageous.

The implementation strategy presented in this plan should be used as a guide for practice implementation and may be subject to revision as new information becomes available and willing landowners are identified. For a detailed description of the BMPs discussed below, refer to Chapter 7.

Water quality assessments indicate in-lake management measures will be needed for East Twin Lake to meet water quality standards and sedimentation assessment criteria. Given the extent of in-lake work required, only a general accounting of appropriate measures and costs are provided.

Specific measures and accurate costs should be determined through a feasibility/design study with results included in a future revision of this plan.

To provide an accurate load reduction estimate from practice implementation, recommended practices were used to develop a “treatment train” (following ACT methodology) that follows the flow of pollutants from the source to the receiving waterbody (Figure 85). The drainage area treatment train is comprised of seven levels of treatment, beginning with education/outreach and avoidance practices, and ending with in-lake management measures.

Figure 85: Water Quality Treatment Train for Twin Lakes

BMP TARGETING

Drainage Area Management Measures and Reductions

A suite of structural and non-structural management practices was identified using aerial assessments and the ACPF toolbox. In addition to these practices, education/outreach and avoidance practices were added to the suite of recommendations for the Twin Lakes drainage (Table 75). Ground used for corn and soybean production is targeted for the largest number of practices. All land cover types and pollutant sources were targeted for education and outreach activities except for water and wetlands, which were not classified as pollutant sources. Figure 86 and Figure 87 present the number and location of acres targeted for individual and groups of practices, as well as areas best suited for those practices. These maps are not "planned" locations, but instead provide a starting point for discussions with willing landowners and enable managers methods to develop this WQMP. Detailed map books can be found in Appendix F of the WQMP.

Table 75: Land Cover Types Targeted for BMPs in the Twin Lakes Drainage

Land Cover Type/ Pollutant Source	Current Acres (Both Drainages)	BMP	Acres Targeted East Twin/West Twin
All	6,587[a]	Education & Outreach	2,813/3,774
Corn-Beans	1,060	Avoidance	580/792
		Terraces - cover crops - no till	64/93
		Contour buffer - cover crop - no till	60/77
		Cover crops-contour buffer	182/202
		Cover crops	356/533
		WASCOBS	113/110
		Wetlands	594/451
		Riparian buffers	127/163
AFOs Non-permitted	29	Avoidance	9/11
		WASCOBS	12/9
Pasture	3,192	Grazing management	771/995
		WASCOBS	221/187
		Wetlands	747/825
Other Crops	278	WASCOBS	104/6
		Wetlands	203/102
Forest	720	WASCOBS	46/82
		Wetlands	84/241
Urban	73	Wetlands	4/24
Streambanks (miles)	9.7	Bank stabilization (miles)	0.96/2.6
OWT Systems (#)	53	Unregistered system upgrade (#)	4/12

Note. [a] Does not include water or wetlands. WASCOBS = Water and Sediment Control Basins.
Note: Grassed waterways, and their conceptual locations, were also identified as a priority BMP, however they were grouped with wetlands in the water quality modeling, due to technical limitations.

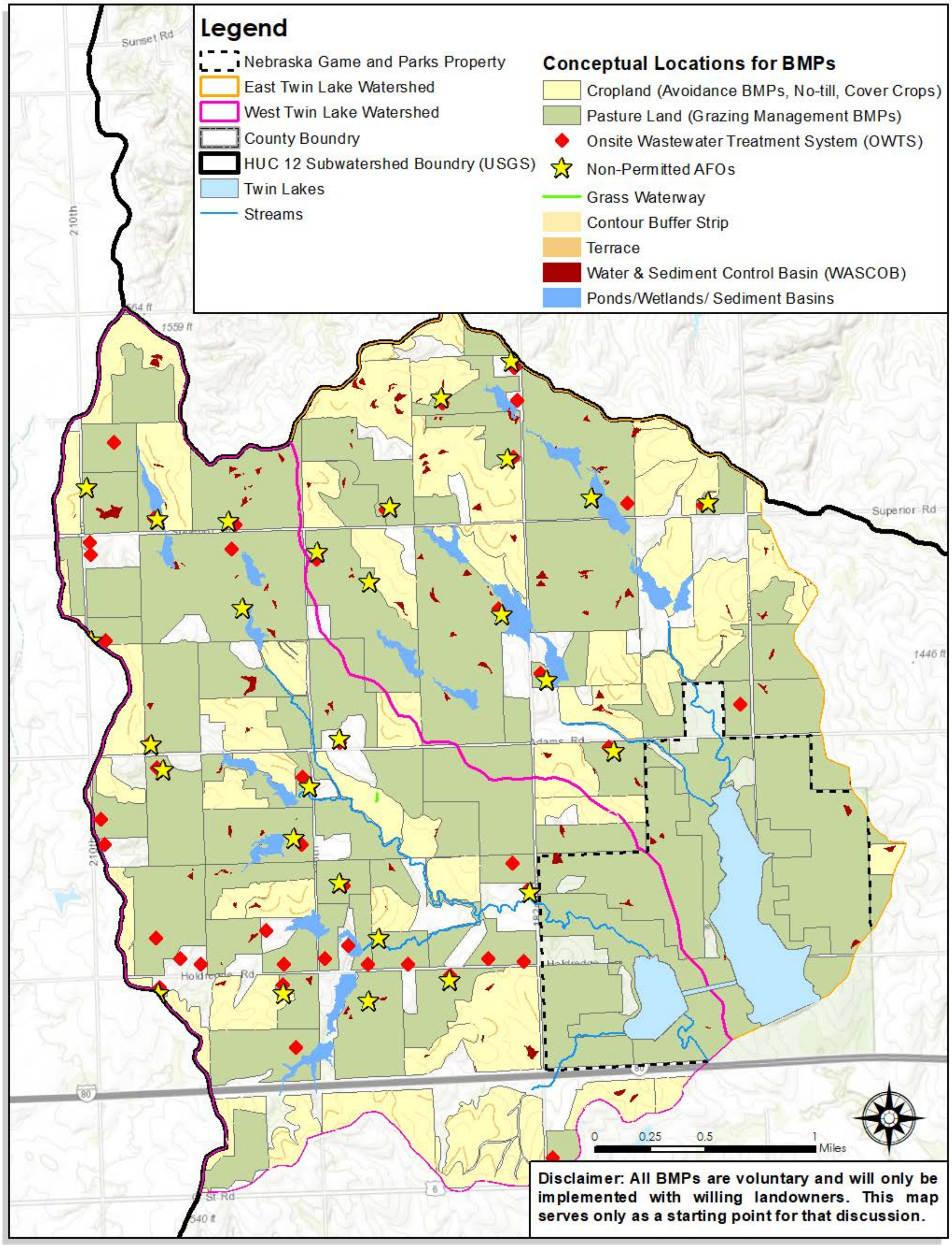


Figure 86: Conceptual locations of in-field and edge-of-field BMPs

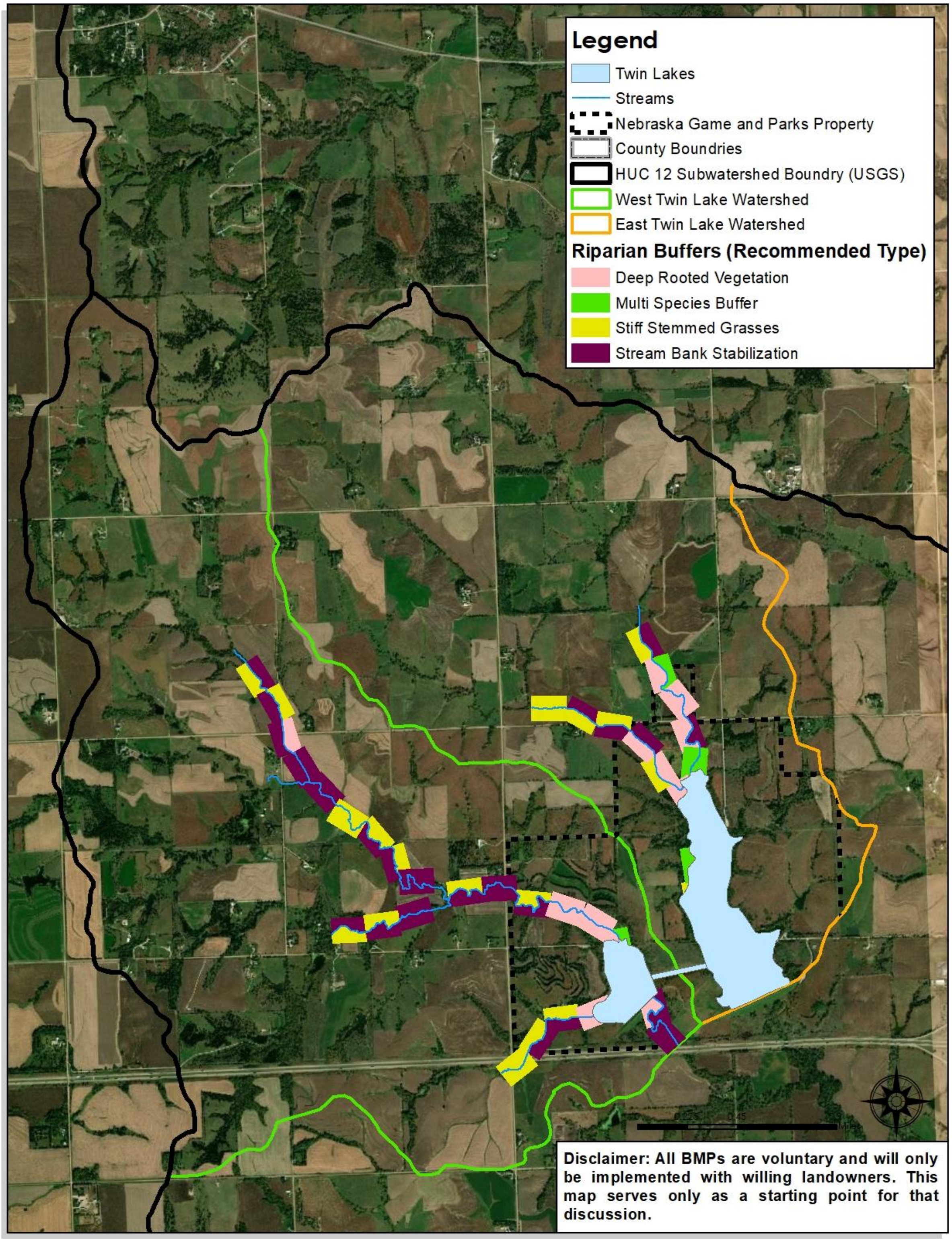


Figure 87: Conceptual locations of in-stream and riparian BMPs

In-Lake Management Measures and Reductions

The proposed implementation strategy for the Twin Lakes drainage area will achieve the nitrogen load reduction target of 34%. In contrast, because of contributions from in-lake sources, it does not achieve the phosphorus loading reduction target of 69%. Therefore, in-lake management practices will be required to achieve load reduction goals. Sediment removal from the lake will be required to address the current aesthetics impairment.

Several in-lake management measures are recommended to reduce internal pollutant loads. Although the conceptual locations for each practice have been identified, it is recommended that all in-lake management measures be further evaluated to facilitate development of conceptual designs and accurate cost estimates. The following management measures were identified and are illustrated in Figure 88.

Sediment Removal

Sediment removal from the East Twin and West Twin lakes will reduce bottom sediment re-suspension and increase the ability of both to attenuate nutrients. In order for Twin Lakes to achieve a full support for the Aesthetics beneficial use, the conservation pool storage volume will need to be increased by approximately 8.7% (223 acre-feet). Because the USACE treats the lakes as one system (Twin Lakes), quantities were not identified for individual lakes; however, water quality and aquatic life would benefit from removing greater quantities of sediment. Areas of East Twin Lake that are less than 12-feet deep are considered a higher priority for deepening (Figure 88). Areas identified for deepening are based on 2002 bathymetric data and should be verified with new data. Specific areas targeted for sediment removal and removal quantities should be defined in a sediment removal plan.

In-Lake Sediment Basins

Water quality basins are an important component of reservoir sedimentation management, primarily through decreasing sediment and nutrient impacts to the lake. Water quality basins identified for the drainage area should be supplemented with in-lake basins in East Twin Lake to further decrease sediment impacts to the main body of the lake. Three in-lake basins have been identified to address pollutant loads from four tributaries contributing the greatest pollutant loads.

Shoreline (Bank) Stabilization

Shoreline erosion accounts for 32% of the total sediment load to East Twin Lake. While, sediment loads are currently below target, addressing this source will allow for easier attainment of load reduction goals and will benefit aquatic habitat. Approximately 1,971 linear feet of shoreline were determined to have a high potential for erosion, whereas 754 linear feet of shoreline were determined to have a moderate erosion potential. The wetland/sediment basin targeted for the primary inflow could be configured to address all of this shoreline area. Any areas not addressed by basins will still require stabilization. A combination of vegetation and hard armoring will be used.

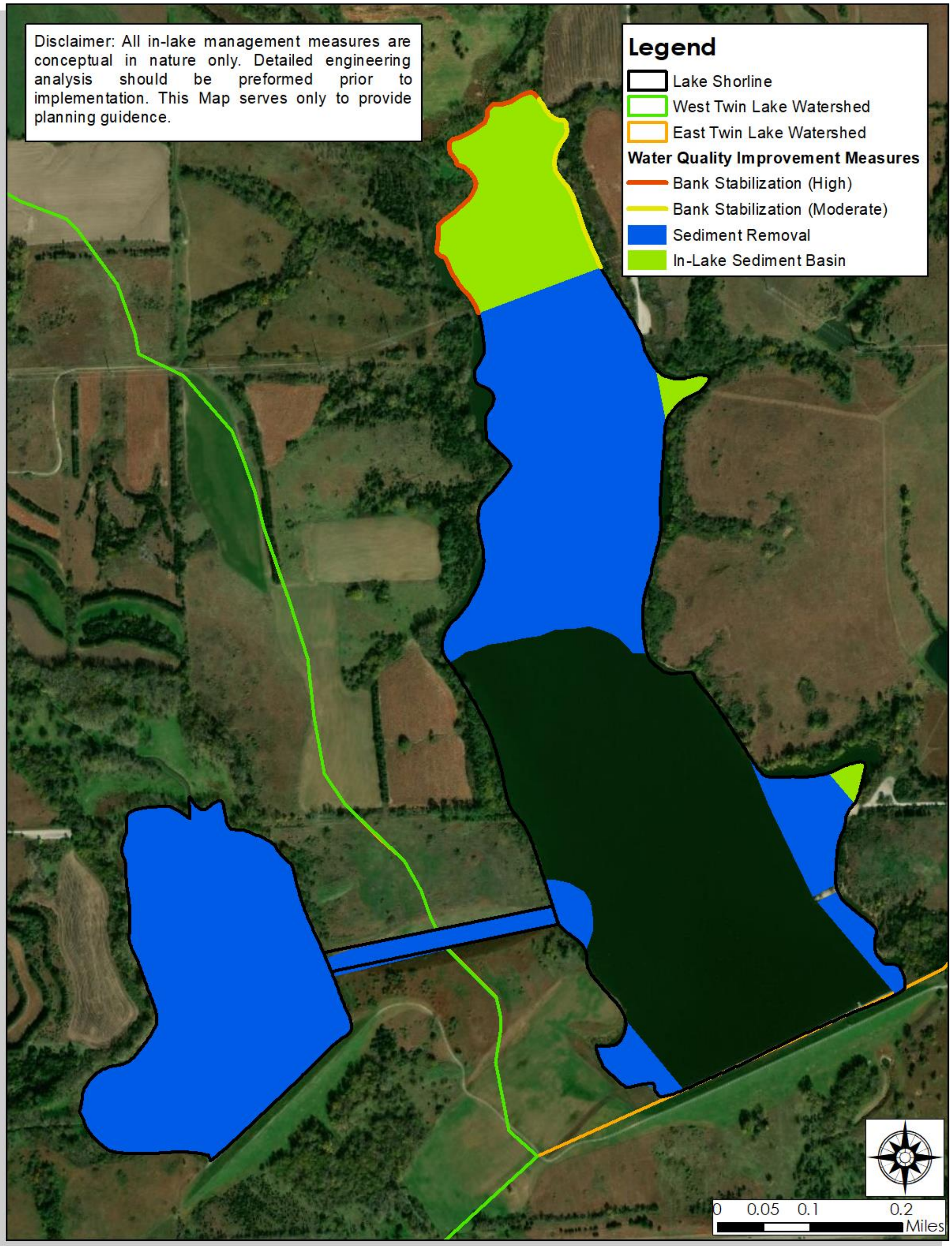


Figure 88: Conceptual Locations for In-Lake Management Measures at Twin Lakes

CRITICAL SOURCE AREAS

Critical Source Areas (CSA) are a relatively small fraction of a watershed that generates a disproportionate amount of pollutant load (Meals, 2012). As discussed in Chapter 7, CSAs occur where a pollutant source in the landscape coincides with an active hydrologic transport mechanism. Identifying CSAs allows for the prioritization of fields where BMPs are likely most needed and allows for financial and technical resources to be used most efficiently.

CSAs in the Twin Lakes Target Area were identified using the field runoff risk assessment in the ACPF Toolbox. This assessment provides a relative risk rating (not an absolute risk rating) and is based on a cross-reference of two factors:

- Slope steepness – Steeper fields have a higher risk of generating runoff
- Distance to stream – The closer a field is to a waterbody, the higher the risk a pollutant will be delivered to waterbody

Once the assessment is complete, each field receives a relative classification, ranging from A (highest risk – most critical), to B (very high), C (high), and other ('present'). One limitation of this tool is that only agriculture landuses (cropland or pasture land) are included. These other land uses (typically rural residences or other natural areas) are identified as "unknown" in the assessment. "Unknown" areas may still have an elevated runoff risk (especially for pollutants such as manure application or failing OWTS's). A "present" or "unknown" classification does not mean that a BMP would not provide benefits to a given field, but rather indicates that other fields have a greater potential to deliver pollutants to a waterbody via surface runoff. In future updates to this plan, an assessment of all fields for runoff risk is recommended.

For the purposes of this plan, areas identified as A or B through the runoff risk assessment, have been identified as CSAs. In the Twin Lakes Target Area (Figure 89), there are 2,220 acres of CSAs (approximately 32% of the Target Area), which are broken down as follows:

- Highest Risk CSA: 365 acres
- Very High Risk CSA: 1,855 acres

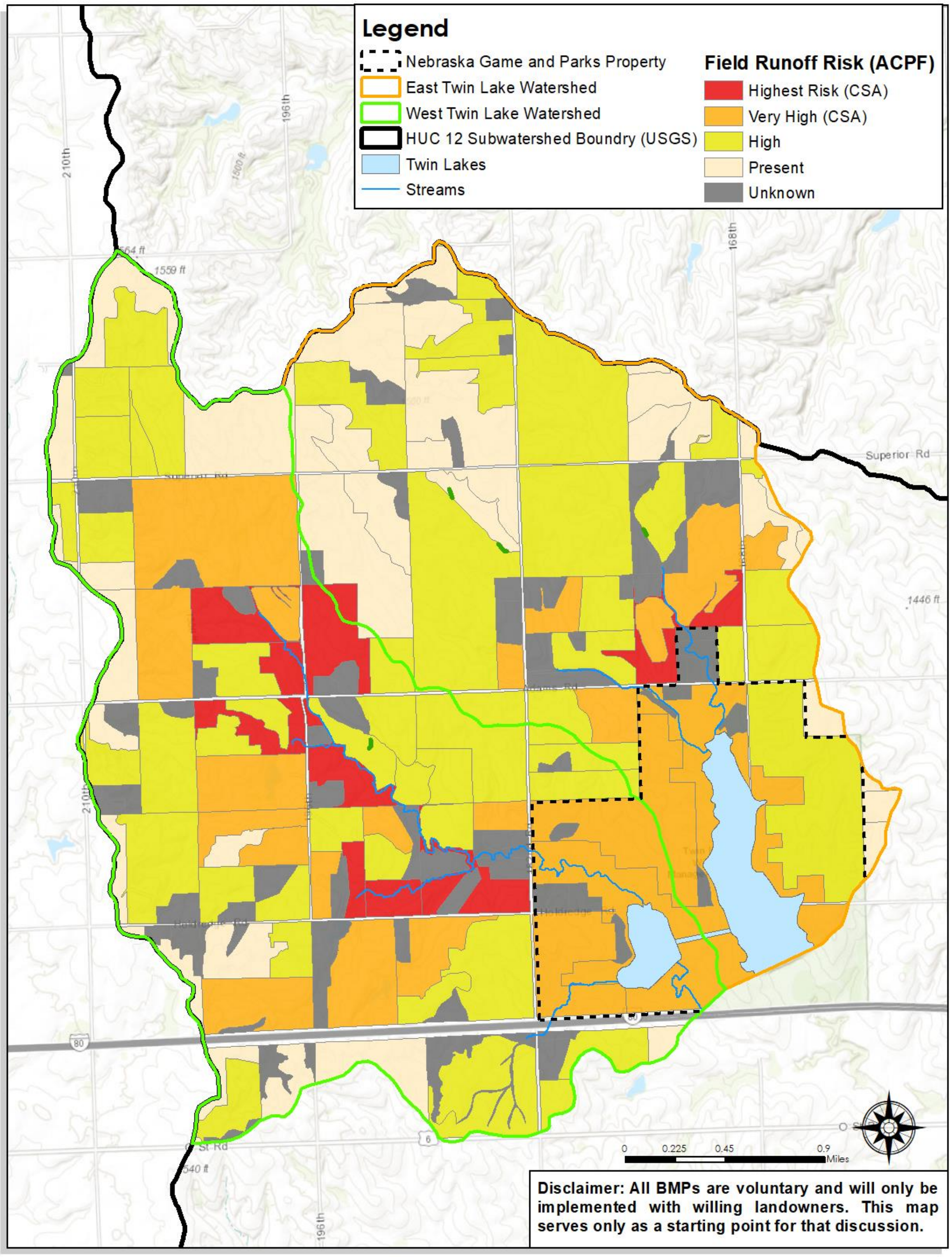


Figure 89: Critical Source Areas at Pawnee Lake as identified with the ACPF Tool

MEETING WATER QUALITY STANDARDS

Implementing a comprehensive strategy for Twin Lakes that includes both external and internal management practices will result in Twin Lakes meeting water quality standards for in-lake nitrogen and phosphorus. It is assumed that if lake nutrient concentrations meet the water quality standard, algae biomass will also meet the standard. Additionally, a full support status will be achieved for the aesthetics use by increasing lake storage capacity. Although no load reduction target for sediment was required, reduction targets for phosphorus and nitrogen will be attained (Table 76, *Source: Water Quality Modeling*
Table 77, and *Source: Water Quality Modeling*

Table 78). No load reduction target for sediment was required. No loading capacities or reductions were determined for West Twin Lake because it lacks an outflow and is connected to East Twin Lake at conservation pool elevation. Additional details can be found in the summary report located in Appendix D.

Although nutrient reduction benefits of implementing external and internal management practices have been estimated and provide a path to meeting water quality standards, cumulative benefits of implementing a comprehensive plan are difficult to accurately project. Thus, a sound monitoring, and data collection network will be critical to adaptively manage Twin Lakes.

Table 76: Estimated Sediment and Nutrient Reductions and Targets for East Twin Lake

Pollutant Amount	Sediment (t/yr)	Phosphorus (lbs/yr)	Nitrogen (lbs/yr)
Beginning load	1,622	5,111	21,212
External load reductions	558	2,583	13,424
Internal load reductions	952	1,769	4,284
Total reductions	1,510	4,353	17,707
Reduction targets	NA	3,539	7,155

Source: Water Quality Modeling

Table 77: Estimated Phosphorus Reductions and Water Quality Targets for East Twin Lake

Phosphorus Amount	Load (lbs/yr)	In-Lake Concentration (*µg/L*)
Beginning total phosphorus load	5,111	98.8
External total phosphorus reductions	2,586	27.4
Internal load reductions/improvements	1,768	26.7
Total phosphorus reductions	4,353	54.1
Expected conditions	758	44.7
Phosphorus loading capacity & water quality standard	1,572	50.0

Source: Water Quality Modeling

Table 78: Estimated Nitrogen Reductions and Water Quality Targets for East Twin Lake

Nitrogen Amount	Load (lbs/yr)	In-Lake Concentration (*µg/L*)
Beginning total nitrogen load	21,212	1,509
External total nitrogen reductions	13,424	955
Internal load reductions/improvements	4,284	305
Total nitrogen reductions	17,707	1,260
Expected conditions	3,505	249
Nitrogen loading target & water quality standard	7,155	1,000

Source: Water Quality Modeling

MONITORING

The LPSNRD will follow established protocol and procedures to: develop sound, defensible monitoring strategies and networks: properly manage data: and disseminate information to decision makers and other stakeholders. Monitoring goals can only be achieved through partnerships with other resource agencies such as NDEQ, USACE, and NGPC. Steps will be taken to ensure collection of scientifically valid data, which may include the development of Quality Assurance Project Plans (QAPP) for state and federal review.

A broad set of monitoring goals and objectives has been developed for East Twin and West Twin lakes. Targeted parameters, monitoring sites, and monitoring frequency have been defined to meet each objective. Monitoring objectives provided below in *italics* may require expanded or new monitoring efforts, whereas objectives and parameters in regular text are currently being addressed through established monitoring sites and current monitoring networks coordinated by NDEQ and USACE. In some cases, objectives can be achieved by adding a parameter or additional sites to current networks. In other cases, specialized studies will need to be conducted to meet the objective. Although in many cases priorities depend on funding, other considerations should also be accounted for, including confidence in current assessments, short term data/information needs, and available staff.

East Twin Lake and Drainage

Monitoring Goal 1: Evaluate the water quality condition of East Twin Lake.

- Evaluate beneficial use support and water quality trends for East Twin Lake.

Monitoring Goal 2: Estimate or verify average annual pollutant loads to East Twin Lake.

- Verify runoff loads of nutrients, sediment, and *atrazine* from the drainage area above East Twin Lake.
- *Quantify nutrient and sediment loads to East Twin Lake from specific land cover types.*
- *Verify sediment and nutrient loads stemming from streambank erosion.*
- *Quantify internal nutrient and TSS loads to East Twin Lake from specific sources.*

- *Quantify sediment and nutrient loads from West Twin Lake.*
- *Estimate current lake conservation pool storage volume.*
- *Quantify annual lake retention of nutrients and sediment.*

Monitoring Goal 3. Gather data needed to complete pre-implementation planning.

- *Evaluate spatial sediment deposition in East Twin Lake.*

West Twin Lake and Drainage

Monitoring Goal 1: Estimate or verify average annual pollutant loads to West Twin Lake.

- *Verify runoff loads of sediment, nutrients, and atrazine from the drainage area above West Twin Lake.*

COMMUNICATION AND OUTREACH

Chapter 6 of this plan provides a broad, programmatic approach that the LPSNRD and its partners will take to address nonpoint source pollution through communication and outreach activities. Specifically, within a target area there are certain pieces of information necessary for successful communication and outreach efforts, which will in turn support the implementation of BMPs. Those items specific to the Twin Lakes Target Area were identified via stakeholder and public input, and are as follows:

- Identified Target Audiences
    - Recreational water users of East and West Twin Lakes
    - Land managers, residents, and property owners within Twin Lakes drainage area
    - Producers with existing BMPs who may be interested in implementing more
    - Rural homeowners on private wells and septic systems
- Methods
    - Utilize parcel ownership information, along with the detailed BMP location maps created with the ACPF Tool to contact specific landowners about BMPs applicable to their properties
        - A postcard mass mailing followed up by phone calls will help start initial implementation efforts and/or increase attendance at public meetings
    - Build a unifying logo, tagline, or message around protecting and restoring Twin Lakes. This would be included on signage and other documents
    - Develop signage to be used at project demonstration sites, key watershed entrances or landmarks, and other highly visible areas
    - Utilize locations within the Villages of Malcolm or Pleasant Dale for the following:
        - Post flyers, distribute press releases, and advertise at local events
        - Hold targeted coffee shop meetings, tailgate sessions, and other informal/casual informational exchanges to build relationships and to learn more about the constraints and hurdles to BMP adoption

- Piggyback on existing events - Training and demonstration field days, information booths, recognition picnics, etc.
    - Such as the BBQ and Blues Fest held annually in Malcolm, nitrogen certification training events, etc.
- Hold an outdoor recreation clinic (kayaking, fishing, etc.) at Twin Lakes

Plan and project sponsors will utilize these target audiences and outreach methods when building project level communication and outreach plans, typically as part of a Project Implementation Plan (PIP). The PIP will identify the specific and tailored actions for each target audience, as discussed in Chapter 6.

SCHEDULE

The timeframe for implementing general actions are provided in Actions are subject to approval by the LPSNRD Board of Directors, NGPC, and USACE, and may change as the plan is implemented. Phase I activities will include the initiation of external management practice implementation and the evaluation of in-lake measures. Phase II will begin upon the five-year revision of this plan. A summary of progress achieved during Phase I will be included in the plan revision.

Table 79. Actions are subject to approval by the LPSNRD Board of Directors, NGPC, and USACE, and may change as the plan is implemented. Phase I activities will include the initiation of external management practice implementation and the evaluation of in-lake measures. Phase II will begin upon the five-year revision of this plan. A summary of progress achieved during Phase I will be included in the plan revision.

Table 79: Schedule for Implementing Twin Lakes Management Strategy

Activity	Phase I						Phase II
	2019	2020	2021	2022	2023	2024	2025-2029
LPSNRD Board of Directors approval of plan	■						
EPA approval of the plan	■						
Monitoring (ongoing)	■	■	■	■	■		
Develop PIP for Watershed BMPs		■					
Organize stakeholder group		■					
Watershed BMP implementation		■	■	■	■	■	
Project evaluation						■	
Final reporting						■	
In-lake BMP feasibility study					■	■	
Update HUC8 watershed plan							■
Continue watershed BMP Implementation							■
Initiate in-lake BMP implementation							■

MILESTONES

Major milestones that pertain to monitoring, planning, and management practice implementation are provided in Table 80. Milestones will be used to gauge progress in meeting the desired project schedule. As the implementation of this plan is initiated, milestones will be adjusted accordingly to address changes in the schedule.

Table 80: Implementation Milestones for Twin Lakes

Activity		Phase I						Phase II
		2019	2020	2021	2022	2023	2024	2025-2029
Monitoring	Coordinate with NDEQ	■	■	■	■	■		
	Finalize strategies and QAPPs		■					
	Assess data (annually)	■	■	■	■	■		
Planning	Develop PIP for BMP implementation		■					
	Apply for funding assistance grants		■					■
	Evaluate progress in meeting goals						■	
	Identify additional BMP needs						■	
	Prepare final report(s)						■	
	RFP for In-lake BMP feasibility study					■		
	Complete in-lake feasibility study						■	
	Revise watershed plan as needed							■
Information /Education	Develop stakeholder group		■					
	Work one-on-one with producers		■	■	■	■	■	
Implementation	Initiate BMP implementation		■					
	Complete Phase I BMP implementation						■	

COST

The preliminary opinion of total cost of implementing the nonpoint source pollution control strategy for Twin Lakes is estimated to be $10,552,076 (Table 81). This does not include costs for bathymetric surveys or final designs as these costs may be included through existing staff or agency budgets or would be contingent on project scoping. When possible, costs were determined from the 2018 USDA-NRCS EQIP practice payment schedule (USDA, 2018). Costs estimated for in-lake measures were based on average unit prices from a wide range of costs from other past projects and should only be used for general planning purposes. These costs are subject to change based on final design of the rehabilitation, inflation, bidding climate at the time of construction, and project size and complexity.

Table 81: Estimated Cost of Implementing Twin Lakes Management Strategy

Practice	Units	Units Targeted	Unit Cost	Total Cost
Education/Information*	years	5	$ 10,000	$ 50,000
Avoidance practices*	acres	1,372	$ 108	$ 148,176
Contour buffer strips (filter strips)	acres	3	$ 500	$ 1,500
Terraces	feet	45,578	$ 4	$ 182,312
Cover crops	acres	1,567	$ 133	$ 208,411
No-till	acres	294	$ 20	$ 5,880
Water and Sediment Control Basins (WASCOB	feet	29,900	$ 4	$ 119,600
Wetlands	#	21	$ 35,000	$ 735,000
Riparian buffers	acres	157	$ 1,650	$ 259,050
Grazing management	acres	1,766	$ 42	$ 74,172
OWTS Upgrade Practice	#	16	$ 5,500	$ 88,000
Non-Permitted AFO Facility BMP	#	22	$ 20,000	$ 440,000
Grassed Waterways	acre	3	$ 6,575	$ 19,725
SubTotal (Drainage Area Treatment)				**$ 2,331,826**
Streambank/channel stabilization & Restoration	feet	37,310	$ 150	$ 5,596,500
SubTotal (In-Stream Work)				**$ 5,596,500**
Lake deepening / Sediment Removal	acre-feet	223	$ 8,000	$ 1,784,000
Shoreline stabilization	linear feet	2,725	$ 110	$ 299,750
Jetties and breakwaters	linear feet	-	$ 500	$ -
In-lake Sediment Basins	acres	15	$ 30,000	$ 450,000
Nutrient inactivation	acres	-	$ 2,200	$ -
In-lake feasibility/design study	each	1	$ 40,000	$ 40,000
SubTotal (In-Lake Work)				**$ 2,573,750**
Updates to WQMP	each	-	$ -	$ -
Additional monitoring*	years	5	$ 10,000	$ 50,000
SubTotal (Planning/Monitoring)				**$ 50,000**
Total				**$10,552,076**

**Based on estimated costs during first 5-year increment only*

10.05 LITTLE SALT CREEK TARGET AREA

INTRODUCTION

The Little Salt Creek Subwatershed is located north of the City of Lincoln, with much of the subwatershed north of I-80 (Figure 90). The headwaters begin just north of West Ashland Road, and the stream flows southeast to its confluence with Salt Creek near I-80 and 27th Street. The subwatershed drains approximately 29,312 acres. A multitude of studies and planning efforts have been conducted in the Little Salt Creek subwatershed, particularly in respect to the Eastern Saline Wetlands located there. Most of this work was either associated with, or is included in, three primary planning documents: *Little Salt Creek Watershed Master Plan* (Intuition Logic, 2009), *Implementation Plan for the Conservation of Nebraska's Eastern Saline Wetlands* (LaGrange and others, 2003), and *Upper Little Salt Creek Saline Wetlands Plan* (Flatwater, 2015b). These plans address water quality concerns in Little Salt Creek and include identification of priority activities to restore and protect the Eastern Saline Wetlands and their unique biology. This WQMP will serve to facilitate a comprehensive implementation of the priority projects found in those documents. The improvement and protection of wetlands throughout this drainage area will require a holistic management approach. BMP implementation will take place in targeted locations across the subwatershed as well as specific projects within the saline wetland properties.

NOTE TO READERS

Information in this section is summarized from the pollutant modeling files and from the *Bacteria Load Estimate Report* (WWE, 2018), a copy of which is also provided in Appendix D. Unless otherwise noted, additional details and background information can be found in that comprehensive document.

Little Salt Creek (LP2-20300) is protected for the following beneficial uses: aquatic life, aesthetics, and agricultural water supplies (NDEQ, 2014). The aquatic life use is currently impaired from selenium, copper, and ammonia and aquatic community assessments also indicate impairment. Additionally, NDEQ has indicated that addressing *E. coli* within this subwatershed is a priority. While Little Salt Creek is not assessed for primary contact recreation or identified as impaired due to *E. coli*, NDEQ did provided *E. coli* loading goals in the 5-alt assessment (NDEQ, 2017b). There are no point source discharges in the Little Salt Creek drainage. This plan has not been designed to address heavy metal (selenium and copper) or ammonia impairments, which are not caused by nonpoint source pollution (see discussion in Section 5.06). This plan is focused on the restoration and protection of the Eastern Saline Wetlands, which are impacted by sedimentation; and the reduction of *E. coli* bacteria loads.

The Eastern Saline Wetlands are assigned the following beneficial uses: aquatic life, agricultural water supply, and aesthetics (NDEQ, 2014). These wetlands are a unique resource and support rare species, including: saltmarsh aster, Texas dropseed, saltwort, and the Salt Creek tiger beetle.

The *Strategic Plan and Guidance for Implementing the Nebraska Nonpoint Source Management Program – 2015 through 2030* identifies the Eastern Saline Wetlands as a priority for both restoration and protection actions (NDEQ, 2015c).

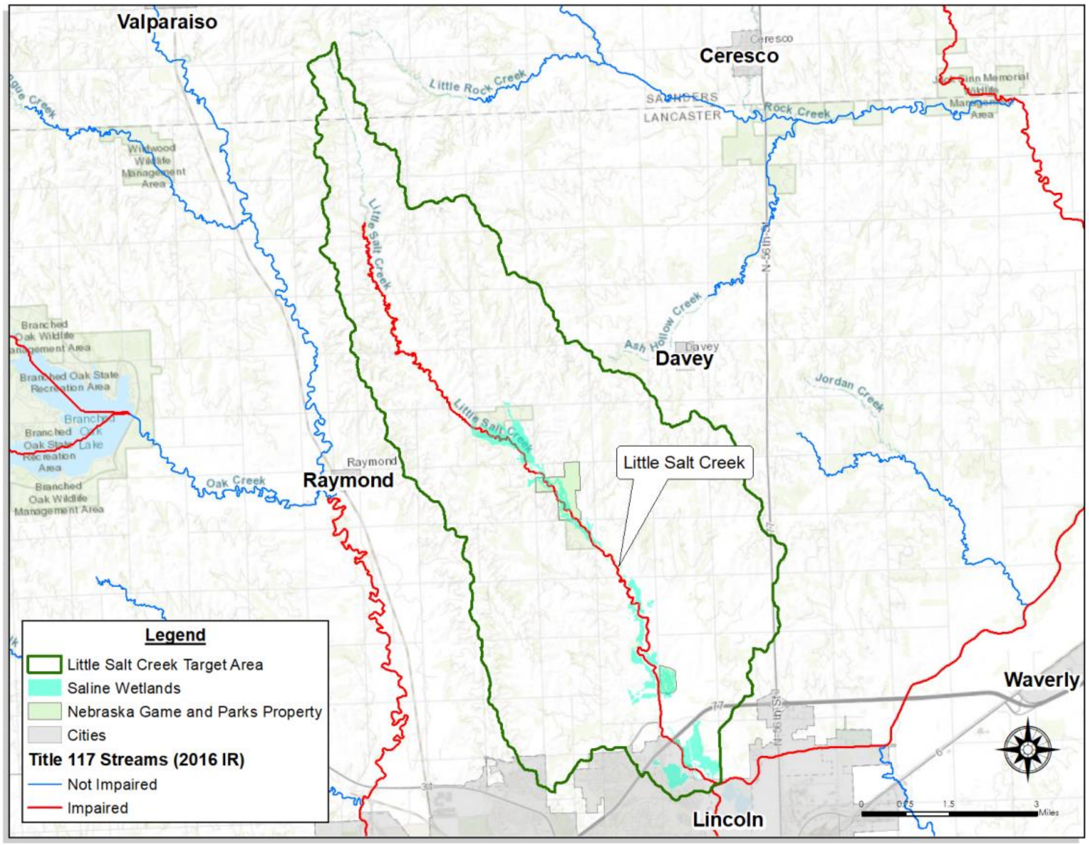


Figure 90: Location of the Little Salt Creek Subwatershed and Saline Wetlands

Little Salt Creek Watershed Master Plan

The City of Lincoln (City) and the Lower Platte South Natural Resources District (LPSNRD) have developed a watershed master plan for HUC 12 subwatersheds within the City and its future growth areas. Since the early 2000's, plans for watershed management have been written singularly. Watershed master plans are planning tools and should be used in conjunction with proposed development and as a guide in the preparation of future capital improvement projects. The *Little Salt Creek Watershed Master Plan* was completed in 2009 (Intuition Logic, 2009). The Master Plan outlines long-term planning tools and improvement projects to address water quality, flood management, and stream stability for development in or near the watershed. The Master Plan also includes a discussion of potential impacts to sensitive natural resources, including the saline wetlands and the federally listed endangered species Salt Creek Tiger Beetle.

Implementation Plan for the Conservation of Nebraska's Eastern Saline Wetlands

The *Implementation Plan for the Conservation of Nebraska's Eastern Saline Wetlands* was completed by the Saline Wetlands Conservation Partnership (SWCP) in 2003 (LaGrange and others, 2003). The SWCP includes the City of Lincoln, Lower Platte South Natural Resources District, Nebraska Game and Parks Commission, and the Nebraska Chapter of Pheasants Forever, Inc. The plan is a holistic watershed approach designed to preserve both wetlands and their surrounding watersheds. The plan's implementation involves local, state, and federal agencies working in tandem with private individuals and organizations to develop additional strategies and programs that encourage saline wetland conservation. The plan established restoration targets for the conservation of about 4,000 acres of saline wetlands using comprehensive strategies that address:

- Natural Resources Management
- Wetland Protection
- Stream Restoration
- Wetland Buffer Management and Development
- Research
- Private Lands

Upper Little Salt Creek Saline Wetlands Plan

The SWCP recently finished a more detailed planning project titled the *Upper Little Salt Creek Saline Wetlands Plan* (Flatwater, 2015b). This plan focused future efforts on the wetland properties owned and managed by the SWCP in the upper portion of the Little Salt Creek subwatershed and their contributing drainage areas. The planning boundary was divided into three groups: saline wetland preservation and rehabilitation area; buffer area; and the watershed protection area. Based on the results of the analysis and planning process, various improvement projects utilizing BMPs were identified for each property. Following completion of this plan, conceptual designs for the Norder Tract property were developed with additional details on the BMPs and costs of each (Flatwater, 2015a).

IMPAIRMENTS

Eastern Saline Wetlands - Sedimentation

Early inventory and assessment work documented impacts and threats to the Eastern Saline Wetlands including: wetland losses from the City of Lincoln expansion and agricultural activities; draining and filling; sedimentation; streambed degradation; and water quality (LaGrange and others, 2003). Nonpoint source impacts to the Eastern Saline Wetlands are addressed in Title 117, Subsection 004.01B1: “Any human activity causing water pollution which would cause a significant adverse impact to an identified “key species” is a violation of these Standards.” Key aquatic species are defined as those that are threatened or endangered. For the Eastern Saline Wetlands those include Saltwort (*Salicornia rubra*) and the Salt Creek Tiger Beetle (*Cincindela* *nevadica lincolniana*) (NDEQ, 2014). For the purposes of the WQMP, the focus is on the impacts sedimentation has on the saline wetlands.

Little Salt Creek – *E. Coli* bacteria

Within the stream, the aquatic life use is currently impaired due to selenium, copper, and ammonia. As discussed in Chapter 5, these pollutants are not addressed in this WQMP; however, NDEQ provided *E. coli* loading goals in the 5-alt assessment (NDEQ, 2017b). Therefore, while Little Salt Creek is not assessed for primary contact recreation or identified as impaired due to *E. coli*, for the purposes of the WQMP we also focus on *E. coli* bacteria.

POLLUTANT SOURCES AND LOADS

While the main threat to the Eastern Saline Wetlands is from sediment, sediment-associated nutrients (phosphorus and nitrogen) can also cause issues. Therefore, identifying sources and loads of these pollutants are also included in this plan. Current pollutant sources and loads for sediment and nutrients were estimated using the STEPL model (TetraTech, 2007) and *E. coli* bacteria sources and loads utilized a spreadsheet model. Additional details such as a summary of data, data sources, and methods can be found in the modeling/implementation reports in Appendix D.

Nutrients and Sediment

The average annual phosphorus load carried by Little Salt Creek is estimated to be 35,878 lbs/yr. The largest contributor of phosphorus to Little Salt Creek is from land used for corn and soybean production, which constitutes 48% of the total load (Figure 91). The average annual nitrogen load carried by Little Salt Creek is 146,285 lbs/yr. The largest contributor of nitrogen to Little Salt Creek is also from land used for corn and soybean production, which constitutes 47% of the total load (Figure 92). The average annual sediment load carried by Little Salt Creek is estimated to be 18,965 t/yr. The largest contributor of sediment is from land used for corn and soybean production, which constitutes 49% of the total load (Figure 93). Streambank erosion contributes a significant amount of phosphorus (31%) and sediment (35%) to Little Salt Creek.

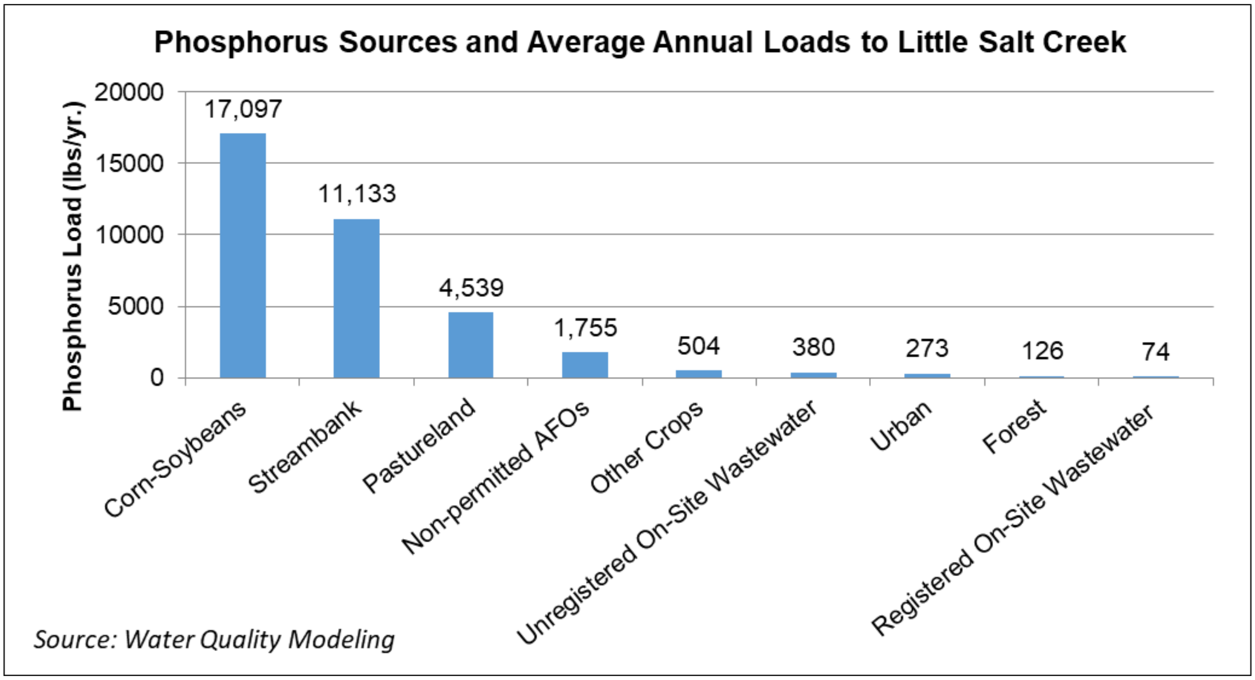


Figure 91: Phosphorus Sources and Annual Average Loads to Little Salt Creek

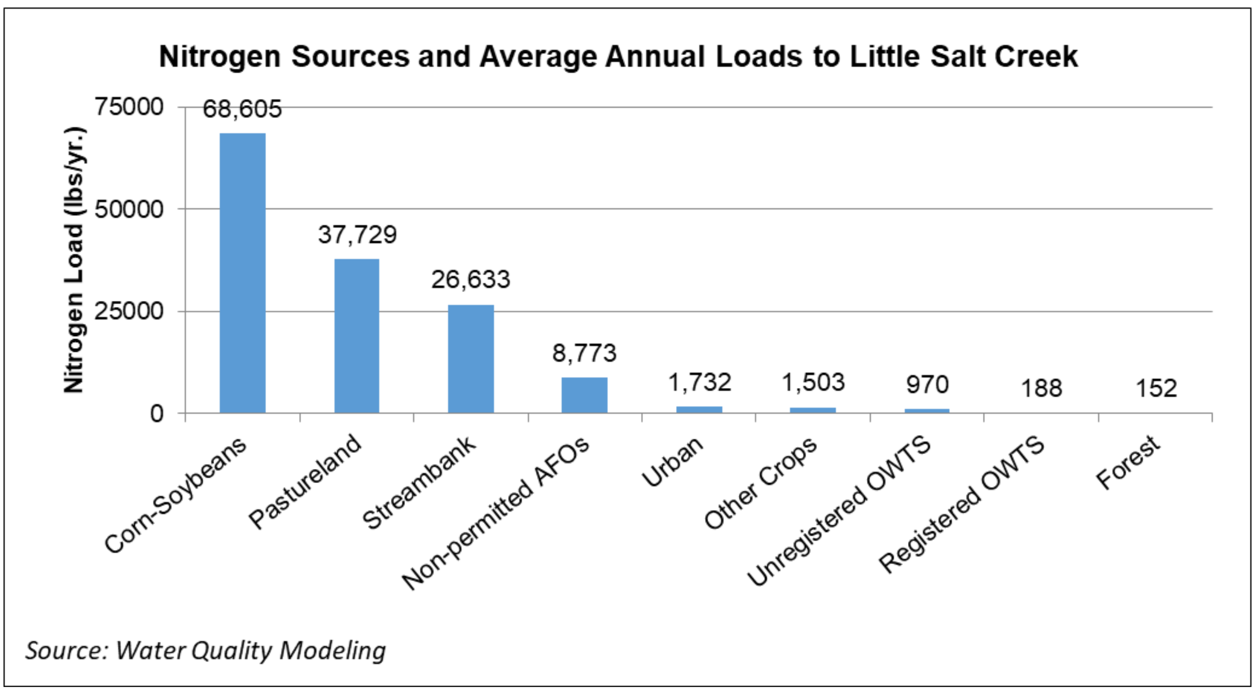


Figure 92: Nitrogen Sources and Annual Average Loads to Little Salt Creek

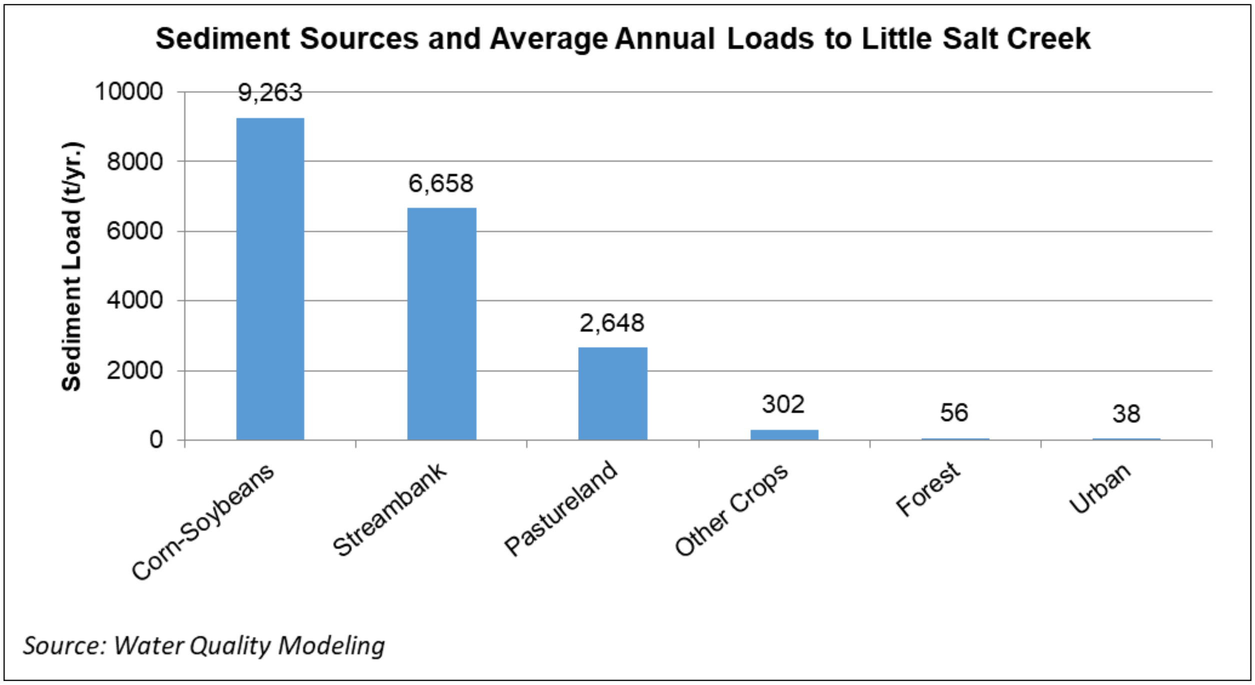


Figure 93: Sediment Sources and Annual Average Loads to Little Salt Creek

E. coli Bacteria

The average annual *E. coli* load carried by Little Salt Creek is estimated to be 318,249 billion colony forming units (CFU)/100mL. The largest contributors of bacteria to Little Salt Creek are from developed landuse (61%) and pasture ground (26%). Readers should note that the majority of urban landuses in this subwatershed include a small portion of the City of Lincoln, numerous acreages and farmsteads, and streets and roads.

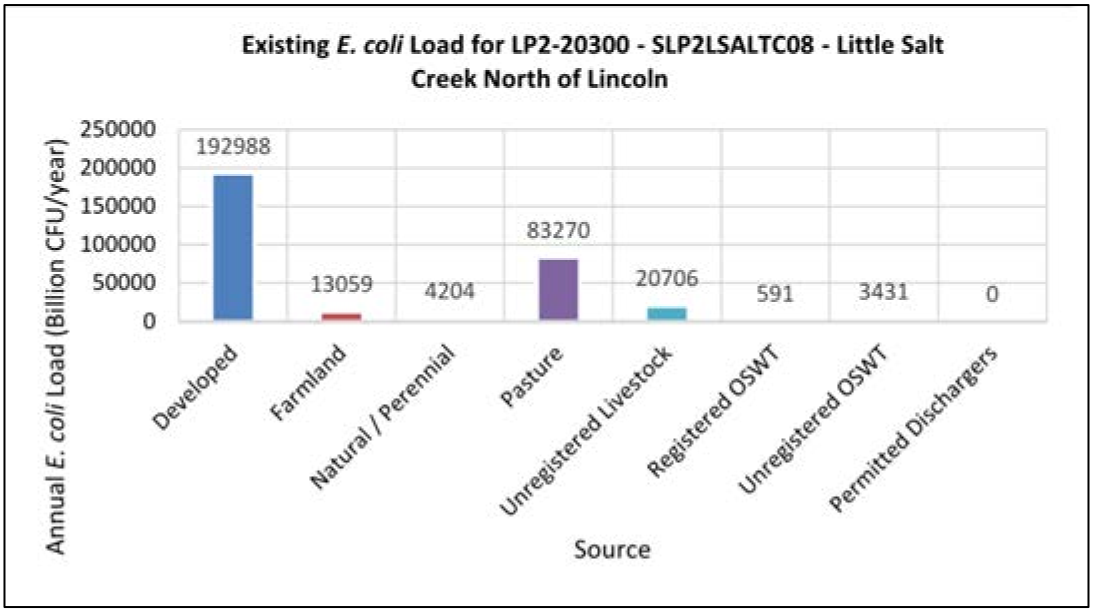


Figure 94: *E. coli* Bacteria Sources and Loads to Little Salt Creek

REQUIRED POLLUTANT LOAD REDUCTIONS

The Eastern Saline Wetlands have not exhibited numerical violations to water quality standards; therefore, pollutant load reduction targets for sediment and nutrients were not determined.

Required *E. coli* load reductions were based on 5-alt assessment data (NDEQ, 2017b) which identified a 62% reduction from 293 CFU/100mL to 111 CFU/100mL. This goal is below the water quality standard of 113 CFU/100mL to account for a margin of safety (Table 82).

Table 82: *E. coli* Pollutant Load Reduction Goals for Little Salt Creek

Stream Segment	Seasonal Geometric Mean (#/100mL)	*E.coli* Above Water Quality Standard (#/100mL)	Reductions needed to meet Water Quality Standards	Expected Geometric Mean with the Margin of Safety (#/100mL)
LP2-20300	293	167	62%	111

Source: NDEQ, 2017b

IMPLEMENTATION STRATEGY

The implementation strategy for the Little Salt Creek subwatershed includes multiple practices which target pollutant sources through the ACT approach, also known as a “treatment train”. All nonpoint source pollutant sources are addressed. It is assumed that AFOs and OWTSs are meeting all legal requirements; however, they are also possible sources of pollutant loads. In all cases, only willing landowners will be included in this voluntary implementation strategy. The identification of BMPs was identified through multiple sources:

- **ACPF tool** – The ACPF tool was used to identify the best suited locations for various BMPs throughout the subwatershed.
- **Aerial analysis** –Additional opportunities for BMPs were found through analysis of aerial photography to identify nonpermitted AFOs and rural residences that may have unregistered OWTSs.
- **Review of existing SWCP planning documents** – the continuation of specific projects identified by the SWCP will be beneficial to holistically improving water quality within the target area.

The implementation strategy presented in this plan should be used as a guide for BMP implementation and may be subject to revision as new information becomes available and willing landowners are identified. Although avoidance practices are not part of the ACPF, they are an important part of this strategy. For additional details about the BMPs identified, please refer to Chapter 7, Appendix D, or the referenced planning documents previously discussed.

A VOLUNTARY PLAN

The implementation of this plan is based entirely on the voluntary actions of landowners and citizens. Individuals must decide if it is an advantage to participate, and it is the responsibility of the LPSNRD and other stakeholders to find ways to make participation advantageous.

To provide an accurate load reduction estimate from implementation efforts, recommended practices were used to develop a “treatment train” that follows the movement of pollutants from the source to the receiving waterbody (Figure 95). The drainage area’s treatment train comprises six levels of treatment, beginning with education/outreach and avoidance practices and ending with near stream improvements (i.e. riparian buffers).

Level 1	• Education & Outreach
Level 2	• Non-Structural Avoidance Practices
Level 3	• "In-field" Practices • Streambank Stabilization • OWTS Upgrade Practice
Level 4	• Water & Sediment Control Basins (WOSCOBS)
Level 5	• Wetlands
Level 6	• Riparian Buffers

Figure 95: Implementation of Priority BMPs through a "Treatment Train" Approach

BMP TARGETING

Subwatershed BMP Recommendations

BMPs for the Little Salt Creek subwatershed were identified to supplement the targeted projects listed in the *Little Salt Creek Watershed Master Plan* (Intuition Logic, 2009) and the SWCP documents. These practices are targeted at reducing erosion and sediment deposition in the Eastern Saline Wetlands, as well as reducing *E. coli* loads to Little Salt Creek. By implementing these practices in the subwatershed, effectiveness of downstream projects and BMPs will be increased. A suite of structural and non-structural management practices were selected based on stakeholder input and the results of technical analysis. Additionally, education/outreach and avoidance practices were added to the suite of recommendations (Table 83).

Land used for corn and soybean production is targeted for the largest number of practices, but all pollutant sources are targeted by at least one BMP practice. Figure 96 and Figure 97 provide an overview of locations where BMPs could potentially be placed. While the locations identified in these maps are not finalized locations, they provide a starting point for discussion with willing landowners and assisted in the development of this plan. Detailed map books can be found in Appendix F.

Table 83: Priority BMPs and Targeted Pollutant Sources for the Little Salt Creek Subwatershed

Land Cover Type/ Pollutant Sources	Current Acres	BMP	Acres Targeted
All	29,023	Education & Outreach	29,023
Corn-Beans	12,830	Avoidance	8,981
		Terraces - cover crops - no till	460
		Contour buffer - cover crop - no till	1,465
		Cover crops-contour buffer	3,037
		Cover crops	5,302
		WASCOBS	2,169
		Wetlands	5,461
		Riparian buffers	2,208
Non-permitted AFOs	55	Avoidance	39
		WASCOBS	55
Pasture	12,710	Grazing management	6,355
		WASCOBS	988
		Wetlands	4,430
Other Crops	967	WASCOBS	149
		Wetlands	908
Forest	1,784	WASCOBS	298
		Wetlands	295
Urban	677	Wetlands	228
OWT Systems	199	Unregistered system upgrade (#)	78

Note: Grassed waterways, and conceptual locations, were also identified as a priority BMP, however they were represented/ grouped with wetlands in the water quality modeling, due to technical limitations.

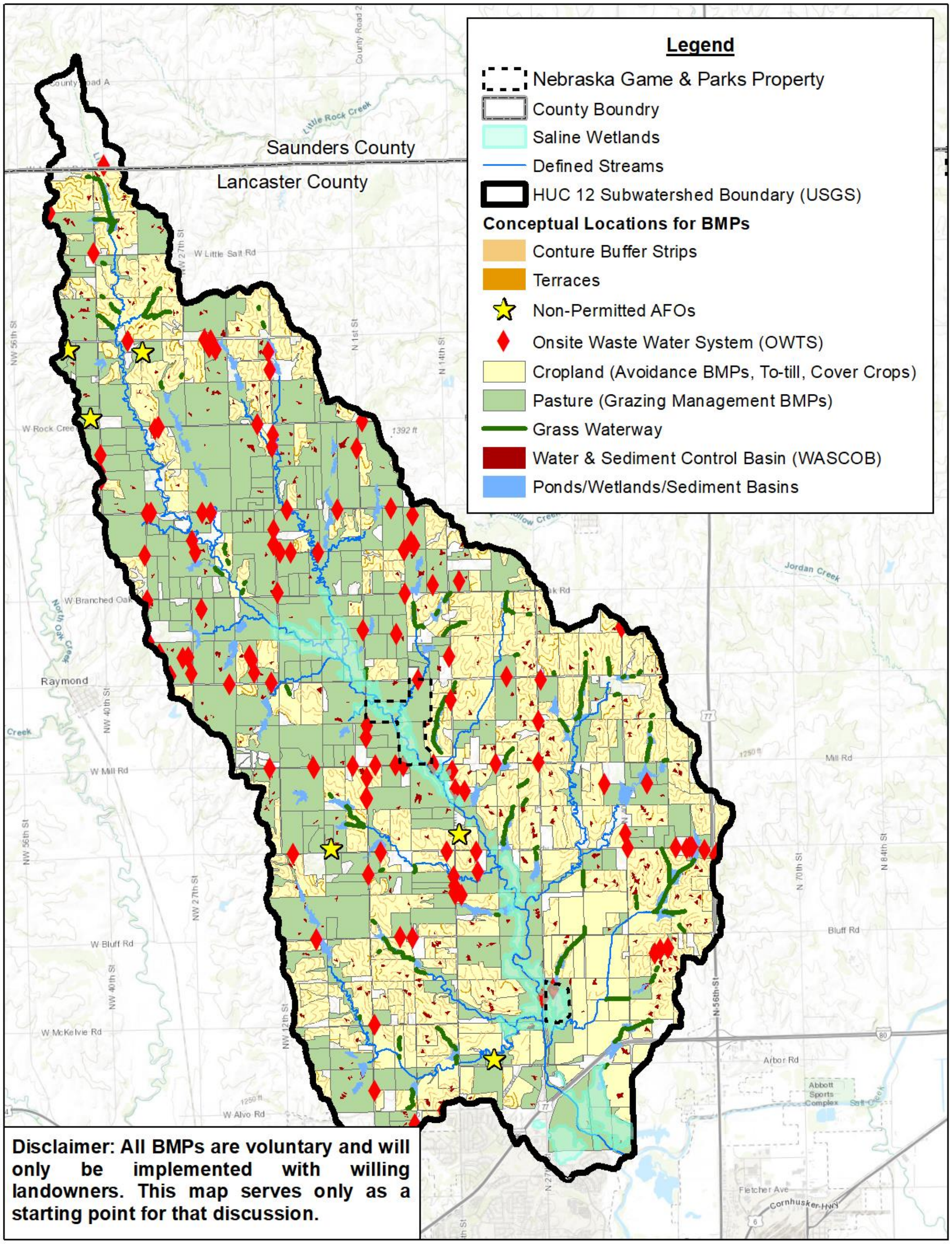


Figure 96: Conceptual location of in-field and edge-of-field BMPs

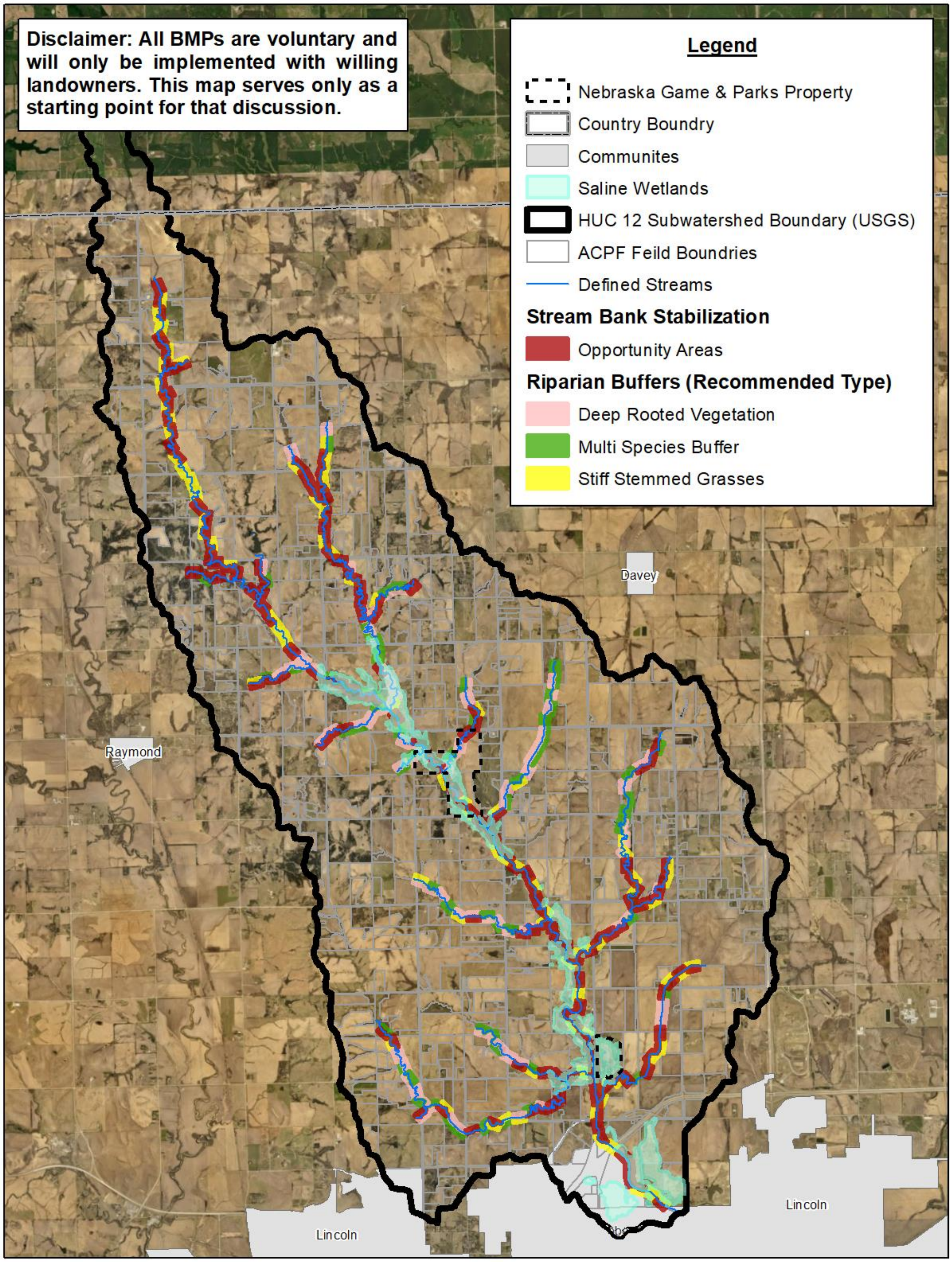
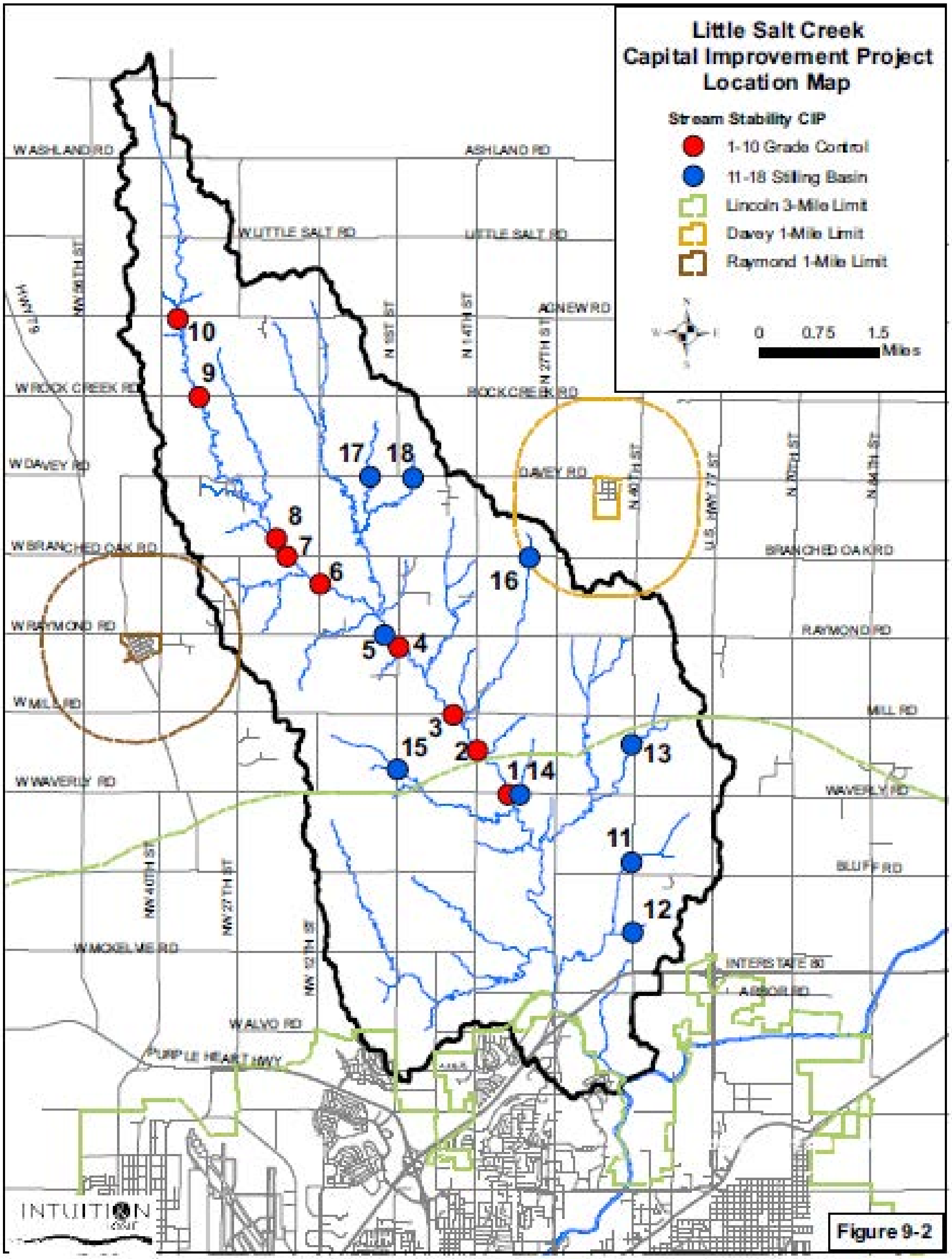


Figure 97: Conceptual locations of in-stream and riparian BMPs

Grade Stabilization on Little Salt Creek

Sediment released from incision and subsequent bank failures along Little Salt Creek negatively impact in-stream aquatic habitat and downstream wetlands. A total of ten priority grade stabilization projects were identified in the *Little Salt Creek Watershed Master Plan* (Intuition Logic, 2009). These grade control practices are targeted at bridge crossings along the main stem of Little Salt Creek to stop incision at these locations (Figure 98). The grade controls will eliminate incision at each bridge and substantially limit the propagation and depth of incision between each structure. Each structure could be constructed with a combination of rock, sheet pile, and/or natural materials such as locked logs and root wads. Grade control structures made of natural materials and shaped to mimic natural stream structures offer additional water quality and ecological benefits compared to sheetpile weirs. Locations and site conditions will determine final designs. Additional details and descriptions for each of the sites can be found in the *Little Salt Creek Watershed Master Plan*. It should be noted, that some of these structures have likely been constructed since the master plan was completed.



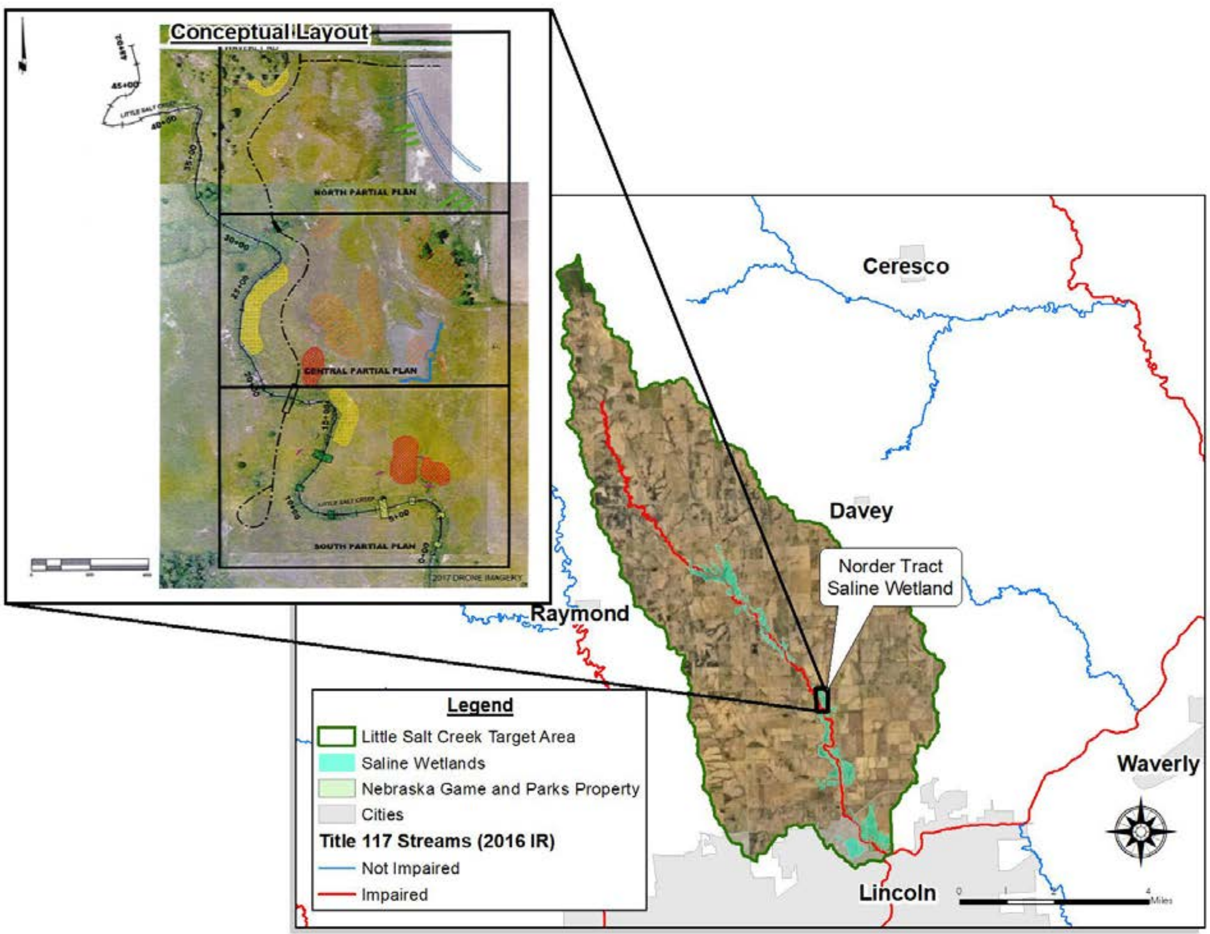
Source: *Intuition Logic, 2009*

Figure 98: Location of Priority In-stream BMPs on Little Salt Creek

Norder Wetland Restoration

The City of Lincoln's Norder Tract Wetland is located within the Little Salt Creek Subwatershed and has been identified as a priority for restoration by the SWCP. This is a unique 79-acre property purchased by the City in 2014 and contains a diverse landscape of saline wetlands, salt flats, stream channel, open water, freshwater wetland, and grassland area habitats (Flatwater, 2018).

Recently, as a supplement to the *Upper Little Salt Creek Saline Wetlands Plan,* a conceptual restoration design memo was developed which identified BMPs on the Norder Tract Wetland to restore the function of the wetland. The BMPs were identified and categorized into three priority groups: grade control, aquatic habitat improvement, and public access/education. An overview of these BMPs is shown in Figure 99. Many of these BMPs address water quality and/or public education priorities identified in this WQMP and are thus included in the implementation approach for the Little Salt Creek Target Area. Additional details on each can be found in the *Norder Wetland Restoration Design Memorandum* (Flatwater, 2018).



Source: Flatwater, 2018.

Figure 99: BMP Concepts for the Norder Wetland Restoration

CRITICAL SOURCE AREAS

Critical Source Areas (CSA) are a relatively small fraction of a watershed that generates a disproportionate amount of pollutant load (Meals, 2012). As discussed in Chapter 7, CSAs occur where a pollutant source in the landscape coincides with an active hydrologic transport mechanism. Identifying CSAs allows for the prioritization of fields where BMPs are likely most needed and allows for financial and technical resources to be used most efficiently.

CSAs in the Little Salt Creek Target Area were identified using the field runoff risk assessment in the ACPF Toolbox. This assessment provides a relative risk rating (not an absolute risk rating) and is based on a cross-reference of two factors:

- Slope steepness – Steeper fields have a higher risk of generating runoff
- Distance to stream – The closer a field is to a waterbody, the higher the risk a pollutant will be delivered to waterbody

Once the assessment is complete, each field receives a relative classification, ranging from A (highest risk – most critical), to B (very high), C (high), and other ('present'). One limitation of this tool is that only agriculture land uses (cropland or pasture land) are included. These other land uses (typically rural residences or other natural areas) are identified as "unknown" in the assessment. "Unknown" areas may still have an elevated runoff risk (especially for pollutants such as manure application or failing OWTS's). A "present" or "unknown" classification does not mean that a BMP would not provide benefits to a given field, but rather indicates that other fields have a greater potential to deliver pollutants to a waterbody via surface runoff. In future updates to this plan, an assessment of all fields for runoff risk is recommended.

For the purposes of this plan, areas identified as A or B through the runoff risk assessment, have been identified as CSAs. In the Little Salt Creek Target Area (Figure 100), there is a total of 5,803 acres of CSAs (approximately 20% of the Target Area), which are broken down as follows:

- Highest Risk CSA: 1,855 acres
- Very High Risk CSA: 3,948 acres

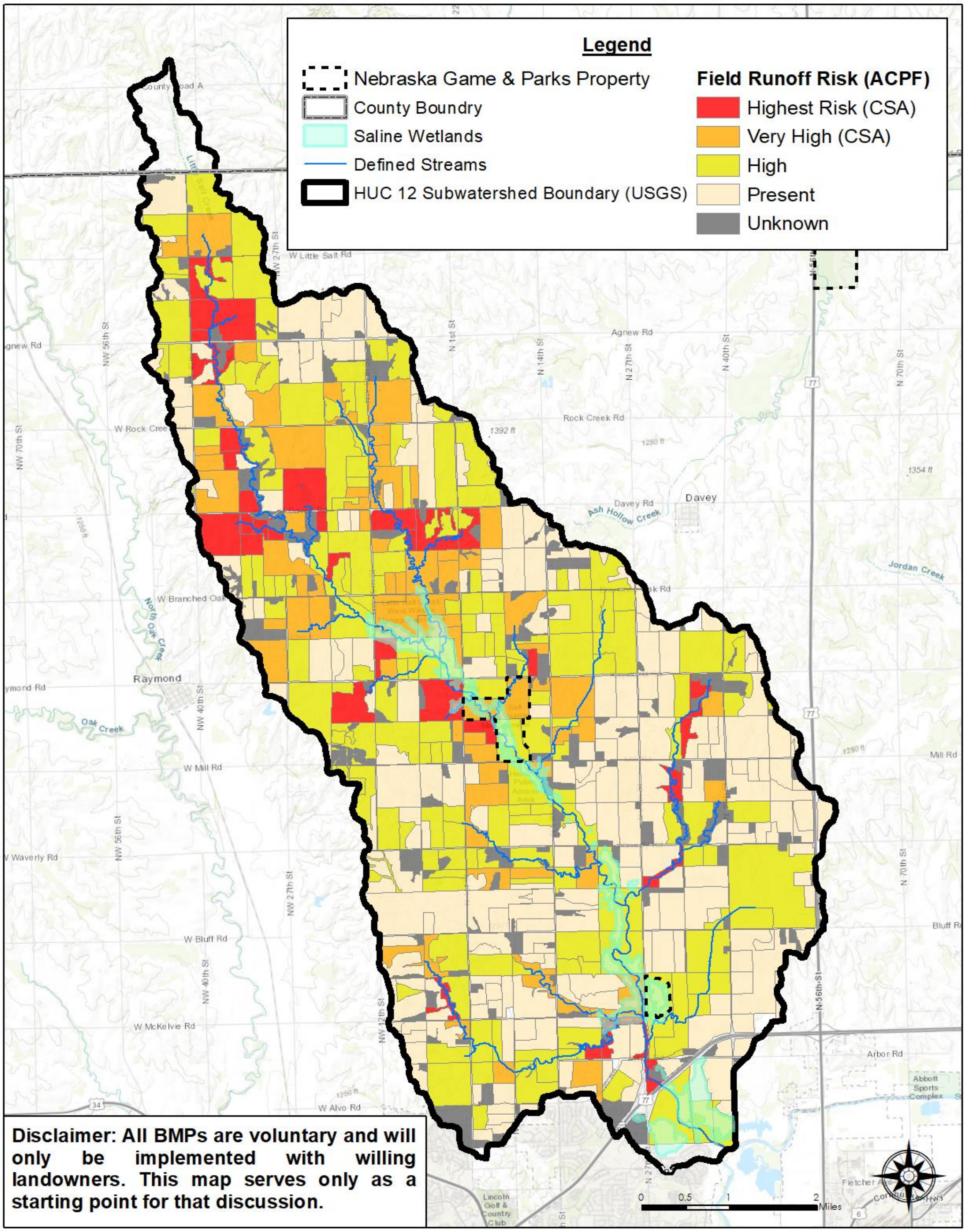


Figure 100: Critical Source Areas at Little Salt Creek as identified with the ACPF Tool

MEETING WATER QUALITY STANDARDS

The Eastern Saline Wetlands are assessed under narrative water quality standards under Nebraska WQS, thus numerical concentration and load reduction targets were not identified. Average annual load reductions associated with subwatershed area BMP implementation were estimated for *E. coli* bacteria, sediment, phosphorus, and nitrogen (Table 84). Sediment, the primary pollutant of concern, would be reduced by approximately 55%. While the focus of this plan is not on ammonia violations in Little Salt Creek, the reduction in annual total nitrogen load (66%) would also reduce ammonia concentrations. While Little Salt Creek is not designated for Primary Contact Recreation, a 68% reduction to the *E. coli* bacteria load will benefit downstream segments of Salt Creek that are impaired due to bacteria. Additionally, by reducing the *E. coli* load, Little Salt Creek will meet its pollutant load reduction goal for an in-stream concentration (111 CFU/100mL) (*Source: Water Quality Modeling*

Table 85).

Table 84: Estimated Pollutant Load Reductions due to BMP Implementation in the Little Salt Creek Subwatershed

	E. coli **(cfu/100mL)**	**Sediment (t/yr)**	**Phosphorus (lbs/yr)**	**Nitrogen (lbs/yr)**
Beginning load	329,000	18,965	35,878	146,285
BMP Load Reductions	224,000	10,384	21,583	86,918
Expected conditions	105,000	8,581	14,295	59,367
BMP Load Reductions (%)	68%	55%	60%	59%

Source: Water Quality Modeling

Table 85: Estimated In-stream *E. coli* Concentration After BMP Implementation

Stream Segment	Existing Seasonal Geometric Mean (#/100mL)	Water Quality Target (#/100mL)	Expected post-implementation Seasonal Geometric Mean (#/100mL)
LP2-20300	293	111	94

Source: Water Quality Modeling

MONITORING AND EVALUATION

The LPSNRD will follow the established protocol and procedures to: develop sound, defensible monitoring strategies and networks; properly manage data; and disseminate information to decision makers and other stakeholders. Monitoring goals can only be achieved through partnerships with other resource agencies such as NDEQ, NGPC, and the City of Lincoln. Steps will be taken to ensure collection of scientifically valid data, which may include the development of Quality Assurance Project Plans (QAPP) for state and federal review. Additional guidance and references are located in Chapter 4.

To adequately design monitoring networks that facilitate water resource management, it is critical to use data for its intended purposes. Thus, it is necessary to establish specific monitoring goals and objectives. A set of monitoring goals and objectives has been developed for the Little Salt Creek Subwatershed. Targeted parameters, monitoring sites, and monitoring frequency have been defined to meet each objective. Monitoring goals and objectives provided below in *italics* may require expanded or new monitoring efforts, whereas objectives and parameters in plain text are currently being addressed.

Monitoring Goal 1: Evaluate the water quality condition of Little Salt Creek.

- Evaluate beneficial use support and water quality trends for Little Salt Creek.
- Monitoring Parameters: heavy metals, pesticides, nutrients, *E. coli,* and field measurements
- Monitoring Frequency: (Annual) Weekly Monthly January-September
- Monitoring Site: Little Salt Creek North of Lincoln, NE (SLP2LSALTC08)

Monitoring Goal 2: Continue existing hydrology monitoring programs in place

Monitoring Goal 3: Evaluate effectiveness of existing BMPs on SWCP properties

- *Monitor changes in composition of salt tolerant species vegetation and/or soil salinity over time*
- *Monitor changes in vegetative communities over time*

COMMUNICATION AND OUTREACH

Chapter 6 of this plan provides a broad programmatic approach that the LPSNRD and its partners will take to address nonpoint source pollution through communication and outreach activities. Specifically, within a target area there are certain pieces of information necessary for successful communication and outreach efforts, which will in turn support the implementation of BMPs. Those items specific to the Little Salt Creek Target Area were identified via stakeholder and public input, and are as follows:

- Identified Target Audiences
    - Recreational water users of public lands along Little Salt Creek
    - Pheasants Forever – Cornhusker Chapter
    - Land managers, residents, and property owners within the Little Salt Creek Subwatershed
    - Producers with existing BMPs who may be interested in implementing more
    - Rural homeowners on private wells and septic systems
    - SWCP member organizations
- Methods

- Utilize parcel ownership information, along with the detailed BMP location maps created with the ACPF Tool, to contact specific landowners about BMPs applicable to their properties
    - A postcard mass mailing followed up by phone calls will help start initial implementation efforts and/or increase attendance at public meetings
- Utilize the existing knowledge and awareness around the Salt Creek Wetlands to build a message around improving watershed conditions
- Develop signage to be used at project demonstration sites, key watershed entrances or landmarks, and other highly visible areas
- Utilize the existing publicly owned lands for the following:
    - Post flyers, distribute press releases, and advertise at local events
    - Hold targeted coffee shop meetings, tailgate sessions, and other informal/casual informational exchanges to build relationships and to learn more about the constraints and hurdles to BMP adoption
- Hold an “Wine and Conservation” at, or in tandem with, local wineries (James Arthur Vineyards, Windcrest, etc) to focus on water quality and agricultural BMPs
- Piggyback on existing events - Training and demonstration field days, information booths, recognition picnics, etc.
    - The communities of Raymond, Davey, and Ceresco could all be targeted
- Hold an outdoor recreation clinic (hiking, birdwatching, etc.) on public lands

Plan and project sponsors will utilize these target audiences and outreach methods when building project level communication and outreach plans, typically as part of a Project Implementation Plan (PIP). The PIP will identify the specific and tailored actions for each target audience, as discussed in Chapter 6.

SCHEDULE

A timeframe for implementing general actions is provided in (Table 86). Actions are subject to approval by the LPSNRD Board of Directors, USACE, and NGPC, and may change as the plan is implemented. Phase I activities will include the initiation of drainage area BMPs, completion of the Norder Wetland Restoration, and completion of grade stabilization projects on Little Salt Creek. Phase II will begin upon the five-year revision of this plan and will include any implementation that was not completed in Phase I. A summary of progress achieved during Phase I will be included in the plan revision.

Table 86: Schedule for Implementation within the Little Salt Creek Subwatershed

Activity	Phase I						Phase II
	2019	2020	2021	2022	2023	2024	2025-2029
LPSNRD Board of Directors approval of plan	■						
EPA approval of the plan	■						
Monitoring (ongoing)	■	■	■	■	■		
Organize stakeholder groups		■					
Drainage area BMP Implementation			■	■	■	■	
Norder Wetland Restoration					■	■	
Grade Stabilization Implementation					■	■	
Project evaluation						■	
Final reporting						■	
Update HUC8 subbasin plan							■
Continue implementation as needed							■

MILESTONES

Major milestones that pertain to monitoring, planning, and management practice implementation are provided in Table 87. These milestones will be used to gauge progress in meeting the desired project schedule. As the implementation of this plan is initiated milestones will be adjusted accordingly to for changes to the schedule.

Table 87: Milestones for Implementation within the Little Salt Creek Subwatershed

Activity		Phase I						Phase II
		2019	2020	2021	2022	2023	2024	2025-2029
Monitoring	Coordinate with NDEQ	■	■	■	■	■		
	Finalize strategies and QAPPs		■					
	Assess data (annually)	■	■	■	■	■		
Planning	Drainage area BMP PIP		■		■			
	Funding Assistance		■		■			
	Norder Wetland Restoration Final Engineering			■	■			
	Grade Stabilization – Final Engineering			■	■			
	Norder/Grade Stabilization PIP				■			
	Apply for funding assistance grants				■			■
	Evaluate progress in meeting goals						■	
	Identify additional BMP needs						■	
	Prepare final report(s)						■	
	Revise WQMP plan as needed							■
Information/ Education	Develop stakeholder group		■					
	Work one-on-one with producers		■	■	■	■	■	
Implementation	Drainage Area BMPs		■	■	■	■	■	
	Norder Wetland Restoration					■	■	
	Grade Stabilization					■	■	

COST

The preliminary opinion of total cost of implementing the nonpoint source pollution control strategy for the Little Salt Creek Target Area is estimated to be $51,393,947 (Table 88). This does not include costs for final designs of engineering projects as these costs would be contingent on project scoping. When possible, costs were determined from the 2018 USDA-NRCS EQIP practice payment schedule (USDA, 2018). These costs are subject to change based on final designs, inflation, bidding climate at the time of construction, and project size and complexity.

Table 88: Implementation costs for the Little Salt Creek Subwatershed

Practice	Units	Units Targeted	Unit Cost	Total Cost
Education/Information*	years	5	$ 10,000	$ 50,000
Avoidance practices*	acres	9,020	$ 108	$ 974,160
Contour buffer strips (filter strips)	acres	450	$ 500	$ 225,000
Terraces	feet	133,485	$ 4	$ 533,940
Cover crops	acres	10,264	$ 133	$ 1,365,112
No-till	acres	1,925	$ 20	$ 38,500
Water and Sediment Control Basins (WASCOB	feet	119,600	$ 4	$ 478,400
Wetlands	#	88	$ 35,000	$ 3,080,000
Riparian buffers	acres	1,200	$ 1,650	$ 1,980,000
Grazing management	acres	6,355	$ 42	$ 266,910
OWTS Upgrade Practice	#	78	$ 5,500	$ 429,000
Non-Permitted AFO Facility BMP	#	6	$ 20,000	$ 120,000
Grassed Waterways	acre	3	$ 6,575	$ 19,725
SubTotal (Drainage Area Treatment)				**$ 9,560,747**
Streambank/channel stabilization & Restoration	feet	265,788	$ 150	$ 39,868,200
Grade Control at Bridges**	#	10	$ 92,000	$ 920,000
SubTotal (In-Stream Work)				**$ 40,788,200**
In-Stream Grade Control Structures (3ft Elev)	cost	1	$218,000	$ 218,000
Head-Cut Repair / Monitoring	cost	1	$36,000	$ 36,000
In-Stream Grade Control Structures (6ft Elev)	cost	1	$195,000	$ 195,000
Stream-Side Saline Habitat Shelves	cost	1	$140,000.00	$ 140,000
Shallow Excavation w/ Dendritic Channels	cost	1	$37,000.00	$ 37,000
Shallow Excavations	cost	1	$63,000.00	$ 63,000
Pond Berm and Outlet Improvements	cost	1	$8,000.00	$ 8,000
Excavation Test Plots	cost	1	$15,000.00	$ 15,000
Grassed Terraces / Waterways	cost	1	$7,000.00	$ 7,000
Public Access (trail, bridge, crossing) [I&E]	cost	1	$ 276,000	$ 276,000
SubTotal (Norder Wetland Restoration)* **				**$ 995,000**
Updates to WQMP	each	-	$ -	$ -
Additional monitoring*	years	5	$ 10,000	$ 50,000
SubTotal (Planning/Monitoring)				**$ 50,000**
Total				**$ 51,393,947**

Based on estimated costs during first 5-year increment only

***As identified in the City of Lincoln Upper Little Salt Creek Master Plan (Intuition Logic, 2009)*

****As identified in the Conceptual Norder Wetland Restoration Design Memorandum (Flatwater, 2018)*

10.06 ANTELOPE CREEK TARGET AREA

INTRODUCTION

Antelope Creek (LP2-20900) is located entirely within the urbanized area of the City of Lincoln (Figure 101). The stream flows from the southeast to the northwest, before merging with Salt Creek. The upper portion of the stream is impounded by Holmes Lake (LP2-L0040). The entire HUC 12 subwatershed is approximately 9,314 acres; however, only the lower portion of the stream is targeted within this plan. The drainage area for this portion of the stream includes everything downstream of Holmes Lake. Additionally, this area's delineation was refined using LiDAR and urban drainage information and mapped as part of the *Antelope Creek Watershed Basin Management Plan* (EA, 2012). The Antelope Creek Target Area is 4,931 acres.

NOTE TO READERS

Much of the information in this section is summarized from the *Antelope Creek Watershed Basin Management Plan (EA, 2012)*. Unless otherwise noted, additional details and background information can be found in that comprehensive document.

The *Antelope Creek Watershed Basin Management Plan* was originally prepared to address impairments to the stream caused by *E. coli* bacteria. Many recommendations in this plan have been carried out by the LPSNRD, City of Lincoln, NDEQ, and other stakeholders. With the development of this District-Wide WQMP, the intent is to integrate previous planning efforts from the watershed plan into this plan and identify additional projects to continue to improve the water quality of the stream.

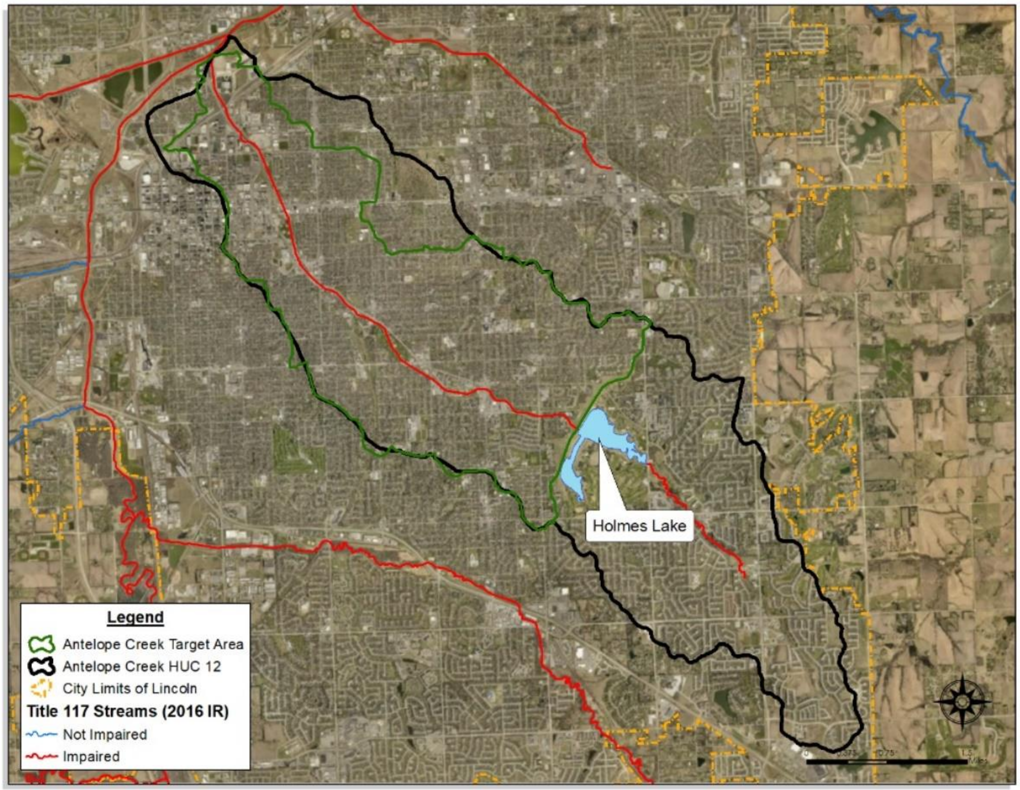


Figure 101: Location of Antelope Creek Target Area

IMPAIRMENTS

Antelope Creek was first listed as impaired for *E. coli* bacteria based on data gathered in 2004. When the planning process for this plan kicked off, the stream was still listed as impaired in the 2016 Integrated Report. Therefore, this plan was originally prepared with sampling data from 2009, which was the most recent data at the time. Water quality modeling and analysis was completed with the 2009 data, and estimated pollutant loads and reductions were identified within the modeling report (Appendix D).

However, when the draft plan was being finalized, new water quality monitoring data and assessments were released by the NDEQ. This new assessment determined that Antelope Creek is no longer impaired (NDEQ, 2018a). New sampling data from 2015 shows that the creek is now below the water quality standard (Figure 102). Unfortunately, due to the timing of this analysis and work already completed for this plan, this new water quality data was unable to be incorporated into the water quality model.

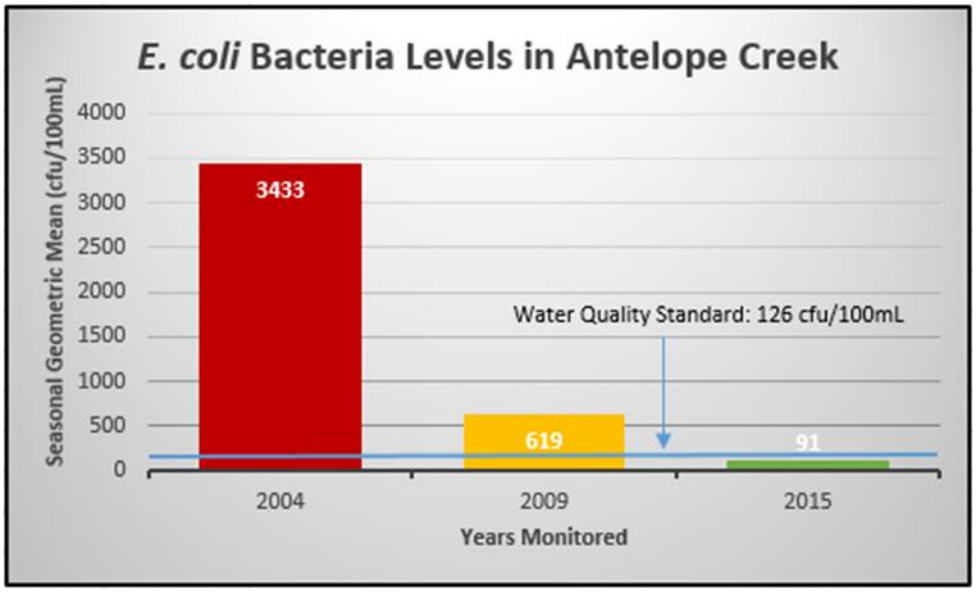


Figure 102: E. coli Bacteria Levels in Antelope Creek

**Note: Figure provided by NDEQ*

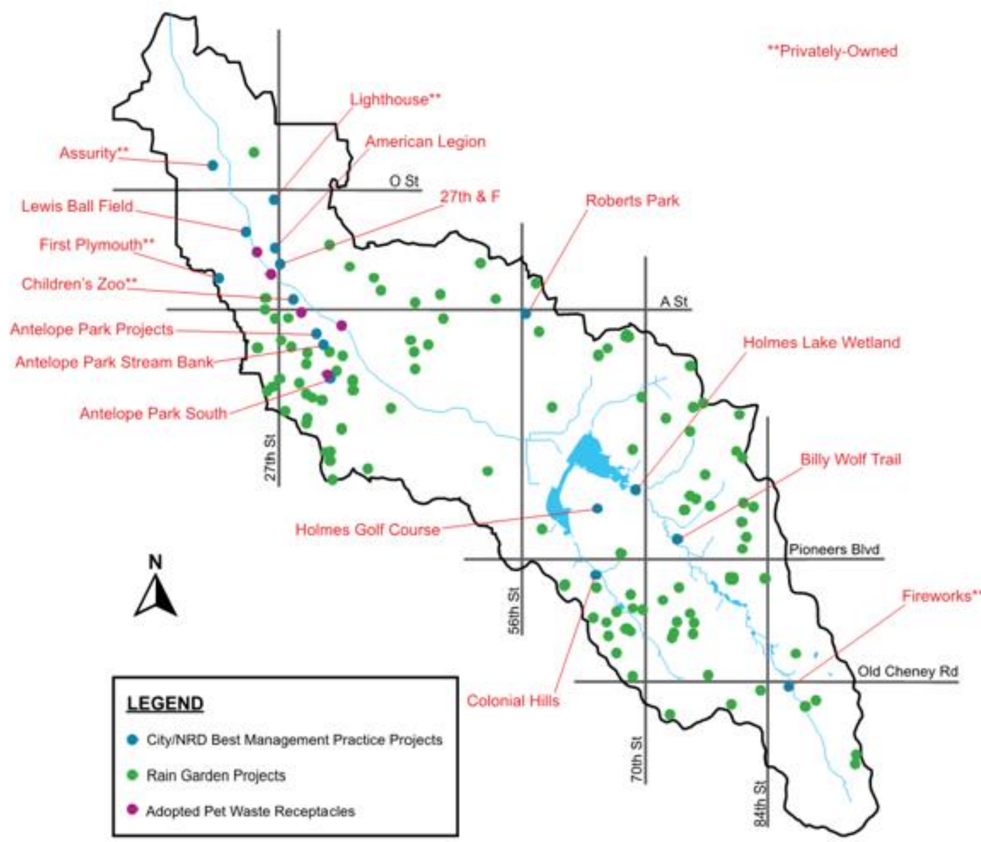
PREVIOUSLY COMPLETED BMPS

Bacteria in surface water is notoriously hard to manage, but through several projects the City of Lincoln, University of Nebraska, and LPSNRD, in conjunction with NDEQ and other project partners, have completed over a dozen projects which have led to the implementation of multiple BMPs and the reduction of *E. coli* pollution to Antelope Creek (Figure 103). Over $11.6 million (Section 319 and match funds) was spent during the 20-year timeframe that work occurred.

These projects included: daylighting the stream near downtown Lincoln; moving the State Fair to Grand Island; constructing new roads with traffic flow and flood control in mind; and multiple Section 319 nonpoint source projects to implement BMPs. Below is a summary of projects completed in recent years (City of Lincoln, personal communication, July 31, 2018):

- 2013 – A total of 12,400 biodegradable pet waste bags were provided to Rickman's Run. They were printed with an educational message on them.
- 2014 – Five pet waste receptacles were installed along Antelope Creek. They are labeled with signs that say "This container only for pet waste". The receptacles were adopted by a local refuse company.
- 2014 – A brochure was created to educate the public about fertilizer and pet waste. This brochure was mailed out to 1,583 residents in the Antelope Park Sub-Basin (focus area for the cost share program).
- 2015 – Pet waste information was added to City of Lincoln Watershed's website: http://lincoln.ne.gov/city/pworks/watershed/home-lawn/pet-waste.htm. There is a map that includes the adopted pet waste receptacles, as well as Parks-owned trash cans (which can be used for disposing of pet waste while making use of the parks).

- 2015/17 – Pet waste public service announcements appeared in four neighborhood newsletters.
- 2015 and beyond – The City gives away pet waste bag dispensers at public events throughout the city. A total of 1,250 dispensers have been purchased since 2015.
- Other projects in the area include the BMPs that were installed:
    - Wetland areas at Rickman's Run
    - Permeable pavers, bioretention, and rain gardens at Lincoln Children's Zoo
    - Disconnection of parking lot and bioretention southwest of the Auld Pavilion in Antelope Park
    - Bioretention in Antelope Park, south of South Street



Source: City of Lincoln and LPSNRD

Figure 103: Summary of BMPs Completed within the Antelope Creek Subwatershed

REQUIRED POLLUTANT LOAD REDUCTIONS

Due to the updated assessment, it is not necessary to reduce pollutant loads within the stream; however, it is still important to maintain the reductions achieved through public education and other BMPs that have been implemented within the watershed. Although the stream is currently meeting water quality standards, stakeholders and the public still consider this stream a high priority resource and thus plan to continue to implement projects to protect water quality.

RECOMMENDED BMPS

> **NOTE TO READERS**
>
> It should be noted that this implementation strategy is not intended to include any requirements outlined in the City of Lincoln's MS4 permit. The following strategies for Antelope Creek are intended to be supplemental to, or above and beyond, any required actions.

Recent sampling conducted by the City of Lincoln has made several findings and recommendations that are relevant to this implementation strategy. The final report (Darshan and others, 2017) concluded that *E. coli* levels in wet weather water collected from Antelope Creek were considerably higher than in dry weather water, which suggests that the contamination is from non-point sources being flushed into the creek by stormwater. Additionally, these results suggest that efforts should be made to reduce to remove direct connections between impervious surfaces and Antelope Creek in order to manage the problem of elevated *E. coli* concentration. These results support the recommendations found in the *Antelope Creek Watershed Basin Management Plan* (EA, 2012), therefore this plan is recommending a continuation of the projects identified in that plan. While many have been implemented (see previous summary), there are several yet to be completed. Additional discussion of these, as well as possible pollutant reduction efficiencies, can be found in Appendix D.

The following implementation activities are recommended within this target area. Many of the activities below have been previously identified and implemented from the *Antelope Creek Watershed Basin Management Plan* (EA, 2012).

- **Watershed education and outreach**
  - This is the backbone of all recommended activities for this target area. Information and education (I&E) is critical to ensuring existing BMPs are properly maintained, and that additional BMPs are understood and supported by the public. Existing programs should be continued and expanded as needed. Chapter 6 of this plan provides a broad programmatic approach that project sponsors can utilize to improve and build upon existing efforts.
- **Pet Waste Reduction Education**
  - It is worth noting that the City of Lincoln already has a pet waste ordinance in place. However, additional management strategies that the City of Lincoln could use to further reduce the *E. coli* loads include the following:
    - Install and maintain several pet waste containers along parks and recreational areas in the Antelope Creek watershed.
    - Signs explaining the importance of picking up pet waste at each container to increase usage of the containers.
    - Assistance from local partners to help with maintenance of pet waste containers, such as neighborhood associations.
    - Notify residents through bill stuffers, letters, news articles, and other means, about the water quality benefits of picking up pet waste and the potential

enforcement actions available to the City for those not complying with local pet waste ordinances.
- Since 2013 the City of Lincoln has adopted many of these recommendations to enhance their pet waste control program. It is recommended that these practices be continued and expanded where possible.

- **Sewer Line Inspection and Maintenance Programs**
  - Aging sanitary sewer pipes can be a significant source of bacteria from developed urban areas. Deteriorated sanitary sewer and stormwater infrastructure, especially conveyance pipes, provide a pathway for bacteria to enter the storm drainage system or shallow groundwater table which can elevate bacteria concentrations in receiving waterbodies.
  - The expansion of the City of Lincoln's existing sewer line inspection program can be an avenue to meet *E. coli* bacteria reduction goals in the Antelope Creek Target Area. Continued sewer collection system cleaning, inspections, and repair practices are essential to ensure sources for *E. coli* are identified and disconnected from receiving waterbodies.
- **Wildlife Control on Bridges**
  - Urban wildlife management is a potential strategy for reducing *E. coli* in Antelope Creek. Bird droppings appear to be a significant source of *E. coli* in the Antelope Creek Basin, and it was discovered that many of the total 29 bridges which span Antelope Creek were lacking structures to reduce or discourage bird nesting and or perching.
  - Retrofitting older bridges and overpasses which span Antelope Creek with practices such as bird spikes and or netting to discourage feeding, watering, roosting, and nesting sites for birds is recommended. This would reduce the amount of time that birds spend in direct contact with the stream, and reduce their pollutant loads.
- **Rain Barrels and Bioretention Practices**
  - The City of Lincoln's residential rain gardens and rain barrel program are effective BMP strategies to help reduce *E. coli* loads. As previously discussed, the City has continued to implement these practices across the target area. It is recommended that these effective programs be continued throughout the target area, especially when the opportunity to combine them with new-development and re-development is available.
- **Structural Projects**
  - Thirteen specific structural projects in the Antelope Creek target area were identified and the expected *E. coli* load reductions due to their construction were quantified (Table 89). It should be noted that since 2013, the City of Lincoln has constructed Projects P02 through P06. It is recommended that the remaining projects be completed.

Table 89: Status of Previously Identified Projects for Antelope Creek Target Area

Project ID	Description	Status
P01	Antelope Park: Channel and Wetland Enhancements from Van Dorn St. to Sheridan Blvd.	Incomplete
P02	Antelope Park: Channel Enhancements from South St. to Van Dorn St.	Complete
P03	Antelope Park: Bioretention Areas SW of 33rd and South St.	Complete
P04	Antelope Park: Stream stabilization and Bioretention	Complete
P05	Roberts Park/East of Holmes Elementary School: Stream restoration and Bioretention	Complete
P06	Lincoln Children's Zoo: Green Roof, Bioretention, and Permeable Pavement	Complete
P07	Woods Park: Bioretention and Hydrodynamic Separators	Incomplete
P08	Gere Library: Bioretention and Hydrodynamic Separators	Incomplete
P09	Eden Park: Bioretention	Incomplete
P10	Retrofit of Existing Dry Detention Cell near 60th and South	Incomplete
P11	Retrofit of Labyrinth Weir on Antelope Creek	Incomplete
P12	Van Dorn Plaza and US Post Office: Bioretention	Incomplete
P13	SE of 40th and Capital Parkway: Bioretention and Hydrodynamic Separators	Incomplete

Source: Antelope Creek Watershed Basin Management Plan (EA, 2012)

IMPLEMENTATION STRATEGY

Implementation within the Antelope Creek Target Area relies upon the continuation of existing programs and projects. Additional details on BMPs and projects within the Antelope Creek Target Area can be found in the *Antelope Creek Watershed Basin Management Plan* (EA, 2012). Because Antelope Creek is no longer listed as impaired, the following elements are not part of this plan: monitoring and evaluation, schedule, milestones, and costs. These items can be found in EA (2012) and will be updated (as needed) within a Project Implementation Plan (PIP) should a project sponsor move forward with utilizing Section 319 funds.

10.07 SPECIAL PRIORITY AREAS

Special priority areas provide flexibility in addressing identified small-scale areas with specific, limited, and timely needs. They address issues that occur widely in the subbasin that may affect not only water quality, but also the health and safety of humans. Additionally, some BMPs do not have specific targeted land uses or an easily defined subwatershed associated with their implementation; thus, these areas do not count towards the 20% Rule.

Some BMPs have a broader appeal and impact on public involvement when implemented on an area-wide basis. Practices are restricted to those necessary to address the specific needs of the special priority area. BMPs address specific issues within areas, many of which cross subwatershed and target area boundaries. Projects in these areas are excellent candidates for partnering opportunities. The following special priority areas are relevant to the Salt Creek Subbasin.

DISTRICT-WIDE SPECIAL PRIORITY AREAS

The following special priority areas were identified as special priority areas for the entire district, therefore, they are discussed in more detail in Chapter 9. No additional discussion is provided in this chapter.

- On-site Wastewater Treatment Systems (OWTS)
- Non-permitted Animal Feeding Operations (AFOs)
- Wellhead Protection Areas (WHP areas) (also referred to as CWSPAs in the LPSNRD)

SALINE WETLANDS

Saline wetlands within the Salt Creek Subbasin were identified as a special priority area by project stakeholders. As discussed in multiple chapters of this plan, these areas are unique to the planning area (Figure 104). The focus as a special priority area will be to implement BMPs within the existing wetlands to restore hydrology, reduce sedimentation, and improve habitat. In addition to the actions targeting the saline wetlands within the Little Salt Creek Target Area, the following activities have been identified by the SWCP as a priority in the coming years:

- Haines Branch - Stream stabilization and wetland restoration within the Pioneers Park Nature Center
- Little Salt - Stream and wetland improvements to enhance ecological connection between habitats
- Rock Creek - Post-project review and planning for addition habitat improvements
- Salt Creek – Saline wetland and salt marsh meadow enhancements at Warner Wetlands

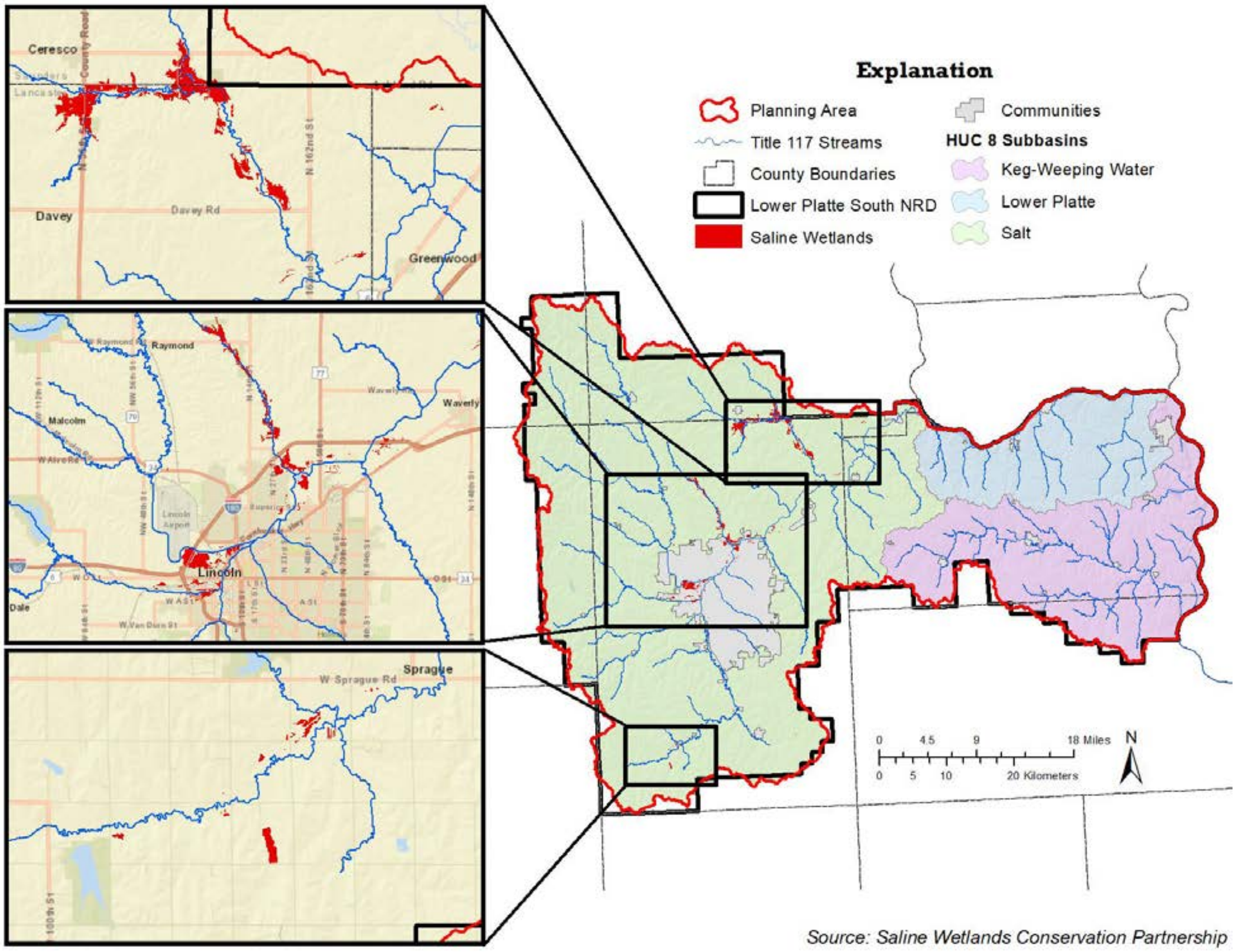


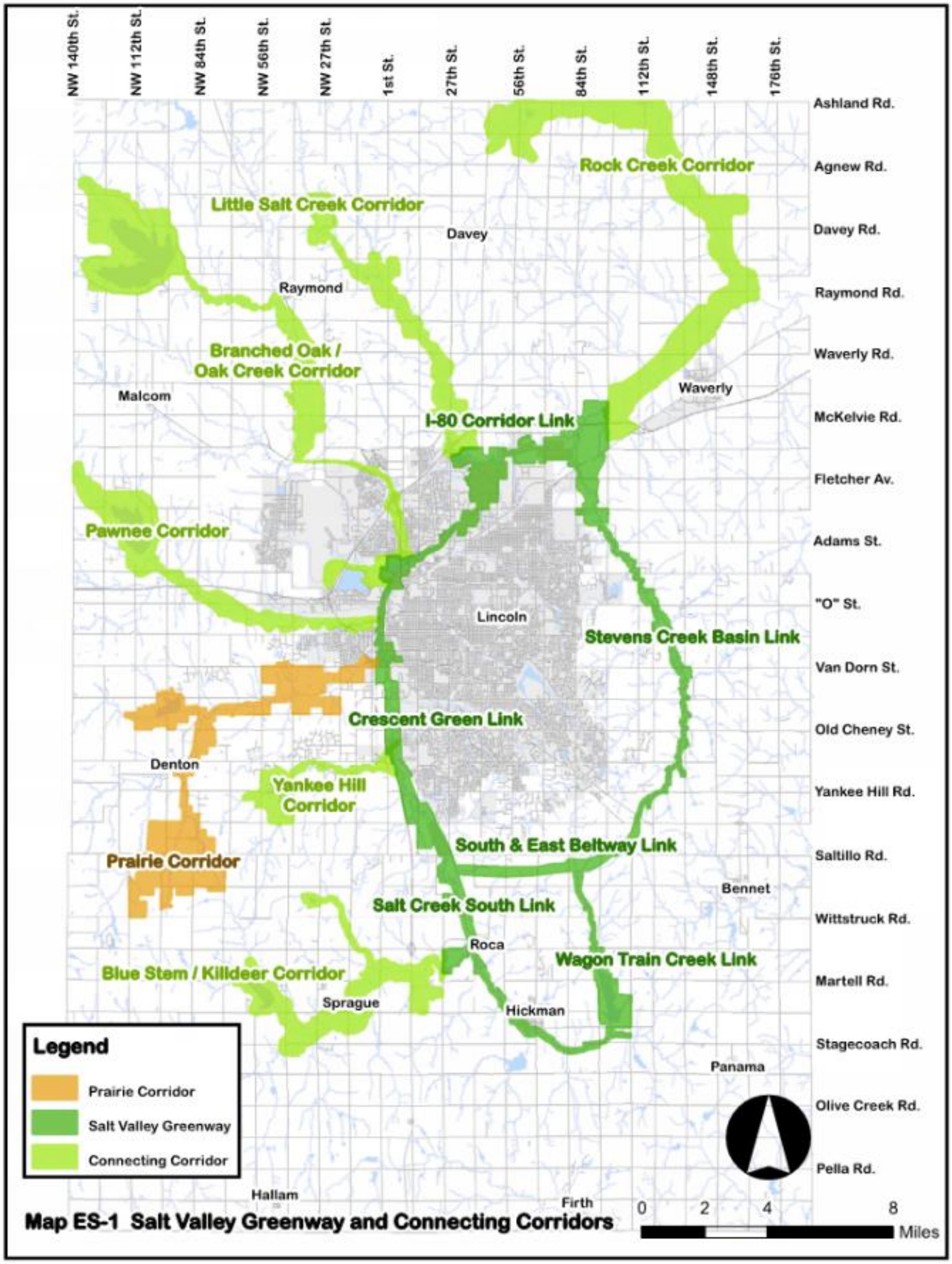
Figure 104: Saline Wetlands Location Map

SALT VALLEY GREENWAY

A greenway is a strip of undeveloped land near an urban area, set aside for recreation or environmental protection. Greenways in and around the City of Lincoln form linkages between wildlife habitat and natural areas and are primarily situated around waterways. Over the last few decades the City of Lincoln and Lancaster County governments have been working towards the vision of a greenway that provide these benefits within the Salt Creek Subbasin area. This vision is more formally outlined in the *Salt Valley Greenway and Prairie Corridor Master Plan* (Flatwater, 2012). The Salt Valley Greenway is a ribbon of open space and greenway links between the Salt Valley drainage basin and the Prairie Corridor on Haines Branch (Figure 105). This area provides opportunities to protect and enhance stream corridors, wetlands, and native prairies for multiple beneficial uses.

The *Salt Valley Greenway and Prairie Corridor Master Plan* outlines many priorities and possible projects to be completed towards realizing the vision of enhanced natural resources. Many of these either directly benefit water quality or could include elements that enhance water quality. This area has been recognized as a special priority area where the LPSNRD or other project partners may capitalize on project opportunities from the *Salt Valley Greenway and Prairie Corridor Master Plan* to further the goals of the WQMP. Many projects completed in these areas also will, or have the potential to, reduce nonpoint source pollution and/or improve aquatic habitat. BMPs in these areas will be defined based on the specific pollutant source being addressed, but BMPs targeting non-permitted livestock and stream restoration will be considered. These projects may consist of:

- Land acquisition
- Conservation easements
- Prairie restoration and management
- Wetland restoration or enhancement
- Riparian zone restoration or enhancement
- Public access and educational opportunities via trail development



Source: Flatwater, 2012

Figure 105: Salt Valley Greenway and Connecting Corridors

ANTELOPE COMMONS (THE PRESERVE)

Antelope Commons is a series of wetlands constructed in 1995 within the channel of Antelope Creek above Holmes Lake (Figure 106). These wetlands function as BMPs to protect the stream and reservoir from nonpoint source pollution originating from the surrounding urban development. This project was installed prior to much of the area's urban development and is thus a likely candidate for renovation to ensure the continued function of this BMP system. BMPs targeted to this area include:

- Urban Stormwater BMPs
- Pet waste management
- Riparian buffers
- Restoration of ponds/wetlands

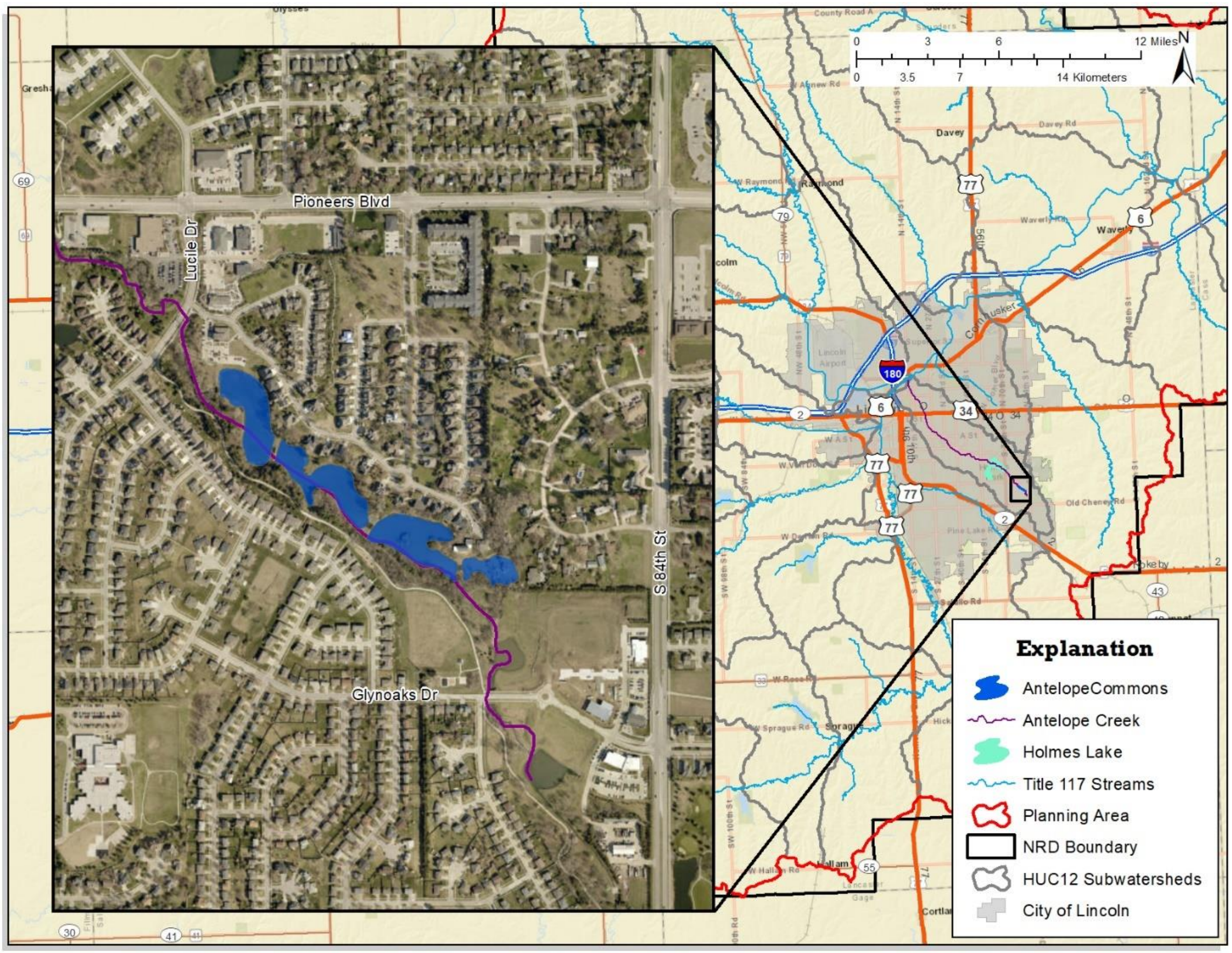


Figure 106: Location of Antelope Creek Commons Special Priority Area

EXISTING SEDIMENT RETENTION STRUCTURES

Many of the area's reservoirs have undergone aquatic habitat restoration activities in the past two decades. These efforts have often included the installation of sediment basins or other retention structures at the headwaters of each reservoir. Controlling sedimentation into a reservoir or lake is critical to maintaining water quality within the waterbody. This is necessary even with significant BMP implementation within the drainage area. This is most commonly accomplished with the installation of sediment retention basins in or directly above reservoirs. If properly designed, basins providing extended wet detention of runoff which can reduce nitrogen, phosphorus, and sediment loads by 55%, 69%, and 72% respectively (TetraTech, 2007). The LPSNRD and partners have previously incorporated water quality basins into the design of existing reservoirs within this subbasin, which include:

- Wagon Train Lake (Lancaster County)
- Yankee Hill Lake (Lancaster County)
- Wildwood Lake (Lancaster County)
- Conestoga Lake (Lancaster County)
- Olive Creek Lake (Lancaster County)
- Meadowlark Lake (Seward County)
- Hedgefield Lake (Lancaster County)

While watershed management and the removal of deposited sediment in the main body of a reservoir are both important aspects of achieving water quality goals, maintaining storage capacity in established water quality basins also plays an important role. To maintain the effectiveness of these basins, it is necessary to periodically clean out collected sediment. Because many of these existing structures were built 10-20 years ago, it is likely they need sediment removal. Stakeholders identified these structures as special priority areas because of the effectiveness in reducing pollutant loads and the immediate opportunity to protect existing waterbodies.

To maintain their pollutant trapping effectiveness, all established basins should be evaluated for storage volume loss and prioritized for sediment removal activities. This will allow resource managers to plan and budget for maintenance activities well into the future. The primary methods used to remove deposited sediment include dredging and dry excavation. While all options should be evaluated for each site, dry excavation has been the most commonly used technique on reservoirs in the planning area.

10.08 MONITORING PRIORITIES

Monitoring priorities were identified by the project team and TAC after review of existing data and a discussion on possible future data needs. While many of these activities may provide general support towards target area implementation, they would take place separately of any target area implementation or pre/post project monitoring activities. Below are lists of these priorities along with a brief description of each.

DISTRICT-WIDE PRIORITIES

The following monitoring priorities are applicable to the entire district; therefore, they are discussed in more detail in Chapter 9. Additionally, other supporting information may be found in Chapter 4. No additional discussion is provided in this chapter.

- Existing BMP Treatment Levels
- Pre-project Monitoring

STEVENS CREEK

This subwatershed is located immediately adjacent to the eastern corporate limits of Lincoln and is slated for urban development. Much of this development pressure has already begun, thus stakeholders identified the need for additional monitoring as a priority. Monitoring would primarily consist of documenting the natural conditions of streambanks, streambed elevations, and the condition of the riparian corridor. This will help managers identify or track degradation of these critical areas over time, allowing for early detection and intervention opportunities.

IMPAIRED AQUATIC COMMUNITIES

NDEQ periodically conducts stream biological monitoring to assess the overall health of a stream ecosystem (see Chapter 4). Within the planning area, monitoring results identified five stream sites with impaired aquatic life. Stakeholders believe it is likely that degraded physical habitat conditions (not chemical water quality conditions) are the cause of these impairments. Due to the nature of this impairment, it was not possible to evaluate it during the development of this plan. In order to identify the true cause of the impairments, a priority action was identified to conduct further stream assessments in the following stream segments:

- Salt Creek (LP2-20000)
- Little Salt Creek (LP2-20300)
- Oak Creek (LP2-20600)
- Salt Creek (LP2-30000)
- Olive Branch (LP2-40300)

BATHYMETRIC SURVEYS

Sediment management in respect to lakes involves controlling erosion at the source, trapping sediment before it reaches the lake, and reclaiming lost storage capacity in the lake and upstream sediment basins. The loss of reservoir conservation pool storage capacity can result in deteriorated water quality and the loss of aquatic habitat. Information gathered from bathymetric surveys can be used for several water quality planning purposes such as: (a) tracking reservoir sedimentation rates over time, (b) determining sediment trapping efficiencies of wetland/ sediment basins, (c) estimating reservoir and sediment basin maintenance requirements and financial needs, and (d) planning for in-lake management measures.

Current bathymetric information is lacking for most of the larger or recreational lakes in the planning area. The identification of priorities for future surveys was based on (a) sites that have had completed nonpoint source projects, (b) sites that are a priority in this plan, or (c) sites that serve as major public recreation areas (Table 90). Sediment basins would be best surveyed every three to five years, as opposed to every seven to ten years for reservoirs. Significant dry or wet periods might warrant longer or shorter intervals between survey periods. To ensure data comparability, it is critical to maintain consistent boundaries across survey periods. The measurement of soft sediment thickness should accompany bathymetric surveys at sites where in-lake improvements are planned. This information is valuable to develop strategies for re-claiming lost lake storage capacity and for locating in-lake sediment control structures.

Table 90: Priority Sites for Bathymetric Surveys

Waterbody	Last Survey Completed	Justification
Pawnee Lake	2002	Plan Priority Area
Twin Lakes	2002	Plan Priority Area
Branched Oak	2003	Largest Lake in planning area
Conestoga	2004	Lake Renovation in Progress
Wagon Train	2002	Lake Renovation-Sediment Basin Construction-Watershed Treatment Completed 2002
Yankee Hill	2005	Lake Renovation-Sediment Basin Construction-Watershed Treatment Completed 2005
Wildwood	2003	Lake Renovation-Sediment Basin Construction-Watershed Treatment Completed 2003

10.09 COMMUNICATION AND OUTREACH PRIORITIES

Stakeholders identified communication and outreach priorities. While many of these activities may provide general support towards target area implementation, they would take place separately of any target area communication and outreach activities. Below are these priorities along with a brief description of each.

DISTRICT-WIDE PRIORITIES

The following communication and outreach priorities are applicable to the entire district; therefore, they are discussed in more detail in Chapter 9. Additionally, other supporting information may be found in Chapter 6. No additional discussion is provided in this chapter.

- LPSNRD Board of Directors
- Rural Water Districts
- County Board
- Village/city governments with WHP areas (also referred to as CWSPAs in the LPSNRD)

HOME OWNERS ASSOCATION

Defining Maintenance responsibility for BMP facilities, identifying who is responsible for maintenance of BMPs, and ensuring that an adequate budget is allocated for maintenance is critical to the long-term success of BMPs. Within the planning area many BMPs are owned and/or maintained by government entities such as the LPSNRD or the City of Lincoln. However, there are also many other BMPs distributed throughout residential areas that are privately owned.

These privately owned BMPS are typically maintained by the property owner or a neighborhood homeowner's association (unless a different ownership/maintenance arrangement has been approved by the City of Lincoln). BMPs must be maintained according to the guidelines in the City of Lincoln Drainage Criteria Manual, and as specified in maintenance plans. However, many of these associations are not aware of this responsibility and may lack an understanding of maintenance required for BMPs to function properly.

Addressing this issue was identified as a priority communication and outreach action. The City of Lincoln will lead the development of information materials and actions targeted at homeowner's associations with stormwater BMPs. This may include, but is not limited to:

- Targeted mailings
- 1-on-1 meetings with association leaders
- Town hall style meetings with targeted neighborhoods
- Brochures outlining overall responsibilities
- Brochures outlining the benefits and functions of stormwater BMPs
- Installation of signage outlining the benefits and functions of stormwater BMPs
- Development of a "BMP Maintenance Guide for Homeowners Associations and Property Owners"

10.10 COST SUMMARY FOR TARGET AREAS

The preliminary opinion of total cost for implementing the nonpoint source pollution control strategy for the three target areas is estimated to be $109,013,999 (Table 91). This does not include costs for bathymetric surveys or final designs of engineering projects. When possible, costs were determined from the 2018 USDA-NRCS EQIP practice payment schedule (USDA, 2018). Costs estimated for in-lake measures were based on average unit prices from a wide range of past project costs and should only be used for general planning purposes. These costs are subject to change based on final design of the rehabilitation, inflation, bidding climate at the time of construction, and project size and complexity. Additionally, costs for the Norder Wetland Restoration and Little Salt Creek stream stabilization came from existing documents as previously discussed.

Major costs vary between the target areas, with the greatest being for in-lake work for Pawnee and Twin Lakes. In-lake work includes such items as sediment removal, shoreline stabilization, construction of jetties and breakwaters, in-lake sediment basins, and nutrient inactivation.

On the surface, in-stream work is a relatively expensive option. This is because, historically, few major or widescale conservation programs have existed to address stream restoration or riparian BMPs. This has left a lot of work to be accomplished. It should be noted that oftentimes specific stream stabilization techniques placed at strategic locations and paired with policies that encourage the establishment of riparian buffer zones can significantly reduce the costs of these efforts. Essentially, this allows nature to do most of the work, while only critical infrastructure or other points of interest are stabilized in-place. In-Stream Work includes such items as streambank/channel stabilization and restoration, grade control at bridges, and riparian buffer establishment.

Watershed Treatment is the lowest cost option of nonpoint source pollution control for all target areas. Watershed Treatment revolves around working with landowners on a voluntary basis to implement BMPs that avoid, control, and treat runoff. Additionally, this includes information and education, and targeted efforts to improve non-permitted AFOs and unregistered OWTSs. Watershed Treatment relies on landowner cooperation to construct BMPs in the most effective areas.

Table 91: Summary of Target Area Implementation Costs

Watershed Treatment	
Pawnee Lake-Middle Creek	$5,907,366
Twin Lakes	$2,331,826
Little Salt	$9,560,747
Subtotal	**$17,799,939**
In-Stream Work	
Pawnee Lake-Middle Creek	$14,043,750
Twin Lakes	$5,596,500
Little Salt	$40,788,200
Subtotal	**$60,428,450**
In-Lake Work	
Pawnee Lake-Middle Creek	$27,066,860
Twin Lakes	$2,573,750
Little Salt	N/A
Subtotal	**$29,640,610**
Norder Wetland Restoration	
Pawnee Lake-Middle Creek	N/A
Twin Lakes	N/A
Little Salt	$995,000
Subtotal	**$995,000**
Planning/Monitoring	
Pawnee Lake-Middle Creek	$50,000
Twin Lakes	$50,000
Little Salt	$50,000
Subtotal	**$150,000**
Total Cost	
Pawnee Lake-Middle Creek	$47,067,976
Twin Lakes	$10,552,076
Little Salt	$51,393,947
Subtotal	**$109,013,999**

CHAPTER 11. LOWER PLATTE RIVER HUC 8 SUBBASIN

11.01 SUBBASIN BACKROUND

The Lower Platte River Subbasin (HUC 8: 10200202) is located in northern Cass County and encompasses 115,393 acres, or approximately 11% of the planning area (entire planning area is 1,048,774 acres). Row crops (corn/soybean) are the predominant land use, with some areas of forest and grass/pasture lands which are concentrated along the northern boundary of the subbasin in the Platte River bluffs. Figure 107 illustrates the land use/land cover within the subbasin. The subbasin is nearly completely rural in nature, with Louisville (estimated population of 1,039) being the largest community in the subbasin. There are two major public recreation areas, both along the Platte River: Platte River State Park and Louisville State Recreation Area.

This chapter is intended to focus primarily on the target areas, special priority areas, and other priorities identified within the Lower Platte River HUC 8 subbasin. Little discussion is given to the rest of the subbasin here, as much of that information can be found throughout the rest of this plan. Information on an inventory of subbasin characteristics is found in the following chapters/section within this plan:

- Land Use: Chapter 3.02
- Existing land treatment (BMPs): Chapter 7.09
- Irrigation: Chapter 3.06
- Permitted facilities: Chapter 5.07
- Water resources: Chapter 3.03
- Existing resource conditions: Chapter 5

A general discussion of the types and sources of the pollutants that are addressed in this chapter can be found in Chapter 5. This subbasin specific chapter provides information for the contribution of pollutant by source within each target area. Additionally, this chapter provides the following information for each target area:

- Pollutant sources and loads;
- Pollutant load reductions needed to meet water quality standards (load reduction goals);
- Pollutant load reductions as a result of BMP implementation;
- Communication and outreach;
- Schedule and milestones;
- Monitoring; and
- Costs.

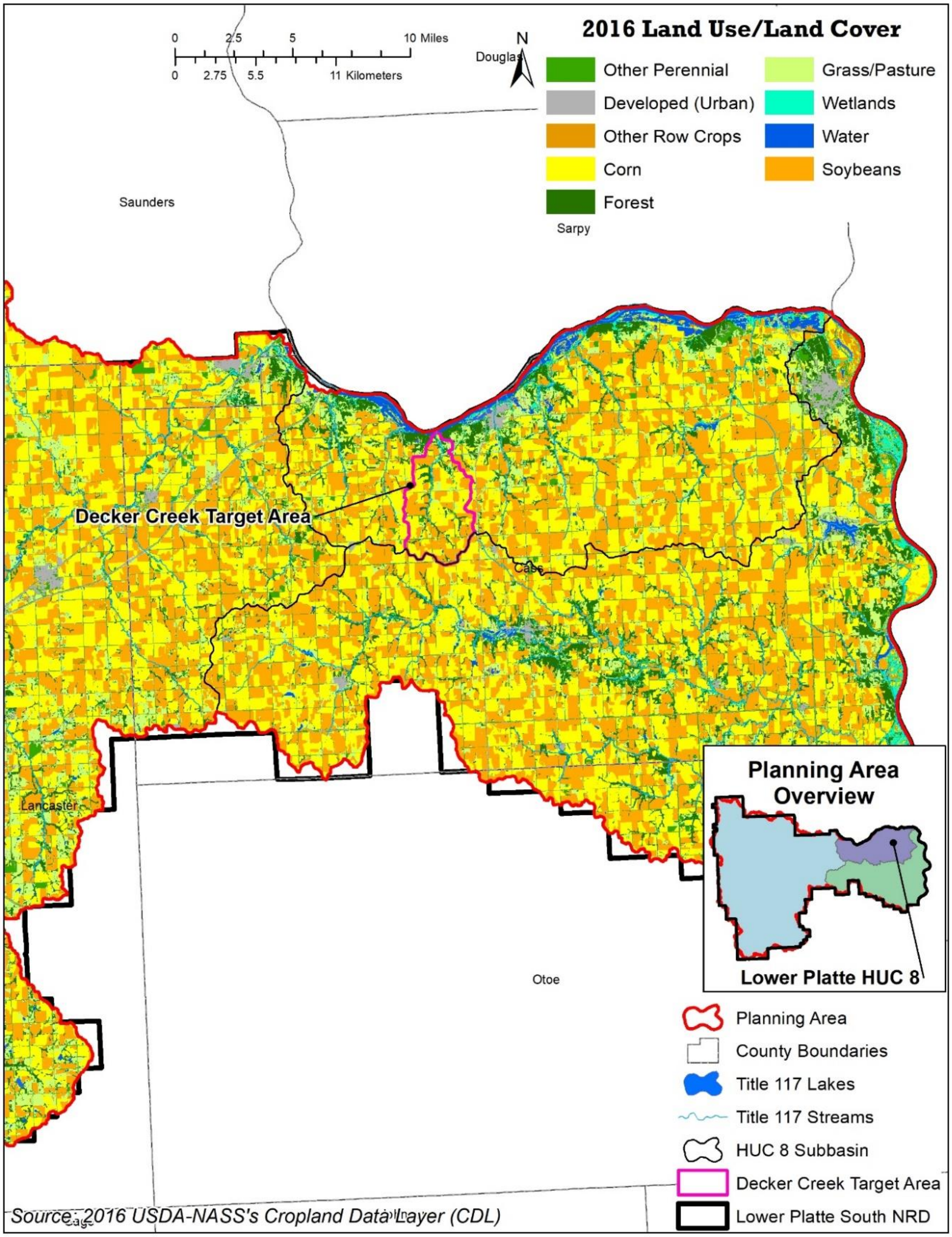


Figure 107: Land Use/Land Cover within the Lower Platte River HUC 8 Subbasin

11.02 OVERVIEW OF PRIORITIES

As discussed in Chapter 9, target areas and special priority areas were selected through a review of water quality data and stakeholder input. As shown in Figure 108 and Table 50, the following areas within this subbasin have been selected for focused implementation efforts:

Target Areas

- Decker Creek

Special Priority Areas

- On-site Wastewater Treatment Systems (OWTS)
- Non-permitted animal feeding operations (AFOs)
- Wellhead protection areas (WHP areas) (also referred to as CWSPAs in the LPSNRD)

As part of the prioritization process in the development of this plan (Chapter 9), target areas were identified based on the contributing area to each priority waterbody identified. The total size of each target area was calculated through GIS analysis to ensure the sum of the targeted areas equaled less than 20% of the total HUC 8 area, satisfying the NDEQ's 20% Rule (NDEQ, 2015). Within the Lower Platte River HUC 8 Subbasin, 7,590 acres are targeted for implementation work or approximately 7% of the HUC 8 area (Table 50). The following sections of this chapter provide information on the implementation strategy for each target area, with additional details and supporting technical information located in Appendix D.

It is also pertinent to note that the WQMP under development for the Lower Platte River Corridor Alliance (LPRCA) also overlaps the geographic area of this HUC 8 subwatershed (see Chapter 1.03 for additional discussion). The LPRCA WQMP has identified target areas (separate from those in this plan) based on improving water quality in the Platte River. Those target areas are the HUC 12s of "Eightmile Creek" and "Turkey Creek-Platte River", as shown in Figure 108 for reference purposes only. Additional details on those target areas and priorities can be found in the LPRCA WQMP (HDR, 2018).

Table 92: Priority Waterbodies and Associated Target Areas within the Lower Platte River HUC 8 Subbasin

Priority Water Body Addressed (Water Body ID)	HUC 12 Subwatershed	Target Area Size (acres)	% of Total HUC 8 Size	Pollutants/Impairments Addressed
Decker Creek (LP1-11200)	102002020203	7,590	7%	*E. coli* bacteria
Total	**n/a**	**7,590**	**7%**	**n/a**

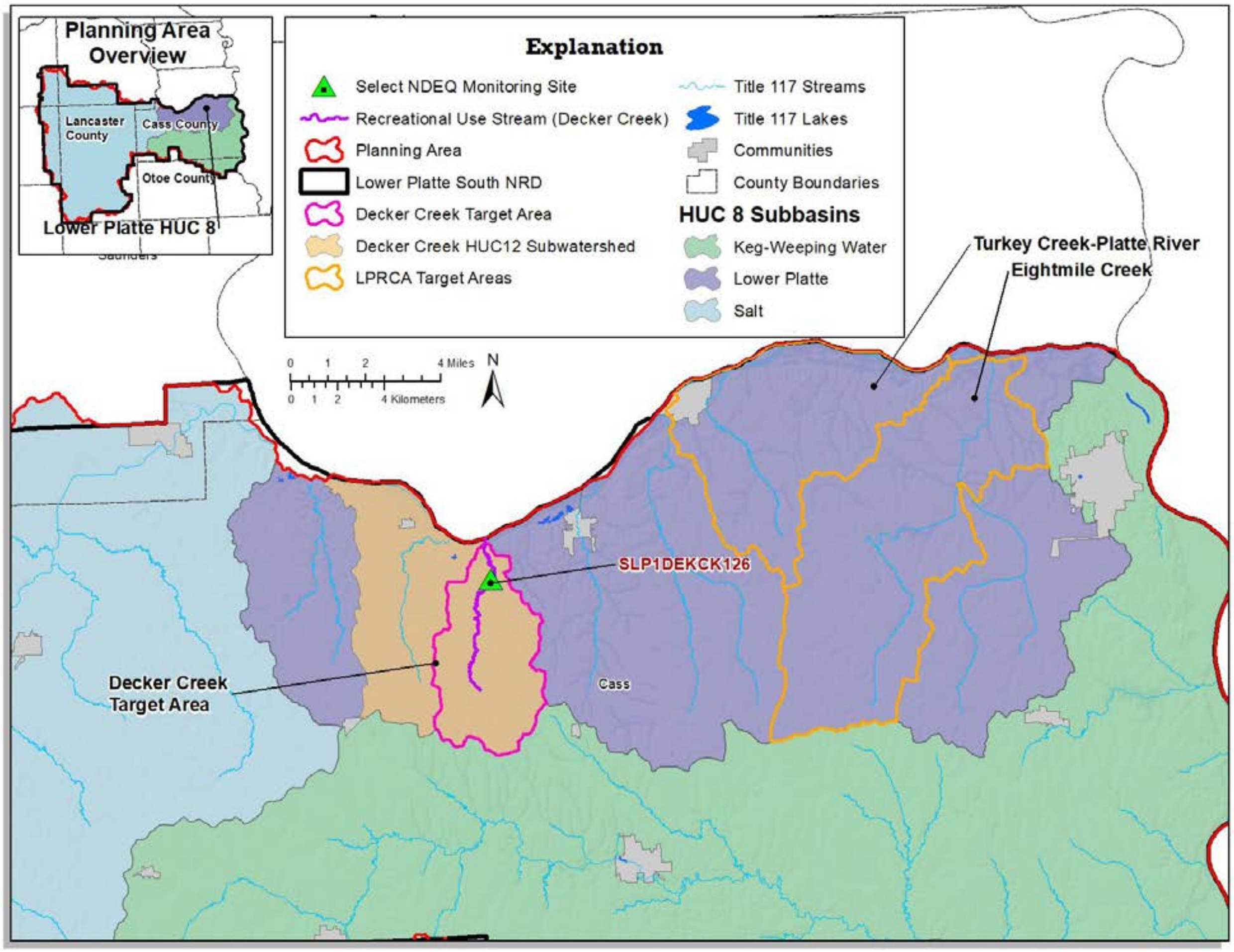


Figure 108: Target Areas within the Lower Platte River HUC 8 Subbasin

11.03 DECKER CREEK TARGET AREA

INTRODUCTION

NOTE TO READERS

Information in this section is summarized from the pollutant modeling files and from the *Bacteria Load Estimate Report* (WWE, 2018), a copy of which is also provided in Appendix D. Unless otherwise noted, additional details and background information can be found in that comprehensive document.

The Decker Creek target area encompasses approximately 7,590 acres of the Decker Creek-Platte River subwatershed (HUC 12: 102002020203). It should be noted that the Decker Creek Target Area is located wholly within this HUC 12 but does not include all of it. The Decker Creek Drainage Area was delineated separately, as the HUC 12 includes the drainage areas for multiple, unrelated, tributaries to the Platte River (Figure 108). Decker Creek (LP1-11200) consists of one stream segment and is a tributary to the Platte River. The headwaters start in rolling agriculture lands, and the stream flows north, approximately 6.5 miles, through the river bluffs before it meets up with the Platte River.

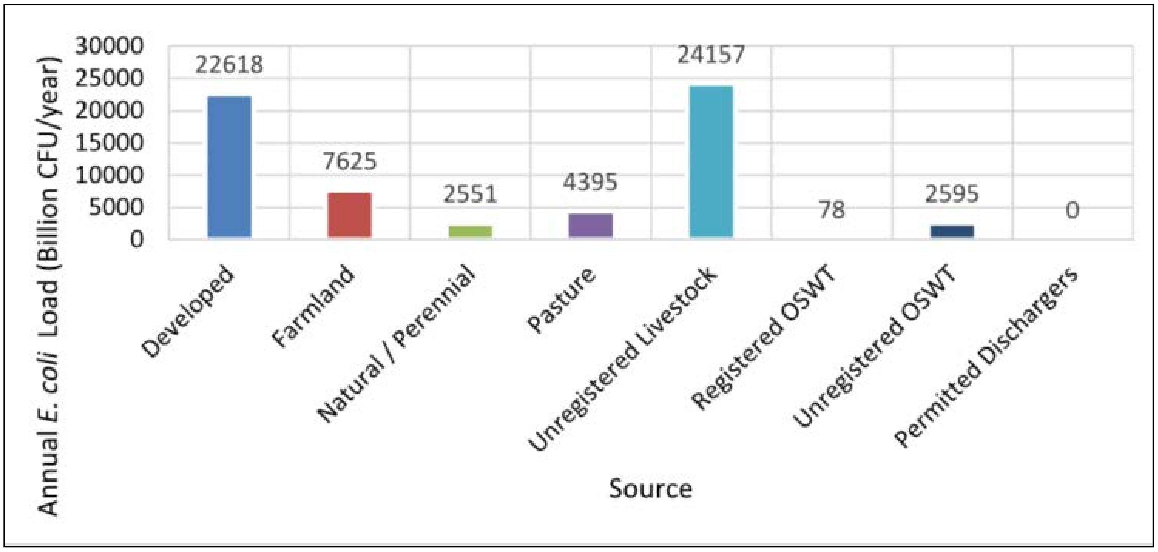
IMPAIRMENTS

Decker Creek's assigned beneficial uses Primary Contact Recreation, Aquatic Life; Aesthetics; and Agricultural Water Supplies (NDEQ, 2014). The creek is fully supporting all assigned beneficial uses except for Primary Contact Recreation, which is impaired due to *E. coli* bacteria (NDEQ, 2016). NDEQ provided *E. coli* loading goals in the 5-alt assessment (NDEQ, 2017b). There are no point source discharges to the Decker Creek drainage area.

POLLUTANT SOURCES AND LOADS

Pollutant loads and source contributions were estimated using multiple methods, including a combination of mathematical calculations and water quality modeling. Additional details such as a summary of data, data sources, and methods can be found in the modeling/implementation report in Appendix D.

The average annual *E. coli* load carried by Decker Creek is estimated to be 76,100 billion colony forming units (CFU). The largest contributors of bacteria to Decker Creek are from non-permitted animal feeding operations (AFOs) (32%) and developed land use (30%). Readers should note that "developed" land uses in the target area consist of numerous acreages, farmsteads, streets, roads, and other impervious surfaces. Sources of bacteria from these urban land uses include both wildlife and pet waste. There are no point source discharges to the Decker Creek drainage area (NDEQ, 2017a).



Source: Water Quality Modeling

Figure 109: Existing *E. coli* Bacteria Loads and Sources to Decker Creek

REQUIRED POLLUTANT LOAD REDUCTIONS

For simplicity, the *E. coli* pollutant load estimates were assumed to be consistent with the concentrations identified in the 5-alt assessment. Therefore, reductions in load estimates were assumed to result in changes to in-stream concentrations by the same relative amount. Required *E. coli* load reductions were based on 5-alt assessment data (NDEQ, 2017) which identified a 98% reduction from 4,076 CFU/100mL to 82 CFU/100mL. This goal is set below the water quality standard of 113 CFU/100mL to account for a margin of safety (Table 93).

Table 93: *E. coli* Pollutant Load Reduction Goals for Decker Creek

Seasonal Geometric Mean (#/100mL)	*E.coli* Above Water Quality Standard (#/100mL)	Reductions needed to meet Water Quality Standards	Expected Geometric Mean with the Margin of Safety (#/100mL)
4,076	3,950	98%	82

Source: Adapted from NDEQ 5-alt data files (NDEQ, 2017)

IMPLEMENTATION STRATEGY

The implementation strategy for the Decker Creek Target Area includes multiple practices which target pollutant sources through the ACT approach, also known as a “treatment train”. All nonpoint source pollutant sources are addressed. It is assumed that AFOs and OWTSs are meeting all legal requirements; however, they are also possible sources of pollutant loads. In all cases, only willing landowners will be included in this voluntary implementation strategy. Multiple sources were used to identify BMPs:

- **ACPF tool** – The ACPF tool was used to identify the best suited locations for various BMPs throughout the target area.
- **Aerial analysis** –Additional opportunities for BMPs were found through analysis of aerial photography. This analysis identified nonpermitted AFOs and rural residences that may have unregistered OWTSs.

The implementation strategy presented in this plan should be used as a guide for BMP implementation and may be subject to revision as new information becomes available and willing landowners are identified. Although avoidance practices are not part of the ACPF, they are an important part of this strategy. For additional details about the BMPs identified, please refer to Chapter 7, Appendix D, or the referenced planning documents previously discussed.

A VOLUNTARY PLAN

The implementation of this plan is based entirely on the voluntary actions of landowners and citizens. Individuals must decide if it is an advantage to participate, and it is the responsibility of the LPSNRD and other stakeholders to find ways to make participation advantageous.

To provide an accurate load reduction estimate from implementation efforts, recommended practices were used to develop a "treatment train" that follows the movement of pollutants from the source to the receiving waterbody (Table 94). The drainage area's treatment train begins with education/outreach and avoidance practices and ends with near stream improvements (i.e. riparian buffers).

Table 94. Implementation of Priority BMPs through a "Treatment Train" Approach

Order	Land Use / Source Targeted	Priority BMP
1	Watershed	Watershed Education
2	All OWTSs	OWTS Upgrade Practice
3	Developed Areas	Pet Waste Management
4	Watershed	Non-structural & avoidance BMPs (Working Lands Management)
5	Pastureland and Unregulated Cattle	Grazing Lands Management BMPs
6	Farmland	Cover Crops
7	Farmland and Pastureland	Riparian Buffers
8	Farmland	Contour Buffer (filter) Strips
9	Unregulated Cattle	Non-Permitted AFO Facility BMPs
10	Watershed	Wetlands/Farm Ponds/Sed. Basins

Order	Land Use / Source Targeted	Priority BMP
11	Watershed	Stream Restoration
12	Farmland	Terraces
13	Watershed	Water and Sediment Control Basins (WASCOBS)

Note: Grassed waterways, and their conceptual locations, were also identified as a priority BMP, however they were grouped with wetlands in the water quality modeling, due to technical limitations.

BMP TARGETING

A suite of structural and non-structural management practices was selected based on stakeholder input and the results of technical analysis. In addition to structural practices, education/outreach and avoidance practices were added to the suite of recommendations for the Decker Creek Target Area (Table 95). All land cover types and pollutant sources were targeted for education and outreach activities except for water and wetlands, which were not classified as pollutant sources. Figure 110 provides an overview of conceptual locations where BMPs could be placed. Please note that, due to technical issues, the ACPF Tool was not utilized to identify locations for streambank stabilization or riparian buffers. All of Decker Creek was targeted for these practices due to observed incision and erosion issues throughout the target area. This map does not show “planned” locations, but instead provides a starting point for discussion with willing landowners and provides managers methods to develop this WQMP. Detailed map books can be found in Appendix F.

Table 95: Priority BMPs and Targeted Pollutant Sources for the Decker Creek Target Area

BMP Type	Land Use/Pollutant Source Targeted or Treated	Priority BMP
Non-Structural	Watershed Wide	Education & Outreach
	Unregistered OWTS	OWTS Upgrade Practice
	Developed	Pet Waste Management
	Cropland	Non-structural & Avoidance BMPs
	Pasture and Non-permitted AFOs	Grazing Lands Management BMPs
	Cropland	Cover Crops
Structural	Cropland and Pastureland	Riparian Buffers
	Cropland	Contour Buffer (filter) Strips
	Non-permitted AFOs	Non-permitted AFO Facility BMPs
	Watershed Wide	Wetlands/Farm Ponds/Sediment Basins
	Watershed Wide	Stream Restoration
	Cropland	Terraces
	Cropland	WASCOBS
	Cropland	Grassed Waterways

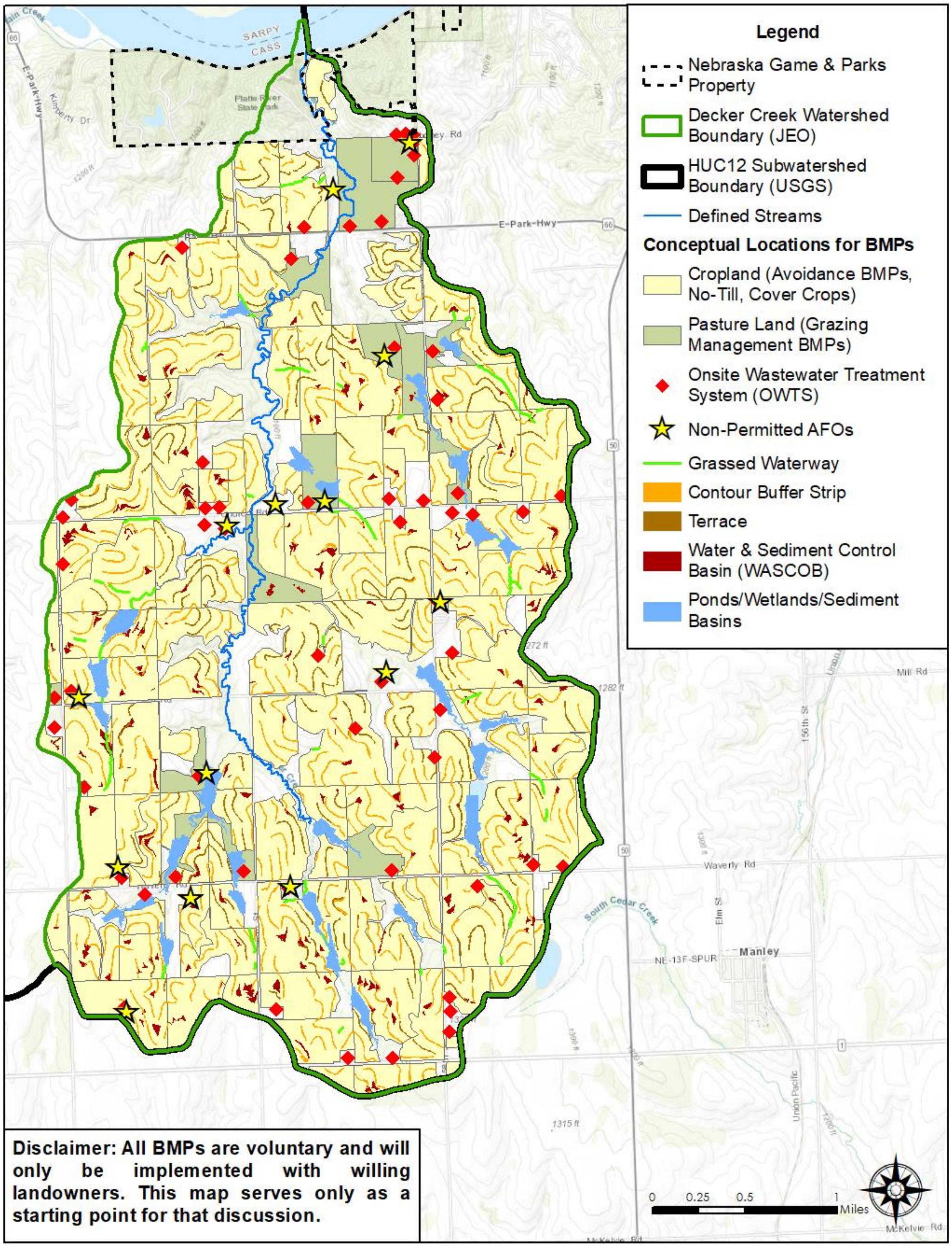


Figure 110: Conceptual locations of in-field and edge-of-field BMPs

CRITICAL SOURCE AREAS

Critical Source Areas (CSA) are a relatively small fraction of a watershed that generate a disproportionate amount of the pollutant load (Meals, 2012). As discussed in Chapter 7, CSAs occur where a pollutant source in the landscape coincides with an active hydrologic transport mechanism. Identifying CSAs allows for the prioritization of fields where BMPs are likely most needed and allows for financial and technical resources to be used most efficiently.

CSAs in the Decker Creek Target Area were identified using the field runoff risk assessment in the Agricultural Conservation Planning Framework (ACPF) Toolbox. This assessment provides a relative risk rating (not an absolute risk rating) and is based on a cross-reference of two factors:

- Slope steepness – Steeper fields have a higher risk of generating runoff
- Distance to stream – The closer a field is to a waterbody, the higher the risk a pollutant will be delivered to waterbody

Once the assessment is complete, each field receives a relative classification ranging from A (highest risk – most critical), to B (very high), C (high), and other (‘present’). One limitation of this tool is that only agriculture landuses (cropland or pasture land) are included. These other land uses (typically rural residences or other natural areas) are identified as “unknown” in the assessment. “Unknown” areas may still have an elevated runoff risk (especially for pollutants such as manure application or failing OWTSs). A “present” or “unknown” classification does not mean that a BMP would not provide benefits to a given field, but rather indicates that other fields have a greater potential to deliver pollutants to a waterbody via surface runoff. In future updates to this plan, an assessment of all fields for runoff risk is recommended.

For the purposes of this plan, areas identified as A or B through the runoff risk assessment have been identified as CSAs. In the Decker Creek Target Area (Figure 111), there are 973 acres of CSAs (approximately 13% of the target area), which are broken down as follows:

- Highest Risk CSA: 135 acres
- Very High Risk CSA: 838 acres

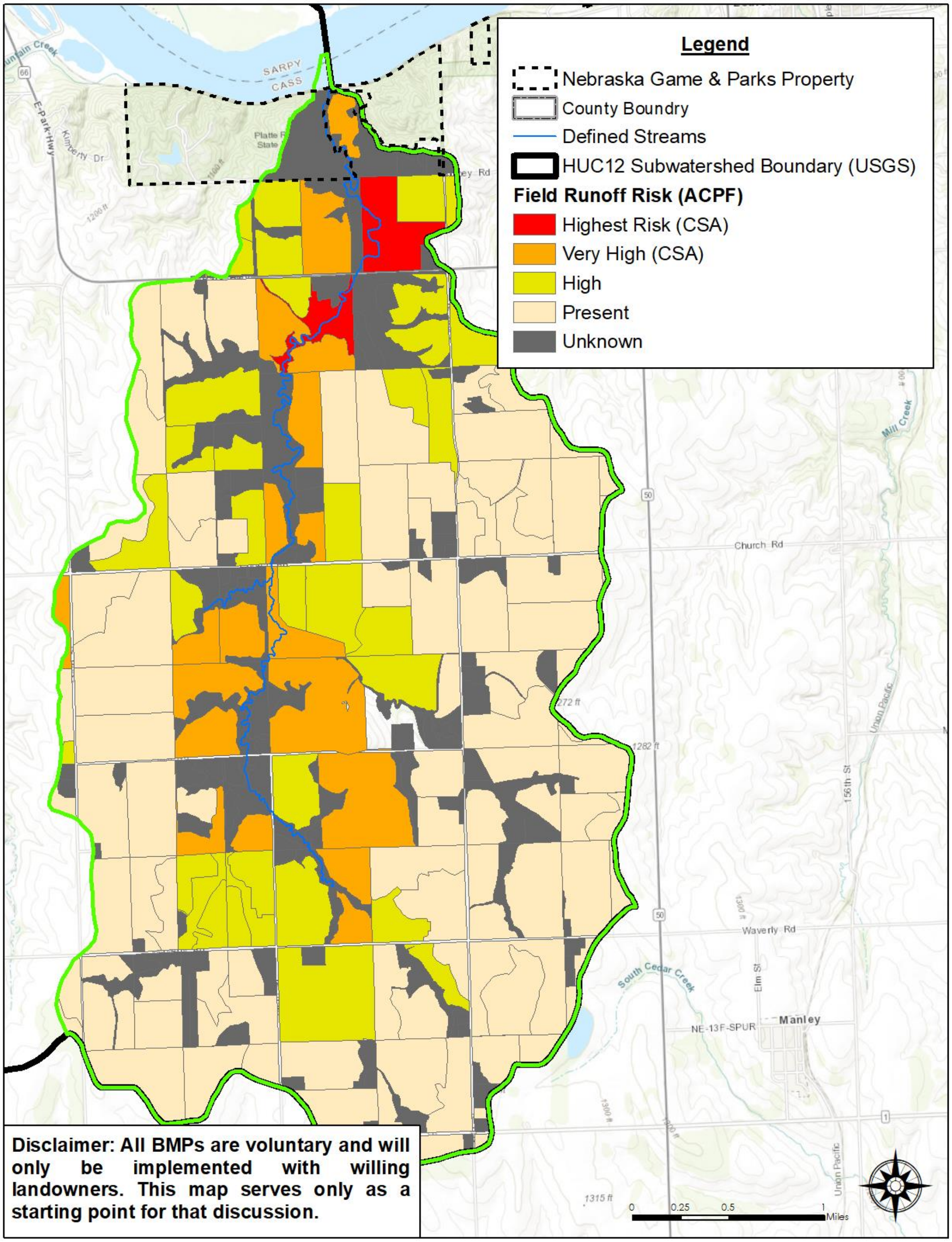


Figure 111: Critical Source Areas in the Decker Creek Target Area Identified with the ACPF Tool

MEETING WATER QUALITY STANDARDS

Average annual load reductions associated with a comprehensive BMP implementation strategy were estimated for *E. coli* bacteria. An estimated 75% reduction in *E. coli* loads was determined to be attainable. Unfortunately, this does not meet the goal of 98% reduction established by the 5-alt assessment (Table 96). Additional details can be found in the summary report located in Appendix D.

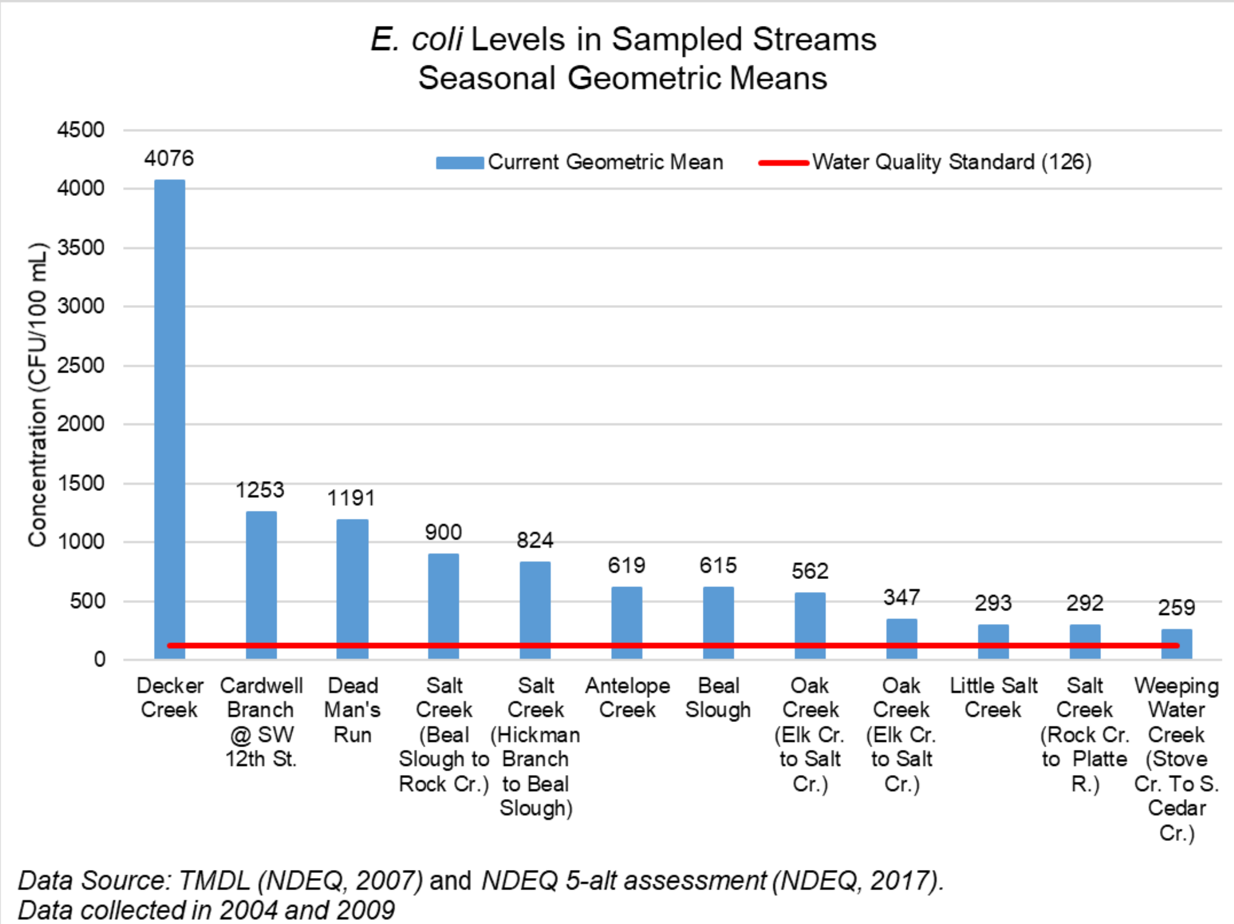
Table 96: Estimated *E. coli* Reductions and Goals After BMP Implementation

***E. Coli* Pollutant Loads/Concentrations**	**CFU/100mL**	**%**
Existing	4,076	n/a
Cumulative Reductions Due to BMP Implementation	-3,069	75%
Estimated Load After BMP Implementation	1007	n/a
Water Quality Goal	82	98%

Source: Water Quality Modeling

There are several factors involved in identifying either a path to meet water quality goals or determining limitations to the goal. BMPs identified were estimated to achieve the maximum feasible reductions based upon existing monitoring data, BMP treatment efficiencies, and sources of bacteria loads. Based on currently available data, it is infeasible to expand conceptual BMP implementation beyond this level. However, through the development of this plan, existing monitoring data indicated that Decker Creek exhibited, by far, the highest levels of *E. coli* bacteria within monitored streams in the planning area (Figure 112).

It is recommended that a detailed monitoring plan be implemented either in conjunction with or prior to BMP implementation efforts. Given that BMP effectiveness in treating *E. coli* can vary significantly between sites, on-site monitoring and sampling will provide a much more accurate assessment of load reductions. This additional and updated data will provide better estimates of pollutant sources and improve targeting of those sources. It is intended that feasibility of achieving required load reductions will be periodically re-evaluated based upon new monitoring and sampling data. Additional discussion is provided in the following Monitoring and Evaluation section.



**During the development of this plan, Antelope Creek (LP2-20900) was determined to no longer be impaired due to E. coli (NDEQ, 2018). However, implementation of activities identified in this plan are still a priority for the LPSNRD and City of Lincoln. The data presented in this figure is from prior to new data becoming available.*

Figure 112: *E. coli* Concentration Levels in Area Streams

MONITORING AND EVALUATION

The LPSNRD will follow the established protocol and procedures to: develop sound, defensible monitoring strategies and networks; properly manage data; and disseminate information to decision makers and other stakeholders. Monitoring goals can only be achieved through partnerships with other resource agencies such as NDEQ. Steps will be taken to ensure collection of scientifically valid data, which may include the development of Quality Assurance Project Plans (QAPP) for state and federal review. Additional guidance and references are in Chapter 4.

To adequately design monitoring networks that facilitate water resource management, it is critical to use data for its intended purposes. Thus, it is necessary to establish specific monitoring goals and objectives. A set of monitoring goals and objectives has been developed for Decker Creek. Targeted parameters, monitoring sites, and monitoring frequency have been defined to meet each objective. Monitoring goals and objectives provided below in *italics* may require expanded or new monitoring efforts, whereas objectives and parameters in plain text are currently being addressed.

Monitoring Goal 1: Evaluate the water quality condition of Decker Creek.

- Evaluate beneficial use support and water quality trends for Decker Creek.
- Monitoring Parameters: heavy metals, pesticides, nutrients, *E. coli,* and field measurements
- Monitoring Frequency: (Annual) Monthly January-December
- Monitoring Site: Decker Creek southwest of Louisville NE (SLP1DEKCK126)

Monitoring Goal 2: Establish a spatially robust monitoring network to further characterize *E. coli* sources

- *Collect grab samples at up to 6 distributed locations across the drainage area*
- *At each monitoring site, conduct stream flow discharge monitoring during collection of grab samples*
- *At SLPDEKCK126, install a long term, continuous stream flow discharge monitoring station*
- *Conduct 1-3 years of annual sampling on a biweekly basis, during the primary recreation season (May 1 – September 30)*
- *Utilize microbial source tracking to better characterize E. coli sources*

COMMUNICATION AND OUTREACH

Chapter 6 of this plan provides a broad programmatic approach that the LPSNRD and its partners will take to address nonpoint source pollution through communication and outreach activities. Specifically, within a target area there are certain pieces of information necessary for successful communication and outreach efforts, which will in turn support the implementation of BMPs. Those items specific to the Decker Creek Target Area were identified via stakeholder and public input, and are as follows:

- Identified Target Audiences
  - Recreational water users of the Platte River
  - Visitors to Platte River State Park
  - Land managers, residents, and property owners within the Decker Creek Target Area
  - Producers with existing BMPs who may be interested in implementing more
  - Rural homeowners on private wells and septic systems
  - YMCA Camp Kitaki staff and management
- Methods
  - Utilize parcel ownership information, along with the detailed BMP location maps created with the ACPF Tool, to contact specific landowners about BMPs applicable to their properties

    - A postcard mass mailing followed up by phone calls will help start initial implementation efforts and/or increase attendance at public meetings
- Utilize the public lands at Platte River State Park, or the nearby YMCA Camp Kitaki (nonprofit) for BMP demonstration sites or education outreach opportunities
- Develop signage to be used at project demonstration sites, key watershed entrances or landmarks, and other highly visible areas
- Utilize the Platte River State Park, or communities of South Bend, and Louisville for the following:
    - Post flyers, distribute press releases, and advertise at local events
    - Hold targeted coffee shop meetings, tailgate sessions, and other informal/casual informational exchanges to build relationships and to learn more about the constraints and hurdles to BMP adoption
- Hold training and demonstration field days
- Hold an outdoor recreation clinic (hiking, birdwatching, kayaking etc.) at Platte River State Park or Camp Kitaki
- Work with Camp Kitaki staff to develop an outdoor education program focused on collecting water quality samples throughout the summer months

Plan and project sponsors will utilize these target audiences and outreach methods when building project level communication and outreach plans, typically as part of a Project Implementation Plan (PIP). The PIP will identify the specific and tailored actions for each target audience, as discussed in Chapter 6.

SCHEDULE

A timeframe for implementing general actions is provided in Table 97. Actions are subject to approval by the LPSNRD Board of Directors and may change as the plan is implemented. Phase I activities will include the initiation of drainage area BMPs and enhanced monitoring. Phase II will begin upon the five-year revision of this plan and will include any implementation that was not completed in Phase I. A summary of progress achieved during Phase I will be included in the plan revision.

Table 97: Schedule for Implementation within the Decker Creek Target Area

Activity	Phase I						Phase II
	2019	2020	2021	2022	2023	2024	2025-2029
LPSNRD Board of Directors approval of plan	■						
EPA approval of the plan	■						
Monitoring (ongoing)	■	■	■	■	■		
Organize stakeholder groups		■					
Drainage area BMP Implementation			■	■	■	■	
Project evaluation						■	
Final reporting						■	
Update HUC8 subbasin plan							■
Continue implementation as needed							■

MILESTONES

Major milestones that pertain to monitoring, planning, and management practice implementation are provided in Table 98. These milestones will be used to gauge progress in meeting the desired project schedule. As the implementation of this plan is initiated milestones will be adjusted accordingly for changes to the schedule.

Table 98: Milestones for Implementation within the Little Salt Creek Subwatershed

Activity		Phase I						Phase II
		2019	2020	2021	2022	2023	2024	2025-2029
Monitoring	Coordinate with NDEQ	■	■	■	■	■		
	Finalize strategies and QAPPs		■					
	Assess data (annually)	■	■	■	■	■		
Planning	Drainage area BMP PIP		■		■			
	Funding Assistance		■		■			
	Apply for funding assistance grants				■			■
	Evaluate progress in meeting goals						■	
	Identify additional BMP needs						■	
	Prepare final report(s)						■	
	Revise WQMP plan as needed							■
Information /Education	Develop stakeholder group		■					
	Work one-on-one with producers		■	■	■	■	■	
Implementation	Initiate BMP implementation		■	■	■	■	■	
	Complete Phase I BMP implementation							

COST

The preliminary opinion of total cost of implementing the nonpoint source pollution control strategy for the Decker Creek Target Area is estimated to be $9,438,765 (Table 99). This does not include costs for final designs of engineering projects, as these costs would be contingent on project scoping. When possible, costs were determined from the 2018 USDA-NRCS EQIP practice payment schedule (USDA, 2018). These costs are subject to change based on final designs, inflation, bidding climate at the time of construction, and project size and complexity.

Table 99: Implementation costs for the Decker Creek Target Area

Practice	Units	Units Targeted	Unit Cost	Total Cost
Education/Information*	years	5	$10,000	$ 50,000
Pet Waste Ordinances/Eduction*	years	5	$ 500	$ 2,500
Avoidance practices*	acres	5,060	$ 108	$ 546,480
Contour (filter) buffers	acres	320	$ 500	$ 160,000
Terraces	feet	147,840	$ 4	$ 591,360
Cover crops	acres	4,500	$ 133	$ 598,500
No-till	acres	850	$ 20	$ 17,000
Water and Sediment Control Basins (WASCOB	feet	55,900	$ 4	$ 223,600
Wetlands	#	27	$35,000	$ 945,000
Riparian buffers	acres	30	$ 1,650	$ 49,500
Grazing management	acres	600	$ 42	$ 25,200
OWTS Upgrade Practice	#	59	$ 5,500	$ 324,500
Non-Permitted AFO Facility BMP	units	7	$20,000	$ 140,000
Grassed Waterways	acre	15	$ 6,575	$ 98,625
SubTotal (Drainage Area Treatment)				**$ 3,772,265**
Streambank/channel stabilization & Restoration	feet	36,960	$ 150	$ 5,544,000
SubTotal (In-Stream Work)				**$ 5,544,000**
Updates to WQMP	each	0	$ -	$ -
Additional monitoring*	years	5	$20,000	$ 100,000
SubTotal (Planning/Monitoring)				**$ 100,000**
Total				**$9,416,265**

**Based on estimated costs during first 5-year increment only*

11.04 SPECIAL PRIORITY AREAS

Special priority areas provide flexibility in addressing identified small-scale areas with specific, limited, and timely needs. They address issues that occur widely in the subbasin that may affect not only water quality, but also the health and safety of humans. Additionally, some BMPs do not have specific targeted land uses or an easily defined subwatershed associated with their implementation; thus, these areas do not count towards the 20% Rule.

Some BMPs have a broader appeal and impact on public involvement when implemented on an area-wide basis. Practices are restricted to those necessary to address the specific needs of the special priority area. BMPs address specific issues within areas, many of which cross subwatershed and target area boundaries. Projects in these areas are excellent candidates for partnering opportunities.

DISTRICT-WIDE SPECIAL PRIORITY AREAS

The following special priority areas were identified as special priority areas for the entire district, therefore, they are discussed in more detail in Chapter 9. No additional discussion is provided in this chapter.

- On-site Wastewater Treatment Systems (OWTS)
- Non-permitted Animal Feeding Operations (AFOs)
- Wellhead Protection Areas (WHP areas) (also referred to as CWSPAs in the LPSNRD)

No other Special Priority Areas were identified within the Lower Platte River Subbasin.

11.05 MONITORING PRIORITIES

Monitoring priorities were identified by the project team and TAC after review of existing data and a discussion on possible future data needs. While many of these activities may provide general support towards target area implementation, they would take place separately of any target area implementation or pre/post project monitoring activities. Below are lists of these priorities along with a brief description of each.

DISTRICT-WIDE PRIORITIES

The following monitoring priorities are applicable to the entire district; therefore, they are discussed in more detail in Chapter 9. Additionally, other supporting information may be found in Chapter 4. No additional discussion is provided in this chapter.

- Existing BMP Treatment Levels
- Pre-project Monitoring

JENNY NEWMAN LAKE

Based on a review of a recent NGPC water quality report (Blank and others, 2017), additional studies are needed to evaluate possible on-site wastewater system influence in runoff to the lake. It is anticipated that this will be a NGPC let project.

DECKER CREEK

Development of a monitoring plan is needed to better identify bacteria sources and better characterize source loadings in the Decker Creek watershed, which are the highest in the district. This additional monitoring data may help to better identify pollutant sources and target implementation efforts. This would be beyond the scope of traditional pre/post project monitoring. Additional details are found in the Decker Creek Target Area section of this chapter.

11.06 COMMUNICATION AND OUTREACH PRIORITIES

Stakeholders identified communication and outreach priorities. While many of these activities may provide general support towards target area implementation, they would take place separately of any target area communication and outreach activities. Below are lists of these priorities along with a brief description of each.

DISTRICT-WIDE PRIORITIES

The following communication and outreach priorities are applicable to the entire district; therefore, they are discussed in more detail in Chapter 9. Additionally, other supporting information may be found in Chapter 6. No additional discussion is provided in this chapter.

- LPSNRD Board of Directors
- Rural Water Districts
- County Board
- Village/city governments with WHP areas (also referred to as CWSPAs in the LPSNRD)

No other Communication and Outreach Priorities were identified within the Lower Platte River Subbasin.

11.07 COST SUMMARY FOR TARGET AREAS

As there is only one target area identified within this subbasin, a cost summary is not available. Additional details are found in the Decker Creek Target Area section of this chapter.

CHAPTER 12. KEG-WEEPING WATER CREEK HUC 8 SUBBASIN

12.01 SUBBASIN BACKGROUND

The Keg-Weeping Water Subbasin (HUC 8: 10240001) is the second largest of the three subbasins addressed in this plan. The area is 206,944 acres (planning area is 1,048,774 acres) and consists primarily of Cass County (Figure 113). Land use/land cover in this subbasin is dominated by agriculture, with 73% of the subbasin area dedicated to row crops (corn/soybean). There are several small urban areas throughout the subbasin which make up a total of 2% of the subbasin area. Remaining land use is divided amongst forest (10%); grass/pasture (7%); and small amounts of open water, wetlands, or other perennial vegetation.

No target areas were identified within this subbasin, therefore this chapter is intended to focus primarily on the special priority areas identified within the Keg-Weeping Water HUC 8 subbasin. Little discussion is given to the rest of the subbasin here, as much of that information can be found throughout the rest of this plan. Information on an inventory of subbasin characteristics is found in the following chapters/sections within this plan:

- Land Use: Chapter 3.02
- Existing land treatment (BMPs): Chapter 7.09
- Irrigation: Chapter 3.06
- Permitted facilities: Chapter 5.07
- Water resources: Chapter 3.03
- Existing resource conditions: Chapter 5

Additionally, it should be pointed out that the boundaries of this HUC 8 subbasin have been limited to just those that are generally within the LPSNRD. The proper boundaries of the HUC 8 include portions of Iowa (Figure 114), due to the way the dataset is developed by the USGS. Additional discussion on that methodology is found in Chapter 1.

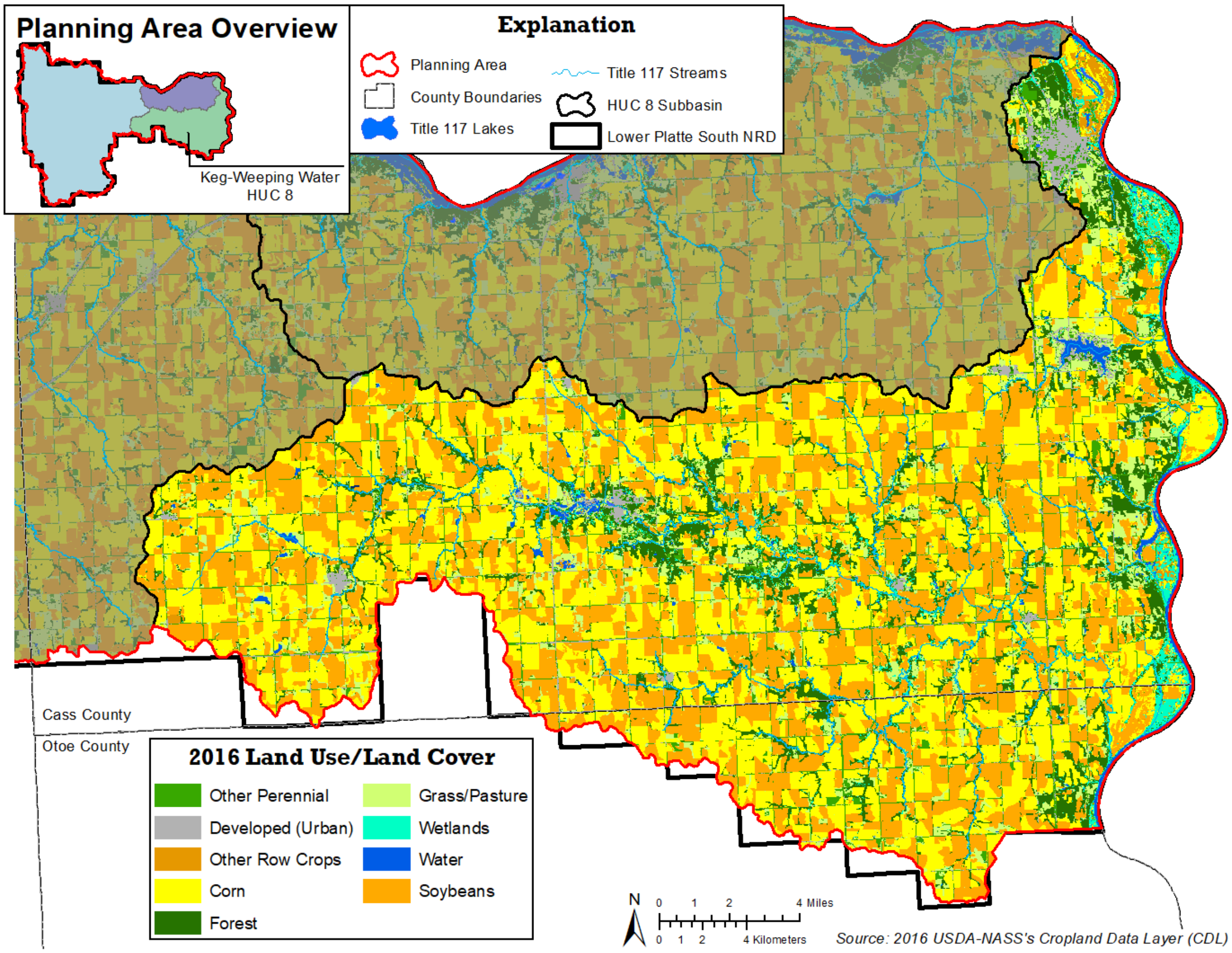


Figure 113: Land Use/Land Cover Within the Keg-Weeping Water HUC 8 Subbasin

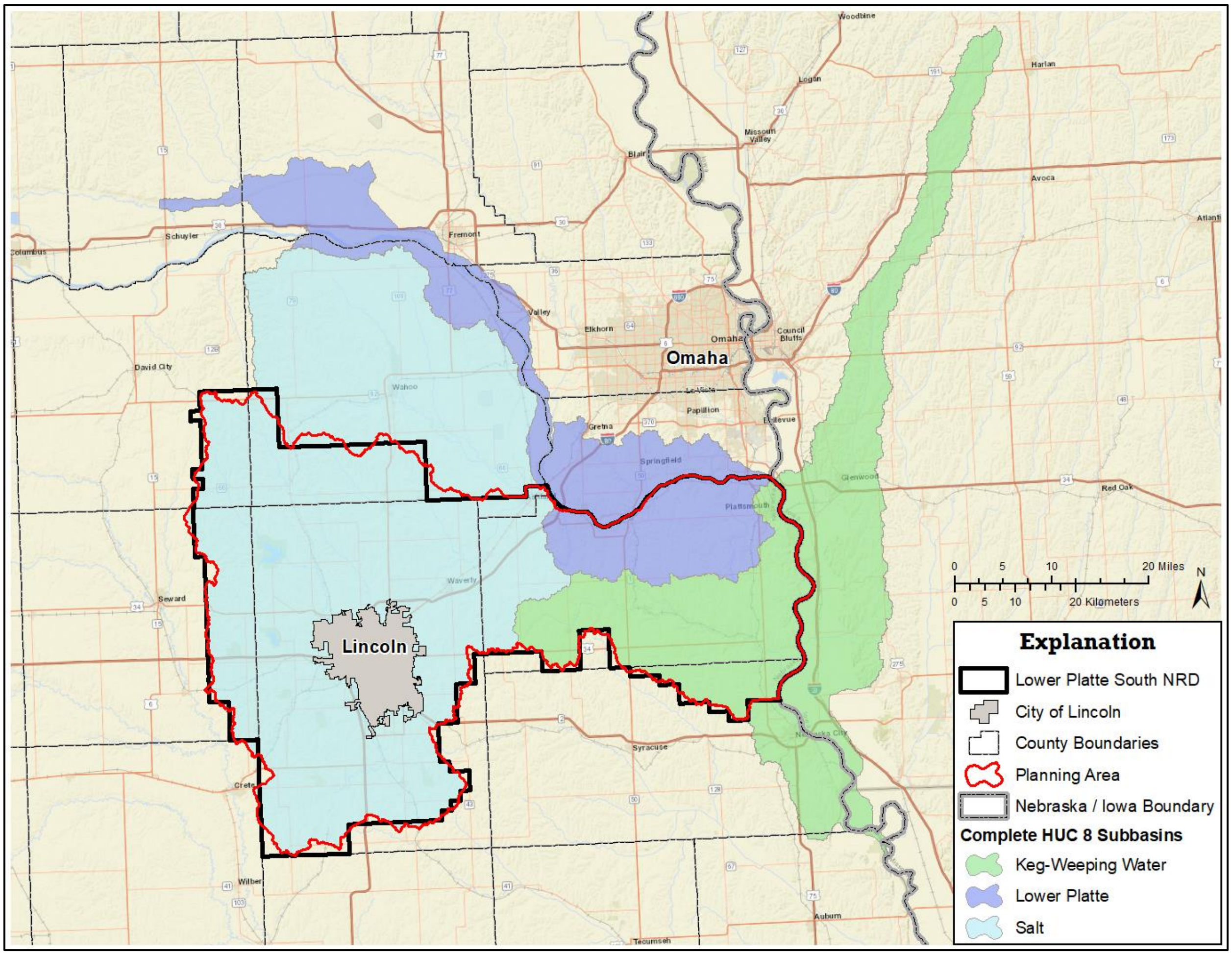


Figure 114: Overview of Full Extent of Keg-Weeping Water HUC 8 Boundaries

12.02 OVERVIEW OF PRIORITIES

As discussed in Chapter 9, target areas and special priority areas were selected through a review of water quality data and stakeholder input. The following areas within this subbasin have been selected for focused implementation efforts:

Target Areas

- No target areas were identified in the Keg-Weeping Water Subbasin.

Special Priority Areas

- Wellhead Protection Areas (WHP areas) (also referred to as CWSPAs in the LPSNRD)
- On-site Wastewater Treatment Systems (OWTS)
- Non-permitted Animal Feeding Operations (AFOs)

12.03 SPECIAL PRIORITY AREAS

Special priority areas provide flexibility in addressing identified small-scale areas with specific, limited, and timely needs. They address issues that occur widely in the subbasin that may affect not only water quality, but also the health and safety of humans. Additionally, some BMPs do not have specific targeted land uses or an easily defined subwatershed associated with their implementation; thus, these areas do not count towards the 20% Rule.

Some BMPs have a broader appeal and impact on public involvement when implemented on an area-wide basis. Practices are restricted to those necessary to address the specific needs of the special priority area. BMPs address specific issues within areas, many of which cross subwatershed and target area boundaries. Projects in these areas are excellent candidates for partnering opportunities.

DISTRICT-WIDE SPECIAL PRIORITY AREAS

The following special priority areas were identified as special priority areas for the entire district, therefore, they are discussed in more detail in Chapter 9. No additional discussion is provided in this chapter.

- On-site Wastewater Treatment Systems (OWTS)
- Non-permitted Animal Feeding Operations (AFOs)
- Wellhead Protection Areas (WHP areas) (also referred to as CWSPAs in the LPSNRD)

No other Special Priority Areas were identified within the Keg-Weeping Water Subbasin.

12.04 MONITORING PRIORITIES

No other monitoring priorities specific to the Keg-Weeping Water Subbasin were identified.

12.05 COMMUNICATION AND OUTREACH PRIORITIES

BEAVER LAKE

Beaver Lake is a private lake community that uses surface water for its water supply. Utilizing surface water for drinking water poses a unique human health threat due to the possibly of blue-green algae blooms and associated elevated levels of microcystin toxins. The project team prioritized I&E activities for both in-lake and watershed management to mitigate possible eutrophication which often leads to these dangerous algae blooms. The project team prioritized Information and Education (I&E) activities for both in-lake management and watershed management to mitigate the possibilities of eutrophication which often leads to these dangerous algae blooms. This I&E outreach program could utilize the results from the HAB public water system project that the community is participating in. Additional discuss on existing monitoring is located in Chapter 4.

12.06 MASTER COST SUMMARY

Cost estimates are only completed for target area activities. Therefore, no cost estimates are provided for the Keg-Weeping Water Subbasin. Cost estimates for the installation of BMPs at special priority areas will be identified on a project level basis.

THIS PAGE LEFT INTENTIONALLY BLANK

CHAPTER 13. BASIN-WIDE IMPLEMENTATION STRATEGY

13.01 INTRODUCTION

This chapter provides an overall summary of activities outlined in this plan, as well as a general framework for implementing them. To facilitate understanding and coordination of activities, a general framework and list of responsibilities for primary partners is provided. Additionally, an overview of implementation by subbasin is provided, including schedules, milestones, budgets, and pollutant load reductions. These efforts are anticipated to take place both on a basin-wide scale and within target areas. Details on the implementation within target areas is provided in Chapters 10 – 12.

This plan lays out a voluntary approach that will demonstrate an incremental, but measurable, approach to reducing pollutant loads and meeting water quality standards. Milestones and monitoring criteria have been identified which will assist the LPSNRD in evaluating progress and making course correction along the way. Based on funding availability and planning guidance, the plan will be implemented through a targeted approach and will be updated at five-year intervals to assess progress and adjust priorities and strategies as needed.

A VOLUNTARY PLAN

The successful implementation of this plan relies upon the voluntary actions of landowners and citizens. Individuals must decide if it is an advantage to participate, and it is the responsibility of the LPSNRD and other stakeholders to find ways to make participation advantageous.

It is important to note that the strategies discussed in this plan are just a few of the many scenarios that could lead to meeting water quality standards. An overarching intention of this plan was not to identify all scenarios (which is not feasible here) but to lay out a reasonable strategy for implementation and allows for adjustment in the future. Ongoing and expanded water monitoring will both assist with implementation and resource prioritization, as well as be utilized in evaluating BMPs and the effectiveness of this strategy. At the five-year update, monitoring results and lessons learned will be identified, along with future/ongoing needs of the district.

13.02 IMPLEMENTATION FRAMEWORK

The overall framework for water quality protection across the basin requires a multi-faceted approach that includes both regulatory and non-regulatory efforts. This plan assumes that regulatory actions are currently enforced and are being implemented by appropriate agencies, and thus the focus is on non-regulatory and voluntary management efforts. The framework for implementation of this plan (Figure 115) relies on both existing programs and new initiatives that are identified to take place district-wide, within target areas, and within special priority areas. Implementation actions will take place at various scales and include installation/adoption of BMPs, monitoring, and information/education efforts. It will be necessary to leverage existing LPSNRD programs (such as landowner cost-share) against outside financial and technical resources (such as the section 319 program) to address all management priorities identified in this plan.

It is necessary for the LPSNRD to balance improvement at both larger receiving waterbodies (Salt Creek, Weeping Water Creek, etc. that are typically long term) with improvement goals for smaller waterbodies, target areas, or special priority areas (typically shorter term) that may exhibit localized impacts. Some projects may provide immediately measurable benefits; whereas others will require long-term implementation before improvements can be measured. Consequently, it is vital that the LPSNRD collaborate with other resource agencies, such as NRCS and NGPC, on any water quality improvement projects. Nitrate related projects, if located within wellhead protection areas (also referred to as CWSPAs in the LPSNRD), will be done in collaboration with each respective community. In most cases, such projects are at the discretion of the community to initiate.

It is imperative that all resource managers, decision makers, and the general public understand natural resources, associated issues, various management tools, expected outcomes, and costs. Understanding can only be achieved through continuous monitoring, analysis, outreach, and communication.

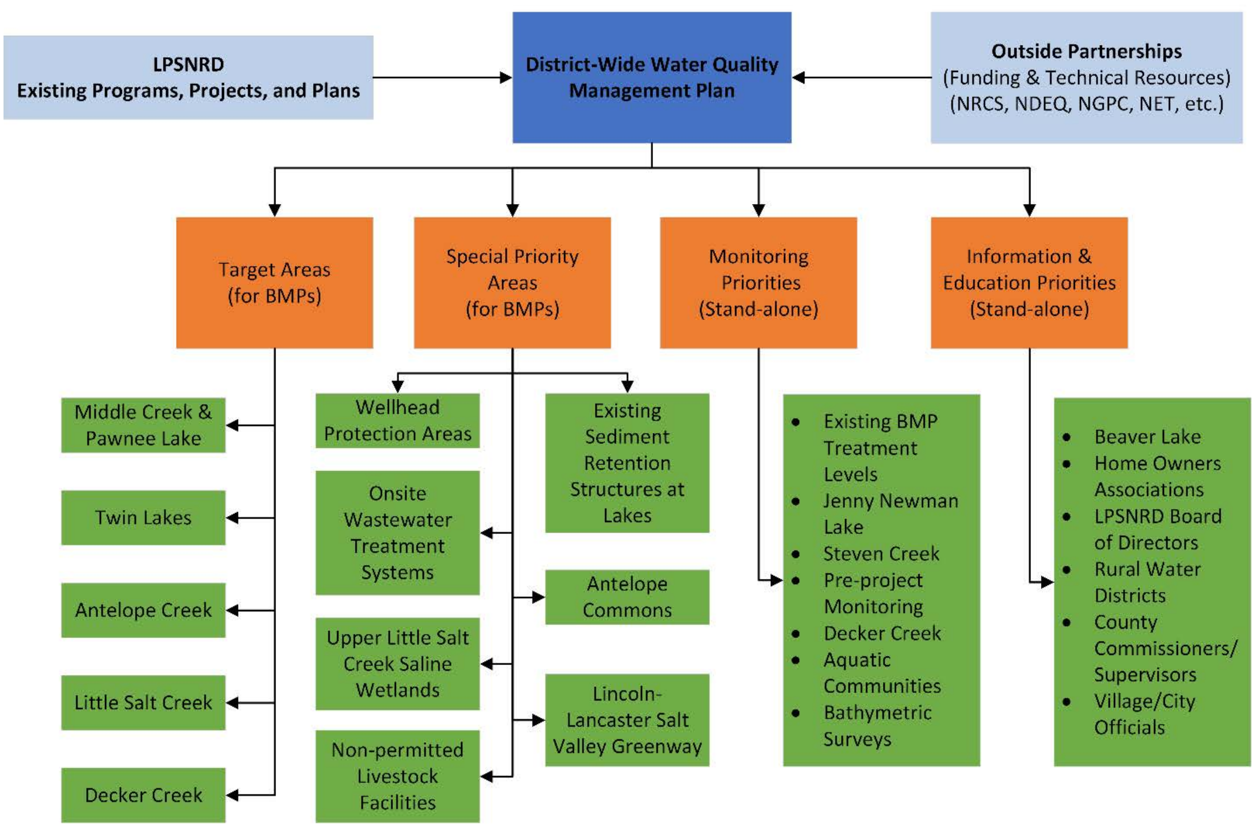


Figure 115: Implementation Framework for the LPSNRD District-Wide WQMP

13.03 IMPLEMENTATION STRATEGIES

Both basin-wide and targeted implementation efforts to address sediment, nutrients, bacteria, and atrazine will be accomplished primarily through existing programs administered by the LPSNRD, NRCS, and other partners. Generally, these programs provide landowners and producers, both in and outside of target areas, access to technical and financial assistance. To enable targeted implementation, these programs (to the greatest extent possible) will be focused on the priorities and impaired waters addressed in this plan. Based on the water quality issues identified in the basin, the plan will rely on the following strategies:

- Promote soil health, which increases productivity and profitability.
- Promote a reduction in the use of manure, commercial fertilizers, and pesticides.
- Reduce the potential for pollutant transport to streams and groundwater.
- Promote healthy, undisturbed riparian areas, including adequate buffers.

FLEXIBLE STRATEGIES

The framework of the plan is flexible to meet the needs of managers and private landowners. While the plan provides structure, it does not intend to force anyone to adhere to specific tactics (i.e. BMPs). The plan offers a framework for managers and a flexible approach for on-the-ground implementation.

While these general strategies can translate to action across the planning area, specific practices will need to be tailored to the specific setting or landowner. A key to getting any individual conservation practice adopted or implemented by private landowners or producers is to identify barriers to adoption. These barriers may be related to: a lack in understanding or knowledge of a practice, logistics, available technical staff, funding, and/or producer costs. To make progress in addressing these and other barriers it is necessary for producers and resource agencies to jointly develop creative strategies that involve all available funding sources.

13.04 STAKEHOLDER COORDINATION

The LPSNRD is the sponsor of this plan, however it has been developed through a stakeholder-driven process which included input from other government agencies that may play a role in implementation. Each agency is unique in its capabilities and its priorities. Agency and stakeholder collaboration is important, therefor the following list summarizes the expected responsibilities of each agency to ensure clear roles and expectations are well understood.

LPSNRD - The LPSNRD will be the local champion of this plan and will lead and coordinate implementation efforts amongst with other agencies. It will provide funding, education, and/or support at various levels, and work with other partners where beneficial.

NDEQ/EPA Section 319 Program - The NDEQ/EPA Section 319 program will provide technical expertise and funding, through educational and grant programs, to assist with implementation of BMPs. This will typically be focused on practices which are innovative, have a high impact on water quality, or that include education or public involvement.

NRCS - The NRCS will lead the effort on implementing traditional BMPs. This will be through technical support and targeted EQIP funding. Additional support may be provided through the State or National Water Quality Initiative.

NGPC - The NGPC manages the fisheries of many of the lakes within the planning area. They will typically lead the effort on lake management or renovation efforts, including in-lake BMPs. Additionally, the NGPC manages or owns numerous public access areas (state parks, etc.) that may benefit from water quality improvements. Projects in these areas will be great partnership opportunities. The NGPC may also provide funding and technical support on various priorities within the plan.

City of Lincoln - The City of Lincoln has a long history of partnering on projects throughout and near the city to improve water quality, including the Antelope Creek Watershed. It is anticipated that the City will lead any efforts within this target area or other areas that are within city limits.

Saline Wetlands Conservation Partnership - The Partnership will take the lead role in projects that protect, restore, or improve saline wetlands within the planning area. This includes work that will take place within any of the Partnership properties. The Partnership may be able to provide match funding or technical resources for these projects.

13.05 FUNDING STRATEGY

OVERVIEW

While the LPSNRD and other stakeholders in the planning area do have taxing authorities that they use to support a variety of public needs, additional support from local, state, and federal funding is essential to accomplish the priorities identified in this plan. Many of these funding sources (such as Nebraska Environmental Trust, NRCS EQIP program, etc.) were identified within Chapter 8; however, because Section 319 funding was used in the development of this plan, special attention is given to this program in this section. This section has been developed in response to requests by NDEQ and EPA to clarify and summarize which BMPs are eligible for funding and implementation through the Section 319 program. It should be noted that this is for planning purposes only, and project specific circumstances, policy changes, or additional project data may change the results of this initial assessment.

SECTION 319 PROJECT FUNDING ELIGIBILITY

Implementing the BMPs identified for each target area or special priority area is critical to reducing pollutant loads and allowing waterbodies to meet water quality standards. However, it is not anticipated that the Section 319 program will participate in all identified activities. The NDEQ/EPA Section 319 program will only provide funding, through grant programs, to assist with implementation of certain priority BMPs. BMPs are eligible for 319 funding by meeting three criteria (Figure 116): addresses an impaired waterbody, is considered cost effective, and is located within a target area or special priority area. This can be summed up by saying the 319 program is interested in getting the most “bang for the buck”. Additionally, 319 funding for BMPs is encouraged to be commensurate with the targeted pollutant load reductions anticipated from each BMPs.

When special priority areas are found outside of target areas, they may still be eligible for Section 319 funding; however, BMPs are restricted to those necessary to address the specific needs of the special priority area. For the purposes of utilizing Section 319 funding, the implementation of BMPs within the special priority area must be administratively tied to a Section 319 project (i.e. part of the same project) where the majority of BMPs are focused within a target area

Figure 116: Graphical Representation of how 319 Eligible BMPs are Identified

This plan has been written to only address pollutants that contribute to the impairment of waterbodies. Water quality modeling was utilized to identify the efficiency that each BMP has on each targeted pollutant. Much of this information is presented in Chapter 7; however, Table 100 is particularly relevant to identifying 319 eligibility for various BMPs. BMPs will only be eligible for Section 319 funding when they have treatment efficiency greater than 0% for a specific pollutant that a targeted waterbody is impaired for. It is assumed that project monitoring, I&E, or BMPs that are education based (OWTS upgrade practice, pet waste management, etc.) will be eligible for 319 funding. These activities have been identified as a priority of the 319 program, despite the difficulty in applying load reductions directly to these actions.

Additionally, 319 funding eligibility relies on cost effectiveness, or BMPs that are a “high impact practice”. In other words, identifying which BMPs provide a high amount of pollutant load reduction per unit of cost, relative to each other. Because this plan is written on a basin-wide scale and covers multiple target areas, including that information is beyond the scope of this plan. BMP cost effectiveness will need to be determined for each project that is requesting 319 funding.

For certain target areas, there may be some BMPs identified as “low priority” for 319 funding. This may happen even if many of them help to meet other management goals of the LPSNRD or participating landowners. These BMPs are still considered an important piece of this plan, and other funding mechanisms should be targeted to fill the funding gap for these BMPs. Also, it should be noted that as better monitoring data is collected, understanding BMP effectiveness may change and cost efficiencies may change over time as well. Therefore, this analysis should be updated in plan updates.

Table 100: Summary of Priority BMPs and Estimated Treatment Efficiencies Summary

Management Practice	Estimated Treatment Efficiency				
	E. coli	TN	TP	TSS (Sediment)	Atrazine
Pet Waste Management	20%	0%	0%	0%	0%
Non-structural & Avoidance BMPs (Working Lands Management)	10%	20%	35%	0%	40%
Grazing Lands Management BMPs	40%	15%	15%	15%	0%
Cover Crops	40%	60%	15%	20%	0%
Riparian Buffers	70%	50%	60%	65%	30%
No-Till Farming	0%	55%	45%	75%	0%
Contour Buffer (filter) Strips	70%	50%	60%	65%	30%
Non-permitted AFO Facility BMPs	75%	60%	80%	70%	0%
Wetlands/Farm Ponds/Sediment Basins	70%	55%	70%	85%	0%
Stream Restoration	35%	77%	77%	77%	0%
Terraces	70%	20%	70%	85%	30%
Water and Sediment Control Basins (WASCOBS)	70%	55%	68%	86%	30%

Grassed Waterways	70%	10%	25%	65%	30%
Urban Stormwater BMPs	30%	40%	43%	78%	0%

Source: Water Quality Modeling
Note: Grassed waterways, and their conceptual locations, were also identified as a priority BMP, however they were grouped with wetlands in the water quality modeling, due to technical limitations.

13.06 PLAN EVALUATION

ADAPTIVE MANAGEMENT

Adaptive management is a process used when there is uncertainty in precisely how selected actions will affect the outcome, but decisions regarding management actions must be made. It is a systematic process of “learning by doing”, as illustrated in Figure 117. This process involves evaluation of alternative hypotheses through the application of an experimental management program. This allows for improving future management decisions in ecosystems based on knowledge gained from previous management actions. Monitoring is designed to reduce uncertainty and move decisions forward. It is a process of using the best available science to test hypotheses, implement management actions, learn from the results, and revise actions as required.

The premise of adaptive management will drive the plan monitoring and evaluation process. The LPSNRD will utilize an adaptive management scheme to evaluate, plan, implement, and adjust. Assessing through monitoring is an ongoing action, with evaluation and adjustments taking place both as necessary and formally every 5-years. All available data will be utilized.

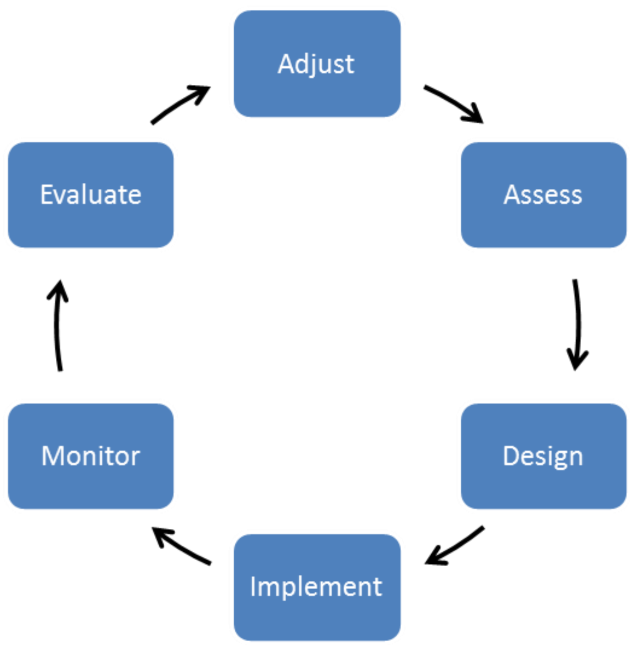


Figure 117: Basic Procedural Steps of Adaptive Management

MEASURING AND EVALUATING PROGRESS

Progress of plan implementation will be monitored by the LPSNRD, who will coordinate with other agencies to identify the extent and level of BMPs implemented. As progress is tracked, the LPSNRD will evaluate these records against the milestones identified in the plan. The BMP Calculator Tool (discussed below) will be useful in this regard.

Progress will be tracked annually, as the LPSNRD works to compile BMP implementation results and monitors water quality. Should it be realized that implementation is falling short of milestones, the LPSNRD should consider assembling stakeholders to review or update strategies.

Implementation records will be compiled into a summary report for review during the 5-year update process. If necessary, these can also be incorporated back into the appropriate water quality model and load reductions can be recalculated. At this time the plan will be formally updated to incorporate these records, new water quality data, and lessons learned to improve the implementation approach. Stakeholders will have an opportunity to review the plan and their input on priorities will be considered in preparation of starting the next increment.

During the 5-year plan update an evaluation will be made as to the degree of implementation that has occurred within each target area. If 20% of BMPs, which were estimated to be needed in order to meet water quality standards, have been installed, the waterbody will be re-evaluated for possible delisting of the impairment on the 2022 303(d) list. If not, the next phase of this implementation plan will begin.

BMP CALCULATOR TOOL

Included as part of this plan is a “BMP Calculator Tool.” This calculator is a Microsoft Excel based tool that was built using average results from the water quality model and provides estimates of loading reductions achieved via individual BMPs. A static version of this can be found in Appendix H, while a copy of the Excel file is provided digitally. The BMP Calculator will allow the LPSNRD to estimate loading reductions achieved through implementation which can be evaluated against plan milestones. Additionally, the BMP Calculator Tool will prove useful when estimating the benefits of future water quality projects, a required item when developing a PIP for a 319 funded project. Over time, it is recommended that the water quality models and the BMP Calculator Tool be updated as future water quality data becomes available, and to ensure they represent the conditions of each target area.

13.07 SUMMARY OF TARGETTED IMPLEMENTATION

The following is a district-wide summary of the activities and accomplishments expected to be achieved though implementation projects during the first 5-year phase of this plan. These summaries are provided by subbasin for each target area, and includes schedules, milestones, budgets, and load reductions. Details for each target area can be found in Chapters 10 – 12.

MASTER SCHEDULE

The master schedule (Table 101) presents a compilation of the major events and activities planned in the individual target areas, during the first 5-year phase of this plan. This master schedule summarizes an approximate timeline based on management actions and will be updated every five years. Detailed schedules can be found in the appropriate subbasin chapter.

Table 101: Master Schedule for the LPSNRD District-Wide WQMP

Subbasin / Target Area **Major Activity**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**
Lower Platte Subbasin						
Decker Creek Target Area						
Secure project funding	X					
Project Monitoring		X	X	X	X	
Organize stakeholders		X				
Implement BMPs and I&E		X	X	X	X	
Project Evaluation						X
Final project reporting						X
Salt Creek Subbasin						
Pawnee Lake and Middle Creek Target Area						
Secure project funding	X					
Project Monitoring		X	X	X	X	
Organize stakeholders		X				
Implement BMPs and I&E		X	X	X	X	
In-Lake BMP feasibility study				X	X	
Project Evaluation						X
Final project reporting						X
East and West Twin Lakes Target Area						
Secure project funding	X					
Project Monitoring		X	X	X	X	
Organize stakeholders		X				
Implement BMPs and I&E		X	X	X	X	
In-Lake BMP feasibility study				X	X	

Project Evaluation						X
Final project reporting						X
Little Salt Creek Target Area						
Secure project funding	X					
Project Monitoring		X	X	X	X	
Organize stakeholders		X				
Implement drainage area BMPs and I&E		X	X	X	X	
Norder Wetland Restoration				X	X	
Grade Stabilization Implementation				X	X	
Project Evaluation						X
Final project reporting						X
Antelope Creek Target Area						
Not applicable						
Keg-Weeping Water Subbasin						
No Target Areas						

MASTER MILESTONES

The master milestones (Table 102) presents a compilation of the major completion dates for the major events and activities planned in the individual target areas, during the first 5-year phase of this plan. This will be updated every five years. Additional details can be found in the appropriate subbasin chapter.

Table 102: Master Milestones for the LPSNRD District-Wide WQMP

Subbasin / Target Area Major Activity	2019	2020	2021	2022	2023	2024
Lower Platte Subbasin						
Decker Creek Target Area						
Develop PIP for BMP Implementation		X		X		
Apply for funding assistance grants		X		X		
Prepare final report(s)						X
Initiate BMP Implementation		X				
Complete Phase 1 BMP Implementation						X
Salt Creek Subbasin						
Pawnee Lake and Middle Creek Target Area						
Develop PIP for BMP Implementation		X				
Apply for funding assistance grants		X				
Prepare final report(s)						X
RFP for In-lake BMP feasibility study					X	
Complete In-lake feasibility study						X
Initiate BMP Implementation		X				

Complete Phase 1 BMP Implementation						X
East & West Twin Lakes Target Area						
Develop PIP for BMP Implementation		X				
Apply for funding as stance grants		X				
Prepare final report(s)						X
RFP for In-lake BMP feasibility study					X	
Complete In-lake feasibility study						X
Initiate BMP Implementation		X				
Complete Phase 1 BMP Implementation						X
Little Salt Creek Target Area						
Develop PIP for BMP Implementation		X		X		
Apply for funding assistance grants		X		X		
Norder Wetland Restoration Final Engineering				X		
Complete Grade Stabilization Projects				X		
Apply for funding for wetlands & grade stabilization					X	
Prepare final report(s)						X
Initiate BMP Implementation		X				
Complete Phase 1 BMP Implementation						X
Antelope Creek Target Area						
Not Applicable						
Keg-Weeping Water Subbasin						
No Target Areas						

MASTER BUDGET

The master budget (Table 103) presents a compilation of the major cost categories for major events and activities planned in the individual target areas during the first 5-year phase of this plan. This will be updated every five years. Additional details can be found in the appropriate subbasin chapter.

Costs opinions were calculated based on literature reviews, project team experience, and information provided by stakeholders. Cost opinions include staff time, design costs, materials cost, and implementations costs, as appropriate. Every effort has been made to prepare realistic cost opinions; however, due to the broad scope and long-term implementation time frame of this plan and affiliated actions, actual costs may vary widely. This may be due to, but not limited to, the following factors: inflation, site specific conditions for structural BMPs, varying methodologies for BMP implementation, or changes to the plan based on monitoring results, or other unforeseen changes to operational costs. Detailed cost opinions will be prepared for each water quality improvement project. Additionally, these estimates were developed for the priority BMPs, but other practices may also be considered. This also includes costs for plan maintenance and updates or other evaluations necessary to implement projects.

This cost opinion should be used for general planning purposes only, as cost opinions and budgeting techniques can vary widely based on the type of project being planned. In addition, the reader should keep in mind that cost opinions are representative of the total cost of implementation, which may ultimately be shared among various stakeholders and land owners through landowner financial assistance and other funding strategies.

Table 103: Master Budget for the LPSNRD District-Wide WQMP

Category	Cost	
Lower Platte Subbasin		
Decker Creek Target Area		
Information & Education	$	52,500
Land Treatment (BMPs) of Drainage Area	$	3,719,765
In-Stream BMPs	$	5,544,000
In-Lake BMPs	$	-
Planning	$	-
Monitoring	$	100,000
Target Area Total	**$**	**9,438,765**
Subbasin Total	**$**	**9,438,765**
Salt Creek Subbasin		
Pawnee Lake and Middle Creek Target Area		
Information & Education	$	50,000
Land Treatment (BMPs) of Drainage Area	$	5,857,366
In-Stream BMPs	$	14,043,750
In-Lake BMPs	$	27,066,860
Planning	$	-
Monitoring	$	50,000
Target Area Total	**$**	**47,067,976**
East and West Twin Lakes Target Area		
Information & Education	$	50,000
Land Treatment (BMPs) of Drainage Area	$	2,281,826
In-Stream BMPs	$	5,596,500
In-Lake BMPs	$	2,573,750
Planning	$	-
Monitoring	$	50,000
Target Area Total	**$**	**10,552,076**
Little Salt Creek Target Area		
Information & Education	$	50,000
Land Treatment (BMPs) of Drainage Area	$	9,510,747
In-Stream BMPs	$	40,788,200
In-Lake BMPs	$	-
Norder Wetland Restoration	$	995,000

Planning	$	-
Monitoring	$	50,000
Target Area Total	**$**	**51,393,947**
Antelope Creek Target Area		
Not Applicable	$	-
Target Area Total	**$**	**-**
Subbasin Total	**$**	**109,013,999**
Keg-Weeping Water Subbasin		
No Target Areas		
District-Wide Activities		
5-year Plan Update	$	150,000
Grand Total	**$**	**118,580,264**

**Based on estimated costs during first 5-year increment only*

LOAD REDUCTION SUMMARY

The load reduction summary (Table 104) presents a summary of beginning load, projected load reduction and final load for each pollutant in the individual target areas. Additional details can be found in the appropriate subbasin chapter.

Table 104: Load Reduction Summary for the LPSNRD District-Wide WQMP

Subbasin / Targeted Waterbody	Pollutant	Pollutant Load		
		Current	Reduction	Final
Lower Platte Subbasin				
Decker Creek (LP1-11200)	*E. coli* (CFU/100 mL)	4,076	3,069	1,007
	Sediment (t/yr)	n/a	n/a	n/a
	Phosphorus (lbs/yr)	n/a	n/a	n/a
	Nitrogen lbs/yr)	n/a	n/a	n/a
	Atrazine (µg/L)	n/a	n/a	n/a
Salt Creek Subbasin				
Pawnee Lake (LP2-L0160)	*E. coli* (CFU/100 mL)	n/a	n/a	n/a
	Sediment (t/yr)	n/a	n/a	n/a
	Phosphorus (lbs/yr)	29,483	26,829	2,654
	Nitrogen lbs/yr)	69,817	57,813	12,004
	Atrazine (µg/L)	n/a	n/a	n/a
Middle Creek (LP2-21100)	*E. coli* (CFU/100 mL)	n/a	n/a	n/a
	Sediment (t/yr)	n/a	n/a	n/a
	Phosphorus (lbs/yr)	n/a	n/a	n/a

	Nitrogen lbs/yr)	n/a	n/a	n/a
	Atrazine (µg/L)	43.45	40.07	3.38
East & West Twin Lakes (LP2-L0240) (LP2-L0260)	*E. coli* (CFU/100 mL)	n/a	n/a	n/a
	Sediment (t/yr)	1,622	1,510	112
	Phosphorus (lbs/yr)	5,111	4,353	758
	Nitrogen lbs/yr)	21,212	17,707	3,505
	Atrazine (µg/L)	n/a	n/a	n/a
Little Salt Creek (LP2-20300)	*E. coli* (CFU/100 mL)	329,000	224,000	105,000
	Sediment (t/yr)	18,965	10,384	8,581
	Phosphorus (lbs/yr)	35,878	21,583	14,295
	Nitrogen lbs/yr)	146,285	86,918	59,367
	Atrazine (µg/L)	n/a	n/a	n/a
Antelope Creek (LP2-20900)*	*E. coli* (CFU/100 mL)	n/a	n/a	n/a
	Sediment (t/yr)	n/a	n/a	n/a
	Phosphorus (lbs/yr)	n/a	n/a	n/a
	Nitrogen lbs/yr)	n/a	n/a	n/a
	Atrazine (µg/L)	n/a	n/a	n/a
Keg-Weeping Water Subbasin				
No target waterbodies				

Source: Water Quality Modeling

**During the development of this plan, Antelope Creek (LP2-20900) was determined to no longer be impaired due to E. coli (NDEQ, 2018). However, implementation of activities identified in this plan are still a priority for the LPSNRD and City of Lincoln.*

5 Alt

Achievement of the LPSNRD District-wide WQMP endpoints indicate *E. coli* pollutant loads are within the loading capacity of each impaired stream segment, the water quality standard of 126 cfu/100 ml is attained, and full support of the designated recreational use has been restored.

REFERENCES

Asplund, T. R., 1996, *Impacts of motorized watercraft on water quality in Wisconsin lakes* (PUBL-RS-920-96), Madison, WI: Wisconsin Department of Natural Resources Bureau of Research. (retrieved from: https://roundthelake.com/PIER%20WI%20DNR/lakes.pdf).

Baral, D., Dvorak, B., Admiraal D., and X. Li., 2017, Fecal contamination and water quality in Antelope Creek: Final Report Prepared for the City of Lincoln, NE.

Bazata, K., 2011, Nebraska Stream Biological Monitoring Program 2004 – 2008 Technical Report: Nebraska Department of Environmental Quality.

Blank, A., and Jackson, J., 2017, Water Quality Study at Louisville SRA and Platte River State Park: Nebraska Game and Parks Commission.

Brown and Caldwell, 2012, Lower Platte South Natural Resources District Water Balance Study: (retrieved from: https://www.lpsnrd.org/Programs/WaterBalanceStudy.pdf). (accessed June 2018).

Canfield, D. E. Jr., & Bachmann, R. W., 1981, Prediction of total phosphorus concentrations, chlorophyll a, and secchi depths in natural and artificial lakes: Canadian Journal of Fisheries and Aquatic Sciences, 38, pg. 414-423. (available at https://doi.org/10.1139/f81-058).

Chapman, S.S., Omernik, J.M., Freeouf, J.A., Huggins, DG., McCauley, J.R., Freeman, C.C., Steinauer, G., Robert, T., and Schlepp, R.L., 2001, Ecoregions of Nebraska & Kansas (color poster with map, descriptive text, summary tables, and photographs): Reston VA, U.S. Geological Survey: map scale 1:1,950,000.

City of Lincoln NE and Lower Platte South Natural Resources District, 2006, Alternative Stormwater Best Management Practices Guidelines: Applied Ecological Services Inc. (available at https://lincoln.ne.gov/city/pworks/watershed/bmp.htm).

Conservation and Survey Division, 2001, Topographic Regions Map of Nebraska: Center for Applied Rural Innovation, p. 62. (available at http://digitalcommons.unl.edu/caripubs/62).

Darshan, B., Dvorak, B., Admiraal, D., and Li, X., 2012, Fecal Contamination and Water Quality in Antelope Creek Final Report 2013-2016: Lincoln NE, City of Lincoln.

Department of Health and Human Services, 2018, Public Water Supply Systems Search: Safe Drinking Water Information System. (available at https://sdwis-dhhs.ne.gov:8443/DWW/).

Divine, D.P., 2014, The Groundwater Atlas of Lancaster County Nebraska: Conservation and Survey Division University of Nebraska-Lincoln, pg. 7. (available at http://snr.unl.edu/csd/download/water/Groundwater_Atlas_LancasterCountyNE_2014.pdf).

Dressing, S.A., 2018, Critical Source Area Identification and BMP Selection: Supplement to Watershed Planning Handbook, Washington DC: United States Environmental Protection Agency, Tetra Tech, 70p. (available at: https://www.epa.gov/sites/production/files/2018-08/documents/critical_source_area_identification_and_bmp_selection_final_5-11-18cover.pdf).

Dzialowski, A. R & Carter, L. D., 2012, Predicting internal nutrient release rates from Central Plains reservoirs for use in TMDL development (Project: X7 97703801): Final report submitted to US Environmental Protection Agency, Region 7, TMDL Program, Water Quality Management Branch, Kansas City, KS.

EA Engineering, Science, and Technology Inc., 2012, Antelope Creek Watershed Basin Management Plan: City of Lincoln Nebraska, Lower Platte South Natural Resources District. (available at https://lincoln.ne.gov/city/pworks/watershed/master-plan/antelope-creek/).

Ehrman D., Herdzina, S., Witthuhn, C., Rezac, R., Mascoe, M., Barry, M., Cameron, K., and Schulz, D., 2017, Lower Platte South Natural Resources District Groundwater Management Plan: Lower Platte South Natural Resources District.

Federal Emergency Management Agency, 2013, 2013 Flood Insurance Study Nebraska and Incorporated Areas, Lancaster County NE: Flood Insurance Study Number 31109CV001B.

Flatwater Group Inc., 2012, Salt Valley Greenway and Prairie Corridor Master Plan: City of Lincoln Parks and Recreation Department. (available at https://lincoln.ne.gov/city/parks/programs/info/links/FinalMasterPlan_AllPages_Aug.pdf).

Flatwater Group Inc., 2015a, Conceptual design memorandum for the Norder Tract Wetland Restoration Planning and Design Charrette Project: Saline Wetland Conservation Partnership.

Flatwater Group Inc., 2015b, Upper Little Salt Creek Saline Wetlands Plan, Lincoln, NE: Lincoln Parks and Recreation.

Flatwater Group Inc., 2018, Design Memorandum Norder Tract Wetland Restoration Planning and Design Charrette Project: Saline Wetlands Conservation Partnership.

Franti, T.G., Roeth, F.W., and Zoubek, G.L., 2003, Best management practices to reduce atrazine runoff from corn fields in Nebraska, Lincoln NE: Cooperative Extension, University of Nebraska Lincoln G97-1323-A. (retrieved from: http://digitalcommons.unl.edu/extensionhist/1431/).

Genskow, Ken and Prokopy, Linda (eds.), 2011, The Social Indicator Planning and Evaluation System for Nonpoint Source Management: A Handbook for Watershed Projects (3rd ed.): Great Lakes Regional Water Program, pg. 104.

HDR, 2018, Water Quality Management Plan for the Lower Platte River Corridor Alliance: Lower Platte South Natural Resources District. Unpublished report.

Horppila, J., and Nurmenen, L., 2001, The effect of an emergent macrophyte (*Typha angustifolia*) on sediment resuspension in a shallow north temperate lake: Freshwater Biology, v. 46, p. 1447-1455. (available at https://doi.org/10.1046/j.1365-2427.2001.00765.x)

Hrabik, R.A., Schainost, S.C., Stasiak, R.H., Peters, E.J., 2015, The Fishes of Nebraska: Conservation & Survey Division, University of Nebraska-Lincoln.

Intuition Logic, 2009, Little Salt Creek Watershed Master Plan, Lincoln NE: Lower Platte South Natural Resources District. (retrieved from: https://lincoln.ne.gov/city/pworks/watershed/master-plan/little-salt-creek/).

Kaul, R. and Rolfsmeier, S., 1993, Native Vegetation of Nebraska Map: Conservation and Survey Division.

Korus, J.T., Howard, L.M., Young, A.R., Divine, D.P., Burbach, M.E., Jess, J.M., and Hallus, D.R., 2013, The Groundwater Atlas of Nebraska, Lincoln: Conservation and Survey Division University of Nebraska-Lincoln.

Kottek, M., J. Grieser, C. Beck, B. Rudolf, and F. Rubel, 2006, World Map of Köppen-Greiger Climate Classification updated: Meteorol. Z., 15, p. 259-263. (available at http://koeppen-geiger.vu-wien.ac.at/).

LaGrange, T., 2005, Guide to Nebraska's Wetlands and their Conservation Needs (2nd ed.): Nebraska Game and Parks Commission, p. 59.

LaGrange, T., 2015, Wetland Program Plan for Nebraska: Nebraska Game and Parks Commission, pg. 70.

LaGrange, T., Genrich, T., Johnson, G., Schulz, D., and Lathrop, B., 2003, Implementation Plan for the Conservation of Nebraska's Eastern Saline Wetlands: Saline Wetland Conservation Partnership.

Laketech, 2018a, Pollutant Modeling and BMP Implementation Recommendations Summary Report for Pawnee Lake and Middle Creek Subwatershed.

Laketech, 2018b, Pollutant Modeling and BMP Implementation Recommendations Summary Report for Twin Lakes.

Lincoln Parks and Recreation, 2015, Upper Little Salt Creek Saline Wetlands Plan, Lincoln: The Flatwater Group Inc.

Lower Platte River Corridor Alliance (LPRCA), 2018, About the Alliance: Lower Platte River Corridor Alliance. (available at http://www.lowerplatte.org/who_we_are/).

Lower Platte South Natural Resources District, 2018, Lower Platte South Natural Resources District [website]. (available at: https://www.lpsnrd.org/).

Martin, D., 2005, Net Irrigation Requirement: A Summary of the CROPSIM Modeling Performed to Develop the Net Corn Crop Irrigation Requirements Map for the State of Nebraska.

Meals, D. W., 1993, Assessing nonpoint source phosphorus control in the LaPlatte River watershed: *Lake and Reservoir Management*, 7, pg. 197-207. (retrieved from: https://doi.org/10.1080/07438149309354271).

Meals, D. W., Sharpley, A. N., and Osmond, D. L, 2012, Lessons Learned from the NIFA-CEAP: Identifying Critical Source Areas, Raleigh, NC: NC State University.

Minnesota Department of Agriculture, 2012, *The agricultural BMP handbook for Minnesota,* Saint Paul, MN. (retrieved from: https://www.eorinc.com/documents/AG-BMPHandbookforMN_09_2012.pdf).

National Centers for Environmental Information (NCEI). 1988-2018. Average Monthly Weather Conditions. Accessed July 11, 2018. (retrieved from: https://www.ncdc.noaa.gov/).

National Environmental Services Center, 2013, Nebraska Septic Stats: National Environmental Services Center. (retrieved from: http://www.nesc.wvu.edu/septic_idb/nebraska.htm#septicstats).

Nebraska Department of Agriculture, 2016, Recommended Atrazine Best Management Practices (BMPs) for Surface Water Quality: Nebraska Department of Agriculture, Natural Resources Conservation Service, and University of Nebraska-Lincoln.

Nebraska Department of Environmental Quality, 2007a, Total maximum daily loads for Middle Creek (LP2-21100) – Parameters of concern: Atrazine, Lincoln, NE: Planning Unit, Water Quality Division. (retrieved from: http://deq.ne.gov/NDEQProg.nsf/OnWeb/TMDLlist).

Nebraska Department of Environmental Quality, 2007b, Total maximum daily loads for Lower Platte River Basin (LP1-10000, LP1-20000, LP2-10000, LP2-10100, LP2-20000, LP2-20400, LP2-20500 and LP2-30000) – Parameters of concern: E. coli, Lincoln, NE: Planning Unit, Water Quality Division. (retrieved from: http://deq.ne.gov/NDEQProg.nsf/OnWeb/TMDLlist).

Nebraska Department of Environmental Quality, 2011a, *Nebraska stream biological monitoring program 2004-2008,* Lincoln, NE: Water Quality Division. (retrieved from: https://deq.ne.gov/NDEQProg.nsf/OnWeb/SBMP).

Nebraska Department of Environmental Quality, 2011b, *Title 130: Nebraska livestock waste control regulations,* Lincoln, NE. (retrieved from: https://deq.ne.gov/RuleAndR.nsf/Title_130.xsp).

Nebraska Department of Environmental Quality, 2012, Title 124 – Rules and Regulations for the Design, Operation and Maintenance of On-site Wastewater Treatment Systems: Nebraska Department of Environmental Quality, pg. 134. (retrieved from: https://www.ndeq.state.ne.us/RuleAndR.nsf/Pages/124-Ch-11).

Nebraska Department of Environmental Quality, 2014, Title 117–Water quality standards for surface waters of the State, Lincoln, NE: Planning Unit, Water Quality Division. (retrieved from: https://deq.ne.gov/RuleAndR.nsf/Title_117.xsp).

Nebraska Department of Environmental Quality, 2015a, Monitoring Programs Report (2015): Nebraska Department of Environmental Quality.

Nebraska Department of Environmental Quality, 2015b, State nonpoint source management plan, Lincoln, NE: Water Quality Division – 2015 through 2030. (retrieved from: https://deq.ne.gov/publica.nsf/xsp/.ibmmodres/domino/OpenAttachment/Publica.nsf/C61A0E8084AD6C6786257362004F4A29/Attach/2015-30%20Nebraska%20NPSMP.pdf).

Nebraska Department of Environmental Quality, 2015c, Strategic Plan and Guidance for Implementing the Nebraska Nonpoint Source Management Program – 2015 through 2030: Nebraska Department of Environmental Quality, pg. 98.

Nebraska Department of Environmental Quality, 2016a, 2016 Nebraska Groundwater Quality Monitoring Report, Lincoln NE: Water Quality Division. (retrieved from: http://deq.ne.gov/Publica.nsf/Pubs_GW.xsp).

Nebraska Department of Environmental Quality, 2016b, 2016 Surface Water Quality Integrated Report, Lincoln, NE: Water Quality Division. (retrieved from https://deq.ne.gov/publica.nsf/pages/WAT234).

Nebraska Department of Environmental Quality, 2016c, Guidance for Writing Basin Management Plans, Lincoln NE, pg. 10.

Nebraska Department of Environmental Quality, 2017a, Electronic transfer of water quality data for the Lower Platte River Basin, Lincoln, NE: Water Quality Division.

Nebraska Department of Environmental Quality, 2017b, Electronic transfer of water quality data for the Lower Platte River Basin (5-alt assessment), Lincoln, NE: Water Quality Division.

Nebraska Department of Environmental Quality, 2017c, Regional Ambient Fish Tissue Monitoring Program, 2016 Data Assessment Report: Nebraska Department of Environmental Quality, p. 34.

Nebraska Department of Environmental Quality, 2017d, *Total maximum daily loads for the Lower Platte River Basin – Parameters of concern: E. coli.* Lincoln, NE: Planning Unit, Water Quality Division. Retrieved from: http://deq.ne.gov/NDEQProg.nsf/OnWeb/TMDLlist

Nebraska Department of Environmental Quality, 2018a, 2018 Water Quality Integrated Report, Lincoln, NE: Water Quality Division. (retrieved from: http://deq.ne.gov/Publica.nsf/Pages/WAT251).

Nebraska Department of Environmental Quality, 2018b, Interactive Mapping – Maps and Data: Nebraska Department of Environmental Quality. (retrieved from: http://deqims2.deq.state.ne.us/deqflex/DEQ.html).

Nebraska Department of Environmental Quality, 2018c, Nebraska Water Monitoring Programs Report 2017: Nebraska Department of Environmental Quality, p. 52.

Nebraska Department of Natural Resources, 2018, Well Database: Nebraska Department of Natural Resources.

Nebraska Game and Parks Commission, 2017a, Natural Heritage Program: Range maps for at-risk species: (retrieved from: http://outdoornebraska.gov/naturalheritageprogram/).

Nebraska Game and Parks Commission, 2017b, Nebraska lake contour maps. (retrieved from: https://maps.outdoornebraska.gov/lakemaps/#!).

Niemisto, J., 2008, *Sediment resuspension as a water quality regulator in lakes* (Unpublished doctoral dissertation), Helsinki, Finland: University of Helsinki. (retrieved from: https://helda.helsinki.fi/bitstream/handle/10138/22321/sediment.pdf).

Osterberg, D., and Kline, A., 2014, A Threat Unmet: Why Iowa's Nutrient Strategy Falls Short Against Water Pollution: The Iowa Policy Project, pg. 27.

Poff, L.N., Allan, J.D., Bain M.B., Karr, J.R., Prestegaard, K.L., Richter, B.D., Sparks, R.E., and Stromberg, J.C., 1997, The Natural Flow Regime: BioScience, 47(11), pg. 769-784, (doi:10.2307/1313099.)

Schneider, R., Stoner, K., Steinauer, G., Panella, M., and Humpert, M. (eds.), 2011, The Nebraska Natural Legacy Project State Wildlife Action Plan (2nd ed.): The Nebraska Game and Parks Commission, pg. 352.

Schueler, T., 1987, Controlling urban runoff: a practical manual for planning and designing urban BMPs, Washington DC: Metropolitan Washington Council of Governments.

Søndergaard, M., Jensen, J.P. & Jeppesen, E., 2003, Role of sediment and internal loading of phosphorus in shallow lakes: Hydrobiologia, v. 506, p. 135-145. (retrieved from: https://doi.org/10.1023/B:HYDR.0000008611.12704.dd).

Taylor, T., and Krueger, L. (eds.), 1997, Mitigation Guidelines for Nebraska's Eastern Saline Wetlands: U.S. Environmental Protection Agency, Region VII, and U.S. Army Corps of Engineers, p. 46.

TetraTech, 2007, Spreadsheet tool for the estimation of pollutant load (STEPL; Version 4.1) [Computer program], Fairfax, VA. (retrieved from: https://it.tetratech-ffx.com/steplweb/models$docs.htm).

TetraTech, 2013, STEPL On-Line Data Access System Developed for the United States Environmental Protection Agency, Fairfax, VA: Tetra Tech, Inc. (available at: http://it.tetratech-ffx.com/steplweb/STEPLdataviewer.htm).

Tomer, M.D., S.A. Porter, D.E. James, K.M.B. Boomer, J.A. Kostel, and E. McLellan, 2013, Combining precision conservation technologies into a flexible framework to facilitate agricultural watershed planning: Journal of Soil & Water Conservation, 68, pg. 113A-120A.

U.S. Army Corp of Engineers, 2017, Electronic transfer of water quality data for Salt Creek Reservoirs (2010-2016), Omaha, NE: United States Army Corp of Engineers, Omaha District.

U.S. Army Corp of Engineers, 2018, Water quality conditions at the Omaha district tributary projects in Nebraska, 2016 Report, Omaha, NE: United States Army Corp of Engineers, Omaha District.

U.S. Bureau of the Census, 2015, American Community Survey 5-year Estimates: U.S. Census Bureau.

U.S. Department of Agriculture, 1980, Soil Survey of Lancaster County, Nebraska: Soil Conservation Service.

U.S. Department of Agriculture, 2009, 2007 Census of Agriculture. (retrieved from: https://www.agcensus.usda.gov/Publications/2007/Full_Report/Volume_1,_Chapter_1_US/usv1.pdf).

U.S. Department of Agriculture, 2014, 2012 Census of Agriculture. (retrieved from: https://www.agcensus.usda.gov/Publications/2012/Full_Report/Volume_1,_Chapter_2_County_Level/Nebraska/nev1.pdf.).

U.S. Department of Agriculture, 2016, Land use / land cover data layer, Washington, DC: National Agricultural Statistics Service. (retrieved from: https://www.nass.usda.gov/Research_and_Science/Cropland/SARS1a.php).

U.S. Department of Agriculture, 2017a, Cropland Data Layer-2016 Published crop-specific data layer [Online], Washington D.C.: National Agricultural Statistics Service. (retrieved from: https://nassgeodata.gmu.edu/CropScape/).

U.S. Department of Agriculture, 2017b, Web Soil Survey, Nebraska: U.S. Department of Agriculture Natural Resources Conservation Service. (retrieved from: https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm).

U.S. Department of Agriculture, 2018, Environmental Quality Incentives Program, Nebraska: U.S. Department of Agriculture Natural Resources Conservation Service. (retrieved from: https://www.nrcs.usda.gov).

U.S. Environmental Protection Agency, 2003a, Ambient Aquatic Life Water Quality Criteria for Atrazine – Revised Draft. EPA-822-R-03023, Washington D.C.: U.S. Environmental Protection Agency, Office of Water.

U.S. Environmental Protection Agency, 2003b, Watershed Analysis and Management Guide for States and Communities, Washington, D.C.: Environmental Protection Agency, p. 211.

U.S. Environmental Protection Agency, 2008, Handbook for Developing Watershed Plans to Restore and Protect Our Waters: United States Environmental Protection Agency, Office of Water, Nonpoint Source Control Branch.

U.S. Environmental Protection Agency, 2018, Registration review of Atrazine, Washington, DC: Office of Water. (retrieved from: https://www.epa.gov/ingredients-used-pesticide-products/atrazine-background-and-updates).

U.S. Fish and Wildfire Service, 2016, Recovery Plan for the Salt Creek Tiger Beetle (Cicindela nevadica lincolniana): US. Fish and Wildlife Service.

U.S. Geological Survey, 2017, Water Boundary Dataset: National Resources Conservation Survey. (retrieved July 17, 2017 from https://datagateway.nrcs.usda.gov/).

University of Nebraska-Lincoln, 2018, Nebraska Invasive Species Program. (retrieved from: https://neinvasives.com/).

Wayne, W.J., 2011, Glaciation: Encyclopedia of the Great Plains: University of Nebraska-Lincoln. (retrieved from: http://plainshumanities.unl.edu/encyclopedia/doc/egp.pe.029).

Wright Water Engineering, 2018, Bacteria Load Estimation Report for the Lower Platte South Nonpoint Source Basin Plan: Nebraska.

LIST OF APPENDICES

APPENDIX A: 11X17 MAPS

APPENDIX B: STAKEHOLDER AND PUBLIC PARTICIPATION MATERIALS

APPENDIX C: TECHNICAL MEMORANDUMS

APPENDIX D: WATER QUALITY MODELING RESULTS/REPORTS

APPENDIX E: BEST MANAGEMENT PRACTICES DESCRIPTIONS

APPENDIX F: ACPF ATLASES

APPENDIX G: NDEQ 5-ALT INFORMATION

APPENDIX H: BMP CALCULATOR TOOL

APPENDIX I: GLOSSARY

THIS PAGE LEFT INTENTIONALLY BLANK

Back cover of plan features a “word cloud”, or a visual representation of themes discussed throughout the plan. The relative size of each word in the image is based on the number of times used in the plan or its relative importance to the plan.

Lower Platte South Natural Resources District
District-Wide Water Quality Management Plan