Lower Platte River
CORRIDOR ALLIANCE

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The voice of the Lower Platte.

WATER QUALITY MANAGEMENT PLAN

for The Lower Platte River Corridor Alliance

Approved by EPA on April 9, 2019

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Nebraska DEQ

The development of this Water Quality Watershed Management Plan for the Lower Platte River Corridor was made possible by funding and technical support provided by the Nebraska Department of Environmental Quality Nonpoint Source Water Quality (Section 319) Program and the Lower Platte River Corridor Alliance partnerships.

March 2019

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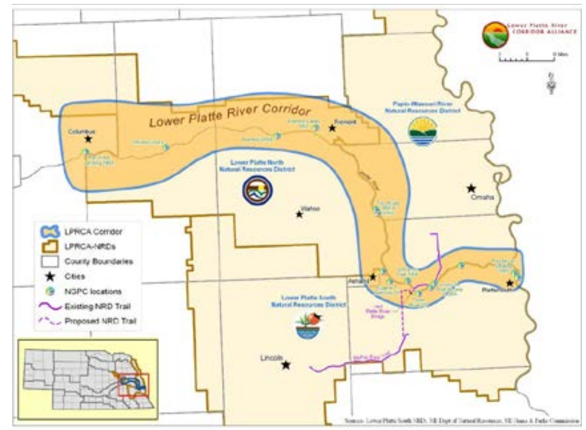
Lower Platte River

INTRODUCTION

The LPRCA included three Natural Resource Districts (NRDs) and six state agencies dedicated to protecting the long-term vitality of the Lower Platte River Corridor. The entities making up the LPRCA are: Lower Platte North NRD (LPNNRD); Lower Platte South NRD (LPSNRD); Papio–Missouri River NRD (PMRNRD); Nebraska Game and Parks Commission (NGPC); Nebraska Department of Natural Resources (NDNR); Nebraska Department of Environmental Quality (NDEQ); Nebraska Military Department; Nebraska Department of Health and Human Services (DHHS); and University of Nebraska – Conservation and Survey Division, School of Natural Resources, and Nebraska Water Center.



Lower Platte River Corridor

The Lower Platte River Corridor generally is defined as the 110 miles of the Lower Platte River, the bluffs, and adjoining public and private lands located within the floodplain of the Lower Platte River from Columbus, Nebraska, to the mouth of the river near Plattsmouth, Nebraska. The Lower Platte River Corridor dissects a portion of 8 counties and 24 communities fall within its boundaries.

In September 2012, LPRCA submitted a Nonpoint Source Pollution Management Project application to NDEQ for funding under the State's Nonpoint Source Water Quality (Section 319) Program. The watershed management portion of this study was funded allowing for the development of this study, the Lower Platter River Watershed – Water Quality Management Plan (Plan).

Department of Environmental Quality Section 319

Under Section 319 of the federal Clean Water Act, the federal government awards funds to the Nebraska Department of Environmental Quality to provide financial assistance for the prevention and abatement of nonpoint source water pollution. This funding is passed through to units of government, educational institutions, and non-profit organizations, for projects that facilitate implementation of the state Nonpoint Source Management Plan.

E. coli bacteria

Members of two bacteria groups, coliforms and fecal streptococci, are used as indicators of possible sewage contamination because they are commonly found in human and animal feces. Although they are generally not harmful themselves, they indicate the possible presence of pathogenic (disease-causing) bacteria, viruses, and protozoans that also live in human and animal digestive systems. Therefore, their presence in streams suggests that pathogenic microorganisms might also be present and that swimming and eating shellfish might be a health risk. Since it is difficult, time-consuming, and expensive to test directly for the presence of a large variety of pathogens, water is usually tested for coliforms and fecal streptococci instead.

The most commonly tested fecal bacteria indicators are total coliforms, fecal coliforms, Escherichia coli, fecal streptococci, and enterococci. All but *E. coli* are composed of a number of species of bacteria that share common characteristics such as shape, habitat, or behavior; *E. coli* is a single species in the fecal coliform group. Nebraska state bacteria water quality standards are based on concentrations of *E. coli*.

Watershed management plans funding by Section 319 are required to follow the guidelines established by EPA for their development. EPA has developed the *Handbook for Developing Watershed Plans to Restore and Protect our Waters* (EPA, 2008) to aid in the development of Section 319 funded watershed management plans. The guidance establishes nine elements that must be included in a watershed management plan. The following provides the element and the location of the presentation of that element within this Plan:

1. Identify causes and sources of pollution
2. Estimate pollutant loading into the watershed and the expected load reductions
3. Describe management measures that will achieve load reductions and targeted critical areas
4. Develop an information/ education component
5. Develop a project schedule
6. Describe the interim, measurable milestones
7. Identify indicators to measure progress
8. Develop a monitoring component
9. Estimate amounts of technical and financial assistance and the relevant authorities needed to implement the plan

TSS – sediment

Total solids are dissolved solids plus suspended and settleable solids in water. In stream water, dissolved solids consist of calcium, chlorides, nitrate, phosphorus, iron, sulfur, and other ions particles that will pass through a filter with pores of around 2 microns (0.002 cm) in size. Suspended solids include silt and clay particles, plankton, algae, fine organic debris, and other particulate matter. These are particles that will not pass through a 2-micron filter. The analyses performed in this watershed plan attempt to characterize the sediment load but use the TSS measurements as the best available data to use as a surrogate.

Total Phosphorus

Phosphorus is an essential nutrient for plants and animals. However, an excess amount of phosphorus in a waterway may lead to low levels of dissolved oxygen and negatively alter various plant life and organisms. Pure, "elemental" phosphorus (P) is rare. In nature, phosphorus usually exists as part of a phosphate molecule (P04). Phosphorus in aquatic systems occurs as organic phosphate and inorganic phosphate. Organic phosphate consists of a phosphate molecule associated with a carbon-based molecule, as in plant or animal tissue. Phosphate that is not associated with organic material is inorganic. Inorganic phosphorus is the form required by plants. Animals can use either organic or inorganic phosphate. Both organic and inorganic phosphorus can either be dissolved in the water or suspended (attached to particles in the water column).

Total Nitrogen

Nitrogen is an essential nutrient for plants and animals. However, an excess amount of nitrogen in a waterway may lead to low levels of dissolved oxygen and negatively

STUDY AREA

The Plan Study Area is approximately 1,120 square miles all within the Lower Platte- Shell, Lower Platte, and Salt Hydrologic Unit Code 8 watersheds (see **Figure ES-1**). In addition, a portion of the Lower Elkhorn watershed was included due to the overall influence of the Elkhorn River to the Lower Platte River **Table ES-1.**

Table ES-1. Study Area Size Details

HUC 8 Name	Square Miles	Percent
Lower Platte – Shell	376.74	33.63
Lower Platte	498.93	44.53
Salt	205.68	18.36
Lower Elkhorn	38.97	3.48
Total	1120.32	100.00

PLAN GOALS

The overarching vision for the development of the Plan is to gain an understanding of select surface water constituent contributions to and distributions within Study Area. The following goals were established for the Plan:

- **Goal 1 – Identification of Management Actions**
  Prioritize watersheds based on contributions of *E. coli* bacteria to the Lower Platte River to determine planning and management actions.
- **Goal 2 – Reduce Point Source Contribution of *E. coli* bacteria**
  Establish a mechanism for point source reduction of *E. coli* bacteria from unregulated septic tank sources.

STAKEHOLDER INVOLVEMENT

Due to the large size of the Plan study area and the overall basis for the Plan development, stakeholder involvement is addressed through a technical advisory group. The technical advisory group was formulated based on input from the technical staff at the participating NRDs, NDEQ, and other state agencies. Stakeholder input in this fashion was obtained through stakeholder meetings at key points in the Plan development as well as at regularly scheduled LPRCA meetings.

POLLUTANT LOADING

The primary pollutant sources being addressed by this study is *E. coli* bacteria. Other constituents being addressed are nutrients total phosphorus (TP), total nitrogen (TN) and sediment (total suspended sediment (TSS) . The existing loadings of *E. coli* will be determined so that appropriate load reductions can be determined, based on best management practices (BMPs) to meet the desired goals and objectives set forth for the Plan.

Point and nonpoint pollutant sources for *E. coli* (as well as other constituents) were identified for each of the 34 sub-watersheds within the Study Area (**Figure ES-2**). Recreational season[1] *E. coli* loadings at key locations throughout Study Area were characterized using load duration curves (LDCs) developed from existing data. As described below, the loadings were apportioned by land use to the 12-digit HUCs within the LPRCA study based on a source tracking study from a nearby basin and using literature-based assumptions regarding decay rate and stream velocity. A full explanation of this method is provide in **Appendix B**.

[1] In Nebraska, the recreational season runs from May 1 through September 30 and is the only period in which the *E. coli* criterion of 126 cfu/100 mL applies. Therefore, bacteria TMDL loading do not apply outside this period and will not be calculated on an annual basis. Although the proposed approach focuses on the recreational season, this is not meant to imply that best management practices would not or should not be applied year-round. In fact, studies have shown that bacteria can survive in stream sediment for extended periods of time only to be resuspended during high flows at a later date (Cervantes 2012).

alter various plant life and organisms. There are three forms of nitrogen that are commonly measured in water bodies: ammonia, nitrates and nitrites. Total nitrogen is the sum of total Kjeldahl nitrogen (ammonia, organic and reduced nitrogen) and nitrate-nitrite. Total nitrogen can be determined as the sum of the total Kjeldahl nitrogen plus nitrate-N and nitrite-N. TN can also be measured by a high temperature persulfate digestion step that converts all of the nitrogen to nitrate, which is then measured by colorimetric or other method.

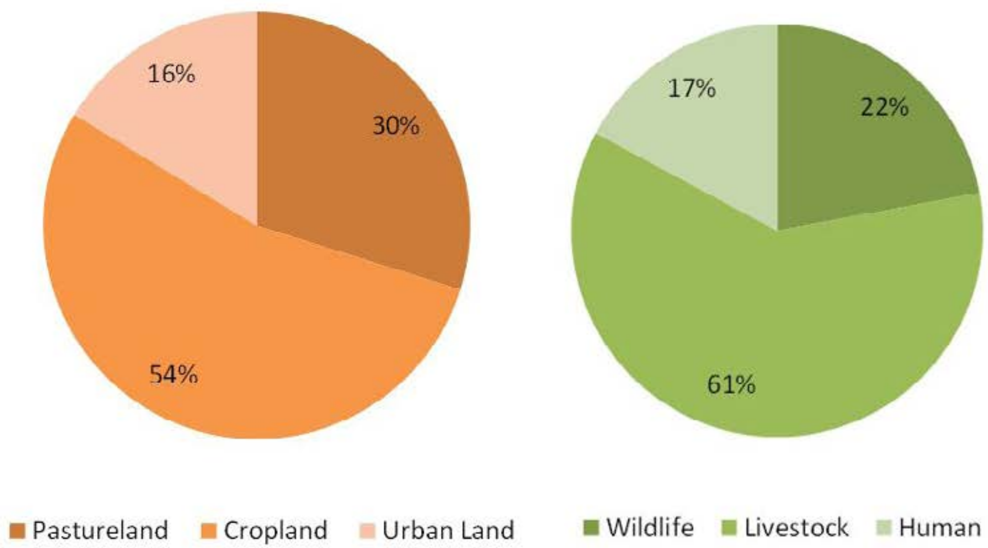
Atrazine

Atrazine is a white, crystalline solid organic compound. One of the most widely used agricultural pesticides in the U.S., atrazine may be applied before and after planting to control broadleaf and grassy weeds. It is used primarily on corn, sorghum, and sugarcane, and is applied most heavily in the Midwest. Atrazine is used to a lesser extent on residential lawns.

The estimated total recreational season *E. coli* loadings by watershed is shown in **Figure ES-3**.

Based on these results, approximately 54% of the bacteria loading within the Study Area originates from cropland due to it being the dominant land use (see graphic below). Based on the breakdown of bacteria sources, approximately 61% of the bacteria loading is estimated to originate from livestock. Wildlife is the next largest source at approximately 22%, followed by humans at 17%. Potential delivery pathways associated with each of the three model sources are discussed below.

Percent Contribution of Bacteria Loadings in the LPRCA Study Area by Land Use and Source



Schramm Bluffs

POLLUTANT LOAD REDUCTIONS

The overarching vision for the development of this Plan is to gain an understanding of the contributions and distribution of select water quality constituents (*E. coli* bacteria, total nitrogen, total phosphorus, total suspended sediments, and atrazine) within the Lower Platte River Corridor to improve and protect surface water quality in the lower Platte River. Due to the establishment of a TMDL for the Lower Platte River Basin (TMDL–LPRB) (NDEQ, 2007) for *E. coli* bacteria, a focus on the reductions needed to meet the water quality standard for this parameter are of utmost importance.

The published TMDL–LPRB calls for targeted load reductions throughout the Lower Platte River Basin to meet water quality criteria that are fully supportive of the primary contact recreation beneficial use. To account for uncertainty in the nonpoint source load reduction, the TMDL–LPRB targets reductions set at 90% of the water quality criterion of 126 col/100 ml. Specifically, the TMDL–LPRB targets an *E. coli* concentration of 113 col/100 ml as a recreational season mean in both the lower (LP1-10000) and upper (LP1-20000) segment of the Lower Platte River. To achieve this target, the TMDL–LPRB calls for an 85% reduction in LP1-20000 based on an observed *E. coli* concentration of 750 col/100 ml. A 64% reduction is called for in LP1-10000 based on an observed geometric mean concentration of 314 col/100 ml which would require an 82% reduction.

While the TMDL–LPRB calls for a 64–85% reduction in *E. coli*, targeted reductions are based here on more recent data collected from the Platte River at Louisville (USGS Gauge 06805500). Per methods described in **Appendix B**, a load duration table was developed for *E. coli* for the Louisville station (**Table ES-2**). The Louisville station is considered representative of the Study Area as it is located near the downstream end of the Platte River. Based on the load duration curve, the most significant bacteria loadings occur during wet weather conditions. However, as the *E. coli* target is applied as a recreational season geometric mean the required reductions are not specific to any one flow regime. Therefore, existing conditions were set equal to the geometric mean weighted across all flow regimes. Based on this approach the Platte River has an *E. coli* concentration of 640 col/100 ml, which requires an 82% reduction to achieve the TMDL target of 113 col/100 ml. The targeted 82% reduction shall broadly apply to the entire Study Area. Contributing drainage areas located outside the study area are beyond the scope of this Plan.

PLAN FORMULATION

Prioritizing Watersheds for Management Measure Implementation

Understanding the potential for load reductions is a valuable tool to aid in determining the benefits a watershed could incur with increased management practices. However, due to the number of assumptions needed for percent of the HUC 12s in the Study Area that have existing treatments and the effectiveness of those treatments, it was determined that the total contributing loads to the observed seasonal geometric means at both North Bend and Louisville for *E. coli* bacteria would be used to determine priority watersheds within the Study Area to begin focused efforts to improve water quality. As described above, some measures to remove *E. coli* bacteria would also be effective in removal of total nitrogen, total phosphorus, total suspended sediments, and atrazine.

Due to the focus on addressing the *E. coli* TMDL, the contributions of each watershed to the observed geometric mean establishing the TMDL was used. The following describes this priority system:

- **Priority 1 Watersheds** – Due to the number of watersheds having large *E. coli* loadings within the Study Area, multiple factors were considered in determining the Priority 1 watersheds. Each NRD analyzed the needs of their respective watersheds when determining priority beyond *E. coli* loading. Due to the amount of agriculture with the watershed, the Lower Platte North NRD considered the availability of landowners willing to implement BMPs in determining priority areas as well as geographical considerations of watershed position (watersheds higher in the contributing drainage area to the lower Platte River. The Lower Platte South and Papio-Missouri River NRDs are situated within areas that are experiencing high levels of agriculture conversion to suburban and urban development uses. These NRDs used future land use planning as a criteria in deciding priority areas to identify which watersheds had availability to establish BMPs prior to development occurring. In addition, the potential for landowner participation in BMPs and most cost effective practices were considered in the prioritization.
- **Priority 2 Watersheds** – The next top ten highest contributing watersheds of *E. coli* contributions (cfu/100 ml) regardless of NRD Boundary.
- **Priority 3 Watersheds** – All remaining watersheds with the Study Area in order of *E. coli* contributions (cfu/100 ml).

Based on the *E. coli* loadings, **Table ES-2–4** provides the Priority 1, 2, and 3 watersheds, respectively. **Figure ES-3** provides these watershed locations within the Study Area.

Based on the management measures described above, the Priority 1 watersheds were analyzed for the potential BMP implementation and the resultant anticipated *E. coli* load reductions. Preliminary estimates indicate that the cumulative reduction for the Priority 1 watersheds would be 75%.

Management Measures

The LPRCA has identified management measures that will occur on a watershed specific basis as well as across the entire Study Area in order to meet the plans, goals and objectives. Also, due to the number of watersheds within the Study Area and likely lengthy duration for overall implementation, these management measures were grouped into Management Initiatives for implementation. These Management Initiatives are (further details on these management measures are provided in the following section, **Management Plan Implementation**):

MANAGEMENT INITIATIVE 1

This Management Initiative will focus on management measures for the reduction of *E. coli* bacteria within Priority 1 watersheds. Each of the NRDs would assist in determining the types of BMPs appropriate for each Priority I watershed and would develop a project implementation plan. Coordination with the NDEQ and USGS would occur to determine the appropriate actions necessary to ascertain water quality information for each Priority I Watershed.

MANAGEMENT INITIATIVE 2

This Management Initiative will be implemented across the entire Study Area concurrently with Management Initiative 1.

1. Implement Voluntary Septic Tank Upgrade Program
2. Contributing Watershed Coordination Plan

Table ES-2: Priority 1 Watersheds

HUC	Subwatershed Name	Recreational Season *E. coli* Loading (cfu/year total)	NRD Name
102002010308	Headwaters Skull Creek	3.04E+16	Lower Platte North
102002010304	Headwaters Bone Creek	2.95E+16	
102002020210	Eightmile Creek	3.05E+16	Lower Platte South
102002020208	Turkey Creek-Platte River	2.77E+16	
102002020204	Buffalo Creek	2.54E+16	Papio-Missouri
102002020211	Zwiebel Creek-Platte River	2.13E+16	
102002020206	Turtle Creek	1.68E+16	

Table ES-3 Priority 2 Watersheds

HUC	Subwatershed Name	Recreational Season *E. coli* Loading (cfu/year total)	NRD Name
102002020101	Rawhide Creek-Platte River	9.49E+16	Lower Platte North
102200031006	Big Slough-Elkhorn River	4.44E+16	Papio-Missouri
102002010301	Shonka Ditch	3.90E+16	Lower Platte North
102002010209	Brewery Hill-Shell Creek	3.88E+16	
102002010310	Lost Creek-Platte River	3.73E+16	
102002020202	Western Sarpy Ditch-Platte River	2.98E+16	Papio-Missouri
102002020203	Decker Creek-Platte River*	2.81E+16	Lower Platte South
102002010307	Village of Abie	2.81E+16	Lower Platte North
102002010309	Outlet Skull Creek	2.69E+16	
102002010303	Deer Creek-Platte River	2.48E+16	

*As of the submittal of this Plan, Lower Platte South NRD is developing a District-wide 319 Watershed Water Quality Management Plan. Decker Creek-Platte River is currently anticipated to be Priority 1 watershed in that plan.

Table ES-4: Priority 3 Watersheds

HUC	Subwatershed Name	Recreational Season *E. coli* Loading (cfu/year total)	NRD Name
102002020103	Elm Creek-Platte River	2.41E+16	Lower Platte North
102002020205	Cedar Creek	2.31E+16	Lower Platte South
102002020104	Otoe Creek-Platte River	2.21E+16	Papio-Missouri
102002020207	Mill Creek-Platte River	2.17E+16	Lower Platte South
102002010306	Tomek Island-Platte River	2.15E+16	Lower Platte North
102002030907	Dee Creek-Salt Creek	2.12E+16	Lower Platte South
102002010305	Outlet Bone Creek	2.11E+16	Lower Platte North
102002020102	Headwaters Otoe Creek	1.79E+16	
102002010302	Headwaters Lost Creek	1.65E+16	
102002020201	Pawnee Creek	1.44E+16	Lower Platte South
102002020105	102002020105	1.43E+16	Papio-Missouri
102002031003	Headwaters Clear Creek	1.11E+16	Lower Platte North
102002031005	Wahoo Creek*	1.07E+16	
102002010311	102002010311	9.97E+15	
102002030906	Callahan Creek	8.45E+15	Lower Platte South
102002031002	Johnson Creek	7.88E+15	Lower Platte North
102002031004	Clear Creek	7.75E+15	

*An EPA 319 Watershed Water Quality Management Plan for Wahoo Creek has been developed for this watershed. Management strategies are addressed in that plan.

Implementation Schedule

The following is a proposed scheduled for the management measures identified here. LPRCA has grouped these measures into two implementation phases. This does not represent a priority for implementation, but rather, the duration of implementation as well as the necessary order of implementation to have the best information available for successful implementation of each management measure. The following provides the implementation schedule. Updates to this schedule are anticipated to occur annually as part of the LPRCA's review of all on-going project and initiatives.

Platte River at Louisville

YEARS 1–2

- Initiate Management Initiative 1 for Priority Watersheds
- Initiate Management Initiative 2

YEARS 3–5

- Initiate and implement BMPs for Priority 1 Watersheds
- Re-evaluate Priority Watersheds (as part of yearly Plan Re-Evaluation)
- Continue Voluntary Septic Tank Inspection Program
- Evaluate Management Initiative 2 and determine future course of action
- Watershed Plan Update (estimated at Year 5) including re-evaluation of Priority Watersheds

YEARS 6–10

- Initiate and implement BMPs for re-assessed Priority 1 Watersheds, as applicable
- Re-evaluate Priority Watersheds (as part of yearly Plan Re-Evaluation)
- Watershed Plan Update (estimated at Year 10) including re-evaluation of Priority Watersheds

YEARS 11–20

- Initiate and implement BMPs for re-assessed Priority 1 Watersheds, as applicable
- Re-evaluate Priority Watersheds (as part of yearly Plan Re-Evaluation)
- Watershed Plan Update (Year 15 and Year 20) and Re-evaluate Priority Watersheds

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

Plan Implementation Costs

The costs for the implementation of this Plan are estimates based on best professional judgments. For Management Measure 2, costs are provided for the development of the performance of septic tank inspections. **Table ES-5** provides the summary of costs.

Table ES-5. Estimate of Plan Implementation Costs

Activity	Cost
Management Initiative 1 Implementation	
Best Management Practice Identification	$5–10k x 6 = $30–$60k
Implementation Cost and Schedule	$13.9m – $37.2m
Management Initiative 2	
Information Materials Development	$5–10k
Voluntary Inspections (15 anticipated for Year 1)	$7.5k
Corrective Actions for Septic Tanks (5) during Year 1	$30k
Voluntary Inspections (15 anticipated for Year 2)	$7.5k
Corrective Actions for Septic Tanks (5) during Year 2	$30k
Plan Update (year 5)	$50k
Information and Education	$1.5k
Plan Re-Evaluations (yearly)	Performed as part of LPRCA administrative actions
Plan Update (year 10)	$50k
Plan Update (year 15)	$50k
Total	**$14.1m – $37.5m**

Figure ES-1. Study Area

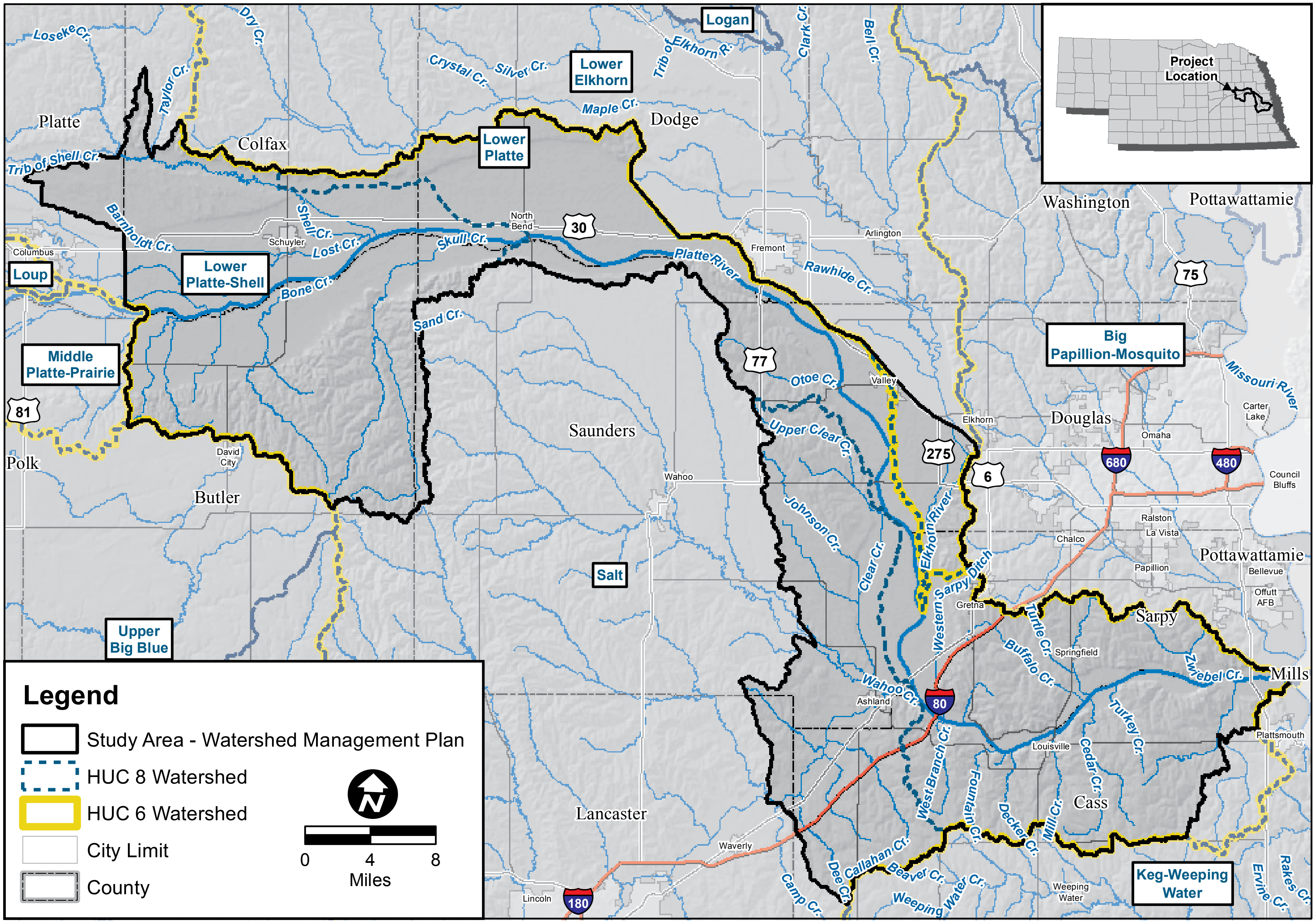


Figure ES-2. Watersheds

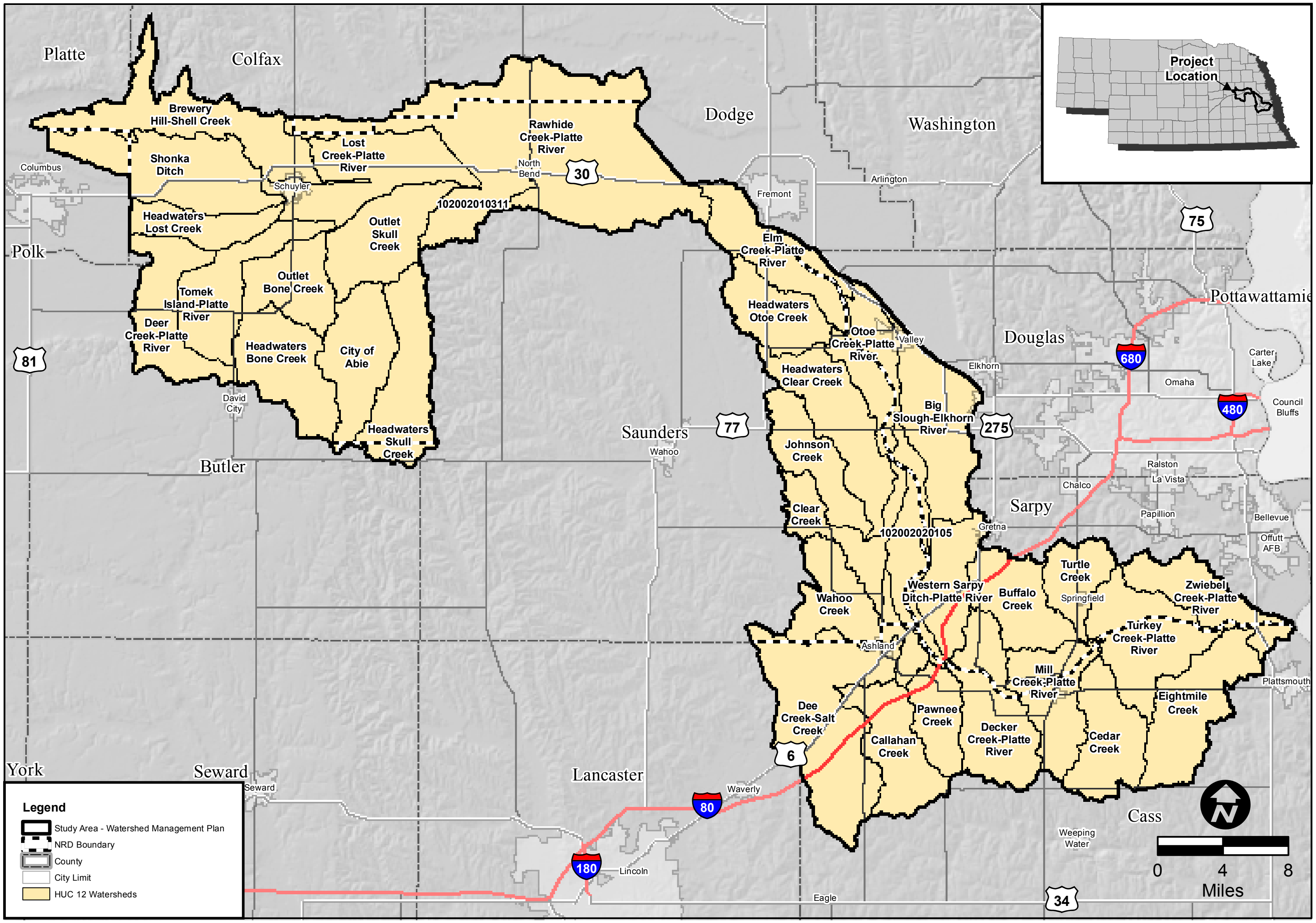


Figure ES-3. Estimated Recreational Season *E. coli* Loadings

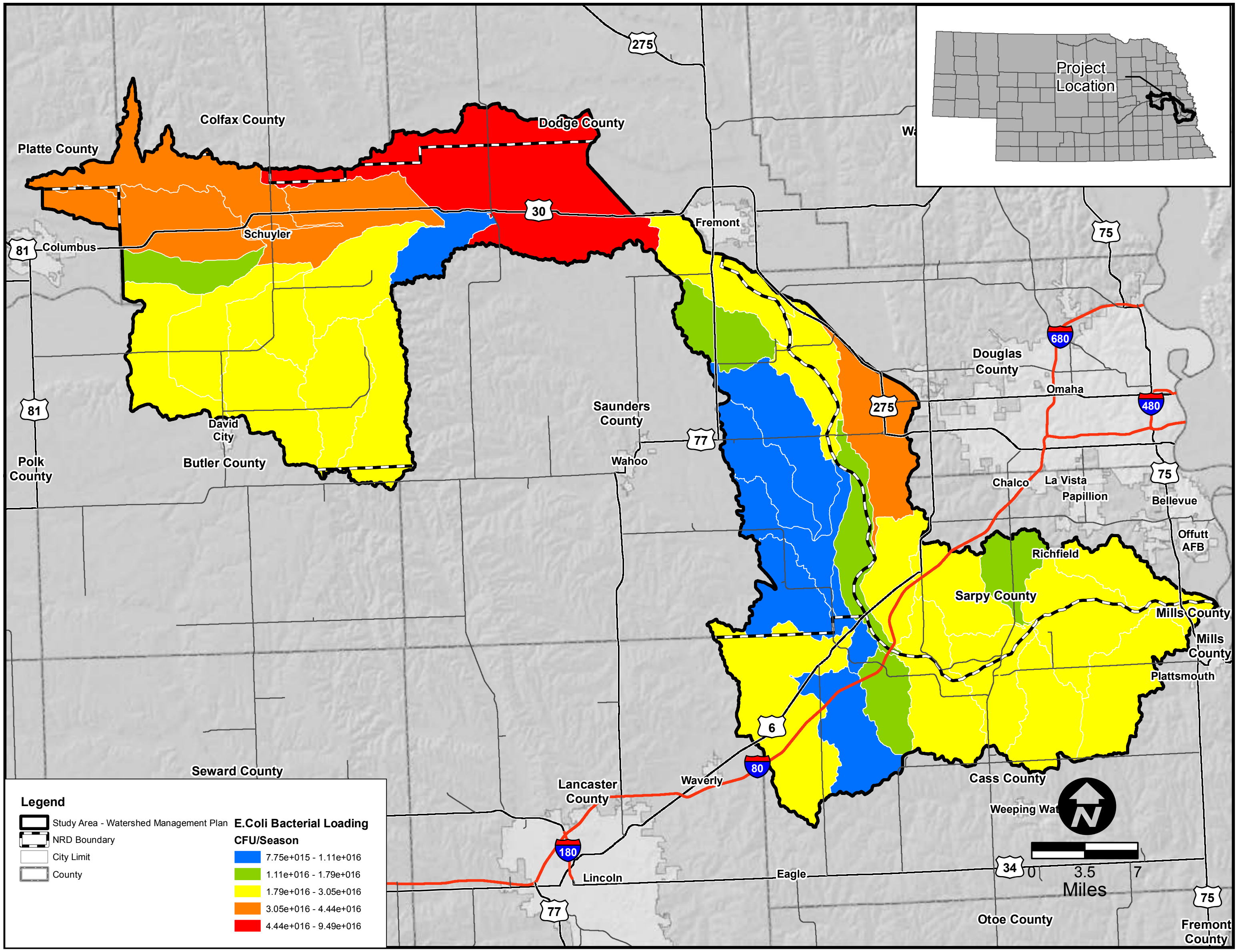
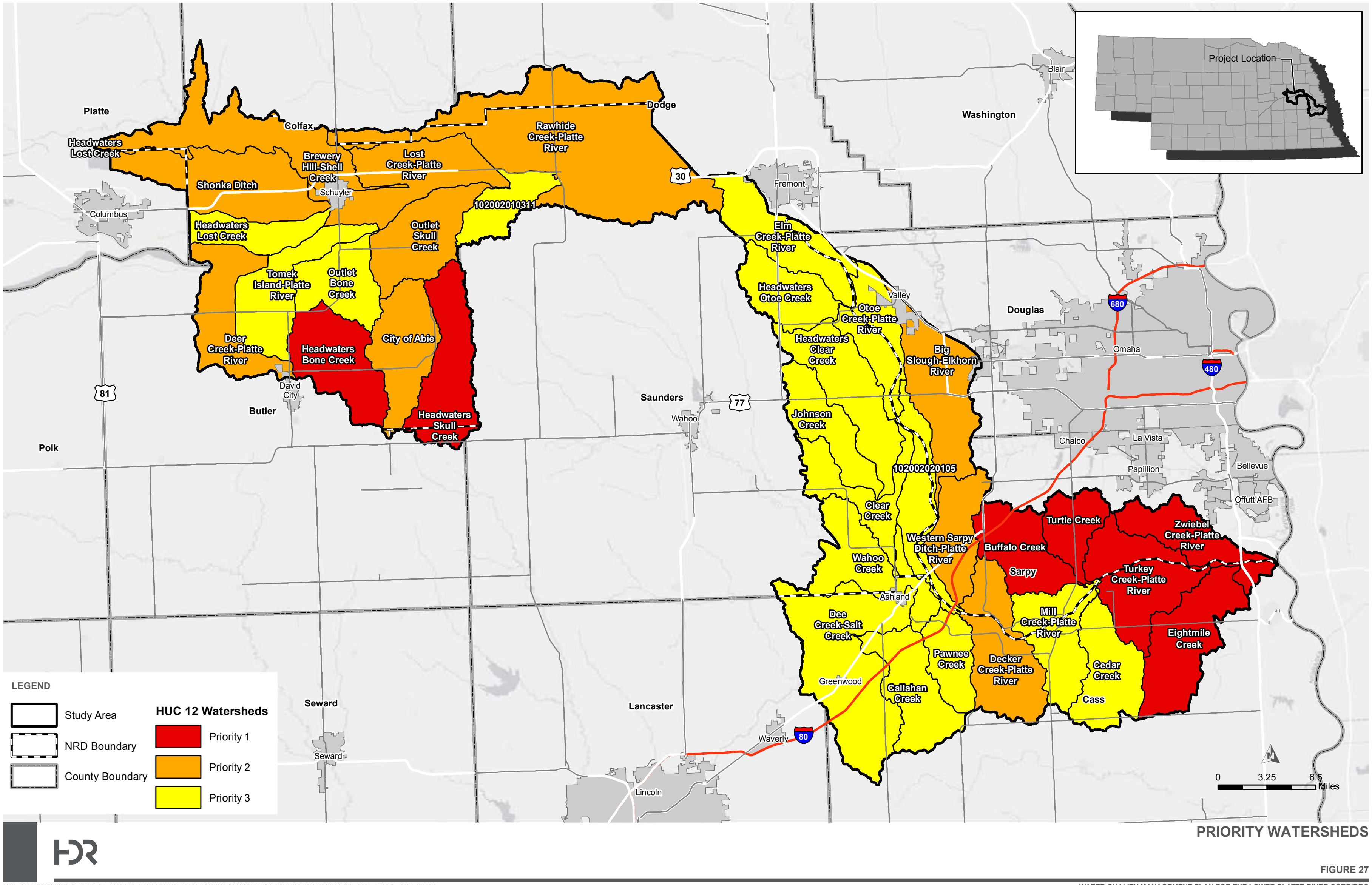


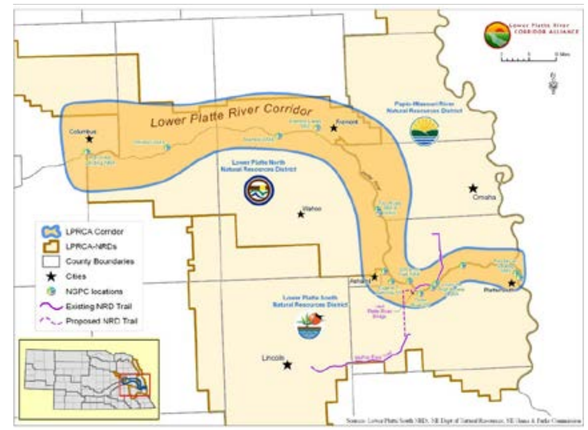
Figure ES-4. Priority Watersheds




Lower Platte River

BACKGROUND OF WATERSHED PLANNING EFFORTS

The Lower Platte River Corridor generally is defined as the 110 miles of the Lower Platte River, the bluffs, and adjoining public and private lands located within the floodplain of the Lower Platte River from Columbus, Nebraska, to the mouth of the river near Plattsmouth, Nebraska. The Lower Platte River Corridor dissects a portion of eight counties and 24 communities fall within its boundaries.



General corridor overview

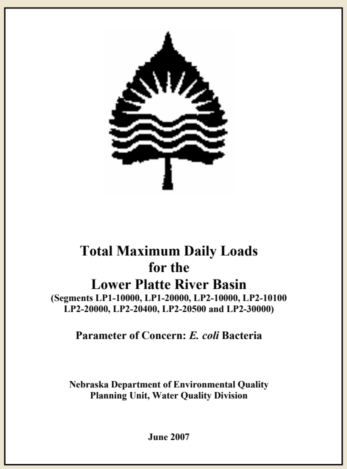
The history of watershed planning efforts in the corridor includes the Lower Platte River Corridor Alliance (LPRCA). The LPRCA included three Natural Resource Districts (NRDs) and six state agencies dedicated to protecting the long-term vitality of the Lower Platte River Corridor. The entities making up the LPRCA at the time this plan was developed were: Lower Platte North NRD (LPNNRD); Lower Platte South NRD (LPSNRD); Papio–Missouri River NRD (PMRNRD); Nebraska Game and Parks Commission (NGPC); Nebraska Department of Natural Resources (NDNR); Nebraska Department of Environmental Quality (NDEQ); Nebraska Military Department; Nebraska Department of Health and Human Services (DHHS); and University of Nebraska – Conservation and Survey Division, School of Natural Resources, and Nebraska Water Center.

LPRCA initiated the *Environmental Suitability Assessment (ESA)* to map existing environmental resources, to identify environmental considerations relative to development suitability, and to develop an environmental resources database to assist

DEQ 319 Program Summary

Under Section 319 of the federal Clean Water Act, the federal government awards funds to the Nebraska Department of Environmental Quality to provide financial assistance for the prevention and abatement of nonpoint source water pollution. This funding is passed through to units of government, educational institutions, and non-profit organizations, for projects that facilitate implementation of the state Nonpoint Source Management Plan.

In 2007, the NDEQ submitted a TMDL for approval by USEPA for *E. coli* under Section 303(d) of the Clean Water Act.


Total Maximum Daily Loads
for the
Lower Platte River Basin
(Segments LP1-10000, LP1-20000, LP2-10000, LP2-10100 LP2-20000, LP2-20400, LP2-20500 and LP2-30000)

Parameter of Concern: *E. coli* Bacteria

Nebraska Department of Environmental Quality
Planning Unit, Water Quality Division

June 2007

Environmental Suitability Assessment

local jurisdictions in making land use decisions. LPRCA partnered with the U.S. Army Corps of Engineers (USACE) on a *Cumulative Impacts Study* that classified and evaluated channel width and emergent sandbar habitat relationships on the Lower Platte River. All previous LPRCA publications, as well as a description of all of its activities unrelated to this water quality management plan, can be found on its website *(http://www.lowerplatte.org)*.

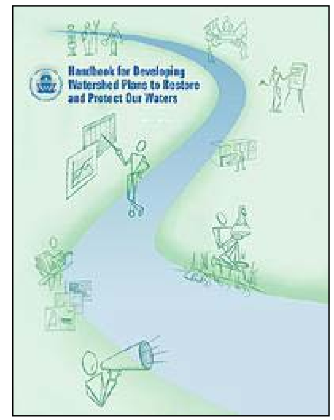
LPRCA and the participating NRDs recognize the need to develop a more complete watershed and water quality management plan. At this time, LPRCA has a strategic plan and several tools available to assist agencies and organizations in developing projects. However, this strategic plan has not formally been incorporated into a watershed plan, following the U.S. Environmental Protection Agency (USEPA) framework, until now.

In September 2012, LPRCA submitted a Nonpoint Source Pollution Management Project application for funding under the State's Nonpoint Source Water Quality (Section 319) Program. The watershed management portion of this study was funded allowing for the development of this study, the Lower Platte River Watershed – Water Quality Management Plan (Plan).

The focus of the Plan is to address the Total Maximum Daily Load (TMDL) for *E. coli* bacteria (*E. coli*) for the lower Platte River basin. In 2007, the NDEQ submitted a TMDL for approval by USEPA for *E. coli* under Section 303(d) of the Clean Water Act. The TMDL was approved by USEPA in September 2008. Designated uses of the lower Platte River include primary contact recreation; aquatic life (Warm water class A and B); agriculture; industrial water supply class A; and aesthetics (NDEQ 2006). Excessive *E. coli* has been determined to be impairing the primary contact recreation beneficial use. The applicable water quality criteria are a recreational season (May 1– September 30) 30 day geometric mean of 126 colony forming units (cfu)/100 mL for *E. coli*.

U.S. ENVIRONMENTAL PROTECTION AGENCY WATERSHED PLANNING PROCESS

By amendment to the federal Clean Water Act in 1987, the Section 319 grant program was established to provide funding for efforts to reduce nonpoint source (NPS) pollution, commonly referred to as stormwater runoff pollution. USEPA provides funds to state and Tribal agencies. States and Tribes then allocate funds through a competitive process to public and non-profit organizations to address current or potential NPS concerns. Funds may be used to demonstrate innovative best management practices (BMPs), support education and outreach programs, restore impaired streams or other water resources, or conduct NPS assessment or applied research. Nebraska's NPS management agency is NDEQ. NDEQ's Nonpoint Source Management Program provides Section 319 grants to local sponsors of eligible projects in the following five categories:



Handbook for Developing Watershed Plans to Restore and Protect Our Waters, 2008

1. Large competitive projects
2. Small projects assistance
3. Community lakes enhancement and restoration assistance
4. Urban runoff management assistance
5. Wellhead area management assistance

USEPA Section 319 guidelines establish nine elements to be used for developing an effective watershed plan for threatened and impaired waters. USEPA has provided guidance (Handbook for Developing Watershed Plans to Restore and Protect Our Waters, 2008. Those nine elements are:

1 Identify causes and sources of pollution

2 Estimate pollutant loading into the watershed and the expected load reductions

3 Describe management measures that will achieve load reductions and targeted critical areas

4 Develop an information/ education component

5 Develop a project schedule

6 Describe the interim, measurable milestones

7 Identify indicators to measure progress

8 Develop a monitoring component

9 Estimate amounts of technical and financial assistance and the relevant authorities needed to implement the plan

Throughout this document these elements will be noted with the USEPA symbol to highlight it as one of the recommended nine elements of an USEPA watershed plan.


Confluence of the Elkhorn and Lower Platte Rivers

LOWER PLATTE RIVER WATERSHED PLANNING APPROACH

Study Area

The first step to evaluate water quality in the Lower Platte River Corridor is to develop a Study Area.

To perform the required analysis, defined watersheds were required. Therefore, the Study Area for this Plan was based on complete HUC 8 watersheds where practicable (see **Figure 1**). The Plan Study Area is approximately 1,120 square miles in all of three HUC 8 watersheds (see **Table 1**). A portion of the Lower Elkhorn watershed was included due to the overall influence of the Elkhorn River to the Lower Platte River. This HUC 8 watershed was divided at the location of a NDEQ water quality monitoring location on the Elkhorn River downstream to the Elkhorn River's confluence with the Platte River.

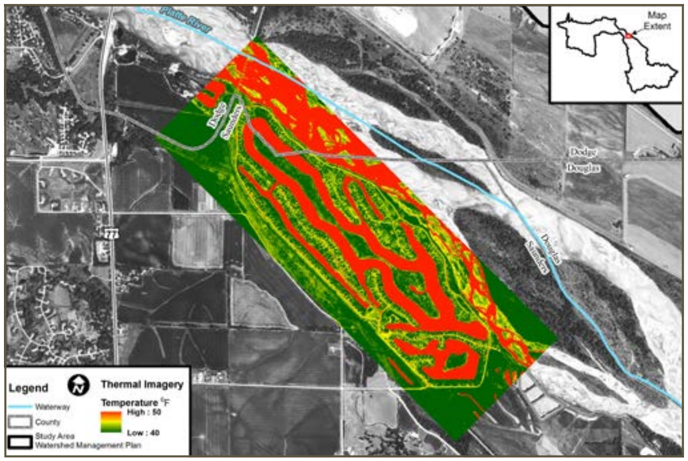
Table 1. Study Area Size Details

HUC 8 Name	Square Miles	Percent
Lower Platte – Shell	376.74	33.63
Lower Platte	498.93	44.53
Salt	205.68	18.36
Lower Elkhorn	38.97	3.48
Total	1120.32	100.00

Basis for Plan Development

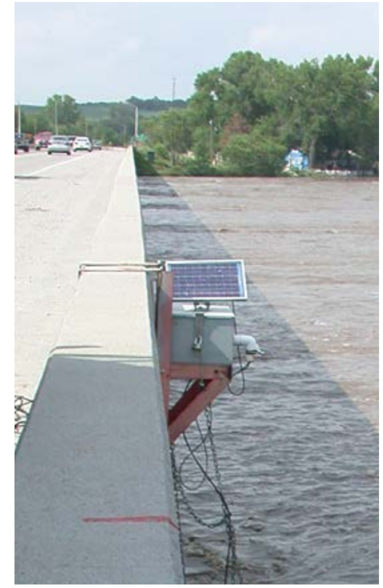
The Study Area for the Plan is larger than the typical size of the watershed evaluated as part of a Section 319 study (see **Figure 1** – Study Area). As a result, the overall intent of the Plan is to identify areas (that is, smaller watersheds with the Study Area, for example) that exhibit the best opportunities for either additional study for focus on *E. coli* load contra particular impairment, or for identification of projects for implementation.

For example, LPRCA partnered with the Center for Advanced Land Management Information Technologies (CALMIT), a unit of the University of Nebraska–Lincoln School of Natural Resources, regarding data gathering using hyperspectral remote sensing focused on observations of vegetation, surface water, and soils. CALMIT conducted flights in 2012 along the Lower Platte River and in three housing areas adjacent to the Platte River to attempt to identify warm water discharges that can indicate NPS pollution from the large number of on-site wastewater treatment systems or other conduits located along the river. Conducting the flights served as a proactive approach to identify those potentially failing systems rather than waiting until those deficiencies are identified through a complaint to NDEQ. As part of the Plan, this information could serve an important role in refinement of the Plan regarding NPS pollution in target watersheds that have been identified as key contributors of *E. coli* or other impairments. Identification and ultimately correction of these failing systems could serve in targeting potential sources of *E. coli* contributions to the Platte River.



CALMIT image identifying Platte River warm water discharges

In addition, LPRCA partnered with the United States Geological Survey (USGS) to provide real-time continuous monitoring of stream-flow characteristics and to increase the awareness and education of water contaminants in recreational waters. Five stream-gauging stations already exist in the lower Platte River basin: Shell Creek near Columbus, Nebraska; Elkhorn River at Waterloo, Nebraska; Salt Creek near Ashland, Nebraska; Platte River at Leshara; and the Platte River at Louisville, Nebraska (other seasonal stream gauges are available, but those were not used for this study). Data on discharge and water quality have already been collected for 2008 through 2015 at these sites. Funding is in place to continue to collect data for the Plan at all of these sites, except Shell Creek at Columbus, for the next three years. The Shell Creek site currently has funding for the remainder of 2016. The data will be analyzed to compare flow rate (that is, discharge) with water contaminant presence and equations will be developed showing the correlation. Generally, heavy rains lead to contaminated runoff in the recreational waterways. Ultimately, LPRCA and USGS have developed equations that "predict" contaminant loads for *E. coli*, phosphorus, nitrate/nitrite, and atrazine. The calculated or predictive values are displayed in tandem with the real-time continuous water quality data. The model has been available online for public use beginning in spring 2016.


Stream-gauging station for water quality monitoring

Impairments for Analysis

The Plan focuses on *E. coli* contributions to the lower Platte River. In addition, four other parameters were analyzed: sediment, total nitrogen, total phosphorus, and atrazine. The existing loads of *E. coli* as well as the other four parameters within the Study Area will be determined so that appropriate load reductions can be determined, based on BMPs to meet the desired goals and objectives set forth for the Plan.

Parameters for Analysis

E. coli bacteria

Members of two bacteria groups, coliforms and fecal streptococci, are used as indicators of possible sewage contamination because they are commonly found in human and animal feces. Although they are generally not harmful themselves, they indicate the possible presence of pathogenic (disease-causing) bacteria, viruses, and protozoans that also live in human and animal digestive systems. Therefore, their presence in streams suggests that pathogenic microorganisms might also be present and that swimming and eating shellfish might be a health risk. Since it is difficult, time-consuming, and expensive to test directly for the presence of a large variety of pathogens, water is usually tested for coliforms and fecal streptococci instead.

TSS–sediment

Total solids are dissolved solids plus suspended and settleable solids in water. In stream water, dissolved solids consist of calcium, chlorides, nitrate, phosphorus, iron, sulfur, and other ions particles that will pass through a filter with pores of around 2 microns (0.002 cm) in size. Suspended solids include silt and clay particles, plankton, algae, fine organic debris, and other particulate matter. These are particles that will not pass through a 2-micron filter. The analyses performed in this watershed plan attempt to characterize the sediment load but use the TSS measurements as the best available data to use as a surrogate.

Total Nitrogen

Nitrogen is an essential nutrient for plants and animals. However, an excess amount of nitrogen in a waterway may lead to low levels of dissolved oxygen and negatively alter various plant life and organisms. There are three forms of nitrogen that are commonly measured in water bodies: ammonia, nitrates and nitrites. Total nitrogen is the sum of total kjeldahl nitrogen (ammonia, organic and reduced nitrogen) and nitrate-nitrite. Total nitrogen can be determined as the sum of the total Kjeldahl nitrogen plus nitrate-N and nitrite-N. TN can also be measured by a high temperature persulfate digestion step that converts all of the nitrogen to nitrate, which is then measured by colorimetric or other method.

The most commonly tested fecal bacteria indicators are total coliforms, fecal coliforms, Escherichia coli, fecal streptococci, and enterococci. All but *E. coli* are composed of a number of species of bacteria that share common characteristics such as shape, habitat, or behavior; *E. coli* is a single species in the fecal coliform group. Nebraska state bacteria water quality standards are based on concentrations of *E. coli*.

Total Phosphorus

Phosphorus is an essential nutrient for plants and animals. However, an excess amount of phosphorus in a waterway may lead to low levels of dissolved oxygen and negatively alter various plant life and organisms. Pure, "elemental" phosphorus (P) is rare. In nature, phosphorus usually exists as part of a phosphate molecule (P04). Phosphorus in aquatic systems occurs as organic phosphate and inorganic phosphate. Organic phosphate consists of a phosphate molecule associated with a carbon-based molecule, as in plant or animal tissue. Phosphate that is not associated with organic material is inorganic. Inorganic phosphorus is the form required by plants. Animals can use either organic or inorganic phosphate. Both organic and inorganic phosphorus can either be dissolved in the water or suspended (attached to particles in the water column).

Atrazine

Atrazine is a white, crystalline solid organic compound. One of the most widely used agricultural pesticides in the U.S., atrazine may be applied before and after planting to control broadleaf and grassy weeds. It is used primarily on corn, sorghum, and sugarcane, and is applied most heavily in the Midwest. Atrazine is used to a lesser extent on residential lawns.

Stakeholder Involvement

Stakeholder participation in the development of a watershed management plan is essential for the following reasons:

- Obtain input on the conditions of the watershed
- Obtain input on existing BMPs
- Formulate obtainable goals and objectives
- Obtain input on implementation

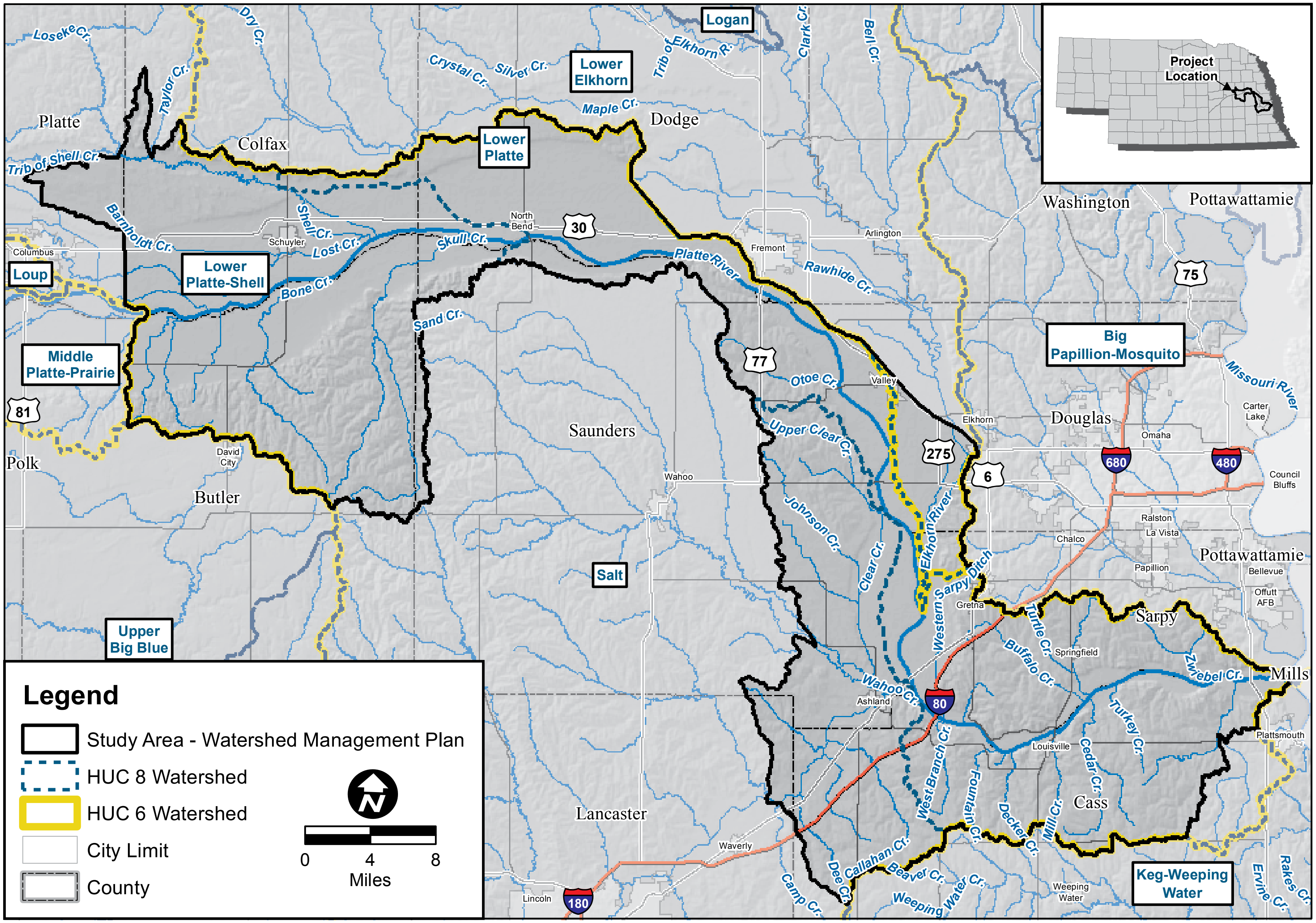
Due to the large size of the Plan Study Area and the overall basis for the Plan development, stakeholder involvement is being addressed through a technical advisory group. The technical advisory group was formulated based on input from the technical staff at the participating NRDs, NDEQ, and other state agencies. Stakeholder input in this fashion was obtained through stakeholder meetings at key points in the Plan development as well as at regularly scheduled LPRCA meetings. The following meetings were held:

- **April 4, 2013** – Stakeholders were asked to provide input on primary goals of the Plan and input on watershed characterization
- **April 23, 2013** – Provided an overview of the stakeholder input meeting and described the planning process for the Plan at LPRCA quarterly meeting
- **August 8, 2013** – Provided an update on the status of pollutant loads within the Study Area at LPRCA quarterly meeting
- **October 29, 2013** – Provided an update of pollutant load analysis at LPRCA quarterly meeting
- **November 13, 2013** – Finalized goals and objectives, pollutant load targets, and BMPs for implementation
- **January 21, 2014** – Presented the draft Plan at LPRCA quarterly meeting

Technical Advisory Group organization participants:

- *Lower Platte North Natural Resources District*
- *Lower Platte South Natural Resources District*
- *Papio-Missouri River Natural Resources District*
- *Nebraska Department of Natural Resources*
- *Nebraska Department of Environmental Quality*
- *Nebraska Game and Parks Commission*
- *Nebraska Army National Guard*
- *Nebraska Department of Health and Human Services*
- *University of Nebraska–Lincoln*

Figure 1. Study Area




Confluence of the Platte and Loup Rivers

This section generally characterizes the natural resources, data sources used for the identification of impairments, data gaps, and pollutant loads and sources of the Study Area (see **Figure 1** for the Plan Study Area).

WATERSHED RESOURCES

Physical Setting

TOPOGRAPHY

The Platte River in eastern Nebraska flows through a broad valley that progressively narrows as it extends downstream, funneling into the Missouri River near La Platte, Nebraska. The Platte River below Salt Creek has less variation in channel width, greater sinuosity, and deeper flow than in its upstream segments bounded by its confluences with the Loup and Elkhorn rivers (Alexander et al. 2013).

HYDROLOGY

Surface Water – There are three main watersheds that contribute to the lower Platte River (not including the central Platte River). The following describes these three watersheds

Loup River – The Loup River watershed encompasses approximately 15,200 square miles of central Nebraska, accounting for nearly one fifth of the state's total land area (Nebraska Department of Environmental Quality [NDEQ] December 2005). The Loup River watershed originates in Sheridan County, Nebraska, and flows approximately 260 miles to Platte County, Nebraska, and the confluence with the Platte River (Nebraska Department of Natural Resources [NDNR 1975], as cited in NDEQ December 2005). The Loup River is composed of three main branches, the North Loup, Middle Loup, and South Loup rivers, which all originate in north central Nebraska and flow generally east to southeast. The North Loup and Middle Loup rivers flow through the Sandhills region and primarily are fed by groundwater springs from the Ogallala Aquifer. The South Loup River flows through an area of loess hills and receives most of its flows from rainfall runoff (Fowler

June 2005). The South Loup River joins with the Middle Loup River just east of Boelus, Nebraska, and the Middle Loup and North Loup rivers combine to form the Loup River northeast of St. Paul, Nebraska. The Loup River then joins the Platte River southeast of Columbus, Nebraska. The Loup River has a confluence with the lower Platte River near Columbus (see **Figure 2**).

Elkhorn River – The Elkhorn River drains approximately 7,000 square miles, and flows east to southeast through the glaciated rolling hills of northeast Nebraska to its confluence with the Platte River approximately 20 miles downstream from Fremont, Nebraska. Surface water use in the Elkhorn River watershed includes irrigation, livestock, and recreation (Dietsch et al. 2009). Streamflows in the Loup and Elkhorn rivers are substantially affected by groundwater seepage, which provides a steady base flow to the lower Platte River even during dry periods. Neither the Loup River nor the Elkhorn River has large, main-channel flood-control dams or reservoirs; therefore, mean annual discharge and instantaneous annual maximum discharge have been affected less in the lower Platte River upstream of its confluence with the Loup River (Alexander et al. 2013). Major tributaries to the Elkhorn River include the South Fork, North Fork, and Logan and Maple creeks (see **Figure 3**).

Salt Creek – Salt Creek drains approximately 1,650 square miles, and flows north to northeast in southeast Nebraska. Its confluence with the Platte River is approximately 7 miles downstream of the confluence of the Platte and Elkhorn rivers (Dietsch et al. 2009). Salt Creek has its source in the southwest corner of Lancaster County, Nebraska, which is 20 miles southwest of Lincoln, Nebraska. Salt Creek's two uppermost branches, Olive Branch and Hickman Branch, join near Roca, Nebraska, to form the main stream. South of Lincoln, Salt Creek is fed by several freshwater streams, but tributaries from the west and north carry saline waters. Approximately 13 miles northeast of Lincoln, below the mouth of Rock Creek (a mildly saline tributary), more freshwater streams flow into Salt Creek before its confluence with the Platte River east of Ashland, Nebraska. Salt Creek is an anomaly among Nebraska streams in that it flows principally to the northeast (see **Figure 4**).

The saline tributaries that gave Salt Creek its name share a common characteristic, their waters originate from, or flow through, Dakota sandstone, the only underlying rock

Confluence of the Platte River and Salt Creek

formation naturally exposed in the region. For the most part, this porous, rust colored, ferruginous sandstone is soft, crumbles under little pressure, and weathers quickly. The ultimate source of the saline waters, though, lies deeper, in ancient shales laid down in Cretaceous times, the Age of Reptiles, approximately 70 to 160 million years ago, when much of central North America was covered by a vast inland sea (Farrar and Gersib 1991).

Groundwater – Groundwater resources in the Study Area vary relative to abundance and quality. While surface water quality has limited impact on groundwater quality, this relationship is still an important factor within the Study Area.

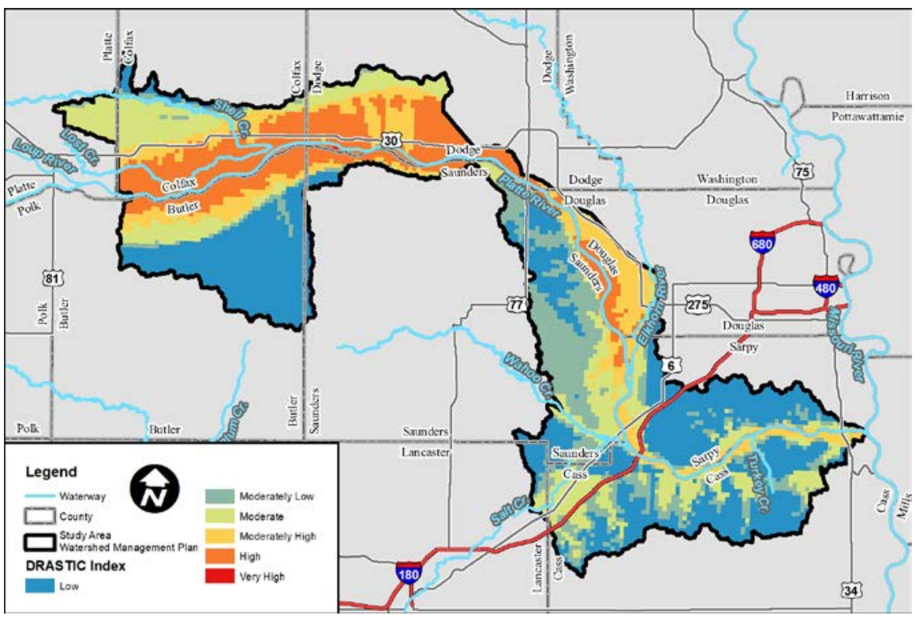
The majority of the Study Area is within the Platte River aquifer and is composed of alluvial sand, gravel, and silt deposited by glacial action. The aquifer is unconfined and hydraulically connected with the Platte River with the largest source of water to the aquifer coming from vertical recharge (NDNR 2013). The depth to water from land surfaces can vary from 0 feet to more than 200 feet (NDEQ 2013), depending on topography. The groundwater in this area is highly variable in quantity and quality.

Surface water and groundwater relationships are important particularly to Nebraskans in two major instances. First, more than one third of the public water supply for the Omaha Metropolitan Area and all of the public water supply for Lincoln, (that is, Nebraska's two largest cities) comes from well fields in close proximity to the Platte River. In addition, many other communities, like Columbus, Fremont, and Valley, depend on the Platte

River for public water supply. Many rural residents also depend on this water supply. A total of approximately 8,850 registered wells are registered within the Study Area (NDNR 2014). Because of this, prevention of contamination of groundwater resources is of great importance in the Study Area.

The USEPA developed a method to evaluation the pollution potential of groundwater called DRASTIC. DRASTIC incorporates factors that control groundwater movement: Depth to water, net Recharge, Aquifer media, Soil media, Topography, Impact of the vadose zone media, and hydraulic Conductivity of the aquifer (USEPA 1987). These factors are used to develop a ranking scheme, which then can be illustrated in colors (green, being low rank, through red, being high ranked). The colors can then be portrayed on a map. As indicated in the graphic below, there is a wide range of values in the Study Area.

Secondly, Nebraska's 23 Natural Resources Districts (NRDs) play a major role in groundwater quantity and quality management, primarily through the Groundwater Management and Protection Act. This act (first adapted in 1985) has provisions related to



the integrated management of hydrologically connected groundwater and surface water. This management practice, termed Conjunctive Use, is the coordinated management of surface water and groundwater supplies to maximize the yield of the overall water resource. The lower Platte River basin is not currently fully appropriated based on the Nebraska Department of Natural Resources' 2014 Annual Evaluation of Availability of Hydrologically Connected Water Supplies

ECOREGIONS

Ecoregions are designed to serve as a spatial framework for the research assessment and monitoring of ecosystems and ecosystem components. Ecoregions denote areas within which ecosystems (and the type, quality, and quantity of environmental resources) generally are similar. By recognizing the spatial differences in the capacities and potentials of ecosystems, ecoregions stratify the environment by its probable response to disturbance (Bryce et al. 1999). These general purpose regions are critical for structuring and implementing ecosystem management strategies across federal agencies, state agencies, and nongovernmental organizations that are responsible for different types of resources within the same geographical areas (Omernik et al. 2000; McMahon et al. 2001).

The Study Area contains two U.S. Environmental Protection Agency (USEPA) Level III and seven USEPA Level IV Ecoregions (see **Figure 5**):

- **Central Great Plains (Level III)** – The Central Great Plains is slightly lower, receive more precipitation, and are somewhat more irregular than the High Plains to the west. The Central Great Plains were once grassland, with scattered low trees and shrubs in the south, but much of this ecoregion is now cropland; the eastern boundary of the region marks the eastern limits of the major winter wheat growing area of the United States. Subsurface salt deposits and leaching contribute to high salinity found in some streams.
  - » **Rainwater Basin Plains (Level IV)** – Found in the extreme southwest corner of the Study Area, the flat to rolling loess-covered plains of the Rainwater Basin Plains encompassed one of the largest concentrations of natural wetlands found in Nebraska. Surface water drainage in this ecoregion is poorly developed, resulting in numerous closed watersheds that drain into low depressional areas. Located in the North American Central Flyway, this ecoregion contains important wetland

habitat used during waterfowl migration. Most of the wetlands have been drained for cultivation and now relatively few areas remain. In addition, cropland agriculture practices and extensive irrigation have contributed to problems with groundwater contamination and major changes in groundwater level.

  - **Platte River Valley (Level IV)** – The Platte River Valley ecoregion is a flat, wide alluvial valley with shallow, braided stream channels on a sandy bed; a contrast to the dissected loess-covered plains of neighboring ecoregions. The alluvial sand and silty soils support cultivated cropland with much of it in center pivot irrigation. Historically, seasonal flooding would scour the valley, inhibiting any significant growth of hardwood riparian vegetation, creating sandbar habitat important to many migrating and nesting bird species. Today, with flood control and extensive water withdrawal for irrigation, most of the former river channel is occupied by hardwood trees.

- **Western Corn Belt Plains** – Once mostly covered with tallgrass prairie, more than 80% of the Western Corn Belt Plains is now used for cropland agriculture and much of the remainder is in forage for livestock. A combination of nearly level to gently rolling glaciated till plains and hilly loess plains, an average annual precipitation of 26 to 37 inches, which occurs mainly in the growing season, and fertile, warm, moist soils make this one of the most productive areas of corn and soybeans in the world. Agricultural practices have contributed to environmental issues, including surface and groundwater contamination from fertilizer and pesticide applications, as well as concentrated livestock production.
  - **Missouri Alluvial Plains (Level IV)** – A very small area on the extreme eastern end of the Study Area is within this ecoregion. This ecoregion is a part of the large, wide, alluvial valley found in neighboring Iowa and Missouri. The generally level alluvial plain is distinct from the more irregular topography of adjacent ecoregions. Soils are deep, silty, clayey, and sandy alluvium. They support extensive cropland, some of it irrigated. Historically, the river was meandering, free flowing, and spread across the floodplain. Dams, levees, and stream channelization have profoundly altered the structure and characteristics of the river valley.
  - **Nebraska and Kansas Loess Hills (Level IV)** – A predominant ecoregion in the Study Area, the greater relief and deep loess hills of the Nebraska and Kansas Loess Hills are markedly different from the flat alluvial valley of neighboring Missouri Alluvial Plains. Dissected hills with deep, silty, well-drained soils support a potential natural vegetation of tallgrass prairie with scattered oak and 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.
  - **Loess and Glacial Drift Hills (Level IV)** – Existing in the corner of the southern and western most corner of the Study Area, the Loess and Glacial Drift Hills are characterized by low, rolling loess-covered hills with areas of exposed glacial till. Loess deposits generally are thinner and there is less oak and hickory forest and more extensive tallgrass prairie than found in the Nebraska and Kansas Loess Hills ecoregion. The flatter 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.
  - **Lower Platte Alluvial Plains (Level IV)** – The Lower Platte Alluvial Plains occurs in the historic floodplain of the Platte River and is an extension of the broad Platte River Valley to the west; however, this ecoregion is within the Western Corn Belt Plains and contains a combination of vegetation, soils, and climate more similar to other areas in its Level III ecoregion. Silty, loamy, and sandy soils are formed from alluvium, though not as sandy as the Platte River Valley to the west. Land use mainly is cropland with areas of irrigated agriculture. Tallgrass prairie, wet meadows, and scattered riparian forests are the potential natural vegetation of the area, with forests generally denser and older than in the Platte River Valley ecoregion.
  - **Northeastern Nebraska Loess Hills (Level IV)** – The Northeastern Nebraska Loess Hills occurs in the extreme northwest portion of the Study Area. This ecoregion is not as weathered as ecoregions to the south. The climate generally is cooler with slightly less annual precipitation than in southern glaciated areas. Cropland agriculture, especially corn, is common and there is more irrigated agriculture and pastureland, but fewer scattered woodlands than in neighboring Western Corn Belt Plains ecoregions.

WATERSHED SOILS

Due to the large size of the Study Area, multiple soil types are present (see **Figure 6**). **Table 2** is a summary of the major soils that are within the Study Area. The U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) maintains a searchable online database (USDA NRCS 2013).

Table 2. Soil Descriptions

Soil Name	Description
Alda fine sandy loam, occasionally flooded	The Alda series consists of very deep, somewhat poorly drained or moderately well drained soils that formed in 20 to 40 inches of stratified loamy alluvium over coarse sand or gravelly sand on flood plains. These soils are moderately deep over coarse sand or gravelly sand and have slope ranging from 0 to 3%. Mean annual temperature is 11 degrees Celsius (°C) (that is, 51 degrees Fahrenheit [°F]), and the mean annual precipitation is 64 centimeters (that is, 25 inches).
Barney silty clay loam, frequently flooded	The Barney series consists of very deep, poorly drained and very poorly drained soils formed in stratified loamy material deposited over sandy and gravelly alluvium on flood plains along major streams. Permeability is rapid or very rapid below the loamy material. Slope ranges from 0 to 2%. Mean annual temperature is approximately 51°F and mean annual precipitation is approximately 23 inches.
Blendon–Muir complex, 0 to 2% slopes	The Blendon series consists of very deep, well drained soils formed in sandy glacial sediments or eolian sediments on terraces and alluvial fans. Permeability is moderate or moderately rapid through the solum and moderately rapid or rapid in the underlying material. Slopes range from 0 to 6% slopes. Mean annual temperature is approximately 46°F and mean annual precipitation is approximately 20 inches. The Muir series consists of very deep, well drained, moderately permeable soils that formed in alluvium. Slopes range from 0 to 7%. Mean annual temperature is approximately 13°C (that is, 55°F) and mean annual precipitation is approximately 76 centimeters (that is, 30 inches).
Contrary–Monona–Ida complex, 6 to 17% slopes	The Contrary series consists of very deep, well drained soils formed in deoxidized and leached Wisconsin-age loess. These soils are on moderately sloping and strongly sloping side slopes, head slopes, nose slopes, and tops of lowered interfluves on dissected till plains. Slopes range from 5 to 14%. Mean annual temperature is approximately 11°C (that is, 52°F) and mean annual precipitation is approximately 86 centimeters (that is, 34 inches). The Ida series consists of very deep, well drained soils formed in calcareous loess. These soils are on side slopes and crests on dissected till plains and on risers on stream terraces. Slopes range from 2 to 60%. Mean annual temperature is approximately 9°C (that is, 49°F) and mean annual precipitation is approximately 74 centimeters (that is, 29 inches).
Gibbon silty clay loam, occasionally flooded	The Gibbon series consists of very deep, somewhat poorly drained soils that formed in stratified, calcareous alluvium. These soils are on flood plains in river valleys of Central Loess Plains, MLRA 75. Slopes range from 0 to 2%. Mean annual temperature is approximately 12°C (that is, 53°F) and mean annual precipitation is approximately 69 centimeters (that is, 27 inches) at the type location.
Gibbon–Wann complex, occasionally flooded	The Wann series includes very deep, somewhat poorly drained soils formed in stratified calcareous alluvium. These soils are on flood plains in river valleys in Central Loess Plains, MLRA 75. Slope ranges 0 to 2%. Mean annual temperature is approximately 11°C (that is, 51°F) and mean annual precipitation is approximately 64 centimeters (that is, 25 inches) at the type location.
Monona silt loam, 17 to 30% slopes	The Monona series consists of very deep, well drained soils formed in loess. These soils are on interfluves and side slopes on dissected till plains and risers and treads on loess covered stream terraces. Slopes range from 0 to 40%. Mean annual temperature is approximately 10°C (that is, 50°F) and mean annual precipitation is approximately 71 centimeters (that is, 29 inches).

Table 2. Soil Descriptions (continued)

Soil Name	Description
Platte–Barney complex, occasionally flooded	The Platte series consists of soils that are shallow over coarse sand to gravelly coarse sand. They are somewhat poorly drained soils. They formed in sandy and loamy alluvium deposited over coarse sand or gravelly sand on river valley flood plains. Slopes range from 0 to 2%. Mean annual temperature is approximately 11°C (that is, 51°F) and mean annual precipitation is approximately 64 centimeters (that is, 25 inches) at the type location.
Platte fine sandy loam, occasionally flooded	See Platte–Barney complex description above for Platte series description.
Platte–Inavale complex, channeled, occasionally flooded	The Inavale series consists of very deep, excessively drained, rapidly permeable soils formed in sandy alluvium on flood plains in river valleys of the Rolling Plains and Breaks, MLRA 73. Slopes range from 0 to 11%. Mean annual temperature is approximately 12°C (that is, 54°F) and mean annual precipitation is approximately 66 centimeters (that is, 26 inches) at the type location.
Wann fine sandy loam, occasionally flooded	See Gibbon–Wann complex description above for Wann series description.

CLIMATE

The average temperature of the lower Platte River valley, based on a 30-year average of data, ranges from 48 degrees Fahrenheit (°F) to 52°F. Between September 2012 and August 2013, the valley received between 24 and 30 inches of precipitation. Based on 30-year average of data, the valley typically receives between 25 and 35 inches of precipitation per year. A percentage of that precipitation comes from the 20 to 40 inches of annual snowfall. Typically, the last spring freeze, at 32°F, occurs the third week of April and the first fall freeze, at 32°F, occurs the first week of October (High Plains Regional Climate Center 2013). The lower Platte River Valley has been in a moderate to extreme drought since July 10, 2012, to date (September 2013) (U.S. Drought Monitor 2013).


Fall colors on the Platte River

Land Uses

Existing land use is used for this Study is from the 2005 University of Nebraska –Lincoln. Existing land use was developed by using multi-date 2005 Landsat 5 Thematic Mapper satellite imagery to determine land use classes (see **Figure 7**).

AGRICULTURE, RANGE, PASTURE, GRASSLAND

Today, thousands of acres in the lower Platte River corridor are irrigated and considered prime agricultural land, selling in excess of $2,500 per acre. Much of the area is cultivated with corn and soybeans, except in the less productive and saline soils where grain sorghum typically is grown. Grazing lands are found in the uplands and the valley bottoms. Beef cow and calf and swine production is prominent on family farm operations scattered throughout the area.


Agriculture and grasslands


Urban, residential and recreation


Wetlands, islands and open water


Riparian forest and woodlands


Sand and gravel mining


Recreation

URBAN LAND: COMMERCIAL AND RESIDENTIAL

The lower Platte River corridor offers a host of characteristics that tend to attract housing developments, such as natural and scenic qualities; recreational opportunities; tourist attractions; accessibility; and close proximity to Nebraska's major metropolitan areas.

Counties and municipalities in the lower Platte River corridor have a variety of planning and zoning regulations to guide land use. The Lower Platte River Corridor Alliance (LPRCA) is attempting to coordinate the land use plans throughout the Corridor.

Development in floodways or floodplains, wastewater management, drinking water and water quality, compatibility with surrounding land uses, and adequate infrastructure are common land use concerns within the corridor.

WETLANDS AND OPEN WATER

Many types of wetlands occur within the lower Platte River corridor. Wetlands closer to the river are riverine wetlands, freshwater ponds, and lakes (which can be products of sand and gravel mining). Freshwater emergent (that is, herbaceous vegetation), freshwater scrub-shrub, and freshwater forested wetlands all occur within the corridor (U.S. Fish and Wildlife Service [USFWS] 2013).

RIPARIAN FOREST AND WOODLANDS

Riparian forests are natural or re-established woodlands next to streams, lakes, and wetlands. Riparian forests serve a water quality improvement function, because they intercept sediment, nutrients, pesticides, and other materials in surface runoff and in shallow subsurface water flow, so those materials do not enter streams, lakes, or wetlands.

SAND AND GRAVEL MINING

The aggregate (that is, sand and gravel) industry has several existing facilities in the lower Platte River corridor. These facilities primarily are owned and operated by three corporations:

- Lyman-Richey Sand and Gravel Company
- Western Sand and Gravel (NEBCO, Inc.)
- Mallard Sand and Gravel (Oldcastle Minerals)

Lied Platte River Bridge

RECREATION AND PUBLIC LANDS

Known as the Platte River Playground, the lower Platte River corridor is a frequent recreation destination for more than 50% of the state's population. Activities include camping, fishing, hunting, hiking, driving, biking, jogging, swimming, canoeing, boating, wildlife watching, and picnicking (see **Figure 8** for locations of state recreation opportunities).

More than 3 million people visit the parks and recreational areas within the corridor each year, generating more than $30 million in annual income for the state.

LPRCA works to promote and enhance a wide array of activities such as the recent development of the Platte River Connection trail system between Omaha and Lincoln, including the rehabilitation of a former railroad bridge for use as a river crossing and fishing pier.

WELLHEAD PROTECTION AREAS AND WELL FIELDS

The Wellhead Protection Program is a voluntary program that assists communities and other public water suppliers in preventing contamination of their water supplies. Wellhead Protection Program activities include delineating the zones of influence that may impact public supply wells, training communities on how to inventory all potential sources of pollution within these vulnerable zones, working with the local officials to identify options to manage these potential pollution sources, working on monitoring plans, and helping develop contingency plans to provide alternate water supplies and site new wells. There are several existing Wellhead Protection Areas within the Study Area (see **Figure 9**).

Multiple well fields and supply wells occur within the Study Area. These include the Metropolitan Utilities District (MUD) Platte West well field, the Lincoln Water System (LWS) well field near Ashland, Nebraska, and the local village and city water supply wells.

MEAD CONTAMINATION PLUME

The Former Nebraska Ordinance Plant (FNOP) site occupies approximately 17,520 acres located 0.5 mile south of Mead, Nebraska, in Saunders County. Groundwater contaminants in the form of explosives (associated with loading, assembling, and packing of munitions at four bomb load lines) and chlorinated solvents (associated with Atlas missile activities), underlie portions of the FNOP site. These groundwater contaminants are contained on site by a battery of pumping wells, maintained by the U.S. Army Corps of Engineers (USACE).

Demographic Summary

More than 60% of the state's population lives within 30 miles of the lower Platte River corridor, including the three largest cites—Bellevue, Lincoln, and Omaha. Along with the incorporated municipalities, several housing developments are located in and along the corridor.

Full and partial body contact recreation is popular on the lower Platte River and includes fishing, swimming, wading, tubing, paddling activities, and other boating, such as airboating. The river within the corridor has been identified as a canoe trail by the

Nebraska Game and Parks Commission (NGPC), which advertises several access points for public users.

Fish and Wildlife Resources

The lower Platte River and its accompanying wetlands provide important habitat and nesting sites for a variety of waterfowl. In recent years, an average of 46 bald eagles has wintered here. In addition, endangered peregrine falcons are attracted to the area during migration due to its large amount of shorebird and waterfowl prey.

Remnants of oak woodlands and oak and hickory forests blanket the river's bluffs and provide year-round and migratory homes for a variety of birds. Cottonwoods in the floodplain provide habitat for a broad range of birds as well as mammals, reptiles, and insects.

Freshwater marsh areas provide habitat for beaver, mink, waterfowl, wading birds, and many other species. The river's significant spring flows, ice, and sediment are the basis for sandbar formation—a critical habitat for the endangered interior least tern and the threatened piping plover.

Highly varied river flows account for a great diversity of habitats and fish species. Since 1987, approximately 48 fish species, including the federally endangered pallid sturgeon, have been documented in the lower Platte River.

Studies done on angler use, angler interest, and economic values of fishing in the lower Platte River found that anglers fished an average of 41 days a year on the river and were most affected by water quality, water quantity, and the presence of natural beauty.

Threatened and Endangered Species

The lower Platte River and portions of the corridor have been deemed to be suitable habitat for three federally listed threatened and endangered species: interior least tern *(Sternula antillarum athalassos)*; piping plover *(Charadrius melodus);* and pallid sturgeon *(Scaphirhynchus albus)*. It should be noted, adjacent water bodies (that is, borrow pits) have been utilized by interior least terns and piping plovers when the river conditions are unsuitable (for example, high water). The state-listed river otter *(Lontra canadensis)* also can be found in the lower Platte River corridor.


Bald eagle

© USFWS/John and Karen Hollingsworth


Soft-shell turtles


Interior least tern

© Nebraska Game and Parks Commission.


Oak and hickory trees


Pallid sturgeon

Photo by Ken Bouc. © Nebraska Game and Parks Commission.


Piping plover with eggs

Photo courtesy of the Tern and Plover Conservation Partnership.

Surface Water Quality

REGULATORY BACKGROUND

NEBRASKA SURFACE WATER QUALITY STANDARDS

The lower Platte River making up the corridor is split into two segments (that is, LP1–10000 and LP1–20000) within Title 117 – Nebraska Surface Water Quality Standards. Both segments are considered to be Warmwater Aquatic Life Class A streams and are assigned the Public and Agriculture Water Supply, Primary Contact Recreation and Aesthetic beneficial uses.

The lower Platte River, because of the beneficial uses assigned to it, must meet certain narrative and numerical water quality criteria. The aesthetic narrative criteria are:

> *…waters shall be free from human-induced pollution which causes:*
>
> *1) noxious odors; 2) floating, suspended, colloidal, or settleable materials that produce objectionable films, colors, turbidity, or deposits; and 3) the occurrence of undesirable or nuisance aquatic life (e.g., algal blooms). Surface waters shall also be free of junk, refuse, and discarded dead animals*

USEPA uses *E. coli* bacteria (*E. coli*) and enterococcus as indicators of fecal contamination of receiving waters, with recommended for use in freshwater environments. These fecal indicator bacteria are present in the intestines of warm-blooded animals and are easier to identify and enumerate in water quality samples than the broad range of pathogens in human and animal feces. Presence of the *E. coli* subgroup indicates that some degree of fecal contamination to the stream has occurred and that water quality conditions may pose increased risk to human health for those swimming or recreating in a water body. The geometric mean standard of 126 colony-forming unit (cfu)/100 mL of *E. coli* is based on an accepted risk level of 8 swimmer illnesses per 1,000 exposures.

The 2016 Nebraska Water Quality Integrated Report prepared by NDEQ identified both segments of the lower Platte River as impaired. Segment LP1–10000 is identified as impaired for aquatic life due to selenium and for a fish consumption advisory. LP1–20000 is identified as impaired for recreation due to *E. coli* (NDEQ, 2016).

E. coli Total Maximum Daily Loads (TMDLs) developed for segment LP1–10000 and LP1–20000 were approved by USEPA Region 7 in 2007 (NDEQ 2007). Reductions identified in the TMDL as necessary to achieve the water quality criteria for segments LP1–10000 and LP1–20000 are 64% and 85%, respectively. The TMDLs indicate a combination of point and nonpoint sources contribute to the recreational use impairment due to *E. coli*. Subsequent to issuance of the TMDL, NDEQ determined that segment LP1-10000 is supportive of recreational uses based on *E. coli* data collected in 2009 (NDEQ 2016).

The lower Platte River has been assigned the public drinking water supply beneficial use and more than 50% of state's population relies on the river for drinking water.

EXISTING SURFACE WATER QUALITY DATA

Water quality data come from several sources. The majority of data comes from the U.S. Geological Survey (USGS) and NDEQ whose stations have data going back more than 10 years in some cases and are sampled consistently every year. USGS has gauge stations along the lower Platte River and at the major tributaries to the Platte River including the Loup River, Shell Creek, Elkhorn River, and Salt Creek. NDEQ has gauge stations along the lower Platte River and at the same major tributaries.

Water Quality Monitoring Network

The LPRCA and United States Geological Survey (USGS) have partnered to collect and present real-time water quality data within the lower Plate River Corridor. This project is conducted by continuous monitoring of stream-flow characteristics, and increasing the awareness and education of water contaminants in recreational waters. Four stream-gauging stations already exist in the lower Platte River basin: Shell Creek near Columbus, Elkhorn River at Waterloo, Salt Creek near Ashland, and the Platte River at Louisville. Data on discharge and water quality have already been collected for the years 2008–2010 at these sites *(LPR WQ-Monitoring Network website)*. LPRCA has received a Nebraska Environmental Trust fund grand to continue to be collect data at these sites for the next two years. The data will be analyzed to compare flow rate (discharge) with water contaminant presence, and equations will be developed showing the correlation. Generally, heavy rains lead to contaminated runoff in the recreational waterways. A water contamination prediction model, based on equations from developed from data collection, will be developed and would be available online to the public in near real-time. See *http://www.lowerplatte.org/what_we_do/current_projects/* for continued updates.

Table 3 lists the USGS gauge stations with enough water quality data to be used for this analysis and **Figure 10a** shows where the sites are located within the watershed. Likewise, **Table 3** also lists the NDEQ surface water quality gauge stations, and are also shown in **Figure 10b**. These gauge stations are used by NDEQ to assess if the water bodies are meeting water quality standards for the biennial Integrated Report (see **Table A-1** in **Appendix A** that displays the period of record and the combined number of samples available for analysis).

Table 3. Surface Water Quality Sampling Sites within the Study Area

Sampling Entity	Station Name	Location
NDEQ	SMP1PLATT225	Platte River near Duncan, Nebraska
USGS	06774000	
NDEQ	SLO1LOUPR115	Loup River at Columbus, Nebraska
NDEQ	SLO1LOUPC150	Loup Power Canal Southwest of Genoa, Nebraska
NDEQ	SLP1LOUPC115	Loup Power Canal, tailrace
NDEQ	SLP1LPRCAN80	Loup Power Canal, main portion of canal
USGS	06793000	Loup River near Genoa, Nebraska
USGS	06792500	Loup River Power Canal near Genoa, Nebraska
NDEQ	SLP1SHELL207	Shell Creek near Columbus, Nebraska
USGS	06795500	
NDEQ	SEL1ELKHR126	Elkhorn River at Waterloo, Nebraska
USGS	06800500	
NDEQ	SLP2WAHOO107	Wahoo Creek at Ashland, Nebraska
USGS	06804700	
NDEQ	SLP2SALTC180	Salt Creek near Ashland, Nebraska
USGS	06805000	
NDEQ	SLP1PLATT150	Platte River at Louisville, Nebraska
USGS	06805500	

OTHER STUDIES

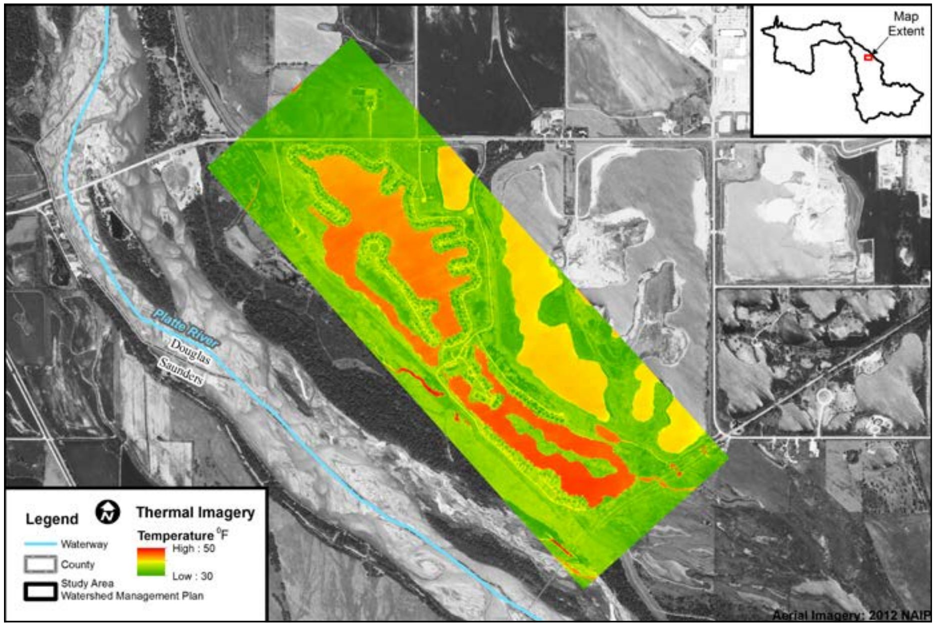
REMOTE SENSING STUDY

Dwellings through the corridor vary greatly and range from one or two room cottages, pre-fabricated buildings, to multi-resident houses. Many of the dwellings have been in place for decades. Where available, residents may have the opportunity to receive utilities from community systems whereas others rely on individual wells and on-site wastewater treatment facilities (that is, septic tanks).

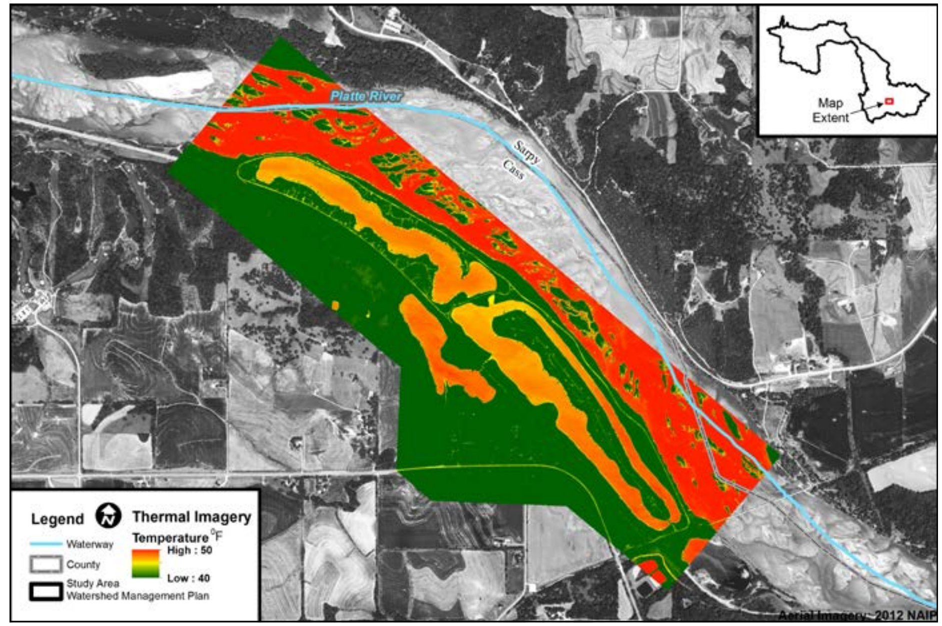
The state of Nebraska has established regulations regarding the constructions, installation, and operation of on-site wastewater treatment systems (OWT). These rules and regulations are administered by NDEQ. According to the 2010 NDEQ Annual report, NDEQ received and responded to 90 complaints regarding OWTs in fiscal year (FY) 2010.

While the rules and regulations have been in place for several years, registration of the installed systems has only been required since 2002. Based on this, the materials used in the past may have varied from the requirements and design. Systems that have been in place for several years currently may not be operating as designed. In the case of septic tank systems, partial or complete failure can be difficult to detect as the main components are not visible (that is, they are underground). Soils that have high infiltration rates make detecting failures a challenge. Failing septic tank systems can impact the individual wells in the vicinity.

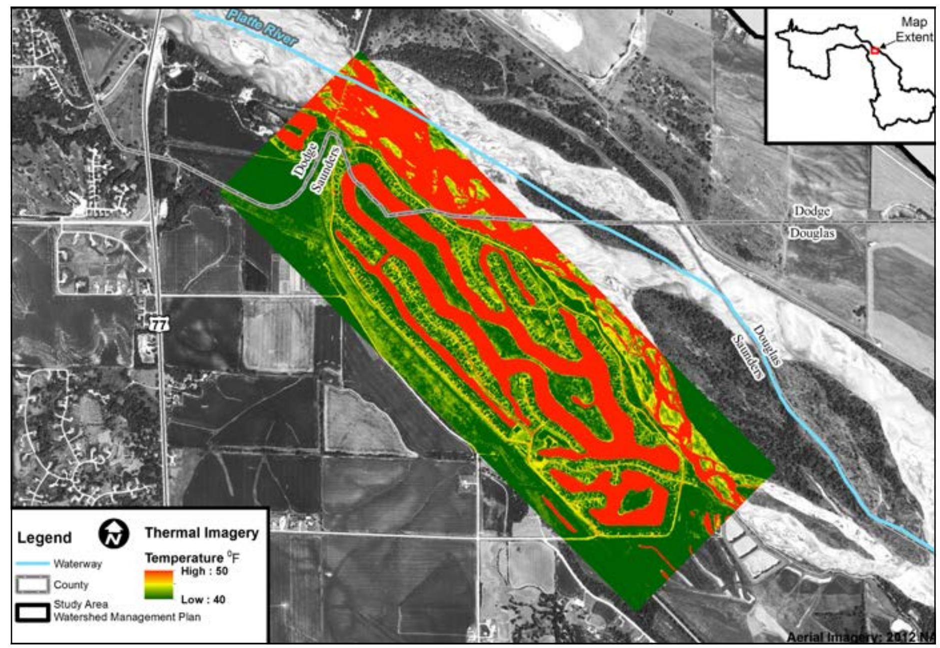
During 2012, LPRCA, with support from NDEQ's 319 Nonpoint source pollution program, partnered with the Center for Advanced Land Management Information Technologies (CALMIT), a unit of the University of Nebraska–Lincoln School of Natural Resources. CALMIT was founded to enhance and expand research and instructional activities in remote sensing, geographic information systems (GIS), automated cartography, and image processing. One of CALMIT's areas of expertise is the use of hyperspectral remote sensing focused on observations of vegetation, surface water, and soils. Past projects in water quality included the remote sensing of lakes to provide information on algae (toxic) densities. To support the information gathering endeavor, CALMIT operates an aircraft outfitted with instruments that include a thermal-infrared camera and an AISA Eagle hyperspectral imaging system.



CALMIT Thermal Energy – Ginger Cover



CALMIT Thermal Energy – South Bend



CALMIT Thermal Energy – Woodcliff

CALMIT conducted flights in 2012 along the lower Platte River and in three housing areas adjacent to the river to attempt to identify warm water discharges that can indicate nonpoint source pollution from the large number of OWTs located along the river. Conducting the flights served as a more proactive approach to identify those potentially failing septic tank systems, rather than waiting until those deficiencies are identified through a complaint to NDEQ. The flights resulted in many hours of infrared spectrum video of the entire corridor and higher resolution imagery of three housing areas within the lower Platte. At the time of publication of this report, the hours of video have not yet been fully analyzed. Initial analysis of the housing imagery shows small isolated areas that could possibly indicate warm water discharges.

POLLUTION SOURCES AND LOADS

Pollutant Sources

The primary pollutant sources being addressed by this study is *E. coli* bacteria. Other constituents being addressed are nutrients total phosphorus (TP), total nitrogen (TN)) and sediment (total suspended sediment (TSS)) . As is typical of watersheds in the United

States, the primary source of pollutant loadings are from nonpoint sources, but there are several point sources within the Study Area as well.

Nonpoint source pollution generally results from land runoff, precipitation, atmospheric deposition, drainage, seepage, or hydrologic modification. The term nonpoint source is defined to mean any source of water pollution that does not meet the legal definition of point source in Section 502(14) of the Clean Water Act (CWA). The CWA definition of point source is:

> *The term "point source" means any discernible, confined and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft, from which pollutants are or may be discharged. This term does not include agricultural storm water discharges and return flows from irrigated agriculture.*

NONPOINT SOURCES

Land uses within a watershed effect the water quality within the watershed through nonpoint source runoff. LANDSAT data from 2005 were obtained to inventory the land use within the Study Area. **Table 4** shows the land use within the entire watershed and **Table 5** breaks up the land use by subbasin. The majority of the watershed has an agricultural land use, which typically has a higher yield of nutrients and sediment than other land uses. The second highest land use is grassed areas, which can be rangeland, pasture, or in Conservation Reserve Program acres. While agriculture and rangeland comprise the majority of the land use (84%) within the Study Area, other sources of nonpoint source pollution exist. Those sources include:

- Wildlife and domestic animals
- Lawns, golf courses, parks
- Animal feeding operations when rainfall events exceed capacity
- Highway, load, parking lot pollutants.

There are 34 subwatersheds in the Study Area. Each subbasin was an entire hydrologic unit code (HUC) 12, delineated as part of the National Hydrologic Dataset (NHD), or a part of a HUC 12, re-delineated to match the boundaries of the Study Area general boundaries. **Figure 7** shows the land use within the Study Area.

Table 4. Land Use within the Study Area

Land Use	Area (Acres)	Area (%)
Agriculture	456,450	64%
Barren	3,510	0.5%
Open water	32,790	5%
Range, pasture, grassland	140,330	20%
Riparian forest and woodlands	56,160	8%
Road	8,840	1%
Urban land	16,970	2%
Wetlands	1,950	0.3%
Total	**717,000**	**100%**

There are four major mechanisms of erosion from which nonpoint source runoff from the land enters into a receiving waterbody. These erosion mechanisms are: sheet, rill, gully, and streambank. Sheet erosion usually is classified as a part of overland flow that occurs uniformly across a slope. This process is applied to runoff from more urban areas where sheet flow across pavement is the typical way constituents are transported to the receiving waterbody. Rill erosion occurs in numerous small channels that are distributed uniformly across the slope; however, these rills occur randomly on the landscape and vary in location during rainfall events. Gully erosion occurs when the topography of the landscape causes runoff to collect and concentrate in a few major waterways before leaving the landscape and entering a receiving stream. Streambank erosion comes from the erosion of the banks of a stream or river; the erosion can occur from natural migration of a channel or from a change in flow regime causing the channel to evolve to accommodate the new regime.

Streambank Erosion

There are two major forms of constituents used in this watershed plan: dissolved and particulate. The dissolved portion, more accurately called soluble, is defined as the concentration of an inorganic or organic constituent of interest contained in the filtrate of a water sample after passing it through a 0.45 micrometer (µm) filter. Note that this may not represent a true dissolved concentration as some colloidal material can pass through a 0.45 µm filter. The particulate portion is the fraction of the constituent that is retained and excluded when passing the sample through a 0.45 µm filter. The particulate portion of the sample typically is attached to sediment and can be estimated to be a fraction of the total sediment load.

Table 5. Land Use by Subbasin

Subbasin Name	Agriculture		Barren		Open Water		Range, Pasture, Grassland		Riparian Forest and Woodlands		Road		Urban Land		Wetlands		Total Subbasin Area
	Area	% Total Area	Area	% Total Area	Area	% Total Area	Area	% Total Area	Area	% Total Area	Area	% Total Area	Area	% Total Area	Area	% Total Area	
102002010311 (102002010311)	3,624	34%		0%	832	8%	2,027	19%	3,705	35%	148	1%	162	2%	41	0%	10,539
102002020105 (102002020105)	3,452	23%	583	4%	4,082	27%	4,430	29%	2,287	15%	104	1%		0%	192	1%	15,130
Big Slough-Elkhorn River (102200031006)	12,703	51%		0%	1,999	8%	4,218	17%	2,422	10%	438	2%	3,142	13%	22	0%	24,944
Brewery Hill-Shell Creek (102002010209)	19,434	68%		0%	344	1%	6,098	21%	1,799	6%	396	1%	368	1%	25	0%	28,463
Buffalo Creek (102002020204)	12,476	75%	92	1%	87	1%	2,114	13%	579	3%	217	1%	897	5%	99	1%	16,561
Callahan Creek (102002030906)	14,686	80%	95	1%	47	0%	2,327	13%	973	5%	220	1%		0%	81	0%	18,429
Cedar Creek (102002020207)	13,406	75%	299	2%	113	1%	2,442	14%	1,354	8%	153	1%	2	0%	76	0%	17,844
Village of Abie (102002010307)	12,455	64%		0%	107	1%	5,856	30%	765	4%	206	1%	197	1%	11	0%	19,596
Clear Creek (102002031004)	7,847	57%	49	0%	108	1%	5,372	39%	245	2%	221	2%		0%	12	0%	13,853
Decker Creek-Platte River (102002020203)	14,374	60%	171	1%	1,271	5%	4,118	17%	3,531	15%	214	1%	314	1%	117	0%	24,111
Dee Creek-Salt Creek (102002030907)	31,958	77%	247	1%	422	1%	5,478	13%	1,876	4%	590	1%	931	2%	239	1%	41,742
Deer Creek-Platte River (102002010303)	10,080	52%		0%	999	5%	5,774	30%	1,975	10%	160	1%	171	1%	50	0%	19,209
Eightmile Creek (102002020210)	17,860	76%	135	1%	261	1%	3,252	14%	1,391	6%	203	1%	355	2%	142	1%	23,599
Elm Creek-Platte River (102002020103)	6,440	33%	322	2%	4,083	21%	4,653	24%	2,950	15%	286	1%	884	5%	20	0%	19,639
Headwaters Bone Creek (102002010304)	10,499	50%		0%	189	1%	8,394	40%	1,531	7%	187	1%		0%	15	0%	20,814
Headwaters Clear Creek (102002031003)	19,926	88%		0%	150	1%	1,652	7%	321	1%	233	1%	334	1%	3	0%	22,619
Headwaters Lost Creek (102002010302)	5,311	49%		0%	116	1%	5,028	47%	206	2%	81	1%	27	0%	7	0%	10,776
Headwaters Otoe Creek (102002020102)	13,316	91%		0%	49	0%	830	6%	230	2%	140	1%	18	0%	0	0%	14,583
Headwaters Skull Creek (102002010308)	16,348	72%		0%	94	0%	5,318	24%	637	3%	204	1%		0%	9	0%	22,610
Johnson Creek (102002031002)	11,537	78%		0%	88	1%	2,543	17%	89	1%	201	1%	284	2%	0	0%	14,742
Lost Creek-Platte River (102002010310)	14,936	57%		0%	2,584	10%	4,603	18%	2,218	8%	504	2%	1,352	5%	46	0%	26,244
Mill Creek-Platte River (102002020205)	7,950	44%	312	2%	1,609	9%	3,653	20%	3,483	19%	255	1%	775	4%	89	0%	18,126
Otoe Creek-Platte River (102002020104)	6,461	41%		0%	2,737	17%	3,970	25%	1,437	9%	205	1%	943	6%	14	0%	15,767

Table 5. Land Use by Subbasin (continued)

Subbasin Name	Agriculture		Barren		Open Water		Range, Pasture, Grassland		Riparian Forest and Woodlands		Road		Urban Land		Wetlands		Total Subbasin Area
	Area	% Total Area	Area	% Total Area	Area	% Total Area	Area	% Total Area	Area	% Total Area	Area	% Total Area	Area	% Total Area	Area	% Total Area	
Outlet Bone Creek (102002010305)	9,103	60%		0%	72	0%	4,643	31%	1,005	7%	157	1%	118	1%	8	0%	15,104
Outlet Skull Creek (102002010309)	10,952	55%		0%	196	1%	6,462	32%	2,104	11%	158	1%	128	1%	29	0%	20,028
Pawnee Creek (102002020201)	7,220	66%	164	1%	71	1%	1,967	18%	1,212	11%	180	2%	151	1%	35	0%	11,001
Rawhide Creek-Platte River (102002020101)	56,922	74%	12	0%	3,605	5%	9,954	13%	4,657	6%	999	1%	654	1%	83	0%	76,886
Shonka Ditch (102002010301)	23,737	82%		0%	102	0%	3,914	14%	356	1%	557	2%	115	0%	9	0%	28,790
Tomek Island-Platte River (102002010306)	9,440	50%		0%	1,817	10%	5,006	26%	2,456	13%	160	1%		0%	59	0%	18,937
Turkey Creek-Platte River (102002020208)	12,957	53%	415	2%	2,374	10%	3,816	16%	4,043	16%	225	1%	528	2%	240	1%	24,599
Turtle Creek (102002020206)	8,235	78%	32	0%	18	0%	1,157	11%	329	3%	137	1%	687	6%	29	0%	10,624
Wahoo Creek (102002031005)	14,135	70%	225	1%	382	2%	3,403	17%	1,178	6%	220	1%	618	3%	88	0%	20,247
Western Sarpy Ditch-Platte River (102002020202)	8,436	57%	188	1%	232	2%	2,309	16%	1,095	7%	293	2%	2,237	15%	38	0%	14,827
Zwiebel Creek-Platte River (102002020211)	8,240	51%	173	1%	1,547	10%	3,551	22%	1,718	11%	190	1%	576	4%	26	0%	16,020
Total Land Use Areas	**456,452**	**64%**	**3,513**	**0%**	**32,789**	**5%**	**140,329**	**20%**	**56,158**	**8%**	**8,841**	**1%**	**16,969**	**2%**	**1,953**	**0%**	**717,004**

POINT SOURCES

As noted in the CWA definition of point source above, there are many types of point sources. NDEQ provided GIS coverage of all National Pollutant Discharge Elimination System (NPDES) permitted facilities within the Study Area. Many of these point sources are potential sources of *E. coli*. This coverage, which can be seen in **Figure 11**, included approximately 1,200 NPDES regulated facilities for wastewater, stormwater and construction, permitted septic tank systems, and confined animal feeding operations (CAFOs). Of these 1,200 facilities, many currently are closed, are stormwater only, or were construction permits for construction that has been completed.

While NDEQ was able to provide a list of NPDES permitted facilities in the Corridor, they were not able to provide discharge or loading information about the permits without using a mapping interface and downloading one or more Discharge Monitoring Report (DMR) for each of the 1,200 facilities. Because this was not feasible, this analysis attempts to account for two main types of NPDES permit holders: NPDES permits that are being tracked by USEPA ECHO system and CAFO permits. NPDES permits that are available in USEPA ECHO database have easily accessible data regarding discharge. It is assumed that these permits are the most important to USEPA. NPDES permitted point sources that are available in USEPA ECHO database are listed in **Table A-2** in **Appendix A**. There are 18 CAFO permits listed in the database obtained from NDEQ. The number of cattle and swine each facility is permitted, available in the database, was combined to obtain a total number of cattle and swine in each watershed. The HUC12 averaged CAFO permit information is listed in **Table A-3** in the **Appendix A.**

Wastewater associated with residential development in the Study Area is a potential for point source pollution. There are many community treatment systems that are permitted and included in the GIS database provided by NDEQ (and shown in **Table A-2**); however,

Sand-Pit Lake Development

there are many communities and residences that do not have NPDES permits and therefore, are unregulated.

The majority of these unregulated point sources are sand-pit lake developments adjacent to the Study Area. In many of the older developments, the individual residences have individual septic tank systems. Many were installed prior to NDEQ permit requirements. Failing, overloaded, or poorly designed septic tank systems are a source of nutrients, bacteria, and biological oxygen demand. In severe cases, fat, oil, and grease may be discharged, which can cause dissolved oxygen depletions and cause aesthetic concerns. The septic tank systems can discharge pollutants directly to the Study Area, deliver pollutants through seepage of the shallow groundwater, or allow pollutants to be carried by surface runoff.

To attempt to quantify the possible constituent loading from these communities, development areas had to be identified. **Figure 12** shows a map of the development areas that are located along the Study Area and that use septic tank systems that, for the most part, do not have an associated NPDES permit. A total of 2,764 dwelling units are approximated to exist within the Study Area that have a septic tank but not an associated NPDES permit. **Table A-4** in the **Appendix A** identifies the locations and the number of dwelling units within each identified development area.

Pollutant Loads

E. COLI

USEPA uses *E. coli* and enterococcus as indicators of fecal contamination of receiving waters, with recommended for use in freshwater environments. These fecal indicator bacteria are present in the intestines of warm-blooded animals and are easier to identify and enumerate in water quality samples than the broad range of pathogens in human and animal feces. Presence of the *E. coli* subgroup indicates that some degree of fecal contamination to the stream has occurred and that water quality conditions may pose increased risk to human health for those swimming or recreating in a water body. The geometric mean criterion of 126 colony-forming unit (cfu)/100 mL of *E. coli* is based on an accepted risk level of 8 swimmer illnesses per 1,000 exposures.

In total, 12 of Nebraska's 13 primary watersheds have water bodies that are affected by *E. coli* (or fecal coliform), spanning both rural and agricultural land uses. This statewide perspective is important because it shows that elevated *E. coli* is a common phenomenon in Nebraska streams and that is not limited to urban areas.

Locally, the middle and lower Platte rivers, the Loup and Elkhorn rivers, and Salt Creek are all impaired by *E. coli*. The middle and lower Platte rivers, the Loup and Elkhorn rivers, and a portion of the Salt Creek watershed have completed TMDLs for bacteria. The TMDLs used a load duration curve methodology to assess bacteria loads and required reductions. The reductions required ranged from 50% up to 97%.

It is beyond the scope of this watershed plan to complete a full bacterial fate and transport model of the entire Study Area, nor did the TMDLs go into that type of detailed analysis. Like the other constituents, the goal was to use existing data and complete a decision level analysis of bacterial loading. However, recreational season[1] *E. coli* loadings at key locations throughout Study Area were characterized using load duration curves

(LDCs) developed from existing data. As described below, the loadings were apportioned by land use to the 12-digit HUCs within the LPRCA study based on a source tracking study from a nearby basin and using literature-based assumptions regarding decay rate and stream velocity. A full explanation of this method is provide in **Appendix B**.

The methodology for attributing sources to land use is based on correlation of results from a fecal source tracking study within a rural Nebraska watershed (Plum Creek Watershed) to pastureland, cropland and urban land uses (Vogel et al. 2007). This methodology assumes that bacteria loading from other land uses (e.g., forest) are negligible. While Vogel et al. (2007) does not explicitly link sources to land use, reasonable assumptions may be applied to make this correlation.

Vogel et al. (2007) attributed *E. coli* contributions within the Plum Creek Watershed to known sources within the recreational season (May through September) as follows:

- Cattle – 43%
- Horse – 5%
- Human – 5%
- Wildlife – 19%
- Unknown – 28%

However, these findings do not account for other livestock sources, which likely represent a significant bacteria source in both the Plum and Lower Platte River Watersheds. For example, according to U.S. Department of Agriculture (USDA) National Agricultural Statistics Service census data the hog inventory in the Middle Platte River Watershed is roughly 16% that of the cattle inventory in the Middle Platte River Watershed, which includes the Plum Creek Watershed. Additionally, the density of hogs in the Lower Platte River Watershed is approximately 3.9 times that in the Middle Platte River Watershed. Based on these findings it was assumed that the "unknown" source is predominantly represented by hogs and other livestock. After accounting for other livestock source and aggregating all livestock into a single category, the breakdown of bacteria sources was assumed as follows:

- Livestock – 75%
- Human – 5%
- Wildlife – 20%

In order to correlate bacteria sources to land uses, the following assumptions were applied:

- Livestock sources were assumed to originate from pastureland and cropland. Pastureland was assumed to have twice the livestock loading rate of cropland because livestock likely have access to pastureland year-round, whereas manure is generally only applied to cropland during certain times of the year. Additionally, pastureland provides livestock direct access to streams which potentially represents a significant bacteria loading source.
- Human sources were assumed to originate from pastureland, cropland and urban land. Pastureland and cropland were weighted at 0.5% the loading rate of urban land. The small contribution from pastureland and cropland reflects the fact that municipal biosolids are applied on less than 1% of the nation's agricultural land (USEPA 2017).
- Wildlife sources were assumed to originate from pastureland, cropland and urban land at equal rates and proportionate to acreage.

Taking these assumptions into account, the relative contribution of bacteria sources distributed by land use may be derived (see **Table 6**).

Table 6. Relative Contribution of Bacteria Sources Distributed by Land Use[1]

	Plum Creek Watershed Acres[2]	Wildlife	Livestock	Human	Total
Pastureland	64	12.8 (18%)	58.9 (81%)	1.1 (1%)	72.8
Cropland	35	7.0 (30%)	16.1 (68%)	0.6 (2%)	23.7
Urban[3]	1	0.2 (6%)	0 (0%)	3.5 (94%)	3.5
	Total	**20**	**75**	**5**	**100**

[1] Values in table represent the relative contribution of bacteria normalized to 100.
[2] Acres in the Plum Creek Watershed are normalized to 100 acres.
[3] Urban land use represents all other land use types.

The total relative bacteria contribution for each land use type was subsequently divided by the respective acreage to derive a relative yield. For example, pastureland has a relative bacteria yield of 1.1 per acre based on dividing 72.8 by 64 acres. After normalizing the relative bacteria yield of pastureland to 1, relative contributions per acre are as follows for each land use type:

- Pastureland: 1.0/acre
- Cropland: 0.6/acre
- Urban Land: 3.1/acre

Based on these relative contributions and literature based assumptions regarding decay rate and stream velocity, recreational season *E. coli* loadings where calculated for each HUC 12 watershed (See **Table 7**). **Figure 13** shows the calculated total recreational season *E. coli* loading per watershed.

Based on these results, approximately 54% of the bacteria loading originate from cropland due to it being the dominant land use (see graphic to the right). Based on the breakdown of bacteria sources presented in **Table 6**, approximately 61% of the bacteria loading is estimated to originate from livestock. Wildlife is the next largest source at approximately 22%, followed by humans at 17%. Potential delivery pathways associated with each of the three model sources are discussed below.

Percent Contribution of Bacteria Loadings in the LPRCA Study Area by Land Use and Source

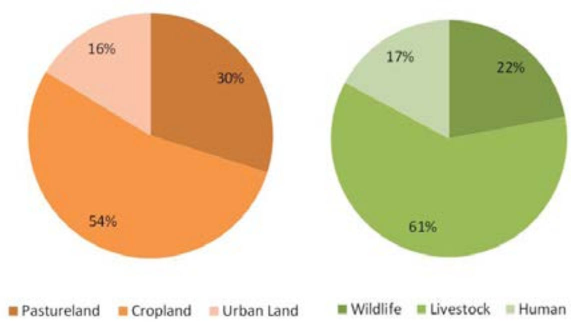


Table 7. Recreational Season *E. coli* Loadings by Watershed

HUC	Name	Recreational Season *E. coli* Loading (cfu/season)			
		Cropland	Pastureland	Urban	Total
102002030906	Callahan Creek	6.67E+15	1.78E+15	0.00E+00	8.45E+15
102002030907	Dee Creek-Salt Creek	1.45E+16	4.22E+15	2.42E+15	2.12E+16
102002031002	Johnson Creek	5.20E+15	1.96E+15	7.16E+14	7.88E+15
102002031003	Headwaters Clear Creek	9.08E+15	1.22E+15	8.34E+14	1.11E+16
102002031004	Clear Creek	3.57E+15	4.18E+15	0.00E+00	7.75E+15
102002031005	Wahoo Creek	6.45E+15	2.64E+15	1.62E+15	1.07E+16
102200031006	Big Slough-Elkhorn River	1.46E+16	8.17E+15	2.16E+16	4.44E+16
102002020102	Headwaters Otoe Creek	1.53E+16	1.61E+15	9.56E+14	1.79E+16
102002020103	Elm Creek-Platte River	7.42E+15	9.63E+15	7.06E+15	2.41E+16
102002020104	Otoe Creek-Platte River	7.45E+15	7.69E+15	6.93E+15	2.21E+16
102002020105	102002020105	3.98E+15	9.71E+15	6.30E+14	1.43E+16
102002020201	Pawnee Creek	8.32E+15	4.13E+15	2.00E+15	1.44E+16
102002020202	Western Sarpy Ditch-Platte River	9.72E+15	4.83E+15	1.53E+16	2.98E+16
102002020203	Decker Creek-Platte River	1.66E+16	8.30E+15	3.19E+15	2.81E+16
102002020207	Mill Creek-Platte River	1.55E+16	5.31E+15	9.30E+14	2.17E+16
102002020101	Rawhide Creek-Platte River	6.56E+16	1.93E+16	9.98E+15	9.49E+16
102002010305	Outlet Bone Creek	1.05E+16	8.99E+15	1.66E+15	2.11E+16
102002010306	Tomek Island-Platte River	1.09E+16	9.69E+15	9.66E+14	2.15E+16
102002010307	Village of Abie	1.44E+16	1.13E+16	2.43E+15	2.81E+16
102002010308	Headwaters Skull Creek	1.88E+16	1.03E+16	1.23E+15	3.04E+16
102002010309	Outlet Skull Creek	1.26E+16	1.25E+16	1.73E+15	2.69E+16
102002010310	Lost Creek-Platte River	1.72E+16	8.91E+15	1.12E+16	3.73E+16
102002010311	102002010311	4.18E+15	3.92E+15	1.87E+15	9.97E+15
102002010301	Shonka Ditch	2.74E+16	7.58E+15	4.06E+15	3.90E+16
102002010303	Deer Creek-Platte River	1.16E+16	1.12E+16	2.00E+15	2.48E+16
102002010304	Headwaters Bone Creek	1.21E+16	1.63E+16	1.13E+15	2.95E+16
102002010302	Headwaters Lost Creek	6.12E+15	9.74E+15	6.52E+14	1.65E+16
102002010209	Brewery Hill-Shell Creek	2.24E+16	1.18E+16	4.61E+15	3.88E+16
102002020204	Buffalo Creek	1.44E+16	4.27E+15	6.72E+15	2.54E+16

Livestock

Model results suggest that 61% of the bacteria loading is from livestock manure, which is predominantly represented by cattle. Bacteria from livestock manure can enter streams and rivers through a number of different pathways including:

- **Manure application** – Livestock manure may be applied to cropland and pastureland as a fertilizer, where it is susceptible to runoff during stormwater conditions.
- **Deposition runoff** – Livestock manure deposited in pastureland is susceptible to stormwater runoff.
- **Direct deposit** – Direct deposits of manure from livestock with access to streams and rivers can represent a significant source of bacteria loading. Unlike livestock manure deposited on pastureland, direct deposits are not subject to die-off prior to entering the stream or river.
- **Waste lagoons** – Irrigation runoff from livestock waste lagoons represents a potential pathway. Waste lagoons are also susceptible to leakage or overflow during major precipitation events (Burkholder et al. 2007).

Wildlife

Model results suggest 22% of the bacteria loading is from wildlife. Wildlife represents a diffuse bacteria source present in all land use types. Delivery pathways can include both direct deposit and runoff during storm events.

Human

Model results suggest 17% of the bacteria loading are from human sources. Human sources of bacteria could potentially enter streams and rivers through a number of different pathways.

- **Wastewater treatment facilities** – Effluent from wastewater treatment facilities can represent a source of bacteria loading. However, according to the USEPA approved Lower Platte River TMDL, WWTFs in segments LP1-10000 and LP1-20000 of the Lower Platte River only have a combined flow of 7.23 cubic feet per second (cfs). The USEPA approved TMDL also indicates that the Lower Platte River has a recreational season 7Q10 (the lowest 7-day average flow that occurs on average once every 10 years) of 920 cfs. Therefore, WWTFs sources just represent 0.8% of the critical low flow. Additionally, the Lower Platte River TMDL indicates most wastewater treatment facilities in the Study Area disinfect, so this likely does not represent a significant source of bacteria loading.
- **Septic systems** – As discussed previously as a pollutant point source, septic tanks are a potential source for bacteria loading. Every septic tank system experiences failure to some degree, since they can never produce zero wastewater discharge. Nationwide, failure rates for septic tank systems vary, but the regional rate of septic failure is reported to range between 5 and 40%, with an average of approximately 10%. In Nebraska however, the failure rate is estimated at 40%. Bacteria loading from failing septic tanks, Swann et al. cite studies with ranges from 103 to 106. Assuming 2.5 people per dwelling unit, commercially available estimates of use can range from 70 to 400 gallons per day from septic tank systems. The low end of the flow rate was used for this analysis. With those assumptions, **Table A-5** in **Appendix A** identifies the development areas within the Study Area with septic tanks and the potential loadings associated with each development. The estimated total annual *E. coli* load from septic tank systems is approximately 2.7 x 1014 colony forming units (cfu/100ml/year (see **Table A-6** in **Appendix A**). To put this value into perspective, this load is 100 to 1,000 times smaller than the load coming in from each of the tributaries to the Study Area. This load is approximately 0.03% of the total combined load of bacteria coming from the various Study Area tributaries.

Table 7. Recreational Season *E. coli* Loadings by Watershed (continued)

HUC	Name	Recreational Season *E. coli* Loading (cfu/season) Cropland	Pastureland	Urban	Total
102002020205	Cedar Creek	9.16E+15	7.68E+15	6.22E+15	2.31E+16
102002020210	Eightmile Creek	2.06E+16	6.56E+15	3.37E+15	3.05E+16
102002020208	Turkey Creek-Platte River	1.49E+16	8.19E+15	4.55E+15	2.77E+16
102002020206	Turtle Creek	9.49E+15	2.30E+15	4.98E+15	1.68E+16
102002020211	Zwiebel Creek-Platte River	9.50E+15	7.21E+15	4.62E+15	2.13E+16
	SUM	**2.53E+17**	**4.56E+17**	**1.38E+17**	**8.47E+17**

- **Sanitary Sewer Overflows and Exfiltration** – Sanitary sewers can release raw sewage on occasion due to a number of reasons such as line breaks, blockages and sewer defects that allow stormwater to overload the system. These type of releases are called sanitary sewer overflows (SSOs). Additional study would be needed to determine if SSOs represent a significant source of bacteria within the Study Area.
- **Illicit Connections** – Illicit connections to storm water systems is a potential source of bacteria in urban areas. However, further study would be required to determine where to what extent illicit connections are contributing to bacteria loading within the Study Area.
- **Biosolids application** – The land application of municipal biosolids is susceptible to runoff during stormwater conditions. Biosolids can be applied to both cropland and pastureland.

[1] In Nebraska, the recreational season runs from May 1 through September 30 and is the only period in which the *E. coli* criterion of 126 cfu/100 mL applies. Therefore, bacteria TMDL loading do not apply outside this period and will not be calculated on an annual basis. Although the proposed approach focuses on the recreational season, this is not meant to imply that best management practices would not or should not be applied year-round. In fact, studies have shown that bacteria can survive in stream sediment for extended periods of time only to be resuspended during high flows at a later date (Cervantes 2012).

Additional Parameters

MODEL REVIEW

Four separate methods were used to understand and attempt to quantify constituent loadings for total phosphorus, total nitrogen, and total suspended sediments from the Study Area. The first method was a simple mass balance procedure, calculating the loading from the watershed by subtracting the constituent loadings from upstream on the Platte River and major tributaries from the loadings at the most downstream station on the Platte River. The second method was to obtain USGS Spatially-Referenced Regression On Watershed attributes (SPARROW) model results of the watershed loading. The third method was to use USEPA Spreadsheet Tool for the Estimation of Pollutant Load (STEPL) model for watershed calculations. The fourth method, calculated watershed loadings in a similar manner to USEPA STEPL model, but was calculated using a much finer delineation than subwatershed scale, which allows for better GIS analysis. An additional analysis was performed on atrazine because this constituent is not included in USEPA STEPL or USGS SPARROW models.

UNCERTAINTY

As has been pointed out in LPRCA stakeholder meetings, there are many uncertainties in this analysis. There are uncertainties in the flow measurements, in the water quality sample collection, the water quality sample analysis, conversion, and data transfer. There are also the uncertainties inherent in collecting samples once a month and on an irregular basis.

The flow measurements obtained by USGS likely have the least uncertainty in the analysis, but even the flow measurements can have measurable error. The flow is measured indirectly by measuring elevation. The uncertainty of the elevation measurement is compounded with the uncertainty of the stage discharge measurements that are used to correlate water surface elevation to flow. The stage discharge relationships are measured approximately monthly, and are not measured in the winter. There is additional uncertainty introduced in using a single curve, although adjusted to the best of USGS' ability, to convert stage to flow.

There are enormous uncertainties associated with the sparse data collection in such a large area. The few sampling stations that exist only sparsely cover the Study Area. The concentrations of the constituents can vary by an order of magnitude depending on the flow rate, time of day, season, and many other factors such as collecting before, during, or after a high flow event.

While additional model complexity might be expected to improve the precision of model results, this has proven to be unfounded in a variety of studies (for example, Gardner et al. 1980; Van der Perk 1997; Lees et al. 2000; Young et al. 1996).

There are many sources of uncertainty in this pollutant loading analysis; however, given the current amount of data available and constraints in staff, time, and budget for all entities in LPRCA, it is not likely that much more frequent data collection at more sites is possible. Therefore, this analysis uses what is available and acknowledges the limitations of the analysis given the amount and quality of data available.

MODEL RESULTS FOR TOTAL PHOSPHORUS, TOTAL NITROGEN, AND TOTAL SUSPENDED SEDIMENTS COMPARED

Given the uncertainty in data and analysis, the use of these four methods yielded a range in values (**Table 8**). As a final estimate, the rounded geometric mean excluding SPARROW results for total phosphorus, total nitrogen, and total suspended sediments are shown in **Table 8**.

The GIS based model was chosen as the model of record for analysis of loading reductions and future watershed calculations. The GIS based model is similar to the STEPL model, but has much finer resolution. The GIS model results are generally lower than the loadings calculated by STEPL, but the relative contributions are similarly proportioned. For future analysis, when studying single HUC 12s, the GIS methodology will be much more useful than the STEPL model, as the resolution of the GIS model is a fine as the available data. Another benefit of using the GIS model is that in incorporates detailed slope information and calculating distance from the nearest stream is a simple matter. These pieces of information are important factors in analyzing the impact of BMPs. Lastly, the GIS based methodology is set up that future analyses can be simple GIS exercises instead of full modeling efforts, which can save time and money in the future.

The following provides the specific details regarding the GIS based model and the results in produces.

Table 8. Model Results Comparison

Model Used	TP (lbs/year)	TN (lbs/year)	TSS (tons/year)
Mass Balance	6,870,000	392,000	823,000
SPARROW	18,587,148	2,326,444	1,400,469
STEPL	6,405,900	442,900	699,000
GIS	2,468,863	205,265	800,312
Rounded Geometric Mean without SPARROW Results	4,772,000	329,000	772,000

GIS BASED MODEL

The GIS based model estimates constituent loadings uses a similar procedure, except instead of averaging the conditions in each subwatershed, each parcel of land, down to the resolution of the land use data, is accounted for. The land use within the Study Area is shown in **Figure 7**. This GIS based methodology has two main pieces, like USEPA STEPL model, the first piece is the sediment loading calculations and the second piece is the urban loading calculations. The sediment loading calculations use Revised Universal Soil Loss Equation (RUSLE) and the urban loading is calculated using the Simple Method. Each is described below.

Revised Universal Soil Loss Equation

Many watershed models use the RUSLE to determine the sources of sediment loading from the watershed. RUSLE, a revised version of the USLE used in USEPA STEPL, is a model created by USDA to determine rates of soil erosion caused by rainfall and associated overland flow. RUSLE can be used to determine the soil erosion based on land uses, including agriculture, rangeland, construction sites, and other lands where rainfall and its associated overland flow causes soil erosion (USDA 2012).

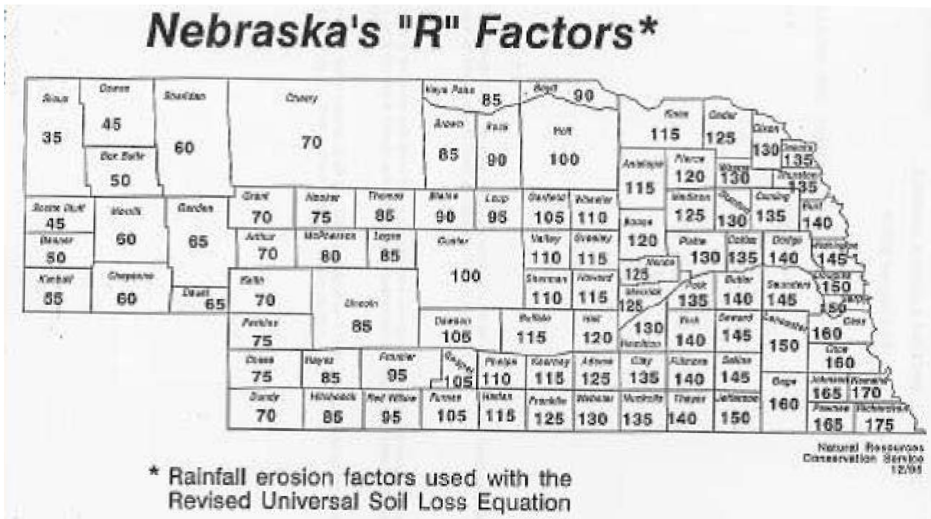
RUSLE computes sheet and rill erosion from rainfall and the associated runoff for each identified land use. As a revision and update of the widely used USLE, RUSLE incorporates data from rangeland and other research sites in the United States to significantly improve erosion estimates on untilled lands. RUSLE was chosen as the model to determine the sediment loading from the watershed due to its applicability to agricultural areas as well as the urban areas. The factors utilized for the equation were versatile to demonstrate the loading coming from the watershed.

RUSLE is written as: $A = RE*K*LS*C*P$

Where:

- A = annual soil loss from sheet and rill erosion in tons per acre
- RE = rainfall erosivity factor
- K = soil erodibility factor
- LS = slope length and steepness factor
- C = cover and management factor
- P = support practice factor

The GIS based analysis begins with the land use GIS files, NRCS soil database, USGS National Hydrography Dataset (NHD), a Nebraska Counties coverage, and a linear roads shapefile. The land use coverage was edited by combining the existing land use coverage with USGS NHD so that areas identified in the NHD are labeled as open water. The land use coverage was cut by the NHD HUC12 coverage. The roads GIS file was buffered to include the right-of-way (ROW) where the buffer size was dependent upon the road type. The buffer sizes used were 20 feet for county roads and 40 feet for highways. The buffered road coverage was then combined with the land use coverage. This land use coverage, with the NHD and road data included, was then cut again with NRCS soils coverage and the county coverage. The result of this procedure was a coverage where each small geographic area contained a single land use with a single soil type in a single county in a single HUC12. This final land use coverage is shown in **Figure 7**.



Re Factor

This value was assigned by county based on the values given by CALMIT in 2001 (CALMIT 2001).

K Factor

K factors for the soils in the watershed are provided by Soil Survey Geographic (SSURGO) Database (NRCS 2009). K factors are shown in **Figure 14**.

LS Factor

Moore and Burch (1986) proposed a methodology to calculate the LS factor using an equation. This method has been adopted and evaluated widely. An example of the use of this approach is shown by Van Remortel and Hamilton (2001). This methodology is described in detail in reports from professors at North Carolina State University and Purdue University.

The equation is based on flow accumulation and slope steepness, all values that can be calculated using standard GIS functions based on elevation. The equation for the LS factor is:

LS = (Flow Accumulation * Cell Size/22.13)^0.4 * (sin slope/0.0896)^1.3

Where:

Flow Accumulation = flow accumulation (flow direction (elevation))

Flow accumulation, flow direction, and slope are standard, prepackaged GIS spatial functions available in ESRI's ArcMap GIS software. Cell size is based on the resolution of the elevation data, which in this case was 10 meters. Elevation data, the foundation of this analysis was obtained from the Nebraska Department of Natural Resources webpage that houses LiDAR data from multiple sources (***http://dnr.nebraska.gov/lidar-map-index***). An ArcMap script was created to calculate the LS factor as well as document the procedure for subdividing the land use. The LS factors are shown in **Figure 15**.

C and P Factors

The C and P factors are similar to the C and P factors used in the STEPL model. The STEPL default C factor was used. All P factors were assigned a value of 1. The use of the value of 1 for the P factor was suggested by the NRCS (NRCS, 2013).

Sediment Delivery Ratio

The sediment delivery ratio (SDR) values for each subbasin were obtained from equations provided in the USEPA STEPL model (USEPA, 2010). The USEPA STEPL model calculates the SDR using the following equation for watersheds larger than 200 acres: SDR=0.417662A^ – 0.134958 – 0.127097, where A is the area of the watershed in acres. The SDR equation was applied to each HUC12 subbasin, equivalent to what was used in USEPA STEPL model.

Soil Phosphorus and Nitrogen Concentrations

Soil percent phosphorus (P) and percent nitrogen (N) concentrations were determined by examining Figures B-3 and B-4 in Haith et al. (1992) as recommended in USEPA STEPL manual. Additional data was obtained from NRCS soil characterization database. This database contains soil phosphorus concentrations as measured throughout the counties within the watershed. Based on the figures and NRCS soil characterization database, the following values were assigned for all 34 HUC models: %N = 0.2, %P = 0.0638.

SIMPLE METHOD

The Simple Method estimates stormwater pollutant loads as the product of mean pollutant concentrations and runoff depths over specified periods of time (usually annual or seasonal) (Schueler 1987). The Simple Method estimates stormwater runoff pollutant loads for urban areas. The technique requires a modest amount of information, including the subwatershed drainage area and impervious cover, stormwater runoff pollutant concentrations, and annual precipitation. With the Simple Method, land uses can be broken into specific areas, such as residential, commercial, industrial, and roadway. Annual pollutant loads can then be calculated for each type of land, or utilize more generalized pollutant values for land uses such as new suburban areas, older urban areas, central business districts, and highways.

The Simple Method estimates pollutant loads for chemical constituents as a product of annual runoff volume and pollutant concentration, as:

$L = 0.226 * R * C * A$

Where: L = Annual load (lbs)
R = Annual runoff (inches)
C = Pollutant concentration (mg/l)
A = Area (acres)
0.226 = Unit conversion factor

The Simple Method calculates annual runoff as a product of annual runoff volume, and a runoff coefficient (Rv). Runoff volume is calculated as:

$R = P * P_j * Rv$

Where: R = Annual runoff (inches)
P = Annual rainfall (inches)
P_j = Fraction of annual rainfall events that produce runoff
Rv = Runoff coefficient

In the Simple Method, the runoff coefficient is calculated based on impervious cover in the subwatershed.

$Rv=0.05+0.9Ia$

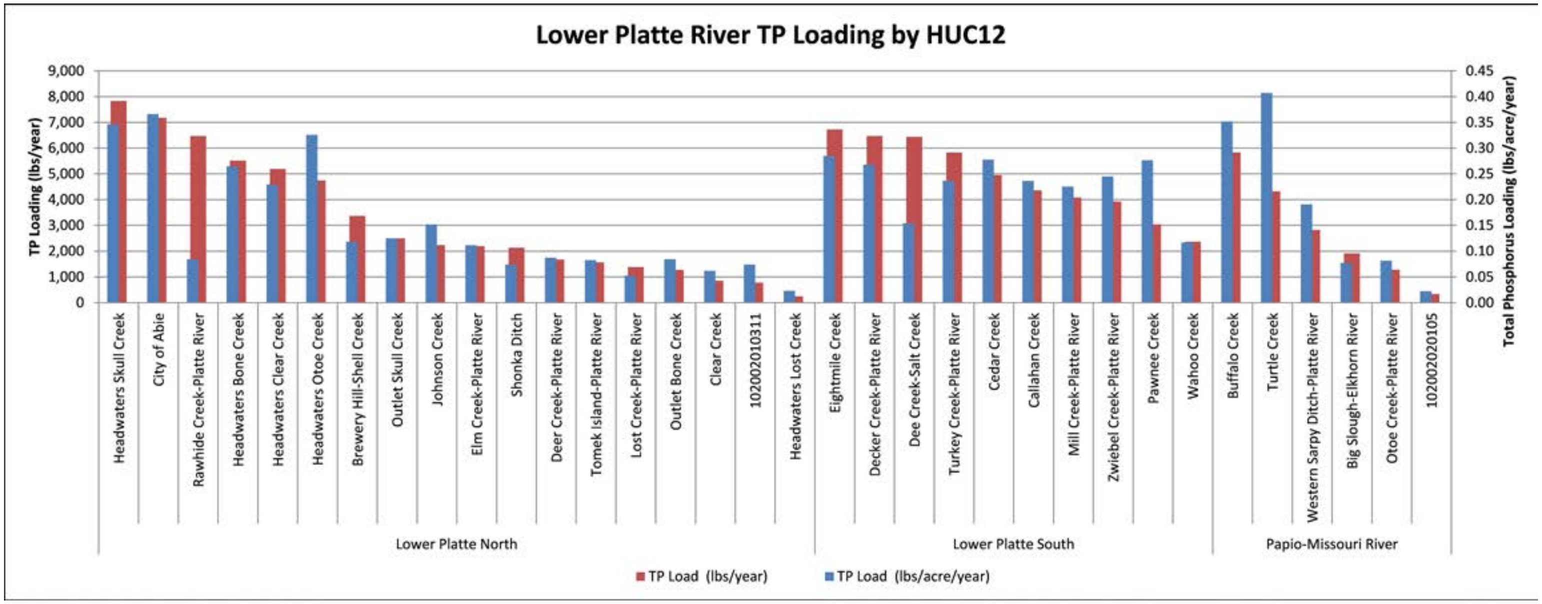
Where: Ia = Impervious fraction.

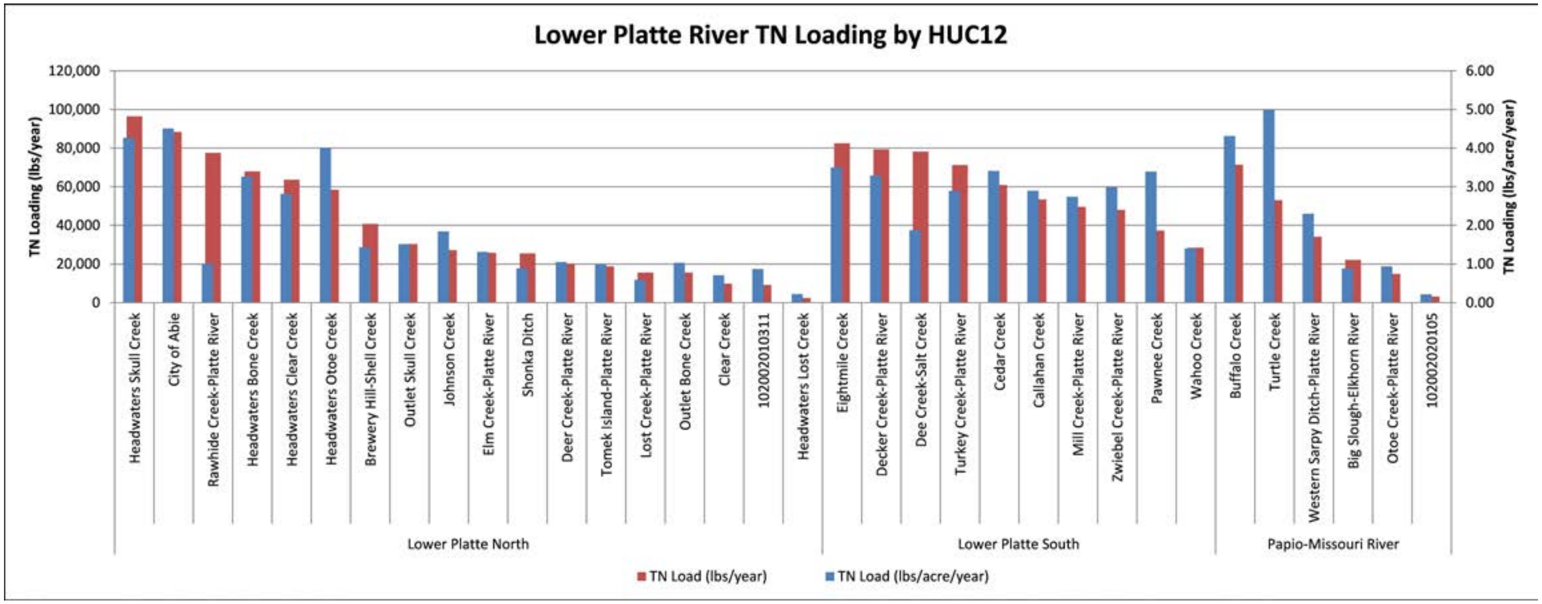
For this analysis, the Simple Method is used to calculate the soluble portion of the phosphorus and nitrogen loads from the land uses labeled as road and urban land. The percent imperviousness for the roads was set to 90% while the percentage for the urban land was set to 45%. The road land use areas were set high because they represent only the roads and portions of the ROW. The urban land use was set based on previous studies of similar development as seen in the municipalities in the Study Area. The phosphorus concentration from the roads was set to the same concentration used in USEPA STEPL, at 0.5 mg/L. The urban land use phosphorus concentration was set to a similar number as used in USEPA STEPL model, but was based on findings in similar studies.

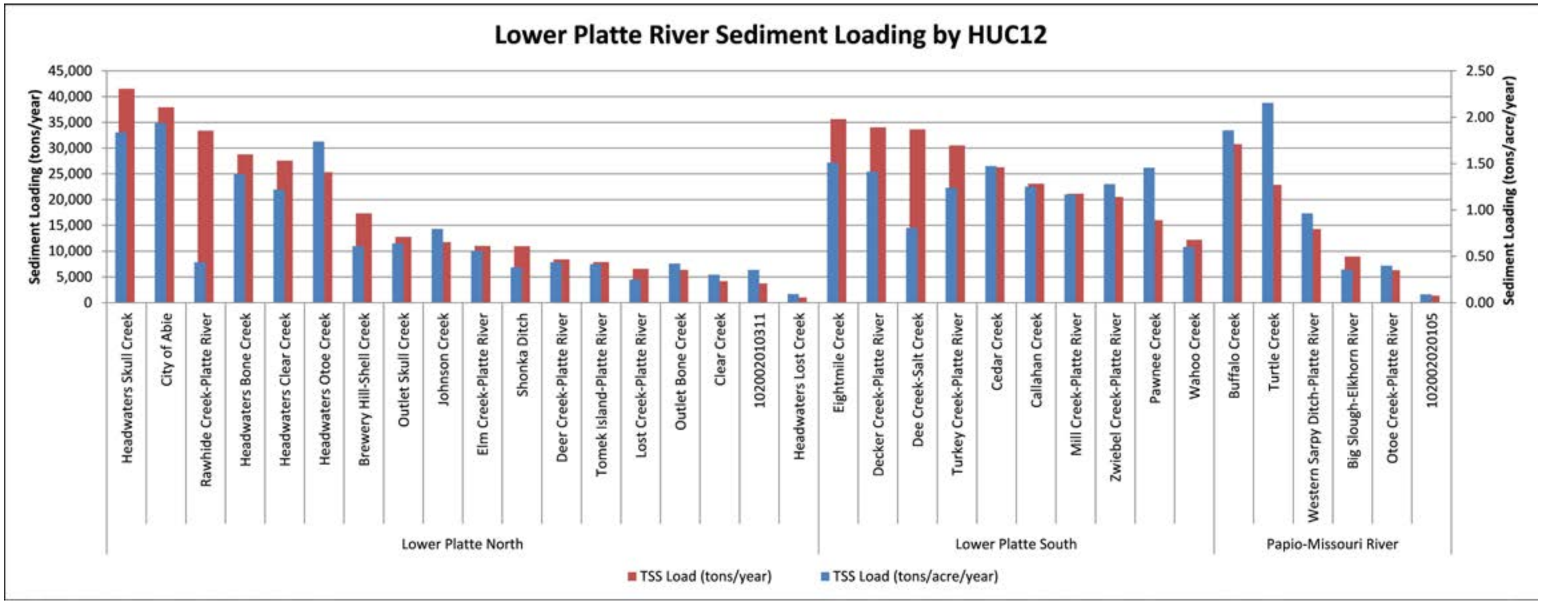
GIS BASED MODEL RESULTS

Total loads from all 34 HUCs for phosphorus, nitrogen, and sediment are shown in the following bar charts and **Tables A-7** through **A-9** in **Appendix A** and for existing conditions. It is evident that the majority of loads originate from the cropland land use, followed by the pasture land use. Total loads from the forest and urban land uses are minimal in comparison.

Examination of total phosphorus (TP), total nitrogen (TN), and total suspended sediment (TSS) loads by HUC is shown in **Figures 16** through **18** for existing conditions. Again, the majority of loads are from the cropland land use, followed by the pasture land use. Patterns are similar between HUCs for phosphorus, nitrogen, and sediment loads. For example, if a HUC has a relatively large nitrogen load, it will also have relatively large phosphorus and sediment loads as well. For phosphorus, nitrogen, or sediment loads, 10 HUCs contribute more than half of the loads: Dee Creek, Rawhide Creek, Decker Creek, Headwaters Skull Creek, Headwaters Bone Creek, Eightmile Creek, Turkey Creek, Buffalo Creek, Headwaters Clear Creek, and the Village of Abie. These results differ from USEPA STEPL results in a few ways. First, the load is more distributed, as it takes more subbasins to account for half the load. Second, the GIS based model allocates more load to the Village of Abie subbasin, which is likely due to the use of the Simple Method for calculating the urban runoff.


Lower Platte River TP Loading by HUC12
TP Loading (lbs/year)
Total Phosphorus Loading (lbs/acre/year)
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Headwaters Skull Creek
City of Abie
Rawhide Creek-Platte River
Headwaters Bone Creek
Headwaters Clear Creek
Headwaters Otoe Creek
Brewery Hill-Shell Creek
Outlet Skull Creek
Johnson Creek
Elm Creek-Platte River
Shonka Ditch
Deer Creek-Platte River
Tomek Island-Platte River
Lost Creek-Platte River
Outlet Bone Creek
Clear Creek
102002010311
Headwaters Lost Creek
Eightmile Creek
Decker Creek-Platte River
Dee Creek-Salt Creek
Turkey Creek-Platte River
Cedar Creek
Callahan Creek
Mill Creek-Platte River
Zwiebel Creek-Platte River
Pawnee Creek
Wahoo Creek
Buffalo Creek
Turtle Creek
Western Sarpy Ditch-Platte River
Big Slough-Elkhorn River
Otoe Creek-Platte River
102002020105
Lower Platte North
Lower Platte South
Papio-Missouri River
TP Load (lbs/year)
TP Load (lbs/acre/year)

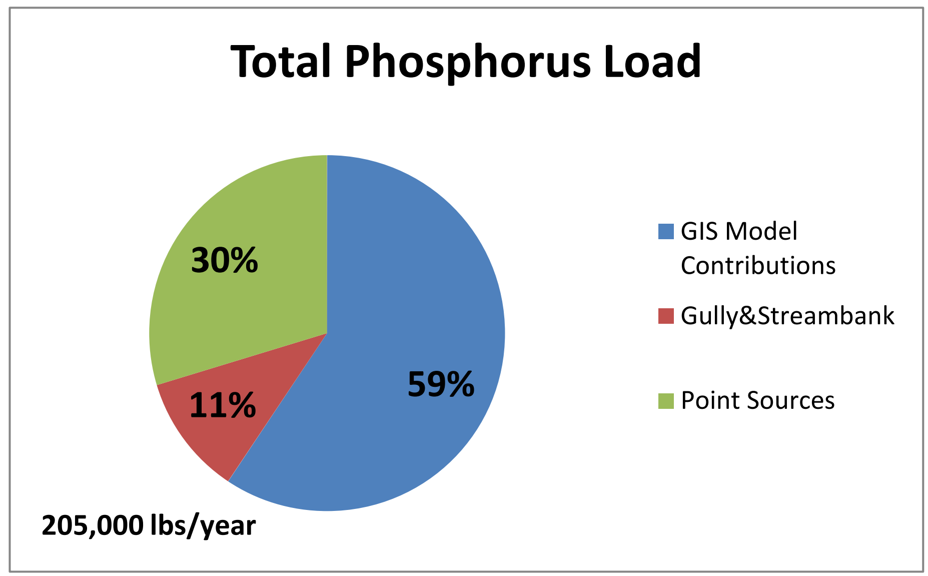

Lower Platte River TN Loading by HUC12
TN Loading (lbs/year)
TN Loading (lbs/acre/year)
120,000
100,000
80,000
60,000
40,000
20,000
0
6.00
5.00
4.00
3.00
2.00
1.00
0.00
Headwaters Skull Creek
City of Abie
Rawhide Creek-Platte River
Headwaters Bone Creek
Headwaters Clear Creek
Headwaters Otoe Creek
Brewery Hill-Shell Creek
Outlet Skull Creek
Johnson Creek
Elm Creek-Platte River
Shonka Ditch
Deer Creek-Platte River
Tomek Island-Platte River
Lost Creek-Platte River
Outlet Bone Creek
Clear Creek
102002010311
Headwaters Lost Creek
Eightmile Creek
Decker Creek-Platte River
Dee Creek-Salt Creek
Turkey Creek-Platte River
Cedar Creek
Callahan Creek
Mill Creek-Platte River
Zwiebel Creek-Platte River
Pawnee Creek
Wahoo Creek
Buffalo Creek
Turtle Creek
Western Sarpy Ditch-Platte River
Big Slough-Elkhorn River
Otoe Creek-Platte River
102002020105
Lower Platte North
Lower Platte South
Papio-Missouri River
TN Load (lbs/year)
TN Load (lbs/acre/year)



Another way to analyze the pollutant loadings is to calculate the loading of TP, TN, and TSS on a per acre basis (see **Table A-10** in **Appendix A**). This way the size of the subbasin is removed as a factor, because as the subbasin increases in size, the more TP, TN, and TSS the subbasin may export. The results of the per acre basis analysis are also shown in the bar charts. When looking at loadings per acre per year, Cedar Creek, Callahan Creek, and Decker Creek top the list of per acre loadings. The top 10 subbasin exporters are different on a total load basis than they are on a per acre load basis. This is function of the ratio of land uses within a subbasin. The top exporter in both cases however, is the Headwaters Skull Creek subbasin. Examination of TP, TN, and sediment loads on a per acre basis, by HUC is shown in **Figures 19** through **21** for existing conditions.

TOTAL WATERSHED LOAD

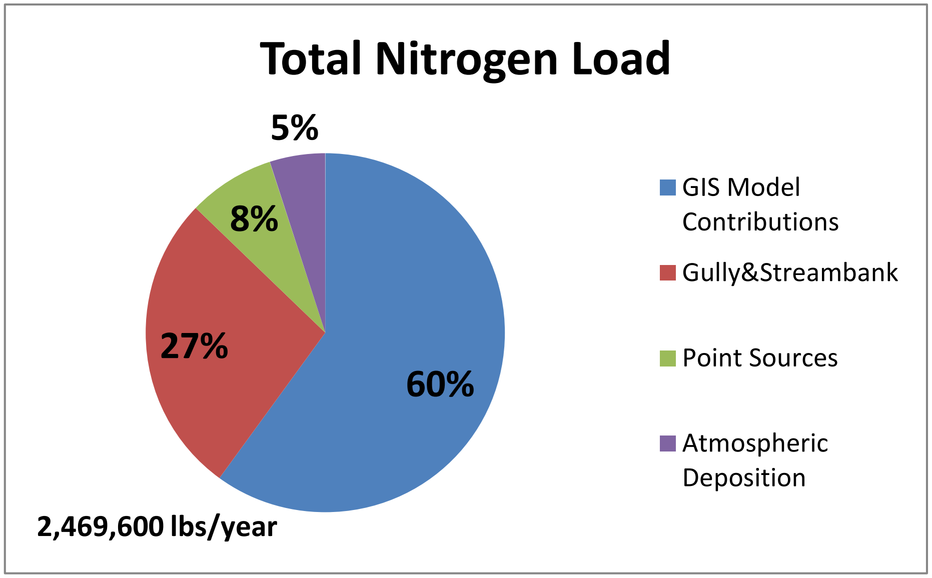
As stated previously, the total watershed load is more than just the loadings from the subbasins, it also includes loadings from point sources, atmospheric deposition, and gully and streambank erosion. This GIS based model does not take into account gully or streambank erosion, just sheet and rill erosion, therefore the data from USGS SPARROW model were used to estimate the gully and streambank erosion in watershed. According

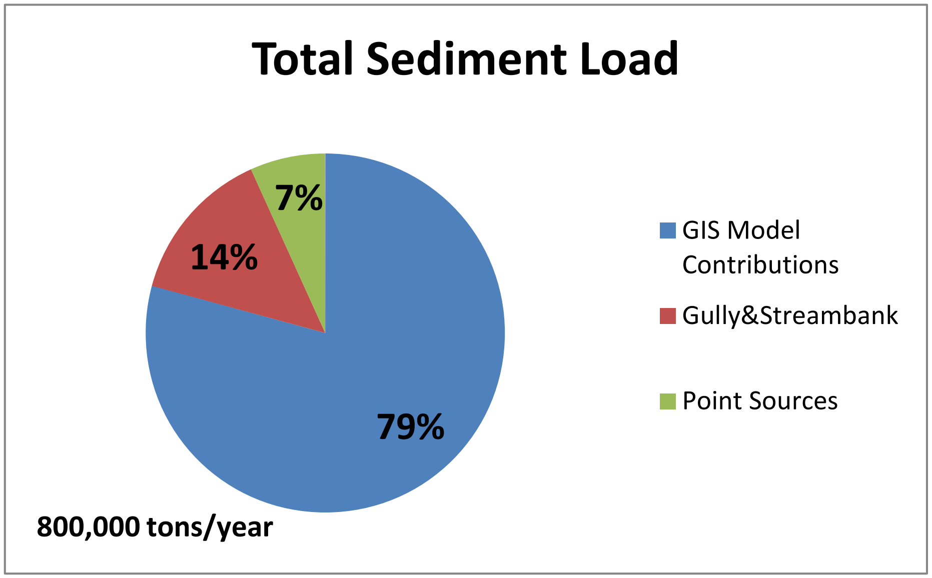


to USGS SPARROW model results, approximately 15% of the total load is from gully and streambank erosion sources.

Other watershed loadings include atmospheric deposition and point source loadings. USGS SPARROW model results were used for the atmospheric deposition loading for TN. The point sources loadings were calculated from data available from USEPA ECHO database (see Point Sources discussion and **Table A-2**).

The following pie chart (at right) and **Table A-11** in **Appendix A** show that with only 14 percent of the total sediment erosion sources coming from gully and streambank erosion, the overwhelming majority of the TP, TN, and TSS loadings are coming from typical agricultural and rural nonpoint sources. The point sources and atmospheric deposition account for a small minority of the total loads.

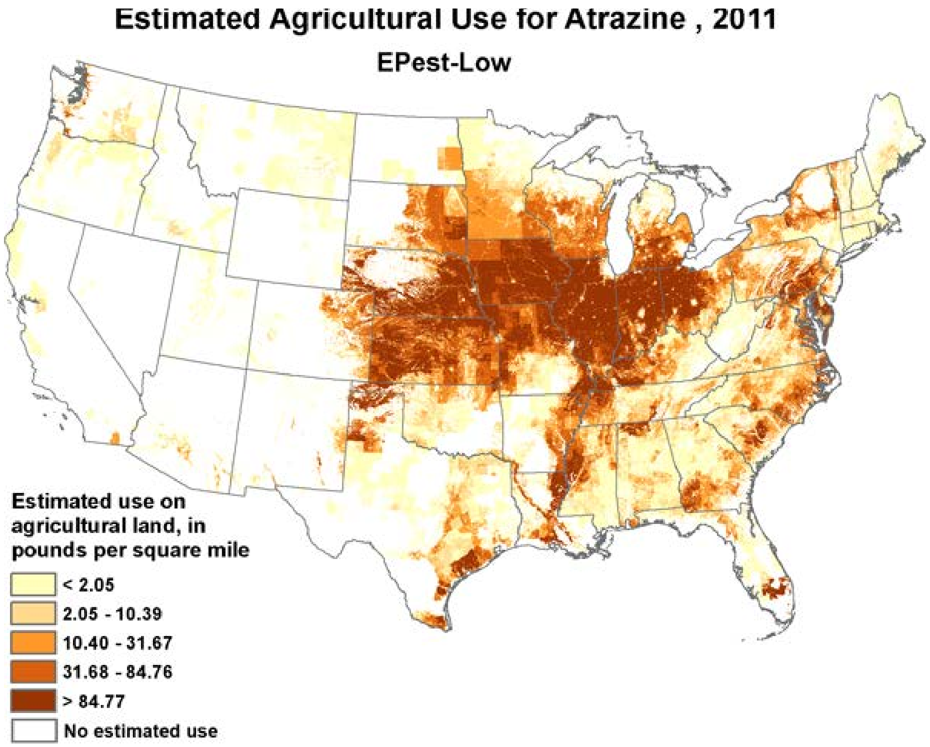


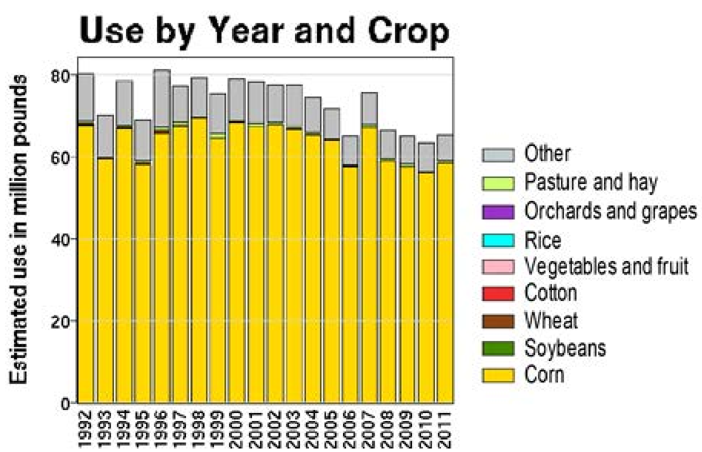


ATRAZINE

Atrazine is one of the most widely used pesticides in the US and is heavily used in Nebraska. The USGS tracks atrazine use agricultural use in the U.S.

No additional model was used to calculate atrazine loadings. Instead, the atrazine loading was calculated by performing the mass balance on USGS surface water quality data and distributing the loading among the agricultural acres within the watershed. It is assumed that atrazine is only applied on agricultural related land use. The total number of agricultural acres above USGS gauge at Louisville is 383,278 acres. This yields 0.025 pounds of atrazine per acre per year from the watershed. The total atrazine load by subbasin is shown in **Table A-12** in **Appendix A**. It should be noted that atrazine loss in runoff depends on the timing of rainfall in relation to timing of when the sample was taken, the intensity and duration of the rainfall, and the time of the year, among other variables. This introduces more variability in sampling for atrazine than for other constituents and could results in misleading results. For example, the majority of the annual atrazine load comes during the late spring or early summer and if that peak is missed or not characterized entirely, then the annual loading could be mischaracterized. (Carr, 1993). As such, this analysis should be considered a screening level analysis only until much more frequent sampling data is available.





Like the nutrient loadings, eight subbasins account for half of the total atrazine load. Rawhide Cree, Dee Creek, Shonka Ditch, HW Clear Creek Brewery Hill-Shell Creek, Eightmile Creek, HW Skull Creek, and Lost Creek. The subbasins exporting the most atrazine are the subbasins with the largest amount of agricultural related acres.

Figure 2. Loup River Watershed

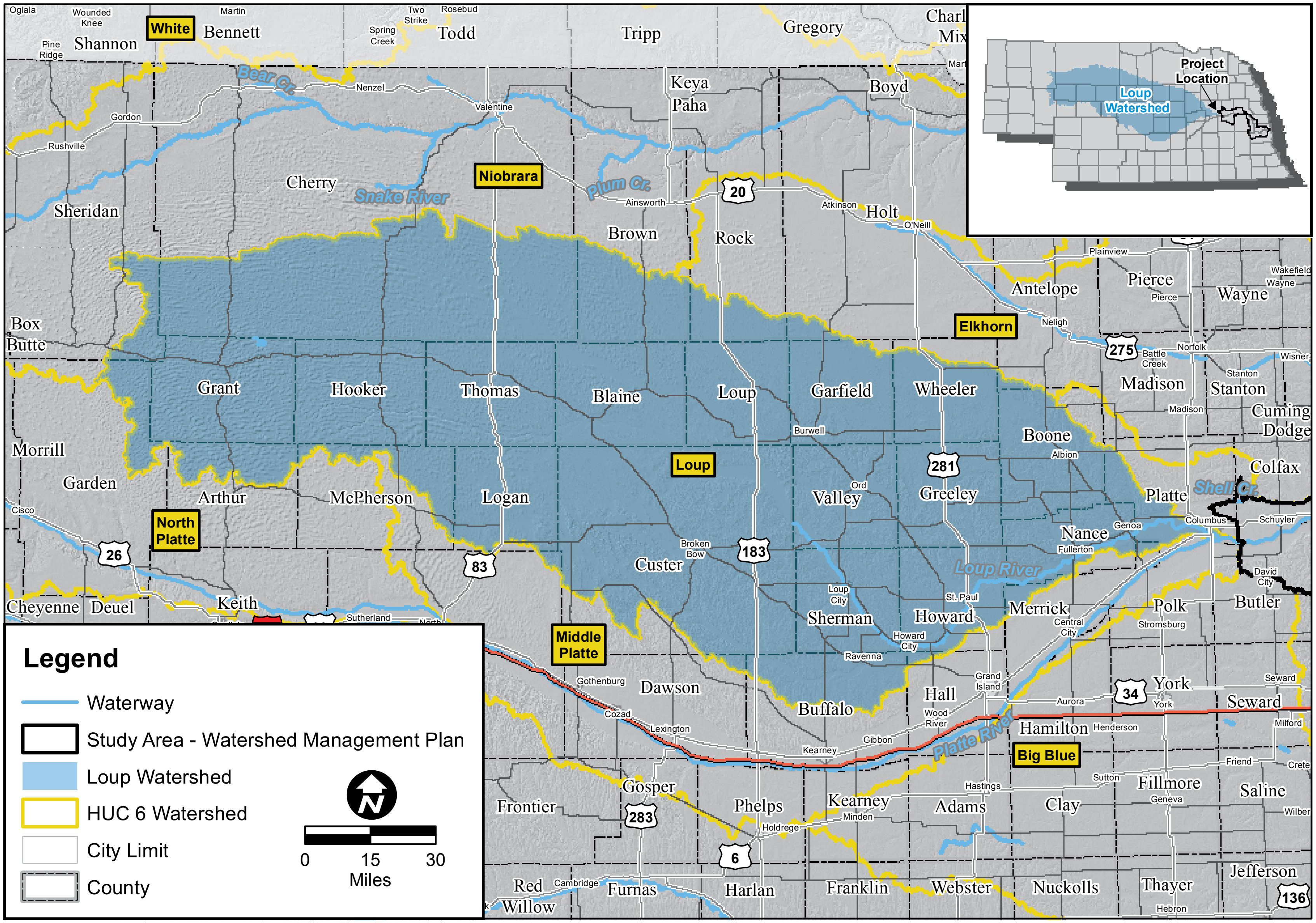


Figure 3. Elkhorn River Watershed

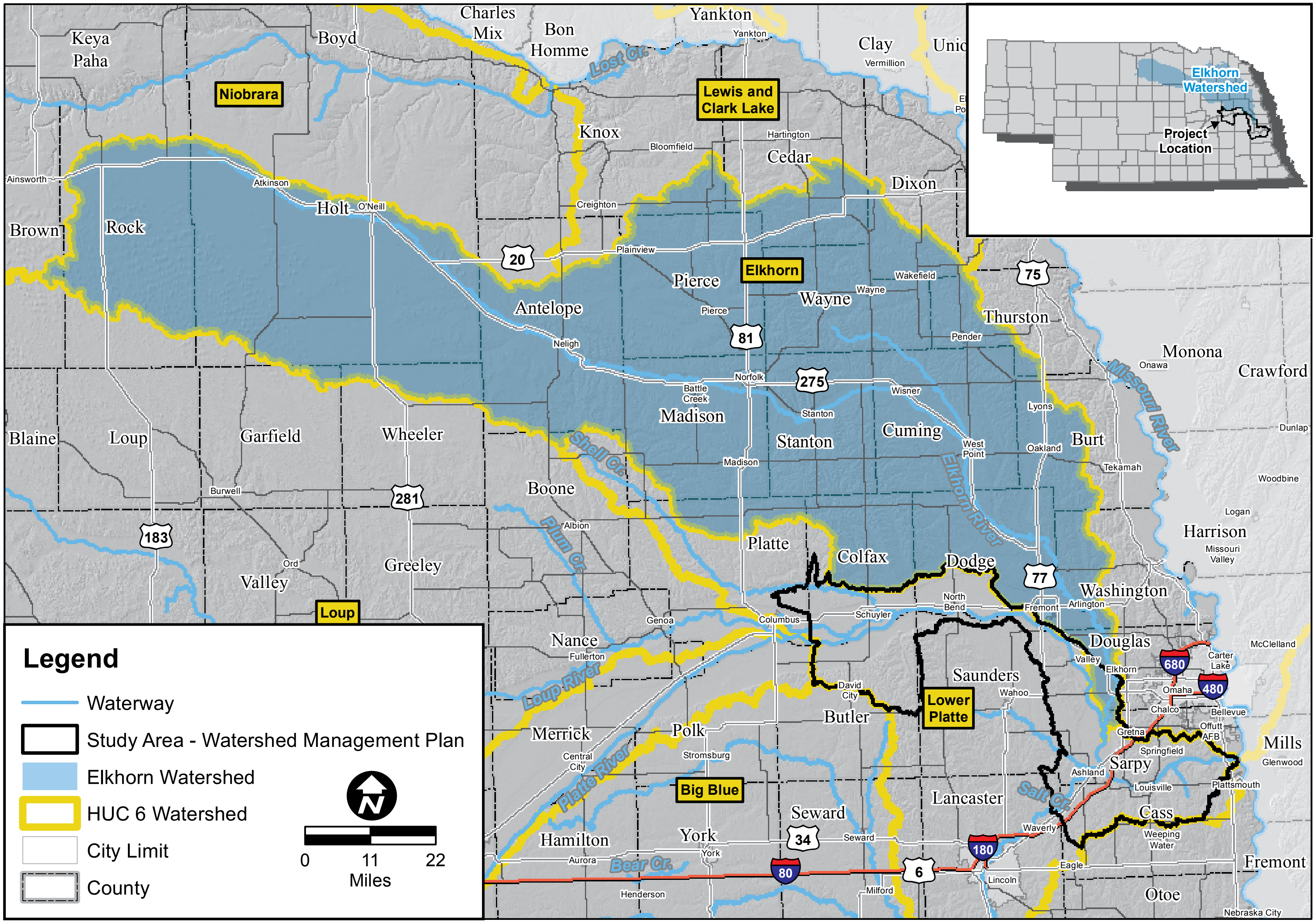


Figure 4. Salt Creek Watershed

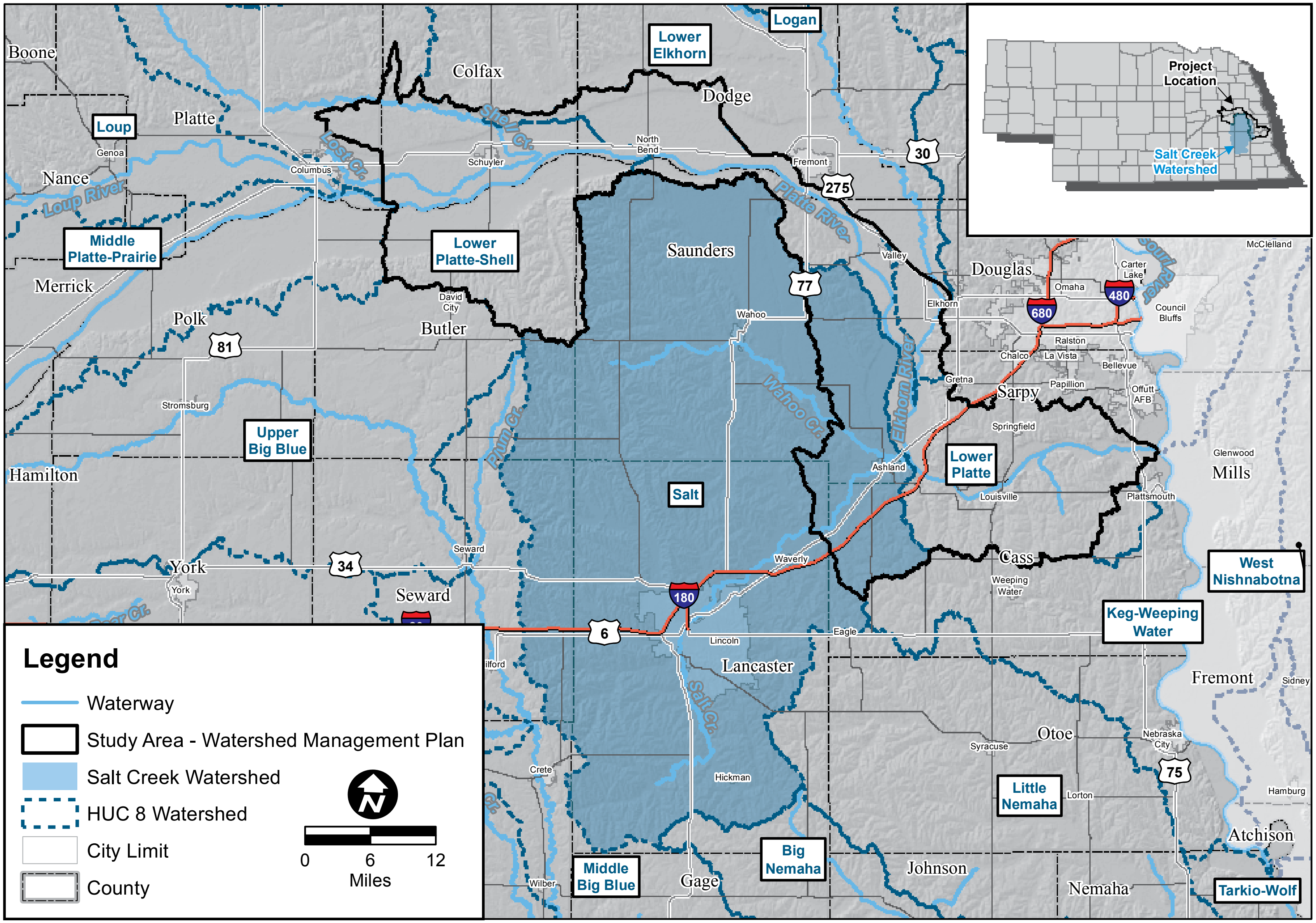


Figure 5. USEPA Level IV Ecoregions

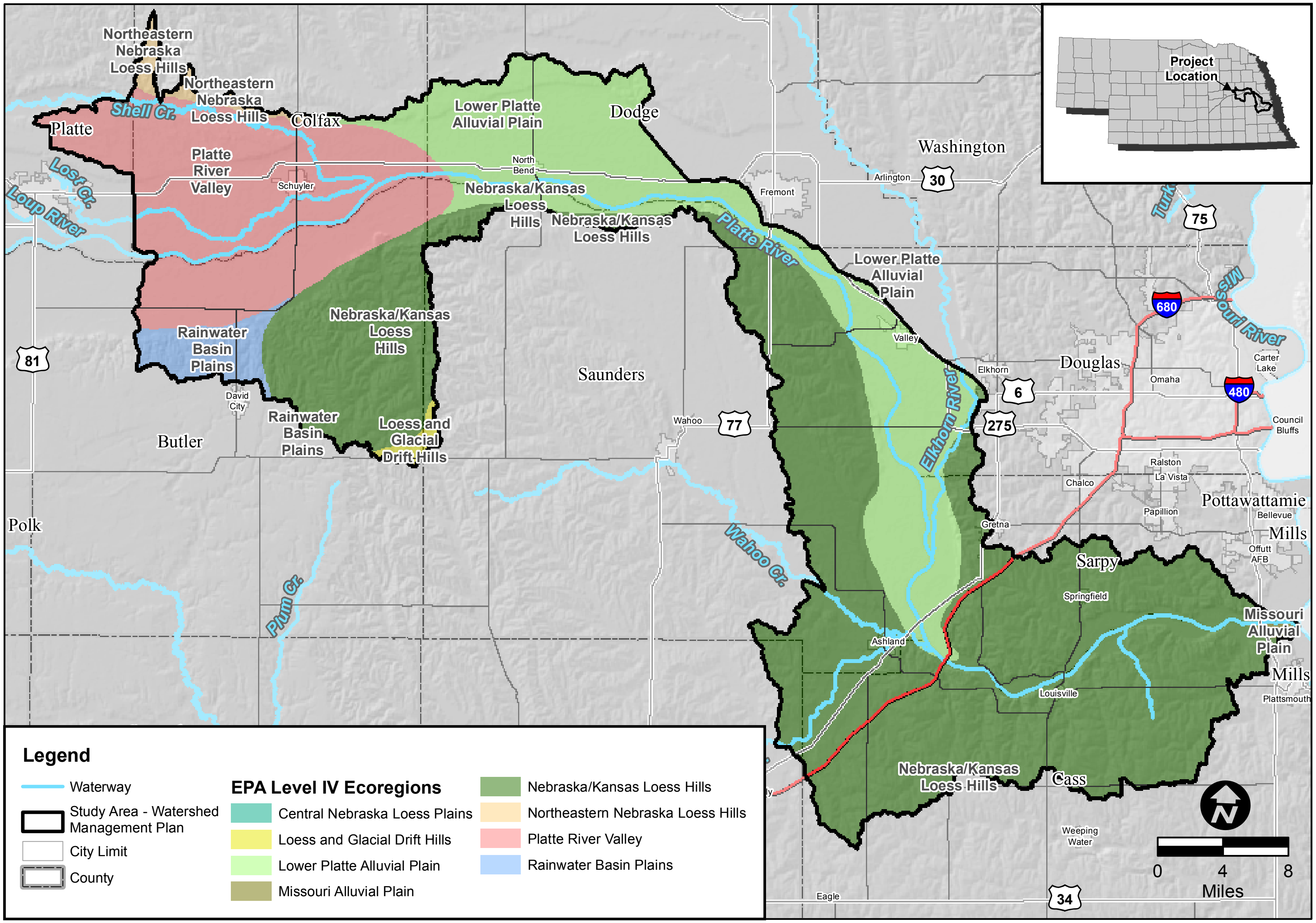


Figure 6. Soil Types

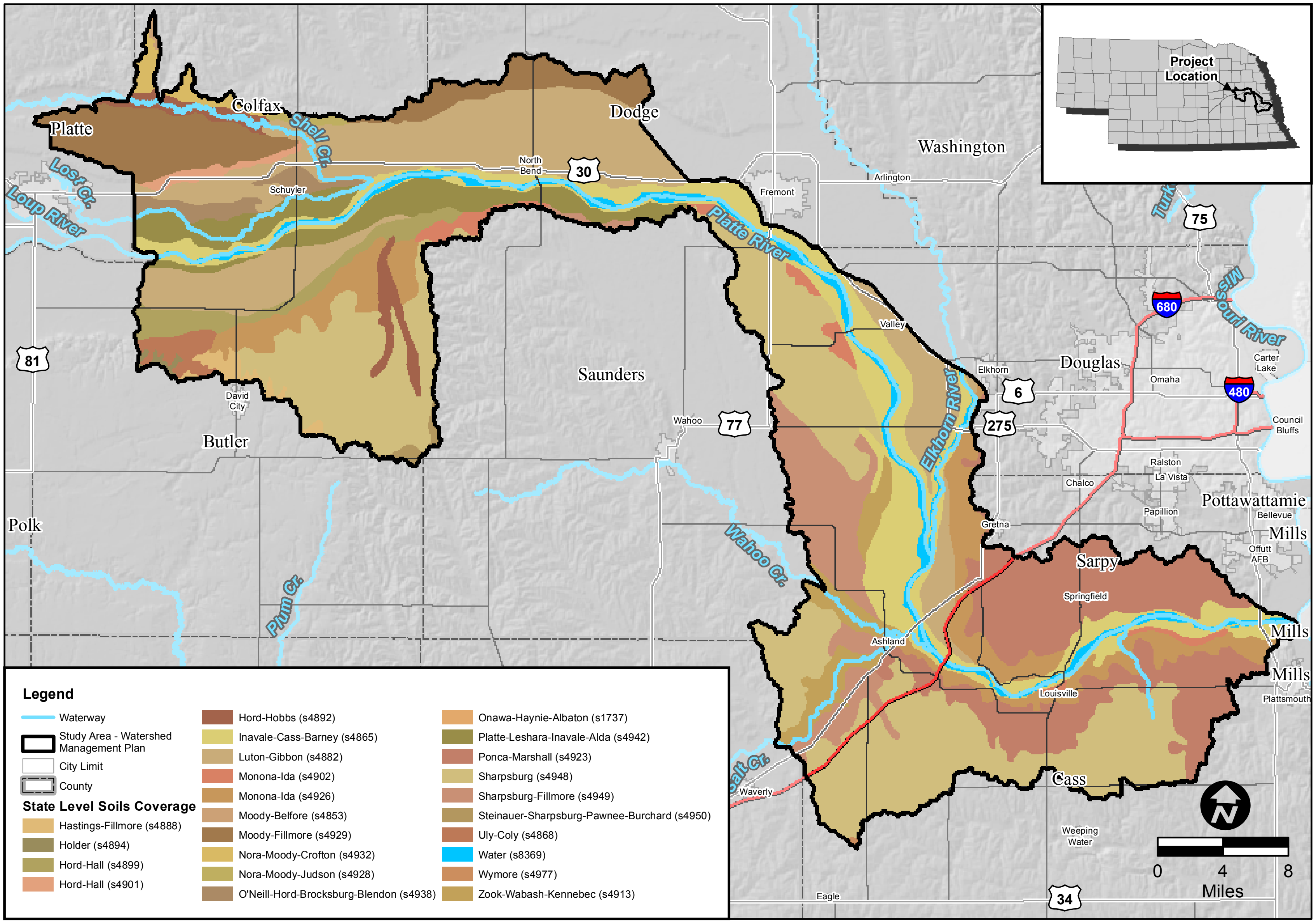


Figure 7. Existing Land Use

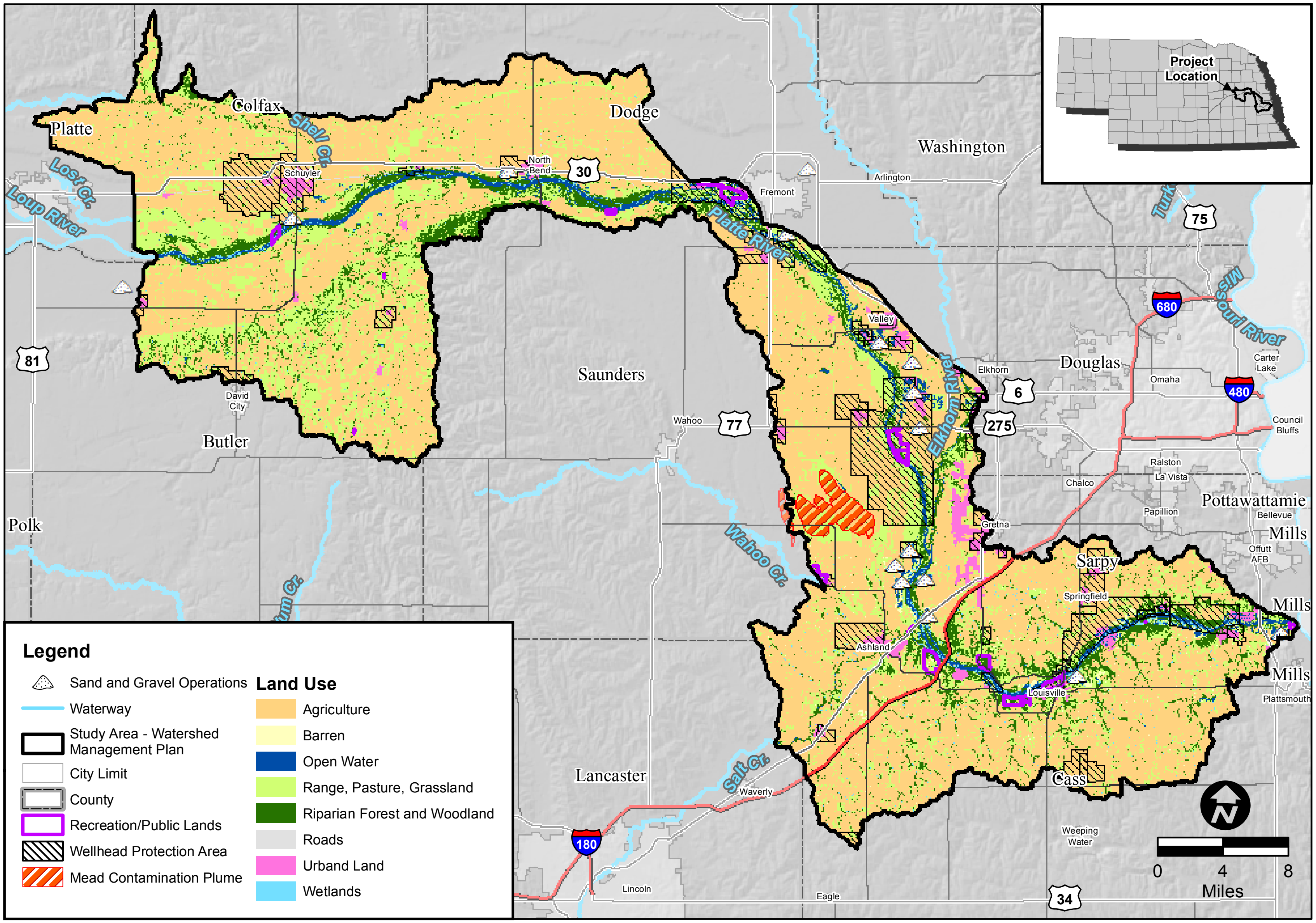


Figure 8. State Public Recreational Opportunities

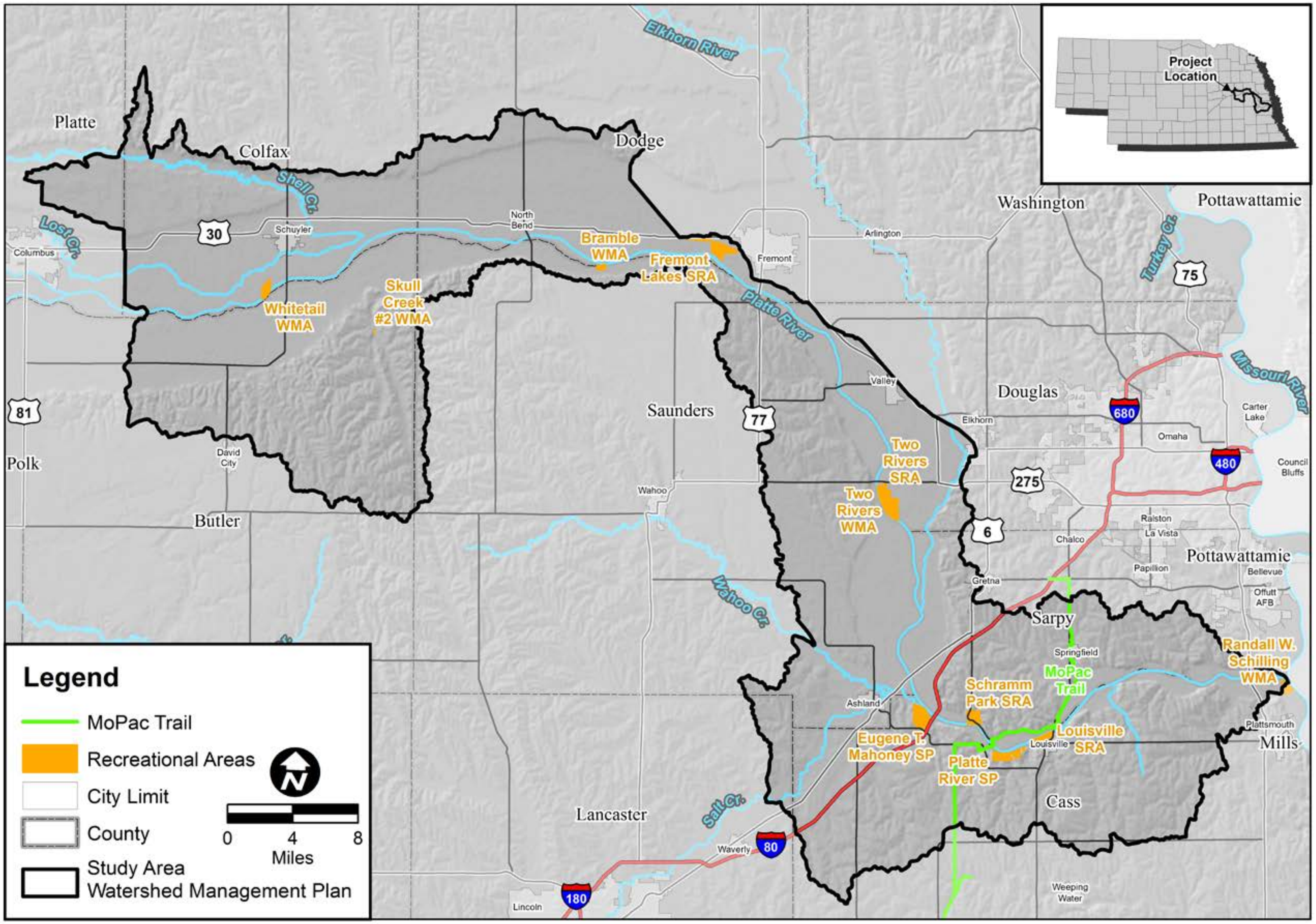


Figure 9. Wellhead Protection Area

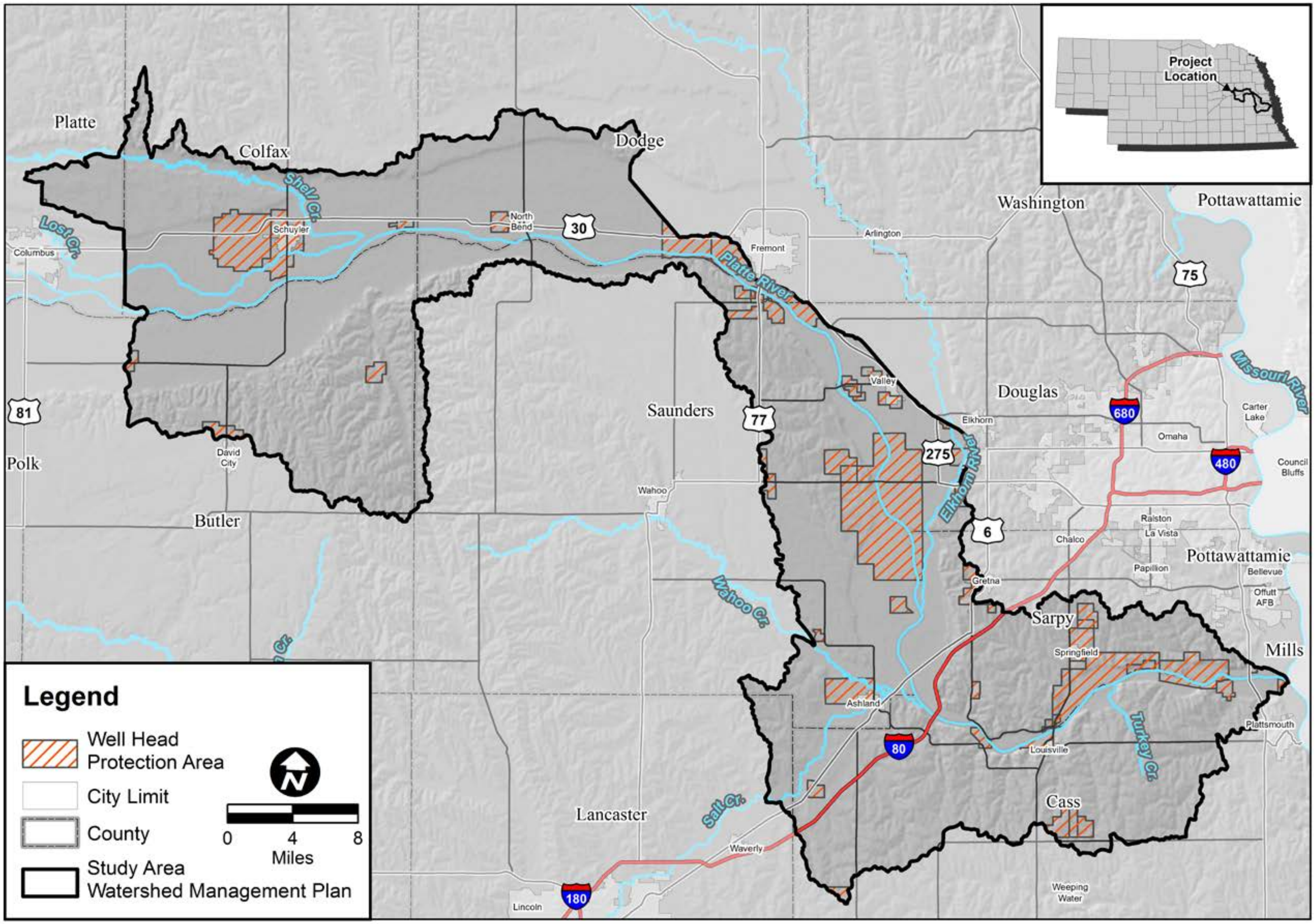


Figure 10a. USGS Water Quality Stream Gauges

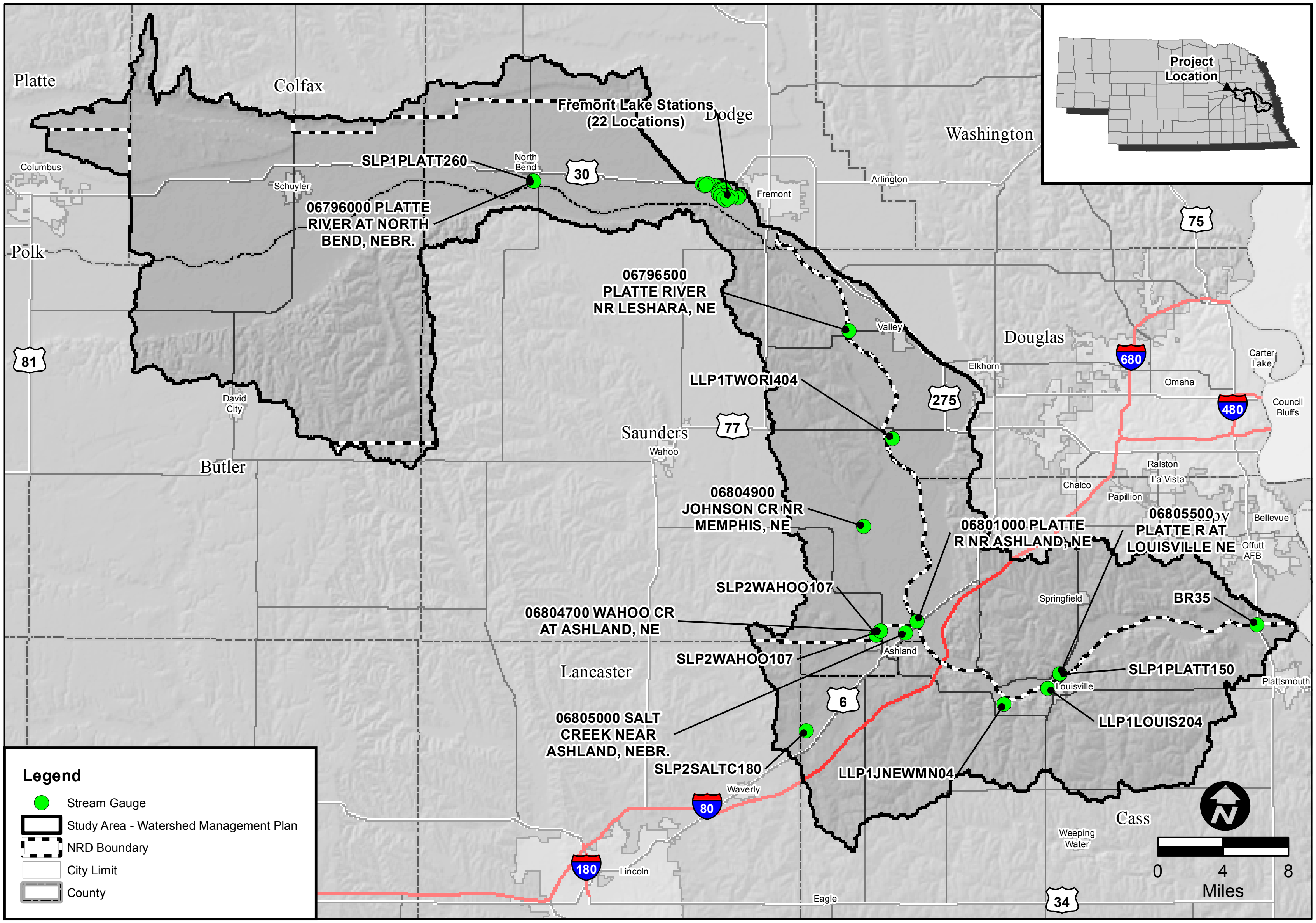


Figure 10b. NDEQ Water Quality Stream Gauges

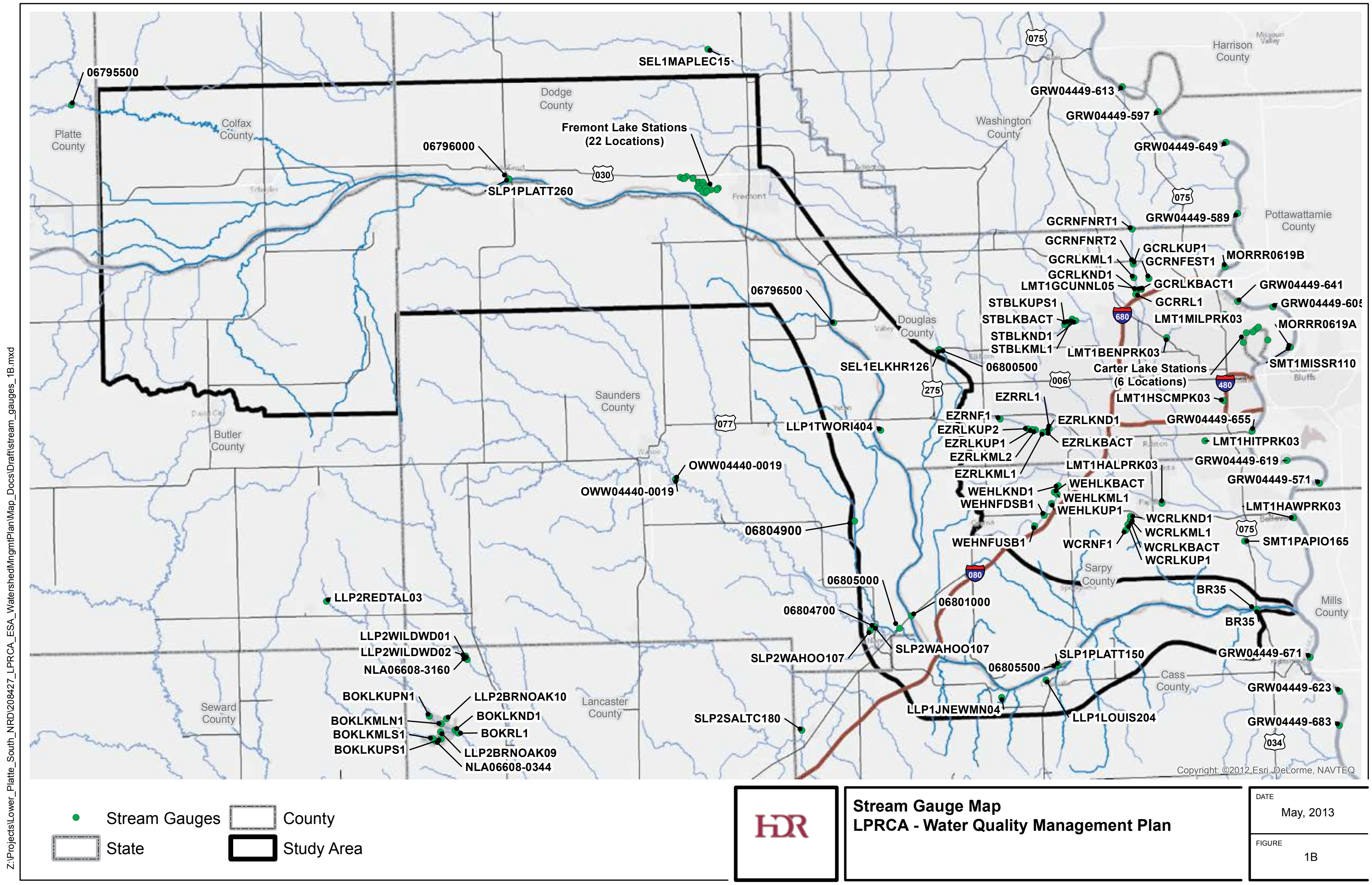


Figure 11. NDEQ Regulated Outfalls

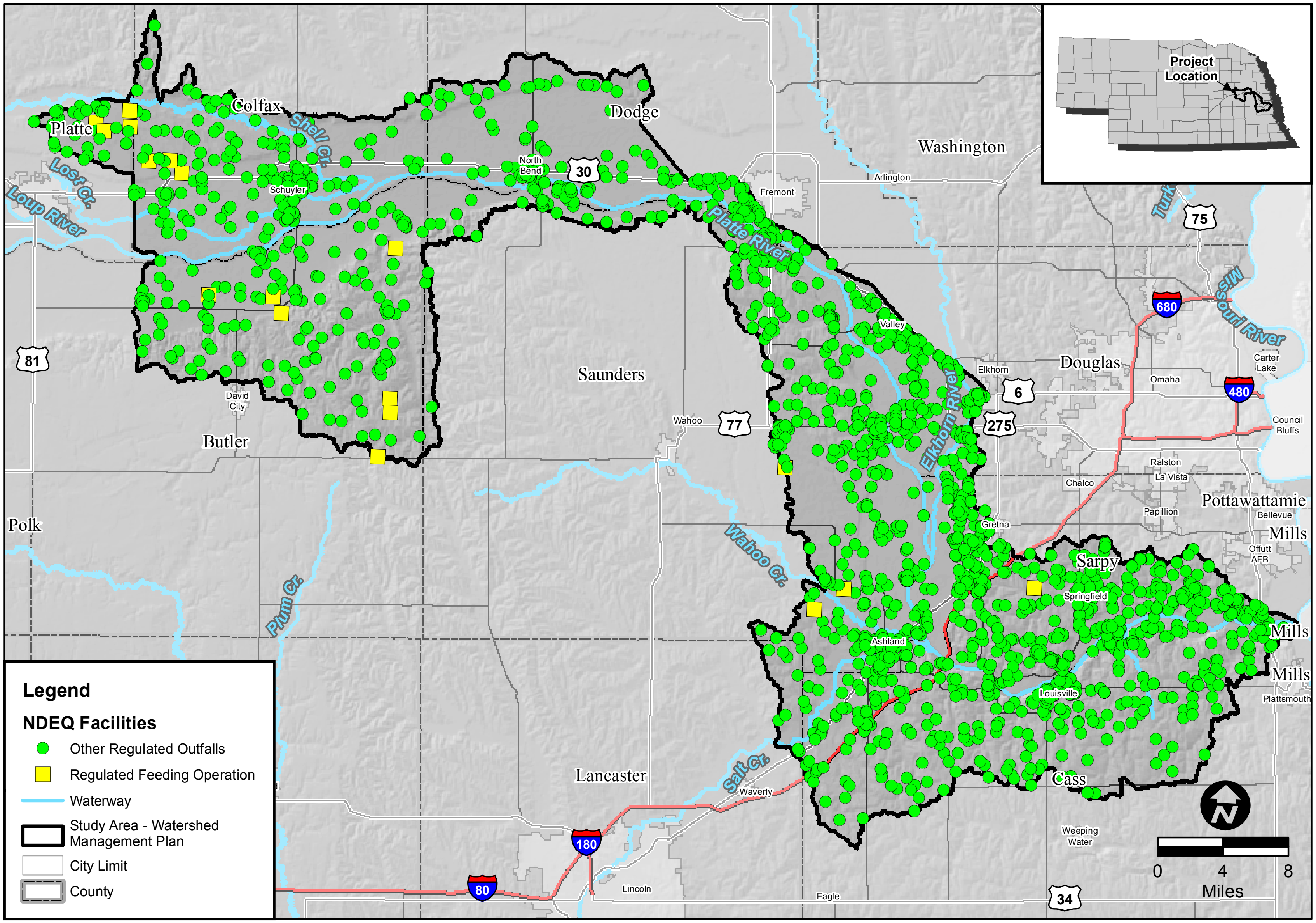


Figure 12. Potential Unregulated Septic Tank Locations

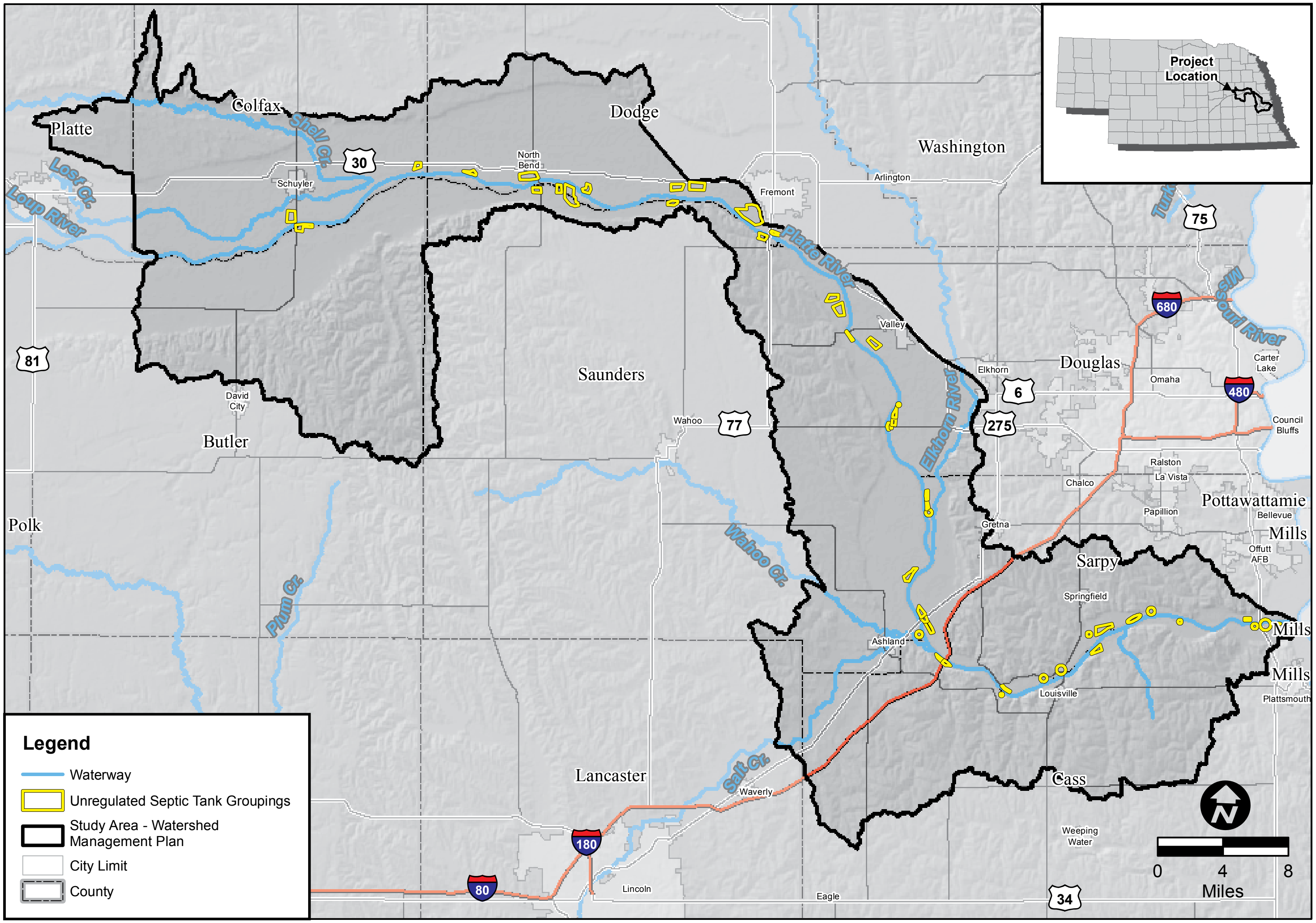


Figure 13. Estimated Recreational Season *E. coli* Loadings

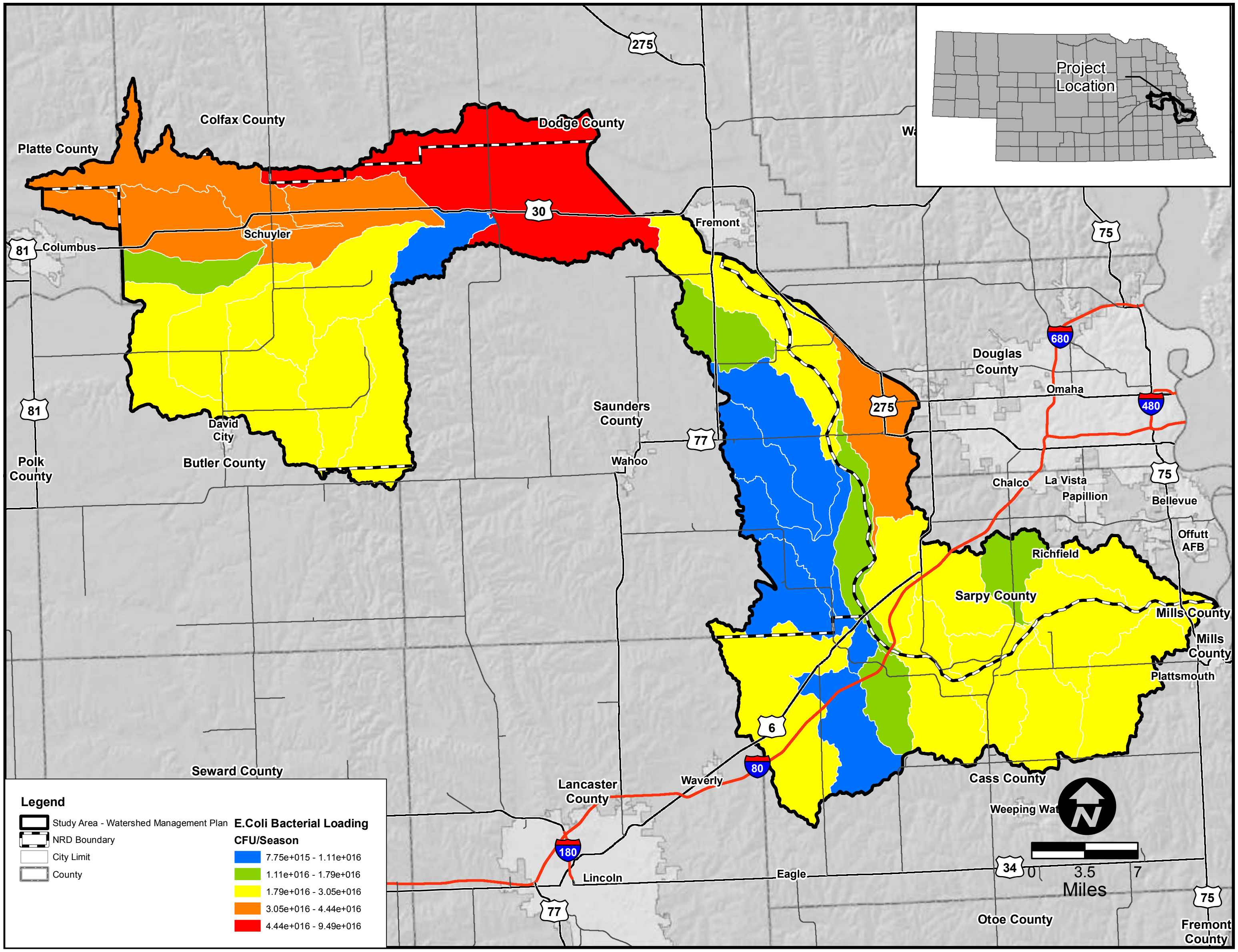


Figure 14. K Factors for RUSLE

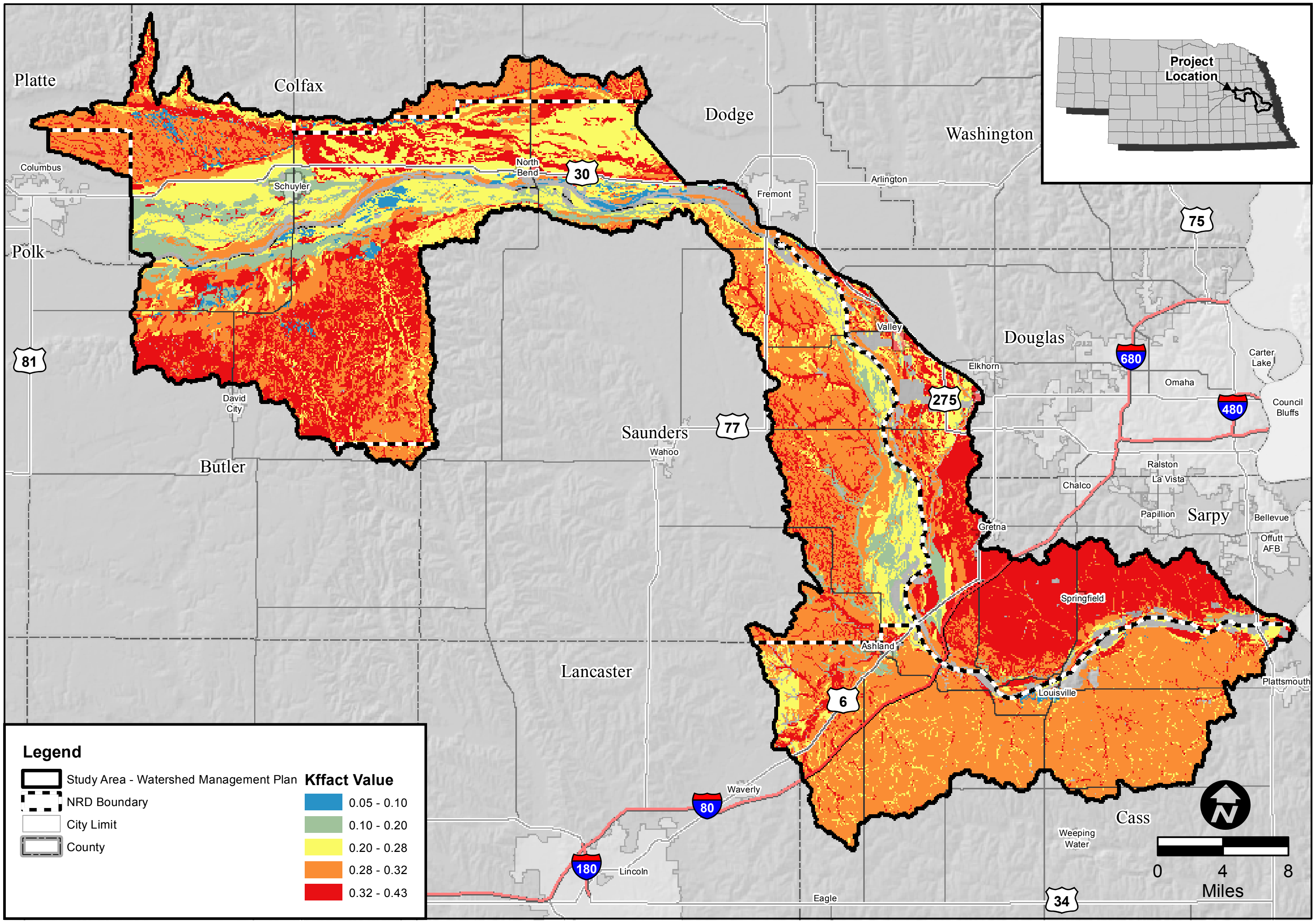


Figure 15. LS Factors for RUSLE

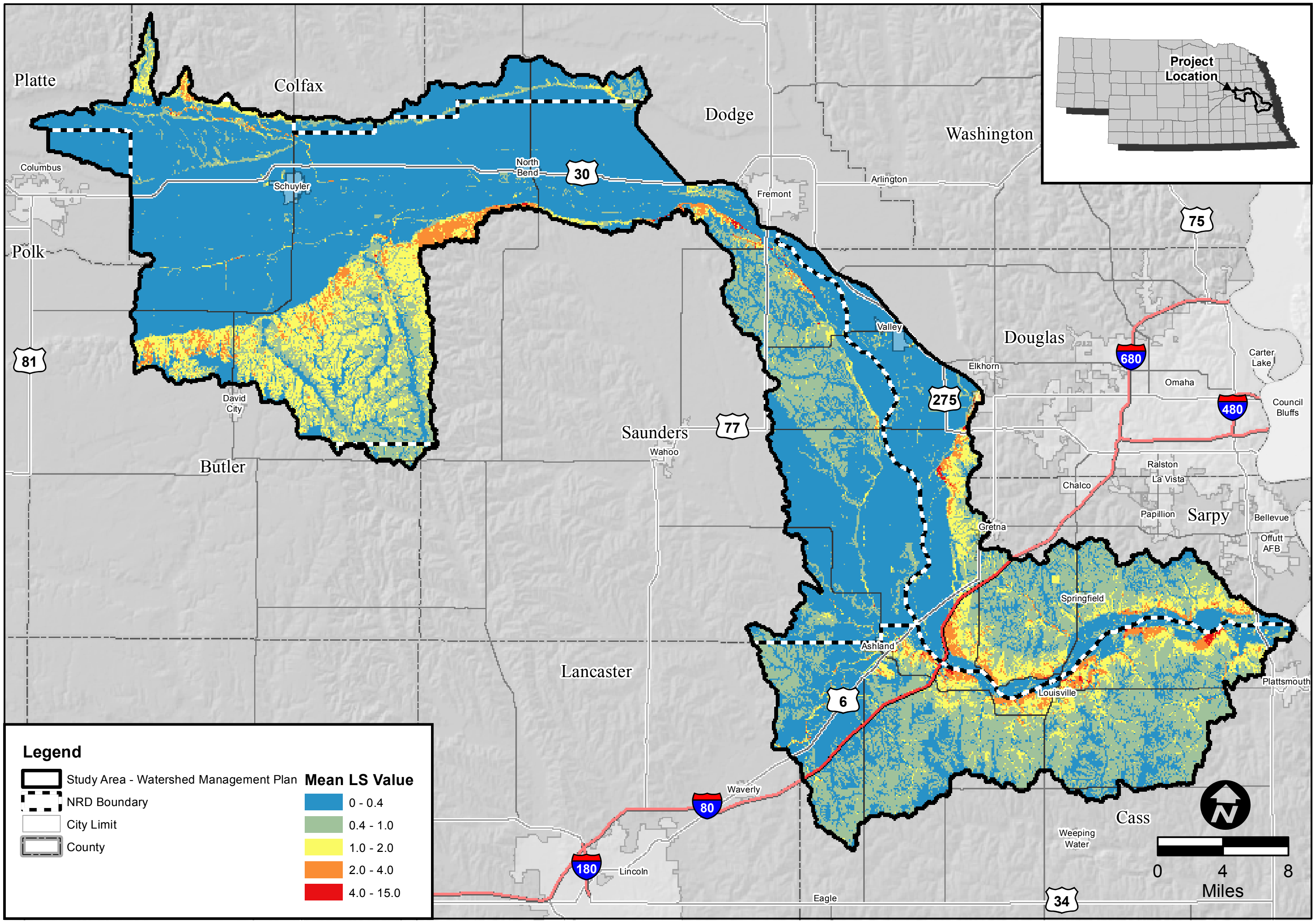


Figure 16. Total Phosphorus Loadings (Lbs/Year) – GIS Model

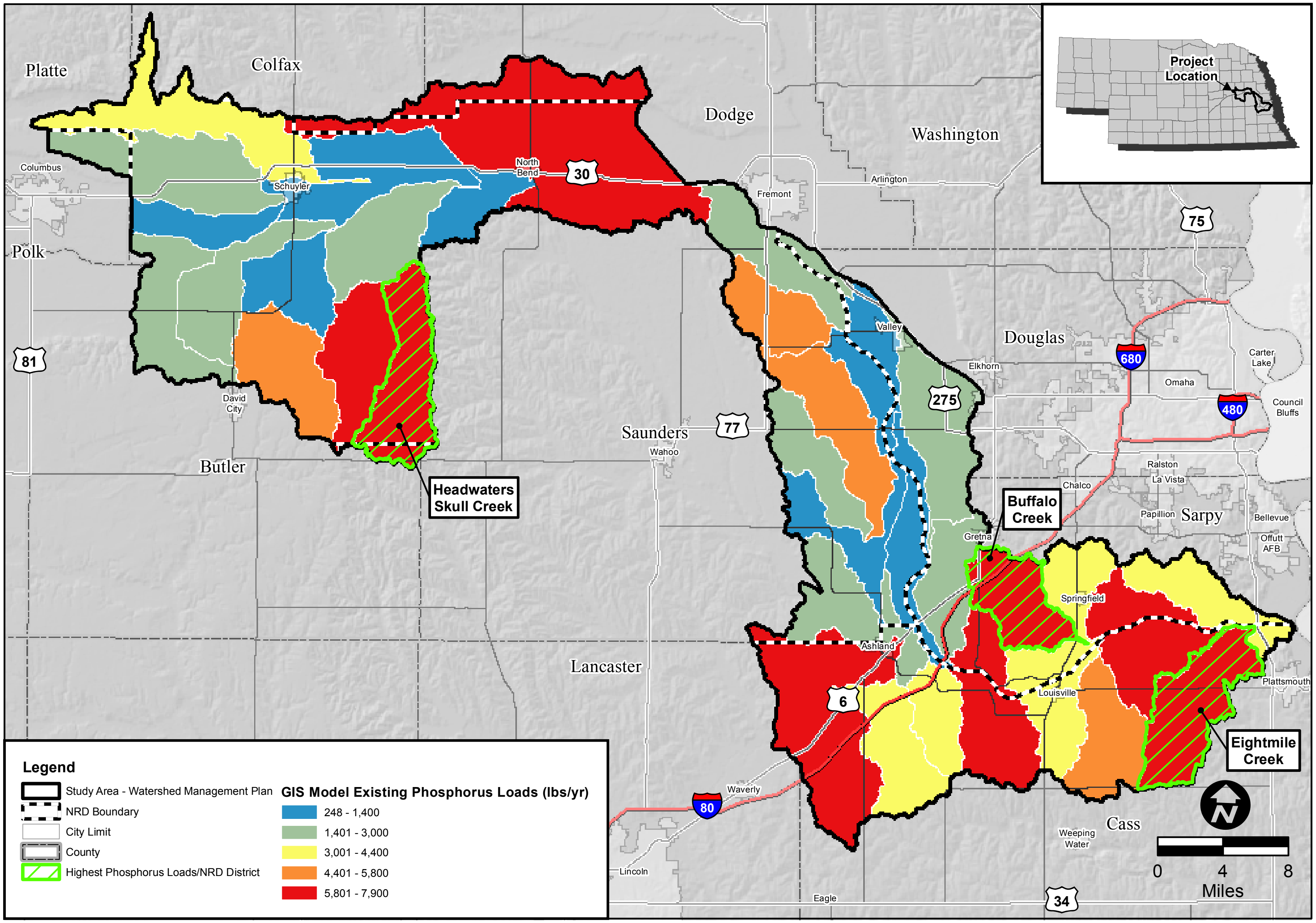


Figure 17. Total Nitrogen Loadings (Lbs/Year) – GIS Model

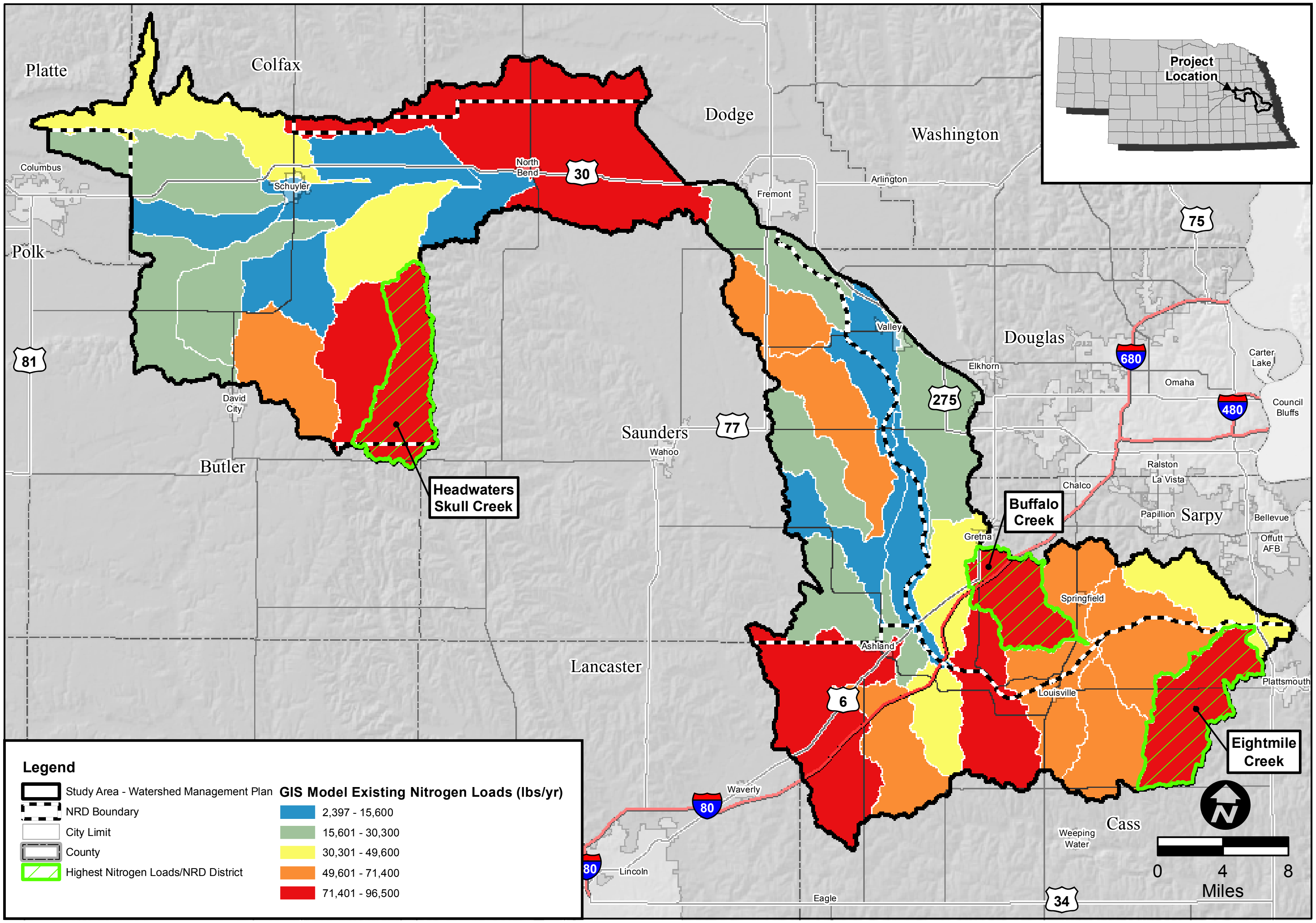


Figure 18. Total Suspended Sediment Loadings (Ton/Year) – GIS Model

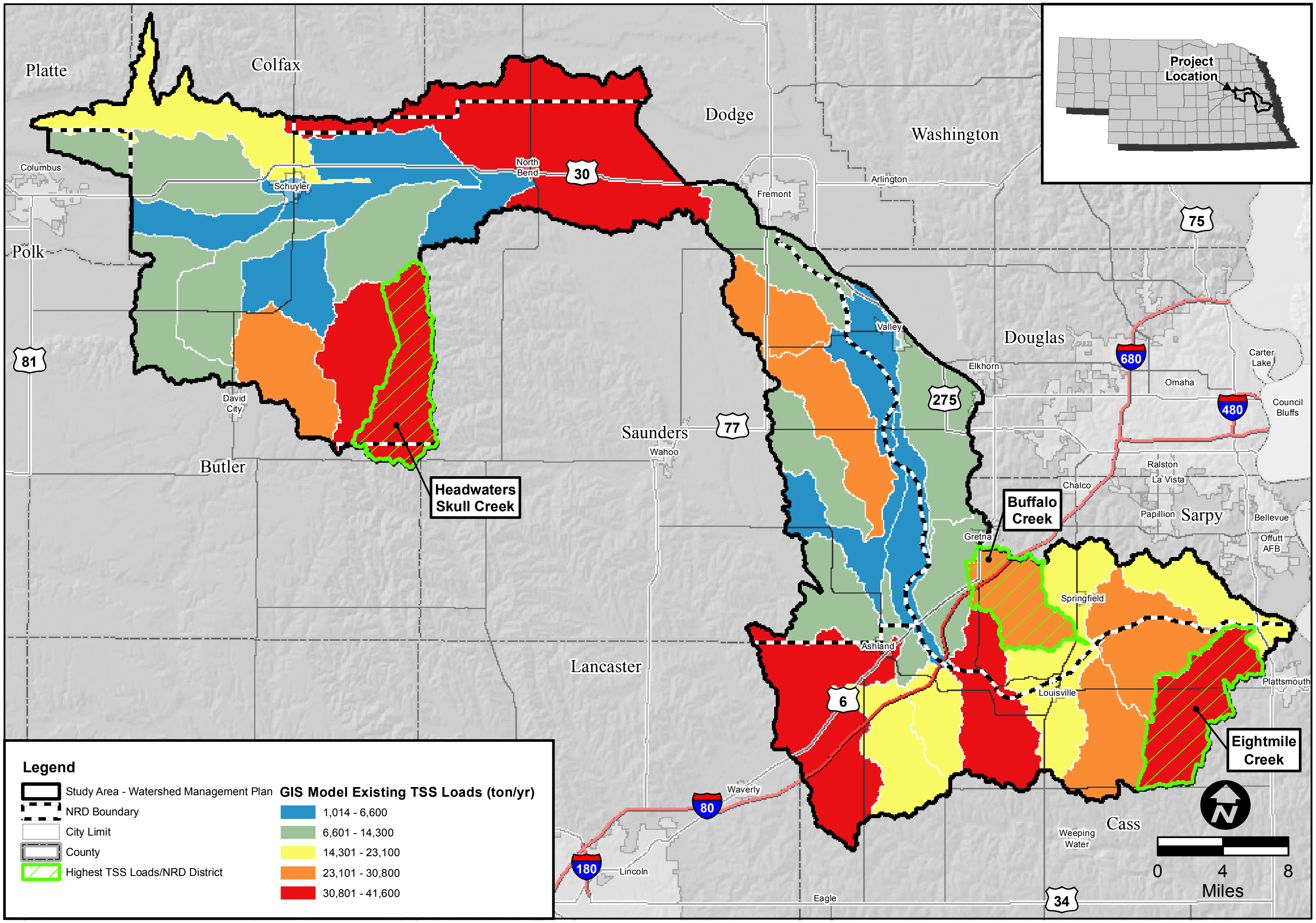


Figure 19. Total Phosphorus Loadings (Lbs/Acres/Year) – GIS Model

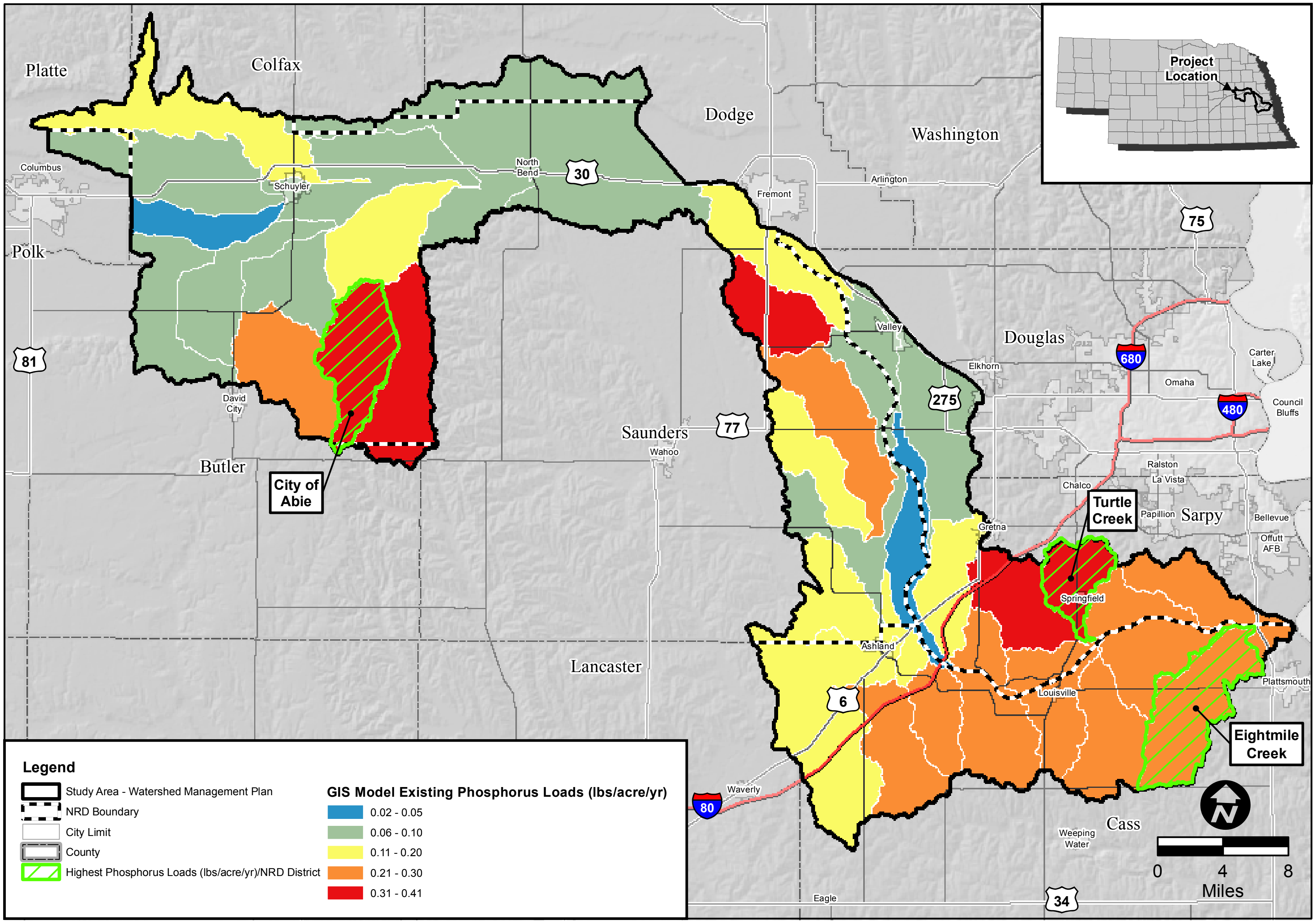


Figure 20. Total Nitrogen Loadings (Lbs/Acres/Year) – GIS Model

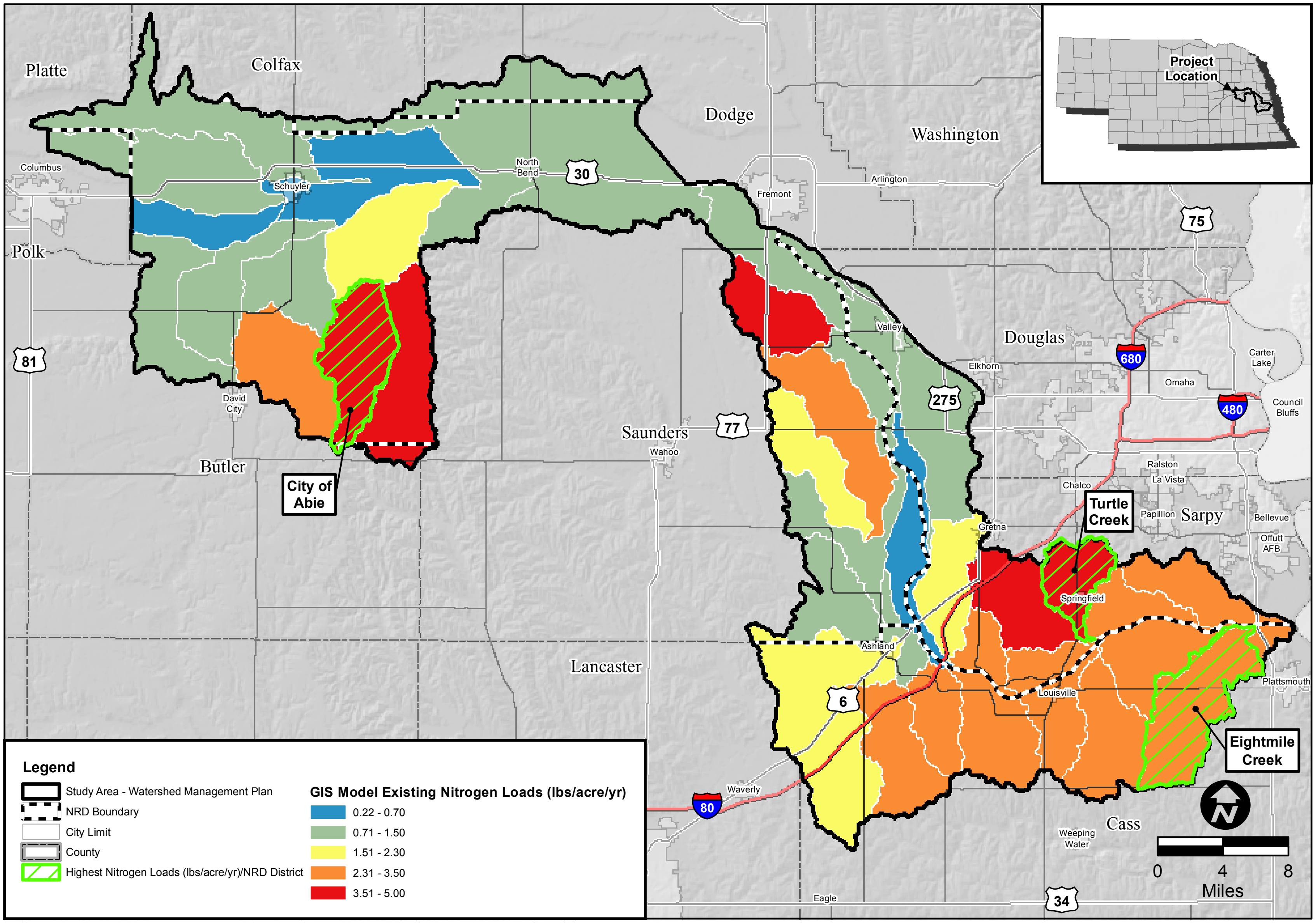
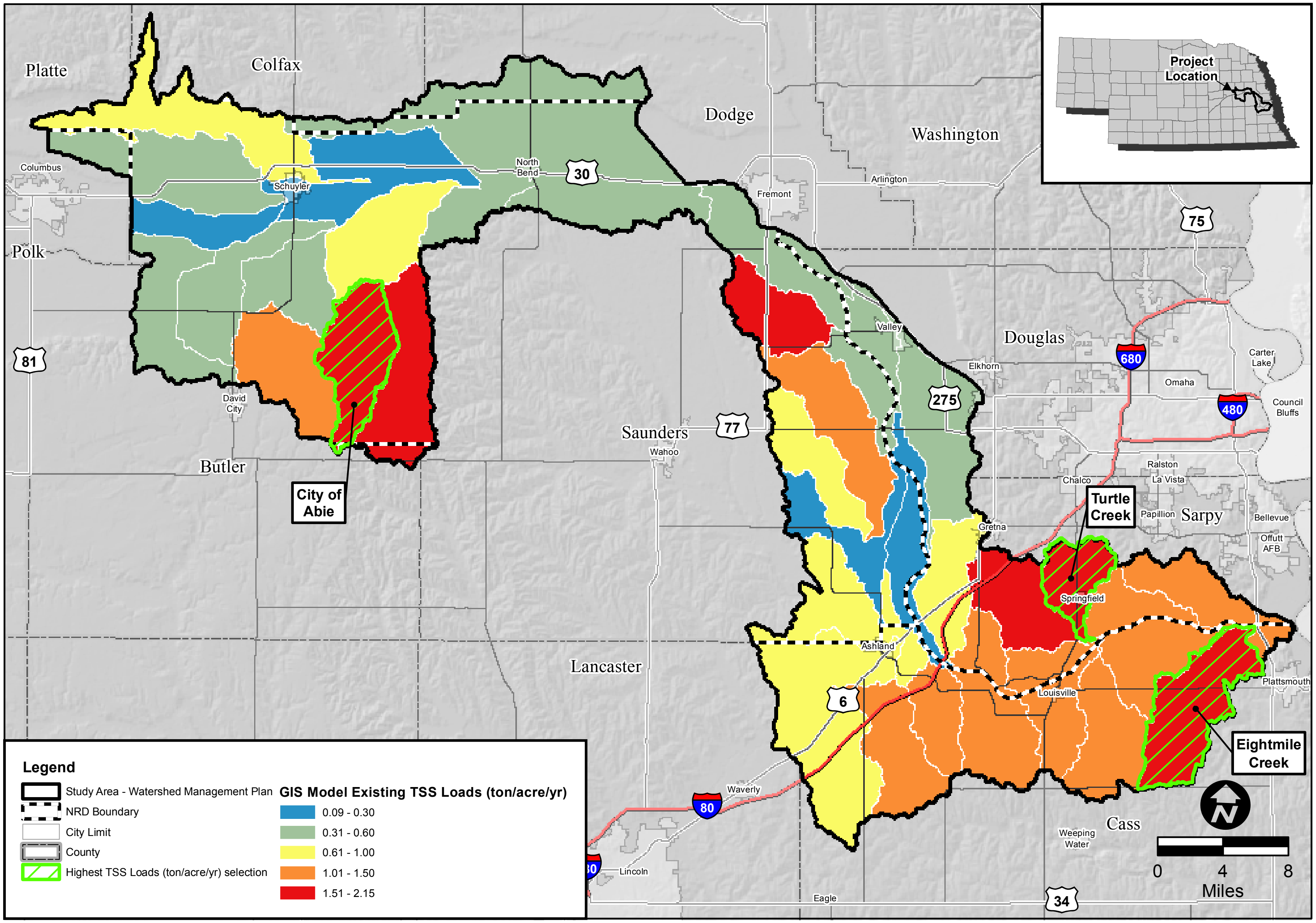


Figure 21. Total Suspended Sediment Loadings (Ton/Acres/Year) – GIS Model



GOALS AND OBJECTIVES FORMULATION

Goals and objectives formulation is a cornerstone of the watershed planning effort and are designed to guide future management decisions related to improvement of water quality. As part of the LPRCA's 2013 strategic planning efforts (see **Appendix C** for a meeting summary), a portion of the meeting was dedicated to identifying issues and concerns as it relates to water quality and a watershed management plan for the lower Platte River. These issues as well as the 2015 State Nonpoint Source Pollution Management Plan (2015 NDEQ) were used to formulate the goals and objectives for this Plan.

GOAL 1

The quality of surface water and groundwater resources within the watersheds of the Lower Platte River Corridor 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.

Objective 1 – Natural resources management actions will be based on sound data and effective directing of resources.

- **Task 1.** Review and, as necessary, revise assessment methods and protocols to assure that data accurately detect and quantify natural resources threats and impairments and that data are useful in guiding management decisions. This includes, but is not limited to evaluation of existing land treatments, analysis of aerial imagery to identify land treatments, evaluation in conjunction with the NRCS and NRD on other known or planned treatments, and a field verification of land treatments.
- **Task 2.** Evaluate threats and impairments to natural resources through ongoing monitoring, data assessment, and special studies. Coordination with the NDEQ and USGS would occur to determine the appropriate actions necessary to ascertain water quality information for each Priority I Watershed.
- **Task 3.** Implement actions in priority/sub-watersheds that will provide reductions in *E. coli* loadings and/or other pollutants to the lower Platte River.
- **Task 4.** Review and, as necessary, revise the lists of priority watershed/sub-watersheds, special priority areas and watershed-wide activities identified for restorative or protective management actions every five years.

Objective 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.

- **Task 1.** Engage in inter-organizational discussion regarding management of natural resources in the lower Platte River watershed.
- **Task 2.** Coordinate with the NDEQ and USGS relative to the water quality monitoring being performed on the lower Platte River and its tributaries.

GOAL 2

Resource managers, public officials, community leaders, and private citizens will understand the effects of human activities on water quality and support actions to restore and protect water resources from impairment by nonpoint source pollution.

Objective 1– Deficiencies in knowledge needed to improve decision making regarding management of natural resources will be identified and investigated.

- **Task 1.** Identify unique and underserved audiences to be engaged through outreach.
- **Task 2.** Identify knowledge gaps in key audiences that impede their participation in actions to manage natural resources.
- **Task 3.** 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
- **Task 4.** Develop a program to assist the general public in assessing septic tank effectiveness and provide options for upgrades if applicable.

Objective 2 – Tools to effectively transfer knowledge and facilitate actions regarding management of natural resources will be developed, improved, and maintained.

- **Task 1.** Develop and implement a train-the-trainer program for advisory group members to improve their capacity to communicate effectively with landowners and conservation partners, promote the goals and objectives of the plan, assist key audiences in participating in conservation programs and activities, and serve as knowledgeable ambassadors to inform and educate landowners about natural resources management in their watershed.
- **Task 2.** Develop and improve effective communication programs, projects, and activities to educate key audiences about management of natural resources.
- **Task 3.** Develop and distribute audience-specific materials to inform and engage community leaders, local media, youth, educators, and other defined audiences regarding natural resources management.
- **Task 4.** Provide technical assistance to participants in conservation programs to help them select, install, and maintain appropriate practices.

Objective 3 – The status, effectiveness, and accomplishments of projects and activities directed toward management of natural resources will be continually assessed and periodically reported to appropriate audiences.

- **Task 1.** Conduct progress and financial reviews of grant-funded implementation projects.
- **Task 2.** Summarize accomplishments and recommendations for further actions in implementing the basin plan in annual and final project reports, periodic reports to partners, and project success stories.

EXISTING CONSERVATION PROGRAMS

There are a number of programs from various agencies that can have a positive impact on water quality in the Lower Platte River Corridor. Summaries of the major programs are provided below.

Conservation Stewardship Program, USDA NRCS

The Conservation Stewardship Program (CSP) is a voluntary program that encourages agricultural and forestry producers to address resource concerns by:

1. Undertaking additional conservation activities and
2. Improving and maintaining existing conservation systems.

CSP provides financial and technical assistance to help land stewards conserve and enhance soil, water, air and related natural resources on their land. The program aims to prevent erosion from cropland, pastureland and rangeland from entering waterways, maintaining grass or woody buffers to intercept field runoff prior to entering waterways, managing areas for wildlife habitat, and scheduling irrigation based on soil moisture and/or evapotranspiration monitoring (NRCS, 2018 ***https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/csp/***). The following are management measures that CSP will provide a cost-share and technical assistance for:

- Access Control
- Brush Management
- Conservation (Crop Rotation)
- Cover Crop
- Early Successional Habitat Development/Management
- Filter Strip
- Integrated Pest Management
- Irrigation Water Management
- Nutrient Management
- Pasture and Hay Planting
- Pest Management
- Prescribed Grazing
- Residue and Tillage Management, No-Till/Strip Till/Direct Seed
- Residue Management, No-Till/Strip Till
- Residue Management, Seasonal
- Upland Wildlife Habitat Management
- Windbreak/Shelterbelt Establishment

Environmental Quality Incentives Program, USDA NRCS

The Environmental Quality Incentives Program (EQIP) is a voluntary conservation program that provides financial and technical assistance to farmers and ranchers who face threats to soil, water, air and related natural resources on their land. Through EQIP, NRCS develops contracts with agricultural producers to implement conservation practices to address environmental natural resource problems. The EQIP program addresses impaired water quality, conservation of ground and surface water resources, reduction of soil erosion and sedimentation and improvement or creation of wildlife habitat for at-risk species (NRCS, May 2009).

Integrated Water Quantity Management Plans

Each of the NRDs associated with the Study area is in the process of identifying priorities for water management. The Lower Platte South, and Papio–Missouri Natural Resources Districts, in cooperation with the Nebraska Department of Natural Resources, have developed and adopted an Integrated Water Quality Management Plans. The Lower Platte North is in the process of developing a plan. These plans will help to develop a comprehensive inventory of all available ground and surface water supplies and all current water uses, projection of future water use needs and identification of potential sources, and desired management of conservation programs. The Integrated Water Quality Management Plans will consider the effects of current and new water uses on existing surface and ground water users, and evaluate alternatives for additional water needed for municipal and industrial growth. In addition, a basin-wide study has been developed, in cooperation with the Nebraska Department of Natural Resources, which evaluates surface water resources in the lower Platte River and is contributing Loup and Elkhorn watersheds.

Soil and Water Conservation Program

The NRDs administers state and local cost-share assistance as an incentive to landowners for the construction and application of soil and water conservation practices. High priority practices include:

- Establishment of warm and cool season grass on cropland
- Construction of new terrace systems
- Construction of sediment and water control basins when part of a new terrace system
- Construction of diversions when part of a new terrace system or dam
- Planned grazing management systems
- Installation of tiled outlets into existing terraces
- Water impoundment and grade stabilization structures
- Irrigation water management
- Tree/shrub planning
- Windbreak renovation
- New grass waterways
- Waterways on 100% no-tilled fields
- Emergency repair of conservation practices

Groundwater Management Plan

The NRDs have developed groundwater management plans that focus on maintaining the quantity and quality of groundwater in our area. This task includes:

- Testing the water of 100 wells for nitrates every five years
- Establishing management areas if the groundwater reservoir life goal can't be met
- Continuing to administer permits for chemigation (application of agricultural chemicals through irrigation)
- Evaluating the need of rural landowners for a dependable drinking water supply

In addition, the PMRNRD began the Eastern Nebraska Water Resources Assessment (ENWRA) project to develop a geologic framework and water budget in eastern Nebraska. PMRNRD also funds a cost share program for capping abandoned wells.

LOAD REDUCTIONS NEEDED

The overarching vision for the development of this Plan is to gain an understanding of the contributions and distribution of select water quality constituents (*E. coli* bacteria, total nitrogen, total phosphorus, total suspended sediments, and atrazine) within the Lower Platte River Corridor to improve and protect surface water quality in the lower Platte River. Due to the establishment of a TMDL for the Lower Platte River Basin (TMDL–LPRB) (NDEQ, 2007) for *E. coli* bacteria, a focus on the reductions needed to meet the water quality standard for this parameter are of utmost importance.

E. coli Reductions Needed to Meet Water Quality Standard

The published TMDL–LPRB calls for targeted load reductions throughout the Lower Platte River Basin to meet water quality criteria that are fully supportive of the primary contact recreation beneficial use. To account for uncertainty in the nonpoint source load reduction, the TMDL–LPRB targets reductions set at 90% of the water quality criterion of 126 col/100 ml. Specifically, the TMDL–LPRB targets an *E. coli* concentration of 113 col/100 ml as a recreational season mean in both the lower (LP1-10000) and upper (LP1-20000) segment of the Lower Platte River. To achieve this target, the TMDL–LPRB calls for an 85% reduction in LP1-20000 based on an observed *E. coli* concentration of 750 col/100 ml. A 64% reduction is called for in LP1-10000 based on an observed geometric mean concentration of 314 col/100 ml which would require an 82% reduction.

While the TMDL–LPRB calls for a 64–85% reduction in *E. coli*, targeted reductions are based here on more recent data collected from the Platte River at Louisville (USGS Gauge 06805500). Per methods described in **Appendix B**, a load duration table was developed for *E. coli* for the Louisville station (**Table 9**). The Louisville station is considered representative of the Study Area as it is located near the downstream end of the Platte River. Based on the load duration curve, the most significant bacteria loadings occur during wet weather conditions. However, as the *E. coli* target is applied as a recreational season geometric mean the required reductions are not specific to any one flow regime. Therefore, existing conditions were set equal to the geometric mean weighted across all flow regimes. Based on this approach the Platte River has an *E. coli* concentration of 640 col/100 ml, which requires an 82% reduction to achieve the TMDL target of 113 col/100 ml. The targeted 82% reduction shall broadly apply to the entire study area.

Contributing drainage areas located outside the study area are beyond the scope of this watershed plan.

Table 9. Recreational Season *E. coli* Loading Calculations for the Platte River at Louisville

Hydrological Condition Class	Flow Duration Interval	Median Flow, cfs	*E. coli* Geomean, cfu/100 mL	Recreational Season Load, cfu/yr
High Flows	0–10%	25,150	8,989	8.41E+16
Moist Conditions	10–40%	10,200	1,355	1.54E+16
Mid-Range Conditions	40–60%	6,360	449	2.12E+15
Dry Conditions	60–90%	3,710	306	1.27E+15
Low Flows	90–100%	1,425	90	4.76E+13
		Weighted Geomean	**640**	**—**

Notes: *E. coli* concentrations based on turbidity regressions derived by USGS (Schaepe et al. 2014). Recreational season *E. coli* load = (median flow) x (*E. coli* geomean) x (unit conversion factor [24,465,525 m•s/ft³•day]) x (# of days in recreation season for hydrological condition class). Weighted geomean = 8,989^0.1* 1,355^0.3*449^0.2*306^0.3*90^0.1.

E. COLI MANAGEMENT TO ACHIEVE REDUCTIONS NEEDED

Load reductions can be achieved through two primary measures: 1) structural controls, and 2) non-structural controls. Structural controls consist of land use treatments and structures design to prevent or minimize pollutants on the landscape from entering a water body. Structural measures include, but are not limited to those detailed in **Table 10. Appendix D** provides descriptions of these measures.

Non-structural controls are measures that are designed to remove the pollutant from the landscape. Non-structural practices are typically less expensive to implement, but often require a change in landowners' operations in order to be successful, which can come at an operational cost. There are many practices available to producers to address specific or multiple issues. Information and educational practices are key to promoting implementation of these measures. Non-structural measures include but are not limited to:

- Crop to grass/CRP
- Cover crops
- Irrigation management
- No-till farming
- Nutrient Management
- Soil sampling
- Terraces
- Diversions
- Contour Farming
- Manure and Land Application Management
- Reduced nutrients in feed
- Pasture management
- On-site waste water management system
- On-site runoff management
- Livestock Exclusion
- Riparian Buffer
- Saturated Buffers
- Soil Health Management

Based on a review of potential measures, **Table 11** identifies select structural and non-structural controls that are anticipated to reduce *E. coli* loadings to achieve the management goal of meeting the TMDL. In order to achieve the targeted 82% reduction, a combination of practices will likely be required for the different land use types. The effective reduction rate is a function of both the combination of practices and the applicable treatment area. Specific control measures were not identified for the 'urban human' source. Additional study is needed to determine what sources are contributing

Table 10. Structural Management Measures

Agriculture Structural Measures	Urban	Stream
• Constructed Wetlands • Wet Detention Basins • Dry Detention Basin • Sediment Control Basin • Grassed Waterways	• Bioswales • Urban Soil Quality Restoration • Rain Gardens • Bioinfiltration Systems • Rainwater Harvesting • Native Landscaping • No/Low-Phosphorus Fertilizers • Low Impact Development • Green Roofs • Soil Health Management • Septic Tank	• Streambank Stabilization • Grade control structures • In-stream wetlands • In-stream weirs • Aquatic habitat development • Riparian zone renovation • Floodplain reconnection

to 'urban human', which potentially include SSOs, illicit connections, failing septic systems, and wastewater treatment facilities. However, 100% reduction was assumed for this category as it is necessary to achieve the overall targeted reduction rate of 82%.

Load Reductions of Other Parameters

Management techniques that would reduce nonpoint sources of *E.coli* bacteria includes utilization of proper conservation treatment to prevent runoff into surface waters. Therefore, land treatments that would reduce loadings of other parameters, such as total phosphorus (TP), total nitrogen (TN) or total suspended sediment (TSS) are viable methods to reduce E.coli bacteria. The following provides measures that address land treatments.

Table A-13 in **Appendix A** shows an estimate of the percent area of each HUC 12 as derived from the land treatment data from the NRCS. The derivation of the average effectiveness of the land treatments is discussed in **Section 2**. During discussions held at watershed stakeholder meetings, many stakeholders felt that there existed

Table 11. Summary of *E. coli* Load Reductions

	Pasture			Cropland			Urban	
	Wildlife	**Livestock**	**Human**	**Wildlife**	**Livestock**	**Human**	**Wildlife**	**Human***
Livestock Exclusion[1]		70%						
Treatment Area*		100% (140,329)						
Manure and Land Application Management [2]		33%	33%		33%	33%		
Treatment Area		100% (140,329)	100% (140,329)		100% (456,452)	100% (456,452)		
Riparian Buffer[1]	70%	70%	70%	70%	70%	70%		
Treatment Area	75% (105,247)	75% (105,247)	75% (105,247)	75% (342,339)	75% (342,339)	75% (342,339)		
Terraces[2]/Dry Detention**				25%	25%	25%		
Treatment Area				10% (45,645)	10% (45,645)	10% (45,645)		
Wet Detention Basins[2,3]/Constructed Wetland/ Bioswale	70%	70%	70%	70%	70%	70%		
Treatment Area	5% (7,016)	5% (7,016)	5% (7,016)	5% (22,823)	5% (22,823)	5% (22,823)		
Grassed Waterways[2]/Cover Crop	50%	50%	50%	50%	50%	50%		
Treatment Area	25% (35,082)	25% (35,082)	25% (35,082)	25% (114,113)	25% (114,113)	25% (114,113)		
Sediment Control Basin[1]	70%	70%	70%	70%	70%	70%		
Treatment Area	25% (35,082)	25% (35,082)	25% (35,082)	25% (114,113)	25% (114,113)	25% (114,113)		
Rain Garden[2,4]							70%	
Treatment Area							10% (1,697)	
Biofiltration[2,4]							58%	
Treatment Area							10% (1,697)	
Effective Reduction	**67%**	**93%**	**78%**	**68%**	**78%**	**12%**	**12%**	**100%*** **
Current Load, col/year	**4.45E+16**	**2.05E+17**	**3.72E+15**	**1.35E+17**	**3.10E+17**	**1.13E+16**	**7.79E+15**	**1.30E+17**
Reduced Load, col/year	**1.47E+16**	**1.36E+16**	**8.25E+14**	**4.35E+16**	**6.70E+16**	**2.44E+15**	**6.83E+15**	**0.00E+00**
Total Current Load								**8.47E+17**
Total Reduced Load After Treatment								**1.49E+17**
Percent Reduction								**82%**
Maximum Load to Meet Water Quality Standard								**1.49E+17**

Bacteria removal efficiencies taken from: 1) Miller et al. 2012, 2) Statistical Tool for the Estimation of Pollutant Load (STEPL) model, Tetra Tech 2011, 3) UWRRC 2014/Wright Water Engineers and Geosyntec 2012, 4) Wright Water Engineers and Geosyntec 2012.

*The number of acres needed throughout the subbasins for each land use is included in parentheses;
**For purposes of this analysis, it was assumed that dry detention basins and terraces function similarly in treating surface water runoff;
***Additional study is needed to determine what sources are contributing to 'urban human', which may include SSOs, wastewater treatment facilities, failing septic systems, and illicit discharges. However, 100% reduction was assumed to achieve the overall targeted reduction rate of 82%.

Measures identified are for the purpose of estimation of potential *E. coli* load reductions. Implementation may include other measures and associated treatment areas.

more land treatment in the watershed than was reflected within the NRCS database. Therefore an across the board 50% land treatment was assumed to be in place for the entire watershed.

The GIS based model was chosen as the model of record for analysis of loading reductions and future watershed calculations. The GIS based model has much finer resolution than other models and will be more beneficial when studying single HUC 12s for which more detailed data is available. Another benefit of using the GIS model is that in incorporates detailed slope information and calculating distance from the nearest stream is a simple matter. These pieces of information are important factors in analyzing the impact of BMPs. Lastly, the GIS based methodology is set up that future analyses can be simple GIS exercises instead of full modeling efforts, which can save time and money in the future.

The loadings from the GIS model were adjusted to include land treatments over much more area than is currently assumed to be covered. The assumed percent area being affected by a land treatment in the future is 75% for agricultural land and 50% for range, pasture, and grassland. Additionally, the effectiveness of the treatments increased.

The effectiveness of TP removal was increased in the model from 40% to 80%. The effectiveness of TN removal was increased in the model from 15% to 66%. The effectiveness of sediment removal in the model was increased from 50% to 85%. **Figures 21** through **26** show the total reduction potential and percent reductions for TP, TN, and TSS, respectively. **Table A-14** through **A-16** in the **Appendix** shows the potential effectiveness of land treatments for each HUC 12 within the Study Area. Increasing the coverage and effectiveness of land treatments results in a total potential reduction of approximately 50,125 tons/year for total phosphorus, 208,600 tons/year for total nitrogen, and 322,975 tons/year of sediment.

Prioritization of Watersheds for Management Measure Implementation

Understanding the potential for load reductions is a valuable tool to aid in determining the benefits a watershed could incur with increased management practices. However, several assumptions are needed when estimating the percent of the HUC 12s in the Study Area that have existing treatments and the effectiveness of those treatments. Therefore, it was determined that the total contributing loads to the observed seasonal geometric means at both North Bend and Louisville for *E. coli* bacteria would be used to determine priority watersheds within the Study Area to begin focused efforts to improve water quality. As described above, some measures to remove *E. coli* bacteria would also be effective in removal of total nitrogen, total phosphorus, total suspended sediments, and atrazine.

The following describes this priority system established to address *E. coli* contributions (cfu/100ml) with within the Study Area:

- **Priority 1 Watersheds** – Due to the number of watersheds having large *E. coli* loadings within the Study Area, multiple factors were considered in determining the Priority 1 watersheds. Each NRD analyzed the needs of their respective watersheds when determining priority beyond *E. coli* loading. Due to the amount of agriculture with the watershed, the Lower Platte North NRD considered the availability of landowners willing to implement BMPs in determining priority areas as well as geographical considerations of watershed position (watersheds higher in the contributing drainage area to the lower Platte River. The Lower Platte South and Papio-Missouri River NRDs are situated within areas that are experiencing high levels of agriculture conversion to suburban and urban development uses. These NRDs used future land use planning as a criteria in deciding priority areas to identify which watersheds had availability to establish BMPs prior to development occurring. In addition, the potential for landowner participation in BMPs and most cost effective practices were considered in the prioritization.
- **Priority 2 Watersheds** – The next top 10 highest contributing watersheds of *E. coli* contributions (cfu/100 ml) regardless of NRD Boundary.
- **Priority 3 Watersheds** – All remaining watersheds with the Study Area in order of *E. coli* contributions (cfu/100 ml).

Based on the *E. coli* loadings provided in **Section 2**, Watershed Characterization, and the contributing criteria described above **Table 12–14** provides the Priority 1, 2, and 3 watersheds, respectively. **Figure 28** provides these watershed locations within the Study Area.

Based on the management measures described above, the Priority 1 watersheds were analyzed for the potential BMP implementation and the resultant anticipated *E. coli* load reductions. Preliminary estimates indicate that the cumulative reduction for the Priority 1 watersheds would be 75%. Load reductions for the individual watersheds can be found in **Table 15** and **Appendix E**.

Table 12: Priority 1 Watersheds

HUC	Subwatershed Name	Recreational Season *E. coli* Loading (cfu/year total)	NRD Name
102002010308	Headwaters Skull Creek	3.04E+16	Lower Platte North
102002010304	Headwaters Bone Creek	2.95E+16	
102002020210	Eightmile Creek	3.05E+16	Lower Platte South
102002020208	Turkey Creek-Platte River	2.77E+16	
102002020204	Buffalo Creek	2.54E+16	Papio-Missouri
102002020211	Zwiebel Creek-Platte River	2.13E+16	
102002020206	Turtle Creek	1.68E+16	

Table 13: Priority 2 Watersheds

HUC	Subwatershed Name	Recreational Season *E. coli* Loading (cfu/year total)	NRD Name
102002020101	Rawhide Creek-Platte River	9.49E+16	Lower Platte North
102200031006	Big Slough-Elkhorn River	4.44E+16	Papio-Missouri
102002010301	Shonka Ditch	3.90E+16	Lower Platte North
102002010209	Brewery Hill-Shell Creek	3.88E+16	
102002010310	Lost Creek-Platte River	3.73E+16	
102002020202	Western Sarpy Ditch-Platte River	2.98E+16	Papio-Missouri
102002020203	Decker Creek-Platte River*	2.81E+16	Lower Platte South
102002010307	Village of Abie	2.81E+16	Lower Platte North
102002010309	Outlet Skull Creek	2.69E+16	
102002010303	Deer Creek-Platte River	2.48E+16	

*As of the submittal of this Plan, Lower Platte South NRD is developing a District-wide 319 Watershed Water Quality Management Plan. Decker Creek-Platte River is currently anticipated to be Priority 1 watershed in that plan.

Table 14: Priority 3 Watersheds

HUC	Subwatershed Name	Recreational Season *E. coli* Loading (cfu/year total)	NRD Name
102002020103	Elm Creek-Platte River	2.41E+16	Lower Platte North
102002020205	Cedar Creek	2.31E+16	Lower Platte South
102002020104	Otoe Creek-Platte River	2.21E+16	Papio-Missouri
102002020207	Mill Creek-Platte River	2.17E+16	Lower Platte South
102002010306	Tomek Island-Platte River	2.15E+16	Lower Platte North
102002030907	Dee Creek-Salt Creek	2.12E+16	Lower Platte South
102002010305	Outlet Bone Creek	2.11E+16	Lower Platte North
102002020102	Headwaters Otoe Creek	1.79E+16	
102002010302	Headwaters Lost Creek	1.65E+16	
102002020201	Pawnee Creek	1.44E+16	Lower Platte South
102002020105	102002020105	1.43E+16	Papio-Missouri
102002031003	Headwaters Clear Creek	1.11E+16	Lower Platte North
102002031005	Wahoo Creek*	1.07E+16	
102002010311	102002010311	9.97E+15	
102002030906	Callahan Creek	8.45E+15	Lower Platte South
102002031002	Johnson Creek	7.88E+15	Lower Platte North
102002031004	Clear Creek	7.75E+15	

*An EPA 319 Watershed Water Quality Management Plan for Wahoo Creek has been developed for this watershed. Management strategies are addressed in that plan.

Table 15: Priority 1 Watershed BMP *E. coli* Load Reduction

HUC	Subwatershed Name	Recreational Season *E. coli* Loading (cfu/year total)	*E. coli* Reduced Load (col/year)	Percent Effective
102002010308	Headwaters Skull Creek	3.04E+16	5.01E+16	83
102002010304	Headwaters Bone Creek	2.95E+16	4.15E+15	85
102002020210	Eightmile Creek	3.05E+16	1.12E+16	60
102002020208	Turkey Creek-Platte River	2.77E+16	1.33E+16	52
102002020204	Buffalo Creek	2.54E+16	9.38E+15	63
102002020211	Zwiebel Creek-Platte River	2.13E+16	6.77E+15	68
102002020206	Turtle Creek	1.68E+16	1.52E+16	86

Management Measures to Achieve Goals

The LPRCA has identified management measures that will occur on a watershed specific basis as well as across the entire Study Area in order to meet the plans, goals and objectives. Also, due to the number of watersheds within the Study Area and likely lengthy duration for overall implementation, these management measures were grouped into Management Initiatives for implementation. These Management Initiatives are (further details on these management measures are provided in the following section, **Management Plan Implementation**):

MANAGEMENT INITIATIVE 1

This Management Initiative will focus on implementation of best management practices for the reduction of *E. coli* bacteria within Priority 1 watersheds. Each of the NRDs would assist in determining the types of BMPs appropriate for each Priority I watershed. Coordination with the NDEQ and USGS would occur to determine the appropriate actions necessary to ascertain water quality information for each Priority I Watershed.

MANAGEMENT INITIATIVE 2

This Management Initiative will be implemented across the entire Study Area concurrently with Management Initiative 1.

- Implement Voluntary Septic Tank Upgrade Program
- Contributing Watershed Coordination Plan

Figure 22. Total Phosphorus Loading Reductions – GIS Model

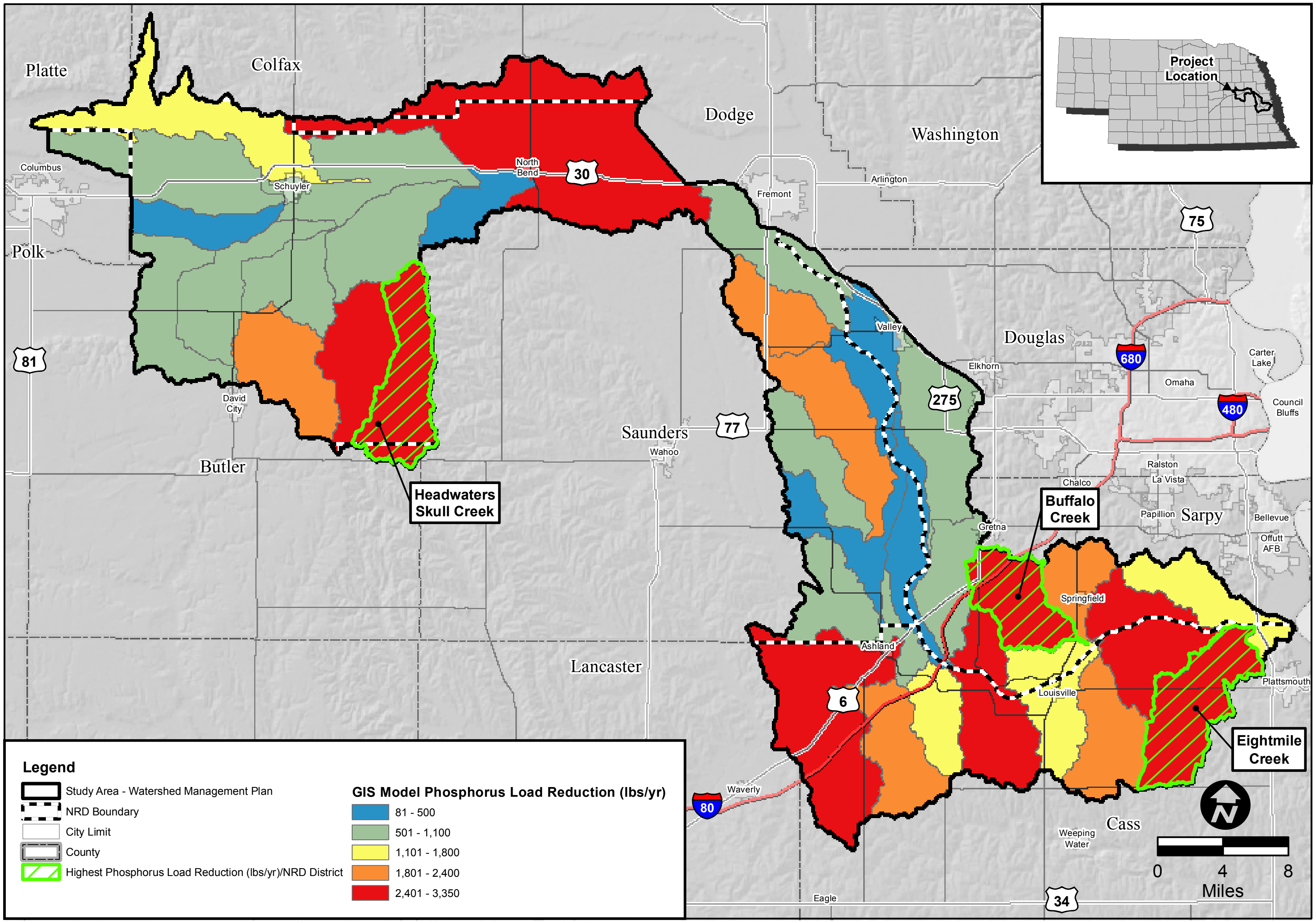


Figure 23. Total Phosphorous Loading Percent Reductions – GIS Model

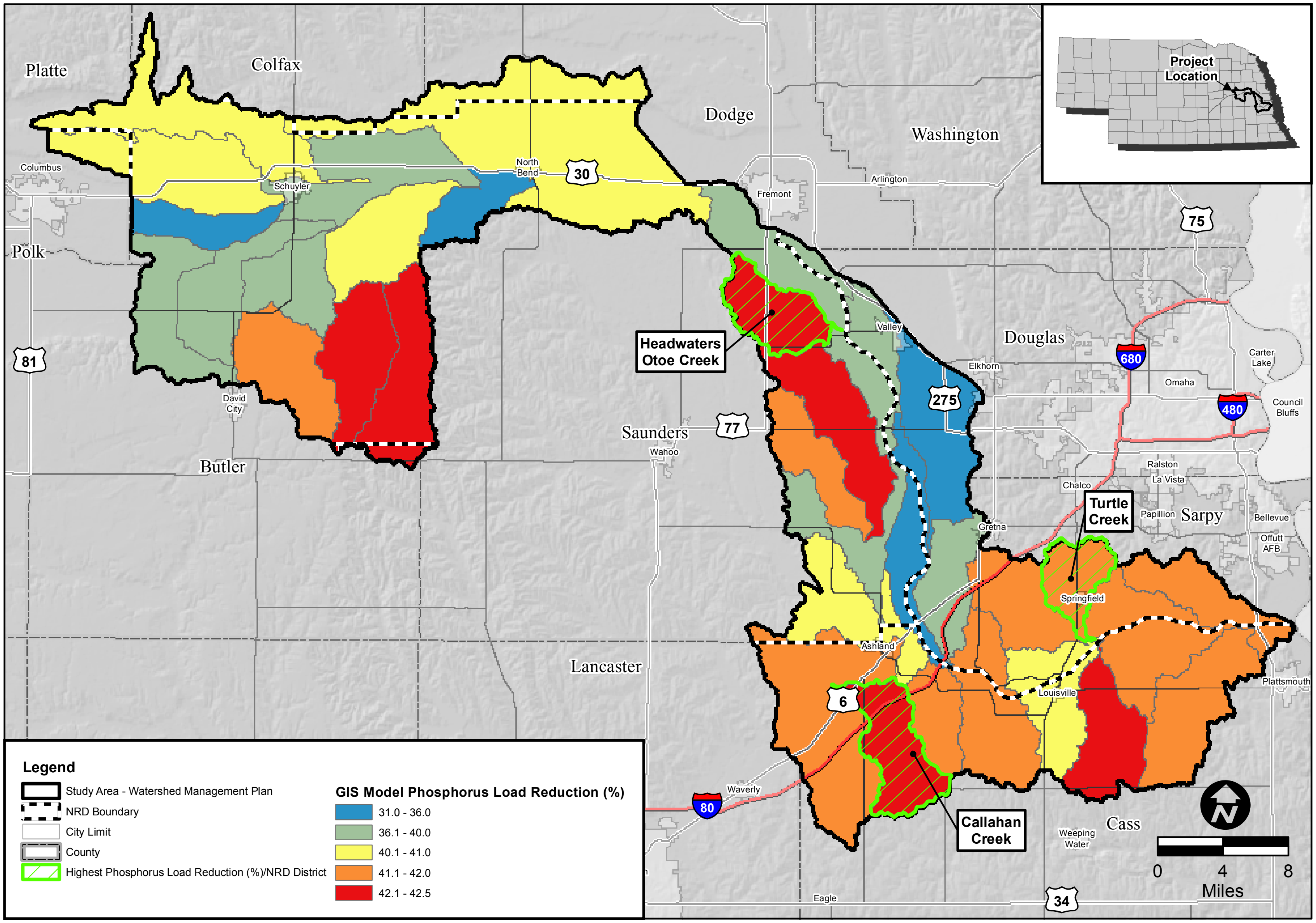


Figure 24. Total Nitrogen Loading Reductions – GIS Model

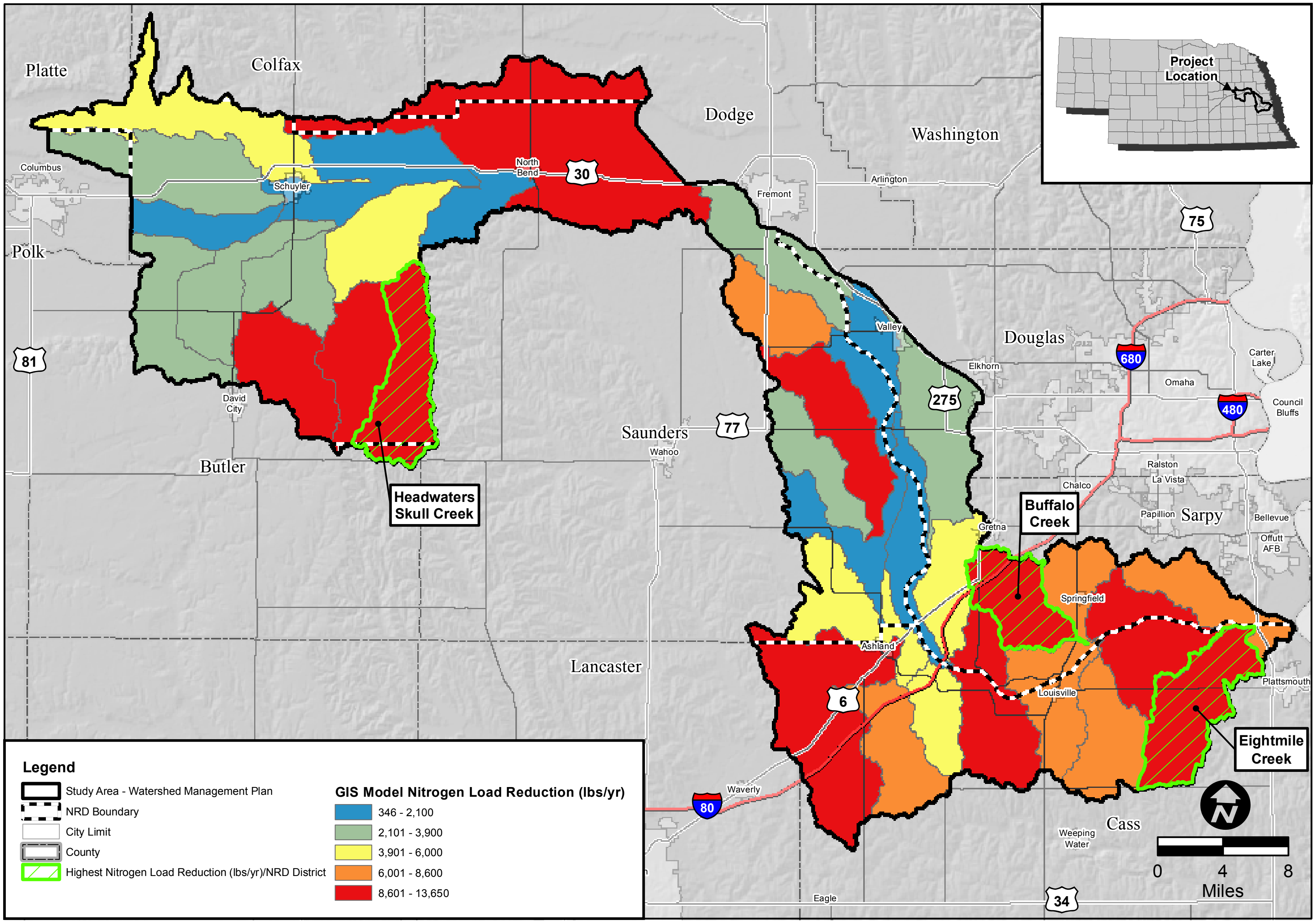


Figure 25. Total Nitrogen Loading Percent Reductions – GIS Model

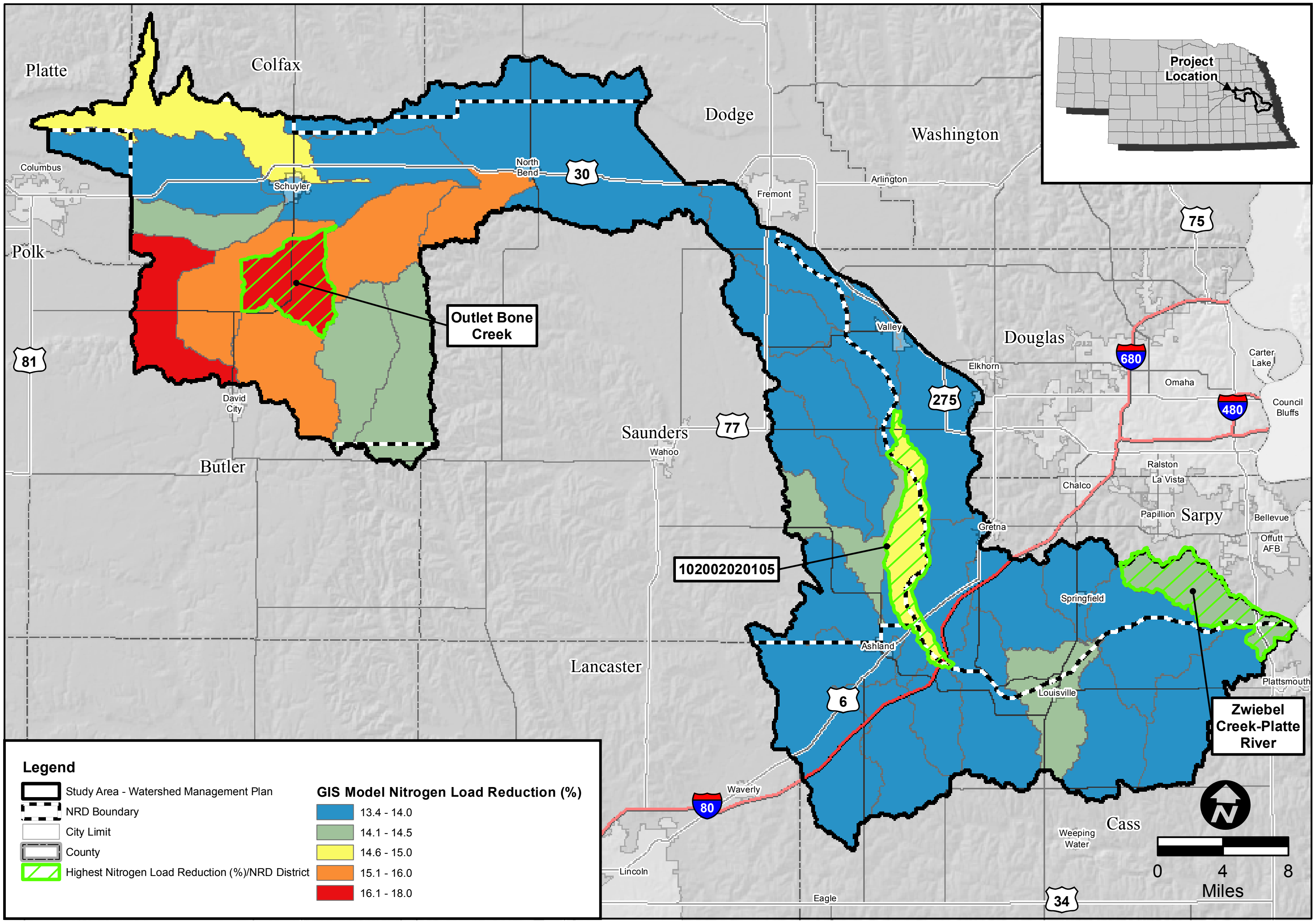


Figure 26. Total Suspended Sediment Loading Reductions – GIS Model

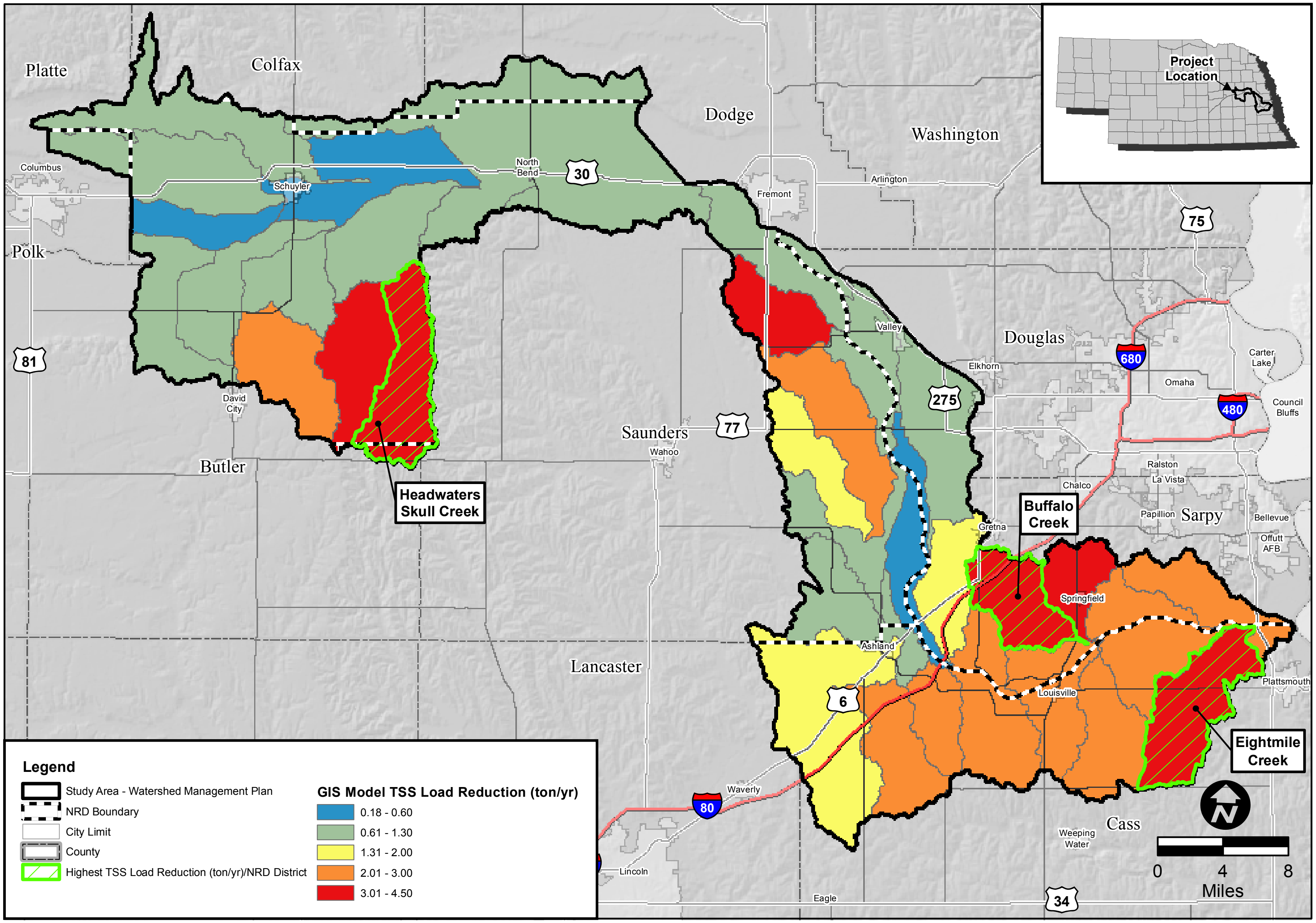


Figure 27. Total Suspended Sediment Loading Percent Reductions – GIS Model

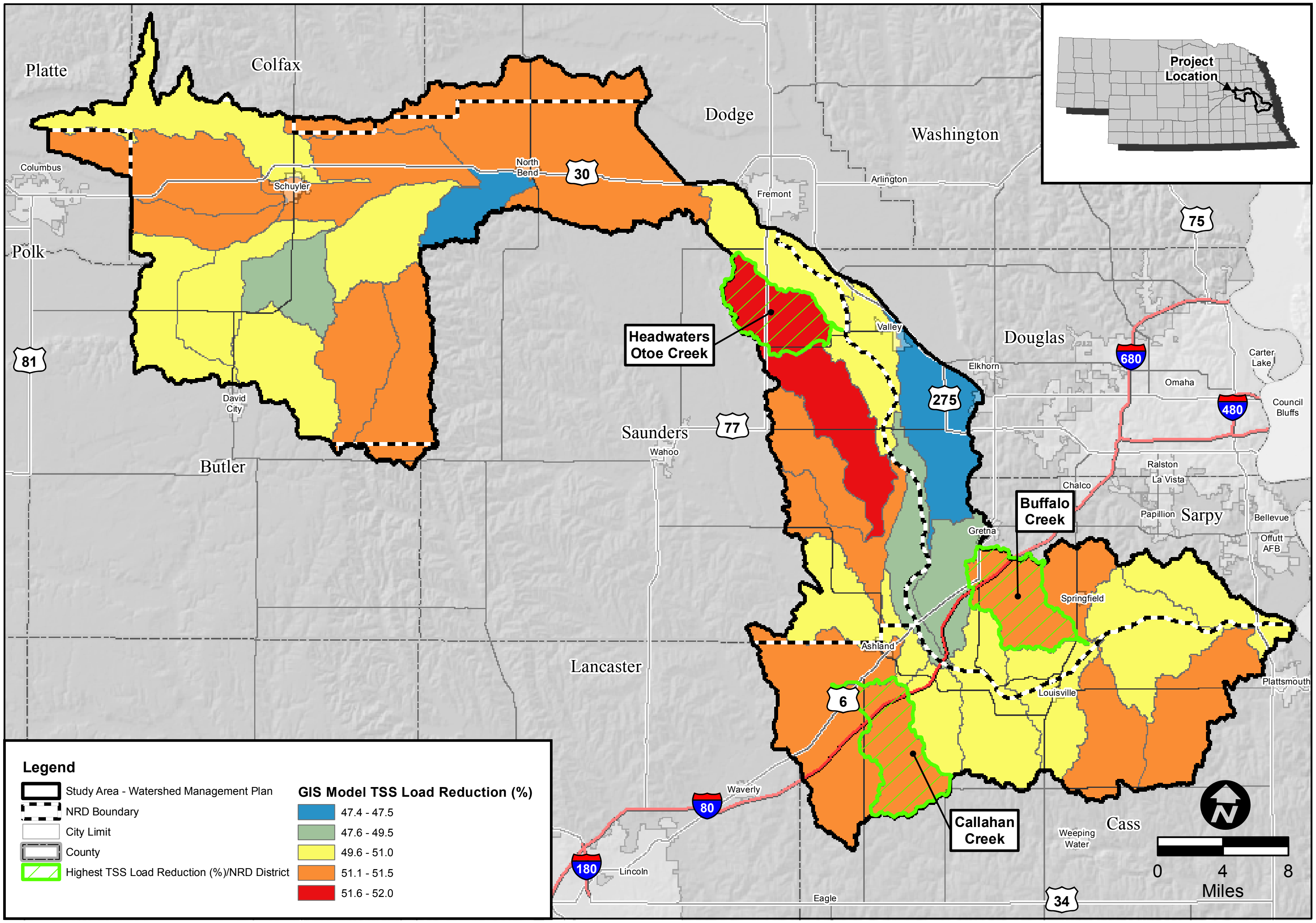
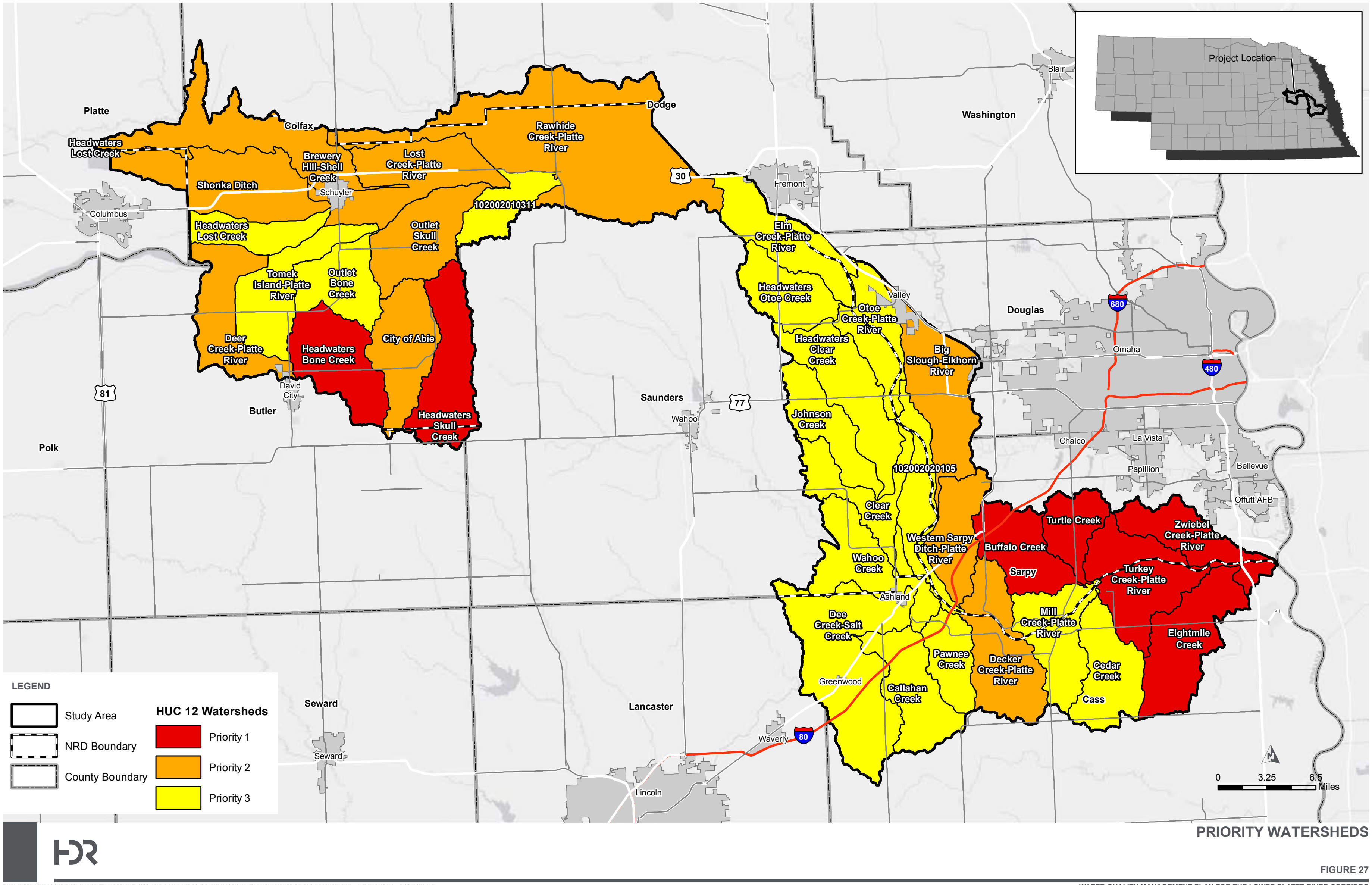


Figure 28. Priority Watersheds



MANAGEMENT MEASURES & IMPLEMENTATION

To meet the goals and objectives of the Plan, implementation of the management measures, as introduced in **Section 4**, would provide actions to advance the improvement of water quality within the lower Platte River. The approach for implementation of this Plan consists of separate management initiatives. The following generally describes these management initiatives. Subsequent activities to these management initiatives are described in the following section (**Plan Re-Evaluation**).

Management Initiative 1

This management initiative focuses on types and locations of best management practices (BMPs) to implement in the Priority I watersheds. Each of the NRDs have assisted in determining the types of BMPs appropriate for each Priority I watershed. Typical BMPs are identified in **Table 10** in **Section 4**. The estimated management measures assumed to be implemented in the Priority I watersheds are provided as part of the *E. coli* load reduction calculations provided in **Appendix E**.

Coordination with the NDEQ and USGS would continue to occur to determine the appropriate actions necessary to ascertain water quality information for each Priority I Watershed. Through this coordination, water quality monitoring efforts would be identified to document the short-term and long-term effects of BMP implementation.


Buffer strip

Management Initiative 2

This initiative focuses on broader measures that are not specific to the Priority 1 Watersheds or other individual HUC 12 watersheds and would occur concurrently with Management Initiative 1. The following provides an overview of each management measure that would be implemented.

VOLUNTARY SEPTIC TANK UPGRADE PROGRAM

More than 60% of the state's population lives within 30 miles of the lower Platte River corridor including the three largest cites: Bellevue, Lincoln, and Omaha. Along with the incorporated municipalities, several housing developments are located in and along the lower Platte River corridor. Many housing developments that began as recreational or seasonal residences along the lower Platte River and adjacent closed sand and gravel mining operations have been established as individual dwellings or as a part of a cluster, either formally or informally organized. Many of these residences date back many decades, and overtime, year-round occupancy has become more prevalent. Where available, these residents may have the opportunity to receive utilities from community systems, whereas others rely on individual wells and on-site wastewater treatment facilities (that is, septic tank systems).

As part of this Plan, a desktop evaluation was conducted to determine the approximate location and number of housing developments that have individual septic tank systems. The desktop evaluation was performed utilizing aerial imagery, NDEQ information for registered (regulated) septic tank systems, discussion with local authorities and NRDs, **Figure 12** identifies these locations. Approximately 2,760 residences are estimated to exist in these housing development areas.

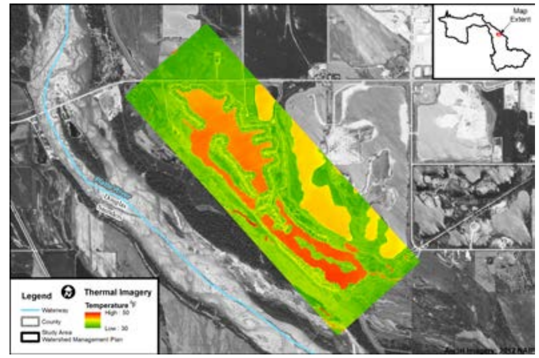
During 2012, LPRCA, with support from the Nebraska Department of Environmental Quality (NDEQ), partnered with the Center for Advanced Land Management Information Technologies (CALMIT), which is a unit of the University of Nebraska–Lincoln School of Natural Resources. CALMIT was founded to enhance and expand research and instructional activities in remote sensing, geographic information systems (GIS), automated cartography, and image processing. One of the CALMIT areas of expertise is the use of hyperspectral remote sensing focused on observations of vegetation, surface water, and soils.

CALMIT conducted flights in 2012 along the lower Platte River corridor and in three housing areas adjacent to the river to identify warm water abnormalities that may indicate nonpoint source pollution from the large number of septic tank systems or other conduits located along the river. Conducting the flights served as a proactive measure to determine if using this method could be used to identify areas that have warm water discharges rather than waiting until septic tank deficiencies are identified through other means, such as total septic tank system failure and repair.

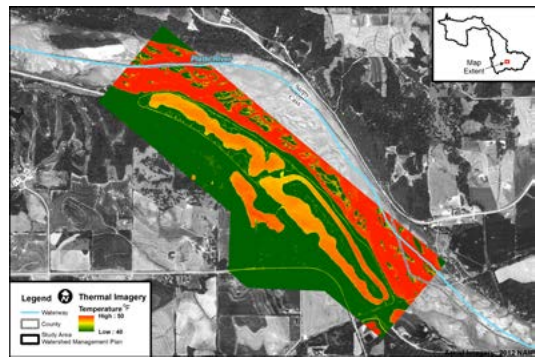
Housing Development

This information, in addition to the HUC 12 modeling and *E. coli* loading information, can be used to initiate a Voluntary Septic Tank Upgrade Program (Program) to upgrade septic systems installed prior to January 1, 2000 to current design standards. Should septic tanks systems that would benefit from measures that would update them to current standards be found, there would be no penalty to the owner, but rather, a cost share program could be developed to facilitate the repair of the septic tank system. The cost share program could be with the Natural Resources District (NRD) associated with the location of residence.

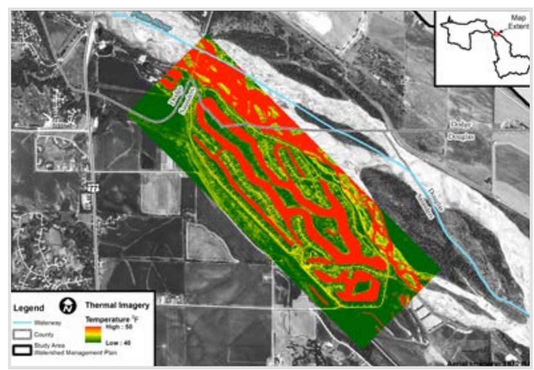
Homeowners must apply to their local NRD for participation in the program prior to taking any action. If approved, the homeowner may contract with a certified on-site wastewater system installer to pump and inspect their septic system. If the system is functioning correctly, the homeowner may submit the inspection report and request up to 60% reimbursement (not to exceed $300) for pumping and inspection costs. Minor repairs will be at the homeowner's expense. If the homeowner wishes to upgrade to current design standards, the homeowner may request up to 60% reimbursement (not to exceed $3,000) for the replacement of the system in addition to 60% reimbursement (not to exceed $300) for pumping and inspection. The homeowner must provide proof that the new system has been properly registered with NDEQ. If the septic system is determined to have failed and the homeowner does not choose to replace the system, no reimbursement will be made for pumping and inspection.



CALMIT Thermal Energy – Ginger Cover



CALMIT Thermal Energy – South Bend



CALMIT Thermal Energy – Woodcliff

The process for the implementation of this Program would include:

- Seek and secure funding to develop the Program details and Year 1 costs for septic tank inspections and remediation. It is anticipated that the cost share would be a 60/40 split (NRD 60/ resident 40) of costs associated with the inspections and agreed upon remediation (if required).
- Develop a detailed information and education plan and materials with NDEQ as part of the promotional strategy for this measure.
- Identify target areas to focus outreach efforts. These areas include the larger development areas (>80 residences) as identified on **Figure 12** and shown in **Table A-4**. If these areas fall within the Priority I Watersheds, a focused effort would be made in those areas first.
- The promotional strategy would consist of mailings to the target areas, information and promotion at the "test your well night" event, and the other avenues for information and education.

Contributing Watershed Coordination Plan

The pollutant loading modeling identified that contributing watersheds, such as the Loup River, Elkhorn River, and Salt Creek watersheds, are contribute a considerable amount of flow within the lower Platte River. The NDNR reviewed 1950–1980 flow data for tributary river and streams to the lower Platte River and the U.S. Fish and Wildlife Service (USFWS) reviewed data from 1975–1994 (for the Louisville, Nebraska USGS gauge only). **Table 16** shows the percent contribution of flows from each of the three river systems at the North Bend, Ashland, and Louisville USGS gauges. Note that other contributions at the Louisville gauge does contribute between 6 and 12% of the total flow.

Due to these flow contributions, the water quality of these rivers and streams has an effect on the overall water quality of the lower Platte River. The following is the status of each of these water bodies on Nebraska's 2012 303 (d) list:

- **Loup River** – Impaired for Recreation—bacteria; and Aquatic Life—fish consumption. A TMDL has been approved.
- **Elkhorn River** – Impaired for Recreation—bacteria. A TMDL has been approved.
- **Salt Creek** – Impaired for Recreation—bacteria; Aquatic Life—Ammonia, Chloride; Fish consumption advisory; Impaired aquatic community; Agriculture Water Supply—conductivity. A TMDL has been approved.

Therefore, while the contributing watersheds not located within the Study Area, gaining an understanding of the measures in place in contributing watersheds would offer a baseline to start from for future management coordination efforts.

Portions of the Salt Creek and Elkhorn River watersheds exist within the Lower Platte South and Papio–Missouri River NRDs, both partners with LPRCA. However, the Loup River watershed and the upper portions of the Elkhorn River watershed are managed by the Upper Loup, Lower Loup, Upper Elkhorn, and Lower Elkhorn NRDs. While coordination among these NRDs is ongoing, a specific discussion relative to water quality monitoring would be beneficial.

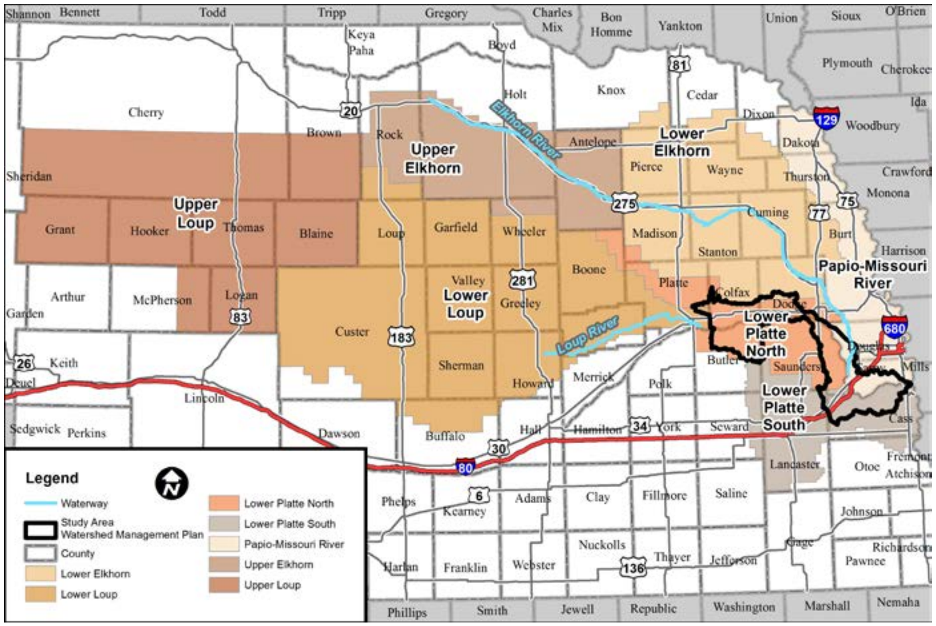
At this point, the Nebraska Association of Resource Districts (NARD) would be essential in organizing a water quality discussion. A round-table discussion at the annual NARD conference with technical representation from each NRD, plus NDEQ and LPRCA, would be a first step in discussing water quality from a larger watershed perspective.

4 INFORMATION AND EDUCATION

The intent of the information and education component of this Plan is to establish the methods that would be used to inform the stakeholders of the LPRCA of the implementation of the management measures for *E. coli* loading reductions developed as part of this Plan. Due to the size of the Study Area and the numerous sub-watersheds within it, obtaining specific public input on sub-watershed areas, project identification and implementation, and partnerships was not feasible. However, information has been provided to the LPRCA stakeholders and made available to the public during the development of the Plan. Numerous updates on the development and progress of the Plan has provided an understanding of the process for the development of the Plan, the types and sources pollution, the management solutions needed to improve and maintain water quality, and the steps required for Plan implementation.

Due to the structure of the LPRCA and its relationship with its stakeholders, the LPRCA is well positioned and has previous experience in performing education and outreach for its initiatives. Ongoing information and education activities would occur for implementation of Management Initiatives 1 and 2. These methods are outlined below.

- **Website:** *http://www.lowerplatte.org/*
- **LPRCA membership email listings** – LPRCA has a comprehensive list of all individuals and/or entities that have provided an email address to be included on its distribution list. This list is a way to reach those individuals with news and information or direction to the LPRCA website or another source.
- **Newsletters**
- **Meetings**
- **Online GIS** for public use for viewing of data and map making
- **Some LPRCA events** that promoted engagement and education in the past have included:
  - » **Water Quality Open** (that is, a golf outing and engagement opportunity)
  - » **Annual lower Platte River kayak tour** – an opportunity for stakeholders and public to be on the river and to participate in associated educational presentations
  - » **Biannual Lower Platte River Summit** – A day-long event featuring speakers, tours, and information sharing
- **Coffee shop meetings** – These are LPRCA scheduled events in communities within



NRD's with contributing watersheds to the lower Platte River

Nebraska's Natural Resources Districts
www.nrdnet.org
Protecting Lives • Protecting Property • Protecting the Future

The mission of the NARD is to assist NRDs in a coordinated effort to accomplish collectively what may not be accomplished individually to conserve, sustain, and improve our natural resources and environment.
http://www.nrdnet.org/

LPRCA to have casual discussions about issues, concerns, or other topics that the public has on the Lower Platte River.

- **Participation** in other community and organization events and meetings
- **Informational kiosks** at access points, parks and recreation areas throughout the Corridor
- **Social media sites**

The website, newsletters, and meetings would all be used as outlets to provide information to the public on the management measures. In addition to these standard tools, the following details the specific measures that may be used for the Program management measure:

- Program specific print materials (for example, pamphlets)
- Press release about the Program
- Specific information on NRD, NDEQ and LPRCA websites
- Mailings to homeowner organizations that have septic tank systems management measures
- Coordination at NRD meetings
- Participation at county fairs or other community events or meetings
- LPRCA and/or NRD "Test Your Well Night" – an opportunity to engage the public through offering free drinking water testing.

Specific outreach for each Management Initiative 1 and 3 would aid in informing landowners in these watersheds about the Plan's objectives, identifying willing partners for project implementation, and addressing specific concerns of landowners and residents. These specific outreach efforts would aid in identifying where projects can be implemented and willing participants for project implementation. Specific outreach efforts (individual mailings, inclusion in development newsletters/websites) would also be tailored for the Voluntary Septic Tank Upgrade Program for target areas within Priority Watersheds.

5 IMPLEMENTATION SCHEDULE

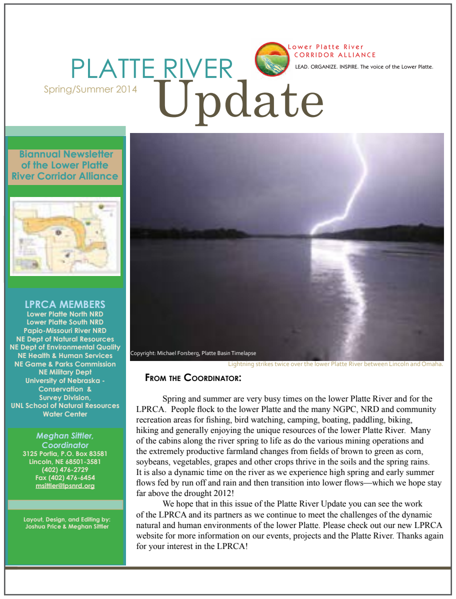
The following is a proposed scheduled for the management measures identified here. LPRCA has grouped these measures into two implementation phases. This does not represent a priority for implementation, but rather, the duration of implementation as well as the necessary order of implementation to have the best information available for successful implementation of each management measure. The following provides the implementation schedule. Updates to this schedule are anticipated to occur annually as part of the LPRCA's review of all ongoing project and initiatives.

- **Years 1–2**
  - » Initiate Management Initiative 1 for Priority 1 Watersheds
  - » Initiate Management Initiative 2
- **Years 3–5**
  - » Initiate and implement BMPs for Priority 1 Watersheds
  - » Re-evaluate Priority Watersheds (as part of yearly Plan Re-Evaluation)
  - » Continue Voluntary Septic Tank Inspection Program
  - » Evaluate Management Initiative 2 and determine future course of action
  - » Watershed Plan Update (estimated at Year 5) including re-evaluation of Priority Watersheds
- **Years 6–10**
  - » Initiate and implement BMPs for re-assessed Priority 1 Watersheds, as applicable
  - » Re-evaluate Priority Watersheds (as part of yearly Plan Re-Evaluation)
  - » Watershed Plan Update (estimated at Year 10) including re-evaluation of Priority Watersheds
- **Years 11–20**
  - » Initiate and implement BMPs for re-assessed Priority 1 Watersheds, as applicable
  - » Re-evaluate Priority Watersheds (as part of yearly Plan Re-Evaluation)
  - » Watershed Plan Update (Year 15 and Year 20) and Re-evaluate Priority Watersheds

MILESTONES FOR IMPLEMENTATION TRACKING

One method of tracking progress of implementation is by establishing incremental goals within the broader context of the management measures. The completion of these sub-tasks within the management measures would enable LPRCA and stakeholders to identify implementation progress. These sub-tasks provide a way to identify short-term (1–2 years), mid-term (3–5 years), and long-term (6–10, 11–20 years) accomplishments, as applicable. A watershed plan update is planned after year 5 and year 10, milestones beyond this period are not developed.

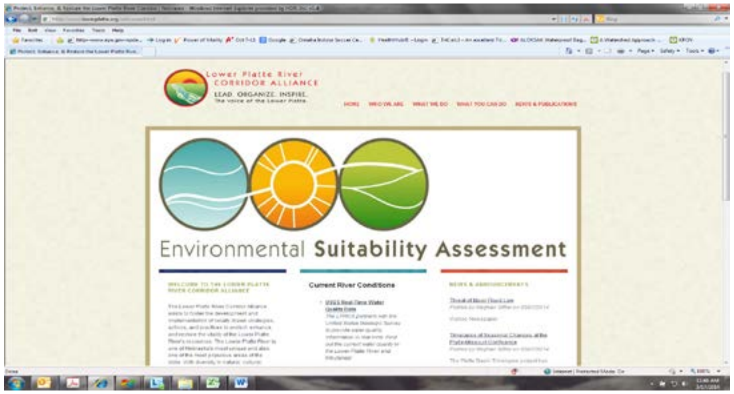
Table 17 provides the milestones of achievement. The ability to meet these milestones is largely dependent upon funding for implementation. Additional details on financial resources needed are discussed below in Identification of Technical and Financial Resources Needed.



Quarterly Newsletter


Annual Lower Platte River Kayak Tour


Biannual Lower Platte River Summit



LPRCA Website

Table 16. Plan Implementation Milestones

Milestone	1 2019	2 2020	3 2021	4 2022	5 2023	6–10 2024–2028	11–20 2029–2038
Complete Watershed Management Plan	X						
Plan Re-Evaluation	Annually						
Implement Information and Outreach Strategies	Ongoing						
Identify funding for Priority 1 Watershed Implementation	X	X	X	X	X	X	X
Implementation of BMPs association with Priority 1 Watersheds			X	X			
	X	X	X				
Priority 1 Watersheds Composite *E. coli* load reduction					6.62E+16 CFU/ Year = 10% of Total Load Reduction Needed to meet TMDL goal at Louisville	TBD[1]	TBD[1]
Initiate Contributing Watershed Coordination Plan		X					
Identify funding for Voluntary Septic Tank Inspection Program	X	X					
Develop Details and Outreach Materials for Voluntary Septic Tank Inspection Program		X					
Perform first septic tank inspection		X					
Perform first cost-share septic tank remediation		X					
Watershed Plan Update (every 5 years)					X	X	X

[1] As Priority I Watersheds are re-evaluated and assigned during Watershed Plan updates, the E. Coli load reductions will be calculated. The intent of full Watershed Plan implementation is to achieve the 1.49E+17cfu annual reduction needed at the Louisville gauge to achieve the TMDL limit.

7 MANAGEMENT EVALUATION CRITERIA

Evaluation criteria are used to determine whether or not the milestones, and ultimately, the management measures are being achieved. The criteria can be used as a way to support an adaptive management approach by providing a way to reevaluate the progress of a management measure. The following are the proposed evaluation criteria for the Management Initiatives:

Management Initiative 1

- **After 1 year of implementation** – five voluntary BMP implementation projects in each of the Priority I Watersheds
- **After 2 years of implementation** – 10 voluntary BMP implementation projects in each of the Priority 1 Watersheds
- **Pollutant Load Reductions** – pollutant load reductions evaluations due to the implementation of the BMPs would be made. Each implemented BMP is expected to provide load reductions. An evaluation of those reductions would be made as BMPs are being implemented and compared against water quality data for *E. coli* load reductions.

Management Initiative 2

- **After 1 year of implementation** – 25 inquiries on voluntary inspections, 15 inspections, and 5 cost-shared remediation efforts completed
- **After 2 years of implementation** – 50 inquiries on voluntary inspections, 30 inspections, and 10 cost-shared remediation efforts completed
- **Coordination meeting** with contributing watershed NRDs held and future actions identified.

8 MONITORING PROGRAM

A monitoring program is essential to effectively track the success of the management measures relative to the established milestones and the evaluation criteria. For LPRCA, monitoring is a routine part of its project related work. LPRCA provides updates to LPRCA partners that indicate progress of projects, use of funds, and direction for future LPRCA initiatives.

The management measures presented in this Plan are not linked directly to a specific goal of reducing pollutant levels. However, monitoring, in the sense of evaluating the implementation of each management measure, is still a critical element for the overall success of the Plan.

Monitoring would be satisfied through the following measures:

- Revisiting of water quality modeling based on Implementation Plan actions and new data as it becomes available
- Review of existing NDEQ and NRD water quality monitoring
- Point source contribution monitoring

COSTS

The costs for the implementation of this Plan are estimates based on best professional judgments. For Management Measure 2, costs are provided for the development of the performance of septic tank inspections. **Table 17** provides the summary of costs.

9 IDENTIFICATION OF TECHNICAL AND FINANCIAL RESOURCES NEEDED

For execution of all the management measures identified in this Plan, assistance from a technical and financial aspect would be required. Technical Financial assistance needs are described below.

Technical Assistance Needs

MANAGEMENT INITIATIVE 1

- **BMP Identification** – The NRD would play a pivotal role in coordinating with land owners identify willing participants. NRCS involvement would be critical in identify BMPs that are appropriate for the landscape. The USGS would assist in providing information on effectiveness on land treatments and potential monitoring

MANAGEMENT INITIATIVE 2

VOLUNTARY SEPTIC TANK UPGRADE PROGRAM

- **NDEQ** – assist with the development of program details, funding, and assistance with performing voluntary inspections and recommendations for actions
- **NRDs** – assist with remedial action cost sharing (or identify other cost sharing sources)

Adaptive Management

Addressing complex conservation and resource management decisions, often involving uncertainties, requires more than public engagement; it requires scientific insights and information, and, in particular, the capacity to generate ongoing knowledge and adjust actions based on that learning.

Definitions of adaptive management vary but generally invoke several consistent characteristics: (a) systematic processes; (b) for improving management practices; (c) through ongoing learning; (d) with a focus on outcomes; (e) assessed through monitoring and evaluation

Scarlett, L. 2013. Collaborative adaptive management: challenges and opportunities. Ecology and Society 18(3):26.

http://www.ecologyandsociety.org/vol18/iss3/art26/#ms_abstract

CONTRIBUTING WATERSHED COORDINATION PLAN

- **NARD** – Assist with the coordination of the round table discussion on water quality issues
- **NRDs** – Participation in the round table discussion on water quality issues

MONITORING PROGRAM

To aid in monitoring efforts, new data as available from the NRCS and NRDs on existing or proposed land treatments would be needed. In addition, information from the NDEQ and/or others on the effectiveness of land treatments would also aid in model re-evaluations.

FINANCIAL ASSISTANCE NEEDS

Financial assistance would vary for each management measure. The following represent the various financial resources needed to execute the Plan:

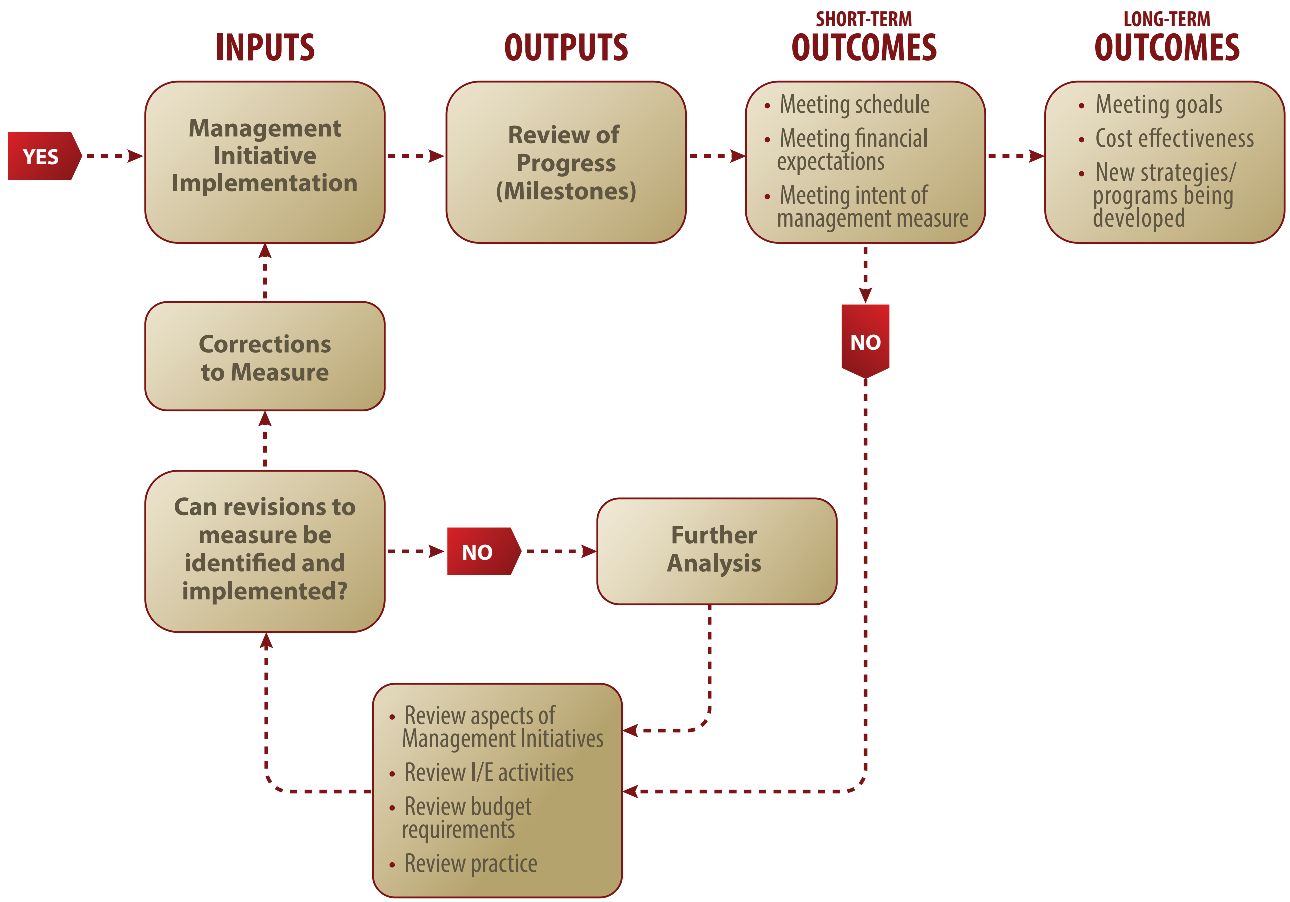
- **LPRCA/NRDs** – provide financial resources and in-kind services
- **NDEQ** and associated EPA Section 319 Grant funding
- **NRDs** – cost share programs for land treatment
- ***Natural Resources Conservation Service*** – use of existing federal programs to reduce soil erosion, improve water quality, and habitat conservation through programs such as Environmental Quality Incentives (EQIP), Agriculture Water Enhancement Program (AWEP), Conservation Reserve Program (CRP), Conservation Stewardship Program (CSP), Wildlife habitat Incentive Program (WHIP) and Wetland Reserve Program (WRP)
- **United States Geological Survey (USGS)** – The USGS participates in cost-share projects with the LPRCA (such as the Water Quality Monitoring Network ***Section 22 Planning Assistance to States (administered by the U.S. Army Corps of Engineers***) – This program can provide assistance for planning efforts for projects that are related to water resources planning
- ***Nebraska Department of Natural Resources*** – Nebraska funding programs to support projects aimed for conservation and management of natural resources
- **Nebraska Game and Parks Commission (NGPC)** – The NGPC provides various funding programs to provide for the maintenance, enhancement, and restoration of existing terrestrial and aquatic habitats
- ***Nebraska Environmental Trust grant funding*** – The Trust seeks projects that bring public and private partners together collaboratively to implement high-quality, cost-effective projects that conserve, enhance and restore the natural environments of Nebraska.

Table 17. Estimate of Plan Implementation Costs

Activity	Cost
Management Initiative 1 Implementation	
Best Management Practice Identification	$5–10k x 6 = $30–$60k
Implementation Cost and Schedule	$13.9m – $37.2m
Management Initiative 2	
Information Materials Development	$5–10k
Voluntary Inspections (15 anticipated for Year 1)	$7.5k
Corrective Actions for Septic Tanks (5) during Year 1	$30k
Voluntary Inspections (15 anticipated for Year 2)	$7.5k
Corrective Actions for Septic Tanks (5) during Year 2	$30k
Plan Update (year 5)	$50k
Information and Education	$1.5k
Plan Re-Evaluations (yearly)	Performed as part of LPRCA administrative actions
Plan Update (year 10)	$50k
Plan Update (year 15)	$50k
Total	**$14.1m – $37.5m**

This **Lower Platte River Water Quality Management Plan (Plan)** consists of Management Initiatives. As shown in **Section 5**, each of these Management Initiatives has unique milestones for which to measure progress. The NRDs and LPRCA will on an annual basis evaluate the overall progress made towards achieving those milestones. In addition, review of milestones will occur from each NRD and/or through LPRCA coordination. These reviews will assist in the 5 year update of the Plan.

To assess the progress and effectiveness of this Plan, LPRCA will implement an adaptive management approach of evaluating management measures, and ultimately, Plan effectiveness. This process is illustrated in the graphic below:



A vital element to this adaptive management approach is being able to address the reasons why a management measure is not providing the desired results. Important questions to be asked may include:

- Were there sufficient financial resources available to implement the management practice as designed?
- Were the financial resources needed to implement the management measure under-estimated?
- Were there sufficient technical resources available to implement the management measure as designed?
- Were the technical resources needed to implement the management measure under-estimated?
- Were adequate information and education activities carried out to implement the management measure as designed?
- Is more time needed to identify management measure results?
- Is new information available to guide decision making?
- Are there cultural barriers that were not anticipated that are restricting successful implementation of the management measure?

During the Plan Re-Evaluation, input received from all stakeholders will be used to aid in future course of action.

LPRCA is organized such that it provides feedback regarding all of its activities to its stakeholders on a regular basis. LPRCA formally does this at public meetings and informally through its website and any distributed newsletters. Through these mechanisms and others, the details, status, and direction for existing management measures, as well as the potential for new management measures, will be provided to stakeholders.

As part of future Plan Re-Evaluations, it may be needed to review the Watershed Priority 2 and 3 classifications. This review, if needed, would include a systematic review of the loading analysis performed for the Study Area, combined with a priority analysis of the watersheds. The priority analysis would include factors such as:

1. Potential for water quality improvements compared to watershed size
2. Location of the watershed relative to future growth and land use changes
3. Urban versus agricultural related contributions to the watershed
4. Current water quality conditions within the watershed
5. Funding availability

Other factors may be developed as part of the priority analysis. The results of the priority analysis would provide a plan for future LPRCA or stakeholder course of action relative to implementation of management measures on a HUC 12 basis.

The process for the development of a watershed prioritization effort generally would follow these steps:

- Assemble data needed for a priority analysis, such as Study Area loading analysis rankings, existing and future land uses, and potential for load reductions.
- Establish a priority analysis through stakeholder engagement. The priority analysis would, through consensus building, determine the factors used and the process for the analysis.
- Perform the priority analysis. The priority analysis may be developed through mathematic computations or geospatially through ArcGIS Model Builder.
- Present and discuss the model results with stakeholders.

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Table A-1. Period of Record and Number of Samples for Sample Locations

Sample Location	Sediment		Nitrogen		Phosphorus		Atrazine		Bacteria	
	Period Used	Number of Samples	Period Used	Number of Samples	Period Used	Number of Samples	Period Used	Number of Samples	Period Used	Number of Samples
Platte River at Ashland	ND		ND		ND		ND		2004-2005	2
Platte River at Duncan	1992-2012	30	1992-2011	57	1992-2011	57	1992-2011	176	2001-2006	35
Elkhorn River at Waterloo	1992-2012	174	1992-2013	137	1992-2013	136	1992-2009	280	2009-2010	75
Platte River at Leshara	ND		1994-1995	45	1994-1995	45	1994-2002	46	ND	
Platte River at Louisville	1982-2012	417	1982-2012	108	1982-2012	561	1991-2010	528	2004-2009	45
Loup River at Genoa – combined	1980-2010	24	1980-2010	14	1980-2010	15	2003-2010	177	2003-2005	78
Platte River at North Bend	1982-2011	94	1982-2011	94	1982-2011	94	2002-2011	127	2004-2009	42
Salt Creek near Ashland	2009-2013	26	2010-2013	23	2010	23	2001-2010	102	2004-2013	76
Shell Creek near Columbus	1992-2012	36	1992-2009	57	1992-2009	71	1992-2010	187	2008-2012	53
Wahoo Creek at Ashland	ND		ND		ND		2001-2010	148	2004-2009	45

Table A-2. NPDES Permitted Facilities in the Study Area (USEPA ECHO Database)

NPDES #	Site	Average Annual Flow (MG)	% of Total NPDES Flow
NE0042358	Schuyler Wastewater Treatment	415	1%
NE0000795	Cargill Meat Solutions Corporation	6,079	8%
NE0040924	North Bend Wastewater Treatment	303	0%
NE0043311	Waterloo Wastewater Treatment	110	0%
NE0112283	Riverside Lakes	37	0%
NE0112488	Lincoln NE Waste Water Treatment Facility (WWTF	8,248	11%
NE0036820	Lincoln Theresa St. WWTF	51,752	70%
NE0026107	Ashland Wastewater Treatment	214	0%
NE0027367	Greenwood Wastewater Treatment	67	0%
NE0111155	Ashland Water Treatment Plant	197	0%
NE0112950	Greenwood Interchange SID WWTF	7	0%
NE0114286	NE Army National Guard Camp Ashland Region IV	48	0%
NE0024376	Yutan Wastewater Treatment Facility	3,287	4%
NE0001368	Hormel Foods	1,628	2%
NE0000906	MUD Platte River Potable Water	543	1%
NE0123862	Pilot Flying J 686	21	0%
NE0024228	Louisville WWTF	110	0%
NE0123838	Sarpy County Sanitary Landfill	205	0%
NE0114251	South Park Estates	4	0%
NE0113450	Valley View	36	0%
NE0113158	Hawaiian Village	33	0%
NE0113441	Lake Ventura	6	0%
NE0041343	Springfield Wastewater Treatment	468	1%

Table A-3. NPDES Permitted CAFO Facilities Summed by Watershed

HUC_12	Name	Beef Cattle	Swine
102002010209	Brewery Hill-Shell Creek	10,000	2,300
102002010301	Shonka Ditch	16,000	4,300
102002010304	Headwaters Bone Creek	1,000	0
102002010305	Outlet Bone Creek	1,000	0
102002010306	Tomek Island-Platte River	5,000	0
102002010308	Headwaters Skull Creek	0	18,860
102002010309	Outlet Skull Creek	2,000	0
102002020204	Buffalo Creek	6,000	0
102002031004	Clear Creek	30,000	0
102002031005	Wahoo Creek	9,100	0

Table A-4. Developments Along the Platte River with Unpermitted Septic Tanks

HUC12	HUC Name	Development Location Description	Dwelling Units
102002020211	Zwiebel Creek-Platte River	Near Plattsmouth-1	12
102002020211	Zwiebel Creek-Platte River	Schmidts Subdivision	25
102002020211	Zwiebel Creek-Platte River	Near Plattsmouth-2	90
102002020210	Eightmile Creek	Near Plattsmouth-2	90
102002020211	Zwiebel Creek-Platte River	Near Plattsmouth-3	60
102002020208	Turkey Creek-Platte River	Near Springfield-3	12
102002020208	Turkey Creek-Platte River	Near Springfield-2	10
102002020208	Turkey Creek-Platte River	Schmid Park	40
102002020205	Mill Creek-Platte River	Cornhusker Lake	25
102002020205	Mill Creek-Platte River	Near Louisville	8
102002020203	Decker Creek-Platte River	Near South Bend-2	10
102002020203	Decker Creek-Platte River	Near South Bend-1	1
102002020105	102002020105	Near Ashland-1	0
102002031005	Wahoo Creek	Willow Island	15
102002020105	102002020105	Willow Island	15
102002020202	Western Sarpy Ditch-Platte River	Thomas Riverside Acres	28
102002020105	102002020105	Thomas Riverside Acres	28
102002020202	Western Sarpy Ditch-Platte River	Linoma Beach Campground	120
102002020105	102002020105	Linoma Beach Campground	120
102002020202	Western Sarpy Ditch-Platte River	Beacon View	25
102002020105	102002020105	Beacon View	25
102002020201	Pawnee Creek	Horseshoe Lake	80
102002020105	102002020105	Horseshoe Lake	80
102002020207	Cedar Creek	Near Cedar Creek	18

(Continued)

Table A-4. Developments Along the Platte River with Unpermitted Septic Tanks (continued)

HUC12	HUC Name	Development Location Description	Dwelling Units
102002020205	Mill Creek-Platte River	Near Cedar Creek	18
102002020205	Mill Creek-Platte River	Villa Springs Community	80
102002020208	Turkey Creek-Platte River	Villa Springs Community	80
102002020206	Turtle Creek	Near Springfield-1	10
102002020205	Mill Creek-Platte River	Near Springfield-1	10
102002020208	Turkey Creek-Platte River	Near Springfield-1	10
102002020105	102002020105	Thomas Lakes	120
102200031006	Big Slough-Elkhorn River	Near Gretna-1	12
102002020105	102002020105	Near Gretna-1	12
102002020105	102002020105	Near Gretna-2	14
102200031006	Big Slough-Elkhorn River	Near Gretna-3	23
102002020105	102002020105	Near Gretna-3	23
102002020104	Otoe Creek-Platte River	Near Venice-1	12
102002020104	Otoe Creek-Platte River	Near Venice-2	9
102002020104	Otoe Creek-Platte River	Near Venice-3	4
102002020105	102002020105	Near Venice-3	4
102002020104	Otoe Creek-Platte River	Near Venice-4	71
102002020105	102002020105	Near Venice-4	71
102002020104	Otoe Creek-Platte River	Near Venice-5	1
102002020104	Otoe Creek-Platte River	Ginger Woods	58
102002020104	Otoe Creek-Platte River	Near Leshara-3	5
102002020103	Elm Creek-Platte River	Near Leshara-1	17
102002020103	Elm Creek-Platte River	Near Leshara-2	3
102002020103	Elm Creek-Platte River	Near Inglewood-1	17

(Continued)

Table A-4. Developments Along the Platte River with Unpermitted Septic Tanks (continued)

HUC12	HUC Name	Development Location Description	Dwelling Units
102002020103	Elm Creek-Platte River	Near Inglewood-2	68
102200031005	Old Channel Rawhide Creek	Near Fremont-1	200
102002020103	Elm Creek-Platte River	Near Fremont-1	200
102002020103	Elm Creek-Platte River	Lake Ventura	102
102002020101	Rawhide Creek-Platte River	Lake Ventura	102
102002020101	Rawhide Creek-Platte River	Timberwood Estates	21
102002020101	Rawhide Creek-Platte River	Cedar Lakes	20
102002020101	Rawhide Creek-Platte River	Wolf Lakes	38
102002020101	Rawhide Creek-Platte River	Legge Lake	36
102002020101	Rawhide Creek-Platte River	Near Morse Bluff-2	15
102002020101	Rawhide Creek-Platte River	Near Morse Bluff-1	18
102002010311	102002010311	Near North Bend	59
102002020101	Rawhide Creek-Platte River	Near North Bend	59
102002010310	Lost Creek-Platte River	Near Rogers-1	47
102002010310	Lost Creek-Platte River	Rogers	45
102002010306	Tomek Island-Platte River	Near Schuyler-2	15
102002010306	Tomek Island-Platte River	Near Schuyler-1	49
102002010310	Lost Creek-Platte River	Near Schuyler-1	49

Table A-5. Septic Tank Loadings for Developments Identified within the Study Area (by Subbasin)

HUC12	HUC Name	Development Location Description	Dwelling Units	Gallons/Day	cfu/day	Septic Load (cfu/year)
102002020211	Zwiebel Creek-Platte River	Near Plattsmouth-1	12	2,100	7.9E+09	1.2E+12
102002020211	Zwiebel Creek-Platte River	Schmidts Subdivision	25	4,375	1.7E+10	2.4E+12
102002020211	Zwiebel Creek-Platte River	Near Plattsmouth-2	90	15,750	6.0E+10	8.7E+12
102002020210	Eightmile Creek	Near Plattsmouth-2	90	15,750	6.0E+10	8.7E+12
102002020211	Zwiebel Creek-Platte River	Near Plattsmouth-3	60	10,500	4.0E+10	5.8E+12
102002020208	Turkey Creek-Platte River	Near Springfield-3	12	2,100	7.9E+09	1.2E+12
102002020208	Turkey Creek-Platte River	Near Springfield-2	10	1,750	6.6E+09	9.7E+11
102002020208	Turkey Creek-Platte River	Schmid Park	40	7,000	2.6E+10	3.9E+12
102002020205	Mill Creek-Platte River	Cornhusker Lake	25	4,375	1.7E+10	2.4E+12
102002020205	Mill Creek-Platte River	Near Louisville	8	1,400	5.3E+09	7.7E+11
102002020203	Decker Creek-Platte River	Near South Bend-2	10	1,750	6.6E+09	9.7E+11
102002020203	Decker Creek-Platte River	Near South Bend-1	1	175	6.6E+08	9.7E+10
102002020105	102002020105	Near Ashland-1	0	0	0.0E+00	0.0E+00
102002031005	Wahoo Creek	Willow Island	15	2,625	9.9E+09	1.5E+12
102002020105	102002020105	Willow Island	15	2,625	9.9E+09	1.5E+12
102002020202	Western Sarpy Ditch-Platte River	Thomas Riverside Acres	28	4,900	1.9E+10	2.7E+12
102002020105	102002020105	Thomas Riverside Acres	28	4,900	1.9E+10	2.7E+12
102002020202	Western Sarpy Ditch-Platte River	Linoma Beach Campground	120	21,000	7.9E+10	1.2E+13
102002020105	102002020105	Linoma Beach Campground	120	21,000	7.9E+10	1.2E+13
102002020202	Western Sarpy Ditch-Platte River	Beacon View	25	4,375	1.7E+10	2.4E+12
102002020105	102002020105	Beacon View	25	4,375	1.7E+10	2.4E+12
102002020201	Pawnee Creek	Horseshoe Lake	80	14,000	5.3E+10	7.7E+12
102002020105	102002020105	Horseshoe Lake	80	14,000	5.3E+10	7.7E+12
102002020207	Cedar Creek	Near Cedar Creek	18	3,150	1.2E+10	1.7E+12

(Continued)

Table A-5. Septic Tank Loadings for Developments Identified within the Study Area (by Subbasin) (continued)

HUC12	HUC Name	Development Location Description	Dwelling Units	Gallons/Day	cfu/day	Septic Load (cfu/year)
102002020205	Mill Creek-Platte River	Near Cedar Creek	18	3,150	1.2E+10	1.7E+12
102002020205	Mill Creek-Platte River	Villa Springs Community	80	14,000	5.3E+10	7.7E+12
102002020208	Turkey Creek-Platte River	Villa Springs Community	80	14,000	5.3E+10	7.7E+12
102002020206	Turtle Creek	Near Springfield-1	10	1,750	6.6E+09	9.7E+11
102002020205	Mill Creek-Platte River	Near Springfield-1	10	1,750	6.6E+09	9.7E+11
102002020208	Turkey Creek-Platte River	Near Springfield-1	10	1,750	6.6E+09	9.7E+11
102002020105	102002020105	Thomas Lakes	120	21,000	7.9E+10	1.2E+13
102200031006	Big Slough-Elkhorn River	Near Gretna-1	12	2,100	7.9E+09	1.2E+12
102002020105	102002020105	Near Gretna-1	12	2,100	7.9E+09	1.2E+12
102002020105	102002020105	Near Gretna-2	14	2,450	9.3E+09	1.4E+12
102200031006	Big Slough-Elkhorn River	Near Gretna-3	23	4,025	1.5E+10	2.2E+12
102002020105	102002020105	Near Gretna-3	23	4,025	1.5E+10	2.2E+12
102002020104	Otoe Creek-Platte River	Near Venice-1	12	2,100	7.9E+09	1.2E+12
102002020104	Otoe Creek-Platte River	Near Venice-2	9	1,575	6.0E+09	8.7E+11
102002020104	Otoe Creek-Platte River	Near Venice-3	4	700	2.6E+09	3.9E+11
102002020105	102002020105	Near Venice-3	4	700	2.6E+09	3.9E+11
102002020104	Otoe Creek-Platte River	Near Venice-4	71	12,425	4.7E+10	6.9E+12
102002020105	102002020105	Near Venice-4	71	12,425	4.7E+10	6.9E+12
102002020104	Otoe Creek-Platte River	Near Venice-5	1	175	6.6E+08	9.7E+10
102002020104	Otoe Creek-Platte River	Ginger Woods	58	10,150	3.8E+10	5.6E+12
102002020104	Otoe Creek-Platte River	Near Leshara-3	5	875	3.3E+09	4.8E+11
102002020103	Elm Creek-Platte River	Near Leshara-1	17	2,975	1.1E+10	1.6E+12
102002020103	Elm Creek-Platte River	Near Leshara-2	3	525	2.0E+09	2.9E+11
102002020103	Elm Creek-Platte River	Near Inglewood-1	17	2,975	1.1E+10	1.6E+12

(Continued)

Table A-5. Septic Tank Loadings for Developments Identified within the Study Area (by Subbasin) (continued)

HUC12	HUC Name	Development Location Description	Dwelling Units	Gallons/Day	cfu/day	Septic Load (cfu/year)
102002020103	Elm Creek-Platte River	Near Inglewood-2	68	11,900	4.5E+10	6.6E+12
102200031005	Old Channel Rawhide Creek	Near Fremont-1	200	35,000	1.3E+11	1.9E+13
102002020103	Elm Creek-Platte River	Near Fremont-1	200	35,000	1.3E+11	1.9E+13
102002020103	Elm Creek-Platte River	Lake Ventura	102	17,850	6.8E+10	9.9E+12
102002020101	Rawhide Creek-Platte River	Lake Ventura	102	17,850	6.8E+10	9.9E+12
102002020101	Rawhide Creek-Platte River	Timberwood Estates	21	3,675	1.4E+10	2.0E+12
102002020101	Rawhide Creek-Platte River	Cedar Lakes	20	3,500	1.3E+10	1.9E+12
102002020101	Rawhide Creek-Platte River	Wolf Lakes	38	6,650	2.5E+10	3.7E+12
102002020101	Rawhide Creek-Platte River	Legge Lake	36	6,300	2.4E+10	3.5E+12
102002020101	Rawhide Creek-Platte River	Near Morse Bluff-2	15	2,625	9.9E+09	1.5E+12
102002020101	Rawhide Creek-Platte River	Near Morse Bluff-1	18	3,150	1.2E+10	1.7E+12
102002010311	102002010311	Near North Bend	59	10,325	3.9E+10	5.7E+12
102002020101	Rawhide Creek-Platte River	Near North Bend	59	10,325	3.9E+10	5.7E+12
102002010310	Lost Creek-Platte River	Near Rogers-1	47	8,225	3.1E+10	4.5E+12
102002010310	Lost Creek-Platte River	Rogers	45	7,875	3.0E+10	4.4E+12
102002010306	Tomek Island-Platte River	Near Schuyler-2	15	2,625	9.9E+09	1.5E+12
102002010306	Tomek Island-Platte River	Near Schuyler-1	49	8,575	3.2E+10	4.7E+12
102002010310	Lost Creek-Platte River	Near Schuyler-1	49	8,575	3.2E+10	4.7E+12

Table A-6. Septic Tank Loadings by Subbasin

HUC Name	Septic Load (cfu/year)
102002010311	5.7E+12
102002020105	5.0E+13
Big Slough-Elkhorn River	3.4E+12
Cedar Creek	1.7E+12
Decker Creek-Platte River	1.1E+12
Eightmile Creek	8.7E+12
Elm Creek-Platte River	3.9E+13
Lost Creek-Platte River	1.4E+13
Mill Creek-Platte River	1.4E+13
Old Channel Rawhide Creek	1.9E+13
Otoe Creek-Platte River	1.5E+13
Pawnee Creek	7.7E+12
Rawhide Creek-Platte River	3.0E+13
Tomek Island-Platte River	6.2E+12
Turkey Creek-Platte River	1.5E+13
Turtle Creek	9.7E+11
Wahoo Creek	1.5E+12
Western Sarpy Ditch-Platte River	1.7E+13
Zwiebel Creek-Platte River	1.8E+13
Total	2.7E+14

Table A-7. Total Phosphorus Subbasin Loadings by Land Use (lbs/year) – GIS Based Model

Subbasin Name	Agriculture	Barren	Open Water	Range, Pasture, Grassland	Riparian Forest and Woodlands	Road	Urban Land	Wetlands	Total
102002010311	567	NA	0	113	79	12	8	0.7	780
102002020105	222	10	0	66	27	8	NA	2.2	336
Big Slough-Elkhorn River	1,438	NA	0	167	42	37	234	0.2	1,919
Brewery Hill-Shell Creek	3,043	NA	0	245	30	32	17	0.4	3,368
Buffalo Creek	5,626	4	0	100	11	22	64	1.6	5,828
Callahan Creek	4,235	4	0	83	15	21	NA	1.1	4,359
Cedar Creek	4,787	17	0	113	26	14	0	1.1	4,959
City of Abie	6,804	NA	0	326	13	21	14	0.2	7,178
Clear Creek	743	1	0	90	3	17	NA	0.1	854
Decker Creek-Platte River	6,100	7	0	226	75	22	35	1.9	6,467
Dee Creek-Salt Creek	6,142	6	0	150	28	50	59	2.9	6,439
Deer Creek-Platte River	1,347	NA	0	275	32	13	8	0.7	1,674
Eightmile Creek	6,506	5	0	138	25	19	33	2.0	6,728
Elm Creek-Platte River	1,963	6	0	98	43	25	59	0.3	2,193
Headwaters Bone Creek	4,938	NA	0	526	29	19	NA	0.3	5,512
Headwaters Clear Creek	5,107	NA	0	42	4	20	20	0.0	5,193
Headwaters Lost Creek	180	NA	0	59	2	6	1	0.1	248
Headwaters Otoe Creek	4,699	NA	0	31	3	13	1	0.0	4,748
Headwaters Skull Creek	7,524	NA	0	276	11	20	NA	0.1	7,831
Johnson Creek	2,156	NA	0	53	1	16	14	0.0	2,242
Lost Creek-Platte River	1,201	NA	0	64	24	37	61	0.5	1,387

(Continued)

Table A-7. Total Phosphorus Subbasin Loadings by Land Use (lbs/year) – GIS Based Model (continued)

Subbasin Name	Agriculture	Barren	Open Water	Range, Pasture, Grassland	Riparian Forest and Woodlands	Road	Urban Land	Wetlands	Total
Mill Creek-Platte River	3,732	12	0	191	63	25	60	1.2	4,084
Otoe Creek-Platte River	1,129	NA	0	75	16	17	47	0.2	1,285
Outlet Bone Creek	960	NA	0	275	23	13	6	0.1	1,277
Outlet Skull Creek	2,145	NA	0	294	41	14	6	0.4	2,499
Pawnee Creek	2,855	9	0	114	26	19	19	0.5	3,043
Rawhide Creek-Platte River	6,113	0	0	192	59	73	31	0.9	6,469
Shonka Ditch	2,015	NA	0	67	4	41	5	0.1	2,133
Tomek Island-Platte River	1,300	NA	0	215	37	13	NA	0.8	1,567
Turkey Creek-Platte River	5,470	14	0	202	87	21	32	3.0	5,830
Turtle Creek	4,193	1	0	56	6	15	55	0.4	4,326
Wahoo Creek	2,183	8	0	97	22	18	37	1.2	2,365
Western Sarpy Ditch-Platte River	2,422	3	0	144	30	31	199	0.5	2,830
Zwiebel Creek-Platte River	3,649	7	0	183	29	18	41	0.3	3,927
Total	113,492	114	0	5,348	967	764	1,167	26	121,877

Table A-8. Total Nitrogen Subbasin Loadings by Land Use (lbs/year) – GIS Based Model

Subbasin Name	Agriculture	Barren	Open Water	Range, Pasture, Grassland	Riparian Forest and Woodlands	Road	Urban Land	Wetlands	Total
102002010311	6,998	NA	0	1,391	637	84	37	4	9,151
102002020105	2,744	60	0	328	68	50	NA	5	3,254
Big Slough-Elkhorn River	17,744	NA	0	1,870	275	270	1,926	0	22,085
Brewery Hill-Shell Creek	37,546	NA	0	2,768	184	223	66	2	40,787
Buffalo Creek	69,416	42	0	1,181	84	183	504	9	71,420
Callahan Creek	52,261	40	0	903	74	169	NA	4	53,451
Cedar Creek	59,067	211	0	1,335	192	116	0	5	60,926
City of Abie	83,956	NA	0	4,017	83	173	111	1	88,341
Clear Creek	9,162	9	0	547	9	112	NA	0	9,839
Decker Creek-Platte River	75,273	79	0	2,773	597	181	368	11	79,284
Dee Creek-Salt Creek	75,788	61	0	1,428	140	358	421	8	78,203
Deer Creek-Platte River	16,617	NA	0	3,262	178	84	32	3	20,176
Eightmile Creek	80,275	58	0	1,585	163	157	319	9	82,567
Elm Creek-Platte River	24,220	35	0	778	201	179	442	1	25,856
Headwaters Bone Creek	60,925	NA	0	6,637	213	160	NA	2	67,937
Headwaters Clear Creek	63,013	NA	0	379	13	152	134	0	63,692
Headwaters Lost Creek	2,221	NA	0	140	1	31	5	0	2,397
Headwaters Otoe Creek	57,978	NA	0	342	15	103	12	0	58,450
Headwaters Skull Creek	92,835	NA	0	3,348	71	169	NA	1	96,423
Johnson Creek	26,608	NA	0	421	5	109	73	0	27,215
Lost Creek-Platte River	14,819	NA	0	279	23	214	231	1	15,568

(Continued)

Table A-8. Total Nitrogen Subbasin Loadings by Land Use (lbs/year) – GIS Based Model (continued)

Subbasin Name	Agriculture	Barren	Open Water	Range, Pasture, Grassland	Riparian Forest and Woodlands	Road	Urban Land	Wetlands	Total
Mill Creek-Platte River	46,046	128	0	2,319	427	213	510	5	49,648
Otoe Creek-Platte River	13,934	NA	0	536	27	125	223	0	14,845
Outlet Bone Creek	11,846	NA	0	3,434	188	93	26	1	15,588
Outlet Skull Creek	26,461	NA	0	3,438	295	106	24	2	30,325
Pawnee Creek	35,224	111	0	1,417	208	172	209	2	37,342
Rawhide Creek-Platte River	75,430	4	0	1,392	185	437	129	1	77,578
Shonka Ditch	24,869	NA	0	424	7	245	20	0	25,566
Tomek Island-Platte River	16,043	NA	0	2,483	191	89	NA	3	18,809
Turkey Creek-Platte River	67,491	153	0	2,461	708	169	214	10	71,206
Turtle Creek	51,732	16	0	669	33	129	485	2	53,066
Wahoo Creek	26,939	81	0	948	148	127	236	4	28,482
Western Sarpy Ditch-Platte River	29,882	24	0	1,810	289	270	1,857	2	34,136
Zwiebel Creek-Platte River	45,023	72	0	2,214	182	146	319	1	47,957
Total	1,400,388	1,183	0	59,255	6,113	5,598	8,935	100	1,481,571

Table A-9. Total Suspended Sediment Subbasin Loadings by Land Use (tons/year) – GIS Based Model

Subbasin Name	Agriculture	Barren	Open Water	Range, Pasture, Grassland	Riparian Forest and Woodlands	Road	Urban Land	Wetlands	Total
102002010311	3,043	NA	0	464	212	11	5	1	3,736
102002020105	1,193	20	0	109	23	5	NA	2	1,351
Big Slough-Elkhorn River	7,715	NA	0	623	92	40	493	0	8,963
Brewery Hill-Shell Creek	16,324	NA	0	923	61	29	5	1	17,342
Buffalo Creek	30,181	14	0	394	28	36	126	3	30,782
Callahan Creek	22,722	13	0	301	25	31	NA	1	23,094
Cedar Creek	25,681	70	0	445	64	21	0	2	26,283
City of Abie	36,502	NA	0	1,339	28	34	28	0	37,932
Clear Creek	3,984	3	0	182	3	12	NA	0	4,184
Decker Creek-Platte River	32,728	26	0	924	199	36	108	4	34,025
Dee Creek-Salt Creek	32,951	20	0	476	47	52	96	3	33,645
Deer Creek-Platte River	7,225	NA	0	1,087	59	10	3	1	8,385
Eightmile Creek	34,902	19	0	528	54	29	90	3	35,626
Elm Creek-Platte River	10,531	12	0	259	67	27	106	0	11,001
Headwaters Bone Creek	26,489	NA	0	2,212	71	32	NA	1	28,805
Headwaters Clear Creek	27,397	NA	0	126	4	24	29	0	27,581
Headwaters Lost Creek	965	NA	0	47	0	1	0	0	1,014
Headwaters Otoe Creek	25,208	NA	0	114	5	18	3	0	25,348
Headwaters Skull Creek	40,363	NA	0	1,116	24	33	NA	0	41,536
Johnson Creek	11,569	NA	0	140	2	13	11	0	11,735
Lost Creek-Platte River	6,443	NA	0	93	8	14	13	0	6,571

(Continued)

Table A-9. Total Suspended Sediment Subbasin Loadings by Land Use (tons/year) – GIS Based Model (continued)

Subbasin Name	Agriculture	Barren	Open Water	Range, Pasture, Grassland	Riparian Forest and Woodlands	Road	Urban Land	Wetlands	Total
Mill Creek-Platte River	20,020	43	0	773	142	42	133	2	21,155
Otoe Creek-Platte River	6,058	NA	0	179	9	18	30	0	6,294
Outlet Bone Creek	5,150	NA	0	1,145	63	13	3	0	6,374
Outlet Skull Creek	11,505	NA	0	1,146	98	17	2	1	12,769
Pawnee Creek	15,315	37	0	472	69	37	62	1	15,993
Rawhide Creek-Platte River	32,796	1	0	464	62	32	12	0	33,367
Shonka Ditch	10,813	NA	0	141	2	18	1	0	10,976
Tomek Island-Platte River	6,975	NA	0	828	64	11	NA	1	7,879
Turkey Creek-Platte River	29,344	51	0	820	236	31	47	3	30,532
Turtle Creek	22,492	5	0	223	11	27	129	1	22,889
Wahoo Creek	11,712	27	0	316	49	17	50	1	12,173
Western Sarpy Ditch-Platte River	12,992	8	0	603	96	57	513	1	14,271
Zwiebel Creek-Platte River	19,575	24	0	738	61	27	79	0	20,504
Total	608,864	394	0	19,752	2,038	858	2,176	33	634,115

Table A-10. Subbasin Loadings Summary – GIS Based Model

Subbasin	TP Load (lbs/year)	TN Load (lbs/year)	TSS Load (tons/year)	TP Load (lbs/acre/year)	TN Load (lbs/acre/year)	TSS Load (tons/acre/year)
102002010311	780	9,151	3,736	0.07	0.87	0.35
102002020105	336	3,254	1,351	0.02	0.22	0.09
Big Slough-Elkhorn River	1,919	22,085	8,963	0.08	0.89	0.36
Brewery Hill-Shell Creek	3,368	40,787	17,342	0.12	1.43	0.61
Buffalo Creek	5,828	71,420	30,782	0.35	4.31	1.86
Callahan Creek	4,359	53,451	23,094	0.24	2.90	1.25
Cedar Creek	4,959	60,926	26,283	0.28	3.41	1.47
City of Abie	7,178	88,341	37,932	0.37	4.51	1.94
Clear Creek	854	9,839	4,184	0.06	0.71	0.30
Decker Creek-Platte River	6,467	79,284	34,025	0.27	3.29	1.41
Dee Creek-Salt Creek	6,439	78,203	33,645	0.15	1.87	0.81
Deer Creek-Platte River	1,674	20,176	8,385	0.09	1.05	0.44
Eightmile Creek	6,728	82,567	35,626	0.29	3.50	1.51
Elm Creek-Platte River	2,193	25,856	11,001	0.11	1.32	0.56
Headwaters Bone Creek	5,512	67,937	28,805	0.26	3.26	1.38
Headwaters Clear Creek	5,193	63,692	27,581	0.23	2.82	1.22
Headwaters Lost Creek	248	2,397	1,014	0.02	0.22	0.09
Headwaters Otoe Creek	4,748	58,450	25,348	0.33	4.01	1.74

(Continued)

Table A-10. Subbasin Loadings Summary – GIS Based Model (continued)

Subbasin	TP Load (lbs/year)	TN Load (lbs/year)	TSS Load (tons/year)	TP Load (lbs/acre/year)	TN Load (lbs/acre/year)	TSS Load (tons/acre/year)
Headwaters Skull Creek	7,831	96,423	41,536	0.35	4.26	1.84
Johnson Creek	2,242	27,215	11,735	0.15	1.85	0.80
Lost Creek-Platte River	1,387	15,568	6,571	0.05	0.59	0.25
Mill Creek-Platte River	4,084	49,648	21,155	0.23	2.74	1.17
Otoe Creek-Platte River	1,285	14,845	6,294	0.08	0.94	0.40
Outlet Bone Creek	1,277	15,588	6,374	0.08	1.03	0.42
Outlet Skull Creek	2,499	30,325	12,769	0.12	1.51	0.64
Pawnee Creek	3,043	37,342	15,993	0.28	3.39	1.45
Rawhide Creek-Platte River	6,469	77,578	33,367	0.08	1.01	0.43
Shonka Ditch	2,133	25,566	10,976	0.07	0.89	0.38
Tomek Island-Platte River	1,567	18,809	7,879	0.08	0.99	0.42
Turkey Creek-Platte River	5,830	71,206	30,532	0.24	2.89	1.24
Turtle Creek	4,326	53,066	22,889	0.41	4.99	2.15
Wahoo Creek	2,365	28,482	12,173	0.12	1.41	0.60
Western Sarpy Ditch-Platte River	2,830	34,136	14,271	0.19	2.30	0.96
Zwiebel Creek-Platte River	3,927	47,957	20,504			

Table A-11. Total Watershed Loadings Source Contributions – GIS Based Model

Source	Total N Load (lbs/year)	Total P Load (lbs/year)	Total Sediment Load (tons/year)	Total N Load (% of Total Load)	Total P Load (% of Total Load)	Total Sediment Load (% of Total Load)
GIS Model contributions	1,481,571	121,877	634,115	60%	59%	79%
Gully and streambank erosion	671,416	22,381	111,903	27%	11%	14%
Point sources	192,476	61,007	54,294	8%	30%	7%
Atmospheric deposition	123,400	0	0	5%	0%	0%
Totals	2,468,863	205,265	800,312	100%	100%	100%

Table A-12. Atrazine Load by Subbasin

Subbasin	Agriculture Area (Acres)	Atrazine (lbs/year)
102002010311	3,624	93
102002020105	3,452	89
Big Slough-Elkhorn River	12,703	327
Brewery Hill-Shell Creek	19,434	501
Buffalo Creek	12,476	321
Callahan Creek	14,686	378
Cedar Creek	13,406	345
City of Abie	12,455	321
Clear Creek	7,847	202
Decker Creek-Platte River	14,374	370
Dee Creek-Salt Creek	31,958	823
Deer Creek-Platte River	10,080	260
Eightmile Creek	17,860	460
Elm Creek-Platte River	6,440	166
Headwaters Bone Creek	10,499	270
Headwaters Clear Creek	19,926	513
Headwaters Lost Creek	5,311	137
Headwaters Otoe Creek	13,316	343
Headwaters Skull Creek	16,348	421
Johnson Creek	11,537	297
Lost Creek-Platte River	14,936	385
Mill Creek-Platte River	7,950	205
Otoe Creek-Platte River	6,461	166

Table A-12. Atrazine Load by Subbasin (continued)

Subbasin	Agriculture Area (Acres)	Atrazine (lbs/year)
Outlet Bone Creek	9,103	235
Outlet Skull Creek	10,952	282
Pawnee Creek	7,220	186
Rawhide Creek-Platte River	56,922	1,467
Shonka Ditch	23,737	612
Tomek Island-Platte River	9,440	243
Turkey Creek-Platte River	12,957	334
Turtle Creek	8,235	212
Wahoo Creek	14,135	364
Western Sarpy Ditch-Platte River	8,436	217
Zwiebel Creek-Platte River	8,240	212
Total	456,452	11,760

Table A-13. Percent of Subbasins Affected by Land Treatments

Name	Estimate of Percent HUC12 Area affected by land treatment as derived from NRCS database.
102002010311	4.7
102002020105	2.2
Big Slough-Elkhorn River	7.2
Brewery Hill-Shell Creek	7.2
Buffalo Creek	2.7
Callahan Creek	2.9
Cedar Creek	5.7
City of Abie	12.9
Clear Creek	7
Decker Creek-Platte River	11
Dee Creek-Salt Creek	4.4
Deer Creek-Platte River	17
Eightmile Creek	2.1
Elm Creek-Platte River	4.1
Headwaters Bone Creek	10
Headwaters Clear Creek	2.1
Headwaters Lost Creek	1
Headwaters Otoe Creek	5.7
Headwaters Skull Creek	12.6
Johnson Creek	2.4
Lost Creek-Platte River	1

Table A-13. Percent of Subbasins Affected by Land Treatments (continued)

Name	Estimate of Percent HUC12 Area affected by land treatment as derived from NRCS database.
Mill Creek-Platte River	6.9
Otoe Creek-Platte River	1.8
Outlet Bone Creek	3
Outlet Skull Creek	3.4
Pawnee Creek	2.4
Rawhide Creek-Platte River	4.5
Shonka Ditch	1.3
Tomek Island-Platte River	1.2
Turkey Creek-Platte River	10.9
Turtle Creek	9.7
Wahoo Creek	3.9
Western Sarpy Ditch-Platte River	2.8
Zwiebel Creek-Platte River	4.8

Table A-14. Potential Pollutant Load Reductions for Total Phosphorous

NRD Name	Subbasin	Existing		Future		Reductions	
		TP Load (lbs/year)	TP Load (lbs/acre/year)	TP2 Load (lbs/year)	TP Load (lbs/acre/year)	TP Reduction (lbs/year)	TP Reduction (%)
Lower Platte North	Headwaters Skull Creek	7,831	0.35	4,524	0.2	3,308	42
	City of Abie	7,178	0.37	4,161	0.2	3,018	42
	Rawhide Creek-Platte River	6,469	0.08	3,817	0.0	2,652	41
	Headwaters Bone Creek	5,512	0.26	3,223	0.2	2,289	42
	Headwaters Clear Creek	5,193	0.23	2,999	0.1	2,195	42
	Headwaters Otoe Creek	4,748	0.33	2,729	0.2	2,019	43
	Brewery Hill-Shell Creek	3,368	0.12	1,992	0.1	1,375	41
	Outlet Skull Creek	2,499	0.12	1,490	0.1	1,009	40
	Johnson Creek	2,242	0.15	1,308	0.1	934	42
	Shonka Ditch	2,133	0.07	1,260	0.0	873	41
	Elm Creek-Platte River	2,193	0.11	1,333	0.1	860	39
	Deer Creek-Platte River	1,674	0.09	1,011	0.1	663	40
	Tomek Island-Platte River	1,567	0.08	944	0.0	622	40
	Lost Creek-Platte River	1,387	0.05	866	0.0	521	38
	Outlet Bone Creek	1,277	0.08	774	0.1	502	39
	Clear Creek	854	0.06	522	0.0	332	39
	102002010311	780	0.07	500	0.0	280	36
	Headwaters Lost Creek	248	0.02	168	0.0	81	32

(Continued)

Table A-14. Potential Pollutant Load Reductions for Total Phosphorous (continued)

NRD Name	Subbasin	Existing		Future		Reductions	
		TP Load (lbs/year)	TP Load (lbs/acre/year)	TP2 Load (lbs/year)	TP Load (lbs/acre/year)	TP Reduction (lbs/year)	TP Reduction (%)
Lower Platte South	Eightmile Creek	6,728	0.29	3,903	0.2	2,825	42
	Decker Creek-Platte River	6,467	0.27	3,783	0.2	2,683	41
	Dee Creek-Salt Creek	6,439	0.15	3,773	0.1	2,665	41
	Turkey Creek-Platte River	5,830	0.24	3,425	0.1	2,405	41
	Cedar Creek	4,959	0.28	2,876	0.2	2,083	42
	Callahan Creek	4,359	0.24	2,523	0.1	1,836	42
	Mill Creek-Platte River	4,084	0.23	2,426	0.1	1,658	41
	Zwiebel Creek-Platte River	3,927	0.25	2,307	0.1	1,620	41
	Pawnee Creek	3,043	0.28	1,784	0.2	1,259	41
	Wahoo Creek	2,365	0.12	1,406	0.1	959	41
Papio-Missouri River	Buffalo Creek	5,828	0.35	3,390	0.2	2,438	42
	Turtle Creek	4,326	0.41	2,515	0.2	1,811	42
	Western Sarpy Ditch-Platte River	2,830	0.19	1,746	0.1	1,084	38
	Big Slough-Elkhorn River	1,919	0.08	1,254	0.1	665	35
	Otoe Creek-Platte River	1,285	0.08	787	0.0	497	39
	102002020105	336	0.02	232	0.0	104	31

Table A-15. Potential Pollutant Load Reductions for Total Nitrogen

NRD Name	Subbasin	Existing		Future		Reductions	
		TN Load (lbs/year)	TN Load (lbs/acre/year)	TN Load (lbs/year)	TN Load (lbs/acre/year)	TN Reduction (lbs/year)	TN Reduction (%)
Lower Platte North	Headwaters Skull Creek	96,423	4.26	82,789	3.7	13,634	14
	City of Abie	88,341	4.51	75,680	3.9	12,661	14
	Rawhide Creek-Platte River	77,578	1.01	66,945	0.9	10,633	14
	Headwaters Bone Creek	67,937	3.26	57,502	2.8	10,435	15
	Headwaters Clear Creek	63,692	2.82	55,072	2.4	8,620	14
	Headwaters Otoe Creek	58,450	4.01	50,521	3.5	7,929	14
	Brewery Hill-Shell Creek	40,787	1.43	34,800	1.2	5,988	15
	Outlet Skull Creek	30,325	1.51	25,607	1.3	4,718	16
	Johnson Creek	27,215	1.85	23,488	1.6	3,727	14
	Elm Creek-Platte River	25,856	1.32	22,331	1.1	3,525	14
	Shonka Ditch	25,566	0.89	22,072	0.8	3,494	14
	Deer Creek-Platte River	20,176	1.05	16,844	0.9	3,332	17
	Tomek Island-Platte River	18,809	0.99	15,814	0.8	2,994	16
	Outlet Bone Creek	15,588	1.03	12,841	0.9	2,747	18
	Lost Creek-Platte River	15,568	0.59	13,477	0.5	2,091	13
	Clear Creek	9,839	0.71	8,421	0.6	1,418	14
	102002010311	9,151	0.87	7,742	0.7	1,409	15
	Headwaters Lost Creek	2,397	0.22	2,051	0.2	346	14

(Continued)

Table A-15. Potential Pollutant Load Reductions for Total Nitrogen (continued)

NRD Name	Subbasin	Existing		Future		Reductions	
		TN Load (lbs/year)	TN Load (lbs/acre/year)	TN Load (lbs/year)	TN Load (lbs/acre/year)	TN Reduction (lbs/year)	TN Reduction (%)
Lower Platte South	Eightmile Creek	82,567	3.50	71,216	3.0	11,351	14
	Decker Creek-Platte River	79,284	3.29	68,210	2.8	11,075	14
	Dee Creek-Salt Creek	78,203	1.87	67,510	1.6	10,693	14
	Turkey Creek-Platte River	71,206	2.89	61,285	2.5	9,921	14
	Cedar Creek	60,926	3.41	52,517	2.9	8,408	14
	Callahan Creek	53,451	2.90	46,104	2.5	7,346	14
	Mill Creek-Platte River	49,648	2.74	42,665	2.4	6,983	14
	Zwiebel Creek-Platte River	47,957	2.99	41,147	2.6	6,810	14
	Pawnee Creek	37,342	3.39	32,120	2.9	5,222	14
	Wahoo Creek	28,482	1.41	24,534	1.2	3,948	14
Papio-Missouri River	Buffalo Creek	71,420	4.31	61,668	3.7	9,752	14
	Turtle Creek	53,066	4.99	45,870	4.3	7,197	14
	Western Sarpy Ditch-Platte River	34,136	2.30	29,502	2.0	4,634	14
	Big Slough-Elkhorn River	22,085	0.89	19,067	0.8	3,018	14
	Otoe Creek-Platte River	14,845	0.94	12,787	0.8	2,058	14
	102002020105	3,254	0.22	2,774	0.2	480	15

Table A-16. Potential Pollutant Load Reductions for Total Suspended Sediment

NRD Name	Subbasin	Existing		Future		Reductions	
		TSS Load (lbs/year)	TSS Load (lbs/acre/year)	TSS Load (lbs/year)	TSS Load (lbs/acre/year)	TSS Reduction (lbs/year)	TSS Reduction (%)
Lower Platte North	Headwaters Skull Creek	41,536	1.84	20,207	0.9	21,328	51
	City of Abie	37,932	1.94	18,503	0.9	19,429	51
	Rawhide Creek-Platte River	33,367	0.43	16,225	0.2	17,142	51
	Headwaters Bone Creek	28,805	1.38	14,179	0.7	14,626	51
	Headwaters Clear Creek	27,581	1.22	13,372	0.6	14,209	52
	Headwaters Otoe Creek	25,348	1.74	12,276	0.8	13,073	52
	Brewery Hill-Shell Creek	17,342	0.61	8,516	0.3	8,826	51
	Outlet Skull Creek	12,769	0.64	6,337	0.3	6,431	50
	Johnson Creek	11,735	0.80	5,698	0.4	6,037	51
	Shonka Ditch	10,976	0.38	5,329	0.2	5,647	51
	Elm Creek-Platte River	11,001	0.56	5,450	0.3	5,551	50
	Deer Creek-Platte River	8,385	0.44	4,190	0.2	4,195	50
	Tomek Island-Platte River	7,879	0.42	3,923	0.2	3,956	50
	Lost Creek-Platte River	6,571	0.25	3,203	0.1	3,369	51
	Outlet Bone Creek	6,374	0.42	3,227	0.2	3,147	49
	Clear Creek	4,184	0.30	2,048	0.1	2,136	51
	102002010311	3,736	0.35	1,967	0.2	1,769	47
	Headwaters Lost Creek	1,014	0.09	495	0.0	519	51

(Continued)

Table A-16. Potential Pollutant Load Reductions for Total Suspended Sediment (continued)

NRD Name	Subbasin	Existing		Future		Reductions	
		TSS Load (lbs/year)	TSS Load (lbs/acre/year)	TSS Load (lbs/year)	TSS Load (lbs/acre/year)	TSS Reduction (lbs/year)	TSS Reduction (%)
Lower Platte South	Eightmile Creek	35,626	1.51	17,369	0.7	18,257	51
	Decker Creek-Platte River	34,025	1.41	16,723	0.7	17,302	51
	Dee Creek-Salt Creek	33,645	0.81	16,418	0.4	17,227	51
	Turkey Creek-Platte River	30,532	1.24	15,022	0.6	15,510	51
	Cedar Creek	26,283	1.47	12,826	0.7	13,458	51
	Callahan Creek	23,094	1.25	11,226	0.6	11,868	51
	Mill Creek-Platte River	21,155	1.17	10,483	0.6	10,672	50
	Zwiebel Creek-Platte River	20,504	1.28	10,077	0.6	10,428	51
	Pawnee Creek	15,993	1.45	7,880	0.7	8,113	51
	Wahoo Creek	12,173	0.60	5,987	0.3	6,186	51
Papio-Missouri River	Buffalo Creek	30,782	1.86	15,021	0.9	15,761	51
	Turtle Creek	22,889	2.15	11,173	1.1	11,716	51
	Western Sarpy Ditch-Platte River	14,271	0.96	7,302	0.5	6,969	49
	Big Slough-Elkhorn River	8,963	0.36	4,713	0.2	4,251	47
	Otoe Creek-Platte River	6,294	0.40	3,088	0.2	3,206	51
	102002020105	1,351	0.09	688	0.0	663	49

HDR

Methodology to Determine *E. coli* Loadings and Reductions for the Lower Platte River Corridor Alliance

Lincoln, Nebraska

August 10, 2017

(Continued)

Contents

INTRODUCTION

Since 2013, the Lower Platte River Corridor Alliance (LPRCA) has been working with the Nebraska Department of Environmental Quality (NDEQ) on a 9-element watershed management plan for the Lower Platte River corridor. This corridor is generally defined as the Lower Platte River, the bluffs, and adjoining public and private lands located within the floodplain of the Lower Platte River from Columbus to the mouth of the river near Plattsmouth. This area, which runs 110 miles, dissects a portion of eight counties and twenty-four communities fall within its boundaries.

Over the period from 2014 to 2015 a draft watershed plan for the Lower Platte River corridor was reviewed by both NDEQ and the U.S. Environmental Protection Agency Region 7 (EPA R7). The watershed plan was subsequently rejected due to insufficient load reduction modeling for *E. coli*. Given that the primary goal of the plan is to address *Escherichia coli* bacteria (*E. coli* or bacteria). impairments, it was determined that revisions were necessary to ensure that it targets restoration practices to fully support the primary contact recreation beneficial use in the Lower Platte River. The purpose of this memorandum is to outline an approach for evaluating *E.coli* contributions, necessary reductions, and identifying potential management practices within the LPRCA watershed management plan study area to meet the requirements of the EPA approved Lower Platte River Total Maximum Daily Load (TMDL).

While models such as Soil Water Assessment Tool (SWAT) and the Hydrologic Simulation Program – Fortran (HSPF) are frequently used to evaluate bacteria loadings and predict stream quality, it should be noted that such modeling efforts are beyond the scope of this project. Rather, the proposed approach relies on spreadsheet calculations, estimated bacteria loadings and literature values to assign bacteria loadings to different land uses. This approach cannot be used to directly measure the impact of specific management practices on instream bacteria levels. However, the proposed approach provides a method to approximate bacteria contributions from different land uses and is useful in helping to identify and prioritize management practices.

This memorandum is organized in three parts. The first part outlines the proposed methodology for determining *E. coli* contributions from the major watersheds and land uses within the LPRCA study area. The second part presents results from the proposed methodology. The third part provides discussion of the results and how they may be used to determine necessary reductions and management practices.

PROPOSED METHODOLOGY

The proposed methodology apportions *E.coli* loadings by watershed and land use type to help prioritize watersheds and target the most effective management practices. The method for calculating *E. coli* loadings within the LPRCA management plan area (i.e., study area) consists of two steps and is based on existing data, literature values, and spreadsheet calculations. Simplistically, this approach consists of calculating the *E. coli* loading at the bottom of the LPRCA study area (USGS gage at Louisville), subtracting out loadings from contributing watersheds, and apportioning the net load to the 12-digit HUCs within the study area after taking into account decay and land use.

The first step of this approach uses existing data to determine recreational season *E. coli* loadings at key locations throughout the study area. It is necessary to evaluate *E. coli* loadings at multiple locations in order to isolate loadings originating solely from the LPRCA study area.

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The second step uses findings from bacteria source tracking study and literature-based assumptions regarding decay rate and stream velocity to apportion the loadings to 12-digit HUCs with the LPRCA study area based on land use.

STEP 1: CALCULATE RECREATIONAL SEASON BACTERIA LOADINGS AT KEY LOCATIONS

The first step of the proposed method was to characterize recreational season[1] *E. coli* loadings at key locations throughout study area using load duration curves (LDCs) developed from existing data. Per EPA guidance, "LDCs are graphical analytical tools used to illustrate the relationships between stream flow and water quality and assist in decision making regarding this relationship" (EPA 2007). As an example, the LDC shown in Figure 1 depicts the *E. coli* load at criteria as the green line and actual observed loadings as blue dots. Where the observed loadings exceed the *E. coli* load at criteria, reductions in *E. coli* may be necessary to meet the criterion. It is important to note that compliance with the *E. coli* criterion is based on a recreational season geometric mean and that exceedances depicted on the LDC do not necessarily indicate non-compliance.

However, LDCs are useful for both characterizing types of sources and determining overall loadings. EPA divides LDCs into high, moist, mid-range, dry, and low flow hydrologic categories to facilitate development of TMDLs. Exceedances of criteria in the higher flow regimes suggest non-point sources influences related to stormwater runoff, whereas exceedances in lower flow regimes suggest point source influences. Using the median flow condition and *E. coli* geometric mean in each hydrologic condition class, the LDC can also be used to approximate the recreational season loading (see example in (Table 1).

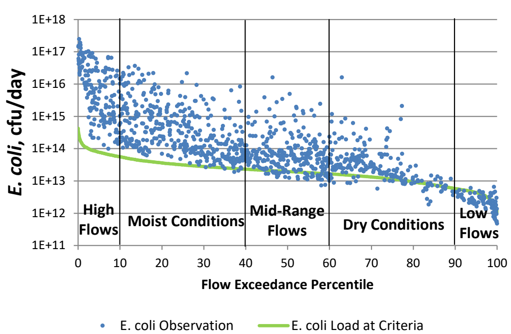

Figure 1. Example LDC Based on USGS Gage 06805500 (Platte River at Louisville) (*E. coli* observations based on turbidity regressions derived by USGS (Schaepe et al. 2014))

[1] In Nebraska, the recreational season runs from May 1 through September 30 and is the only period in which the *E. coli* criterion of 126 cfu/100 mL applies. Therefore, bacteria TMDL loading do not apply outside this period and will not be calculated on an annual basis. Although the proposed approach focuses on the recreational season, this is not meant to imply that best management practices would not or should not be applied year-round. In fact, studies have shown that bacteria can survive in stream sediment for extended periods of time only to be resuspended during high flows at a later date (Cervantes 2012).

Table 1. Example of Total Estimated Recreational Season *E. coli* Loading Based on USGS Gage 06805500 (Platte River at Louisville)

Hydrological Condition Class	Flow Duration Interval	Median Flow, cfs	*E. coli* Geomean, cfu/100 mL	Recreational Season Load, cfu/yr
High Flows	0-10%	25,150	8,989	8.41E+16
Moist Conditions	10-40%	10,200	1,355	1.54E+16
Mid-Range Conditions	40-60%	6,360	449	2.12E+15
Dry Conditions	60-90%	3,710	306	1.27E+15
Low Flows	90-100%	1,425	90	4.76E+13
			Total Recreational Season Loading	1.03E+17

Notes: *E. coli* concentrations based on turbidity regressions derived by USGS (Schaepe et al. 2014). Recreation season *E. coli* load = (median flow) x (*E. coli* geomean) x (unit conversion factor [24,465,525 ml▪s/ft^3▪day]) x (# of days in recreation season for hydrological condition class).

Five key locations were identified to characterize *E. coli* loadings throughout the study area (Table 2 and Figure 2). Four of the five locations are LPRCA sponsored USGS stations (Shell Creek near Columbus [USGS site 06795500]; Elkhorn River at Waterloo [USGS site 06800500]; Salt River near Ashland [USGS site 06805000]; and Platte River at Louisville [USGS site 06805500]). The fifth location represents the upstream boundary condition and is defined by the Platte River East of Columbus. The Platte River East of Columbus site is identified in the EPA approved Middle Platte River TMDL, but is not a USGS station.

Table 2. Key Locations Used to Characterize *E. coli* Loadings in the LPRCA Study Area

Station	Station	Bacteria Period of Record	Flow Period of Record
Platte River at Louisville	06805500	2008-2016	1986-2016
Salt River near Ashland	06805000	2008-2016	1990-2016
Elkhorn River at Waterloo	06800500	2008-2016	1987-2016
Shell Creek near Columbus	06795500	2008-2016	1987-2016
Platte River East of Columbus	SMP1PLATT199	2006	*

*Flow derived from USGS gage stations 06796000 (Platte River at North Bend) and 06795500 (Shell Creek near Columbus). Only flows from recreational season (May – September) were used.

E. coli and flow data were obtained from the USGS for the each of the four LPRCA sponsored stations[2]. USGS has developed regression models relating turbidity and specific conductance (USGS site 06795500 only) to *E. coli* at each of the four LPRCA sponsored stations (Schaepe et al. 2014). The regression models provide near-real-time estimates of *E. coli* levels since 2008. Unlike the LPRCA sponsored stations, the Platte River East of Columbus site is not a USGS gage station and does not have flow data or real-time *E.coli* data. Therefore, *E. coli* levels were based on the recreational season geometric mean of NDEQ's most recent data for this segment, which is 152 cfu/100 mL[3]. Flows for the Middle Platte River TMDL were derived from near-by gage stations. Load duration curves and bacteria loading tables for each of the key monitoring stations is located in Attachments A and B, respectively.

[2] USGS *E. coli* data available from https://nrtwq.usgs.gov/ne/.
[3] The recreational season geometric mean of 152 cfu/100 mL is based on a 2006 *E. coli* dataset collected at station SMP1PLATT199.

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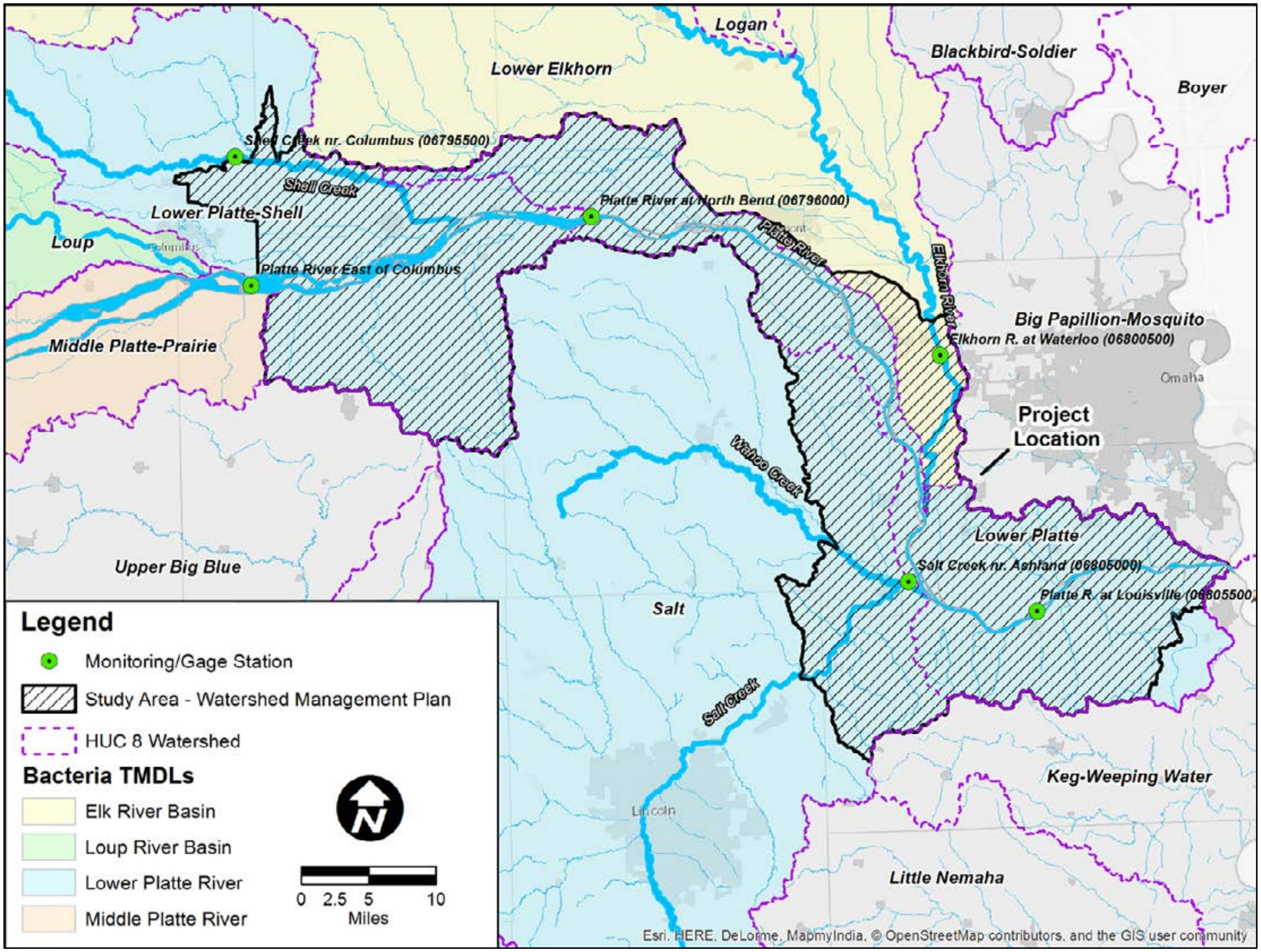

Figure 2. LPRCA Project Study Area

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STEP 2: APPORTION BACTERIA LOADINGS

The second step of the proposed methodology is to apportion bacteria loadings calculated in Step 1 to the 12-digit HUCs located in the study area using a spreadsheet model that accounts for bacteria die-off and land use. Based on the location of the monitoring stations, modeling was conducted for three separate regions (Figure 3).

- **Model Region 1** – This represents the main corridor of the LPRCA study area excluding the Salt River Basin and those 12-digit HUCS located downstream of the Platte River at Louisville station. There are 22 12-digit HUCs located in Model Region 1. Bacteria loading to this region were characterized by the Platte River at Louisville station after subtracting out delivered loadings from the other monitoring stations (Salt River near Ashland, Elkhorn River at Waterloo, Shell Creek near Columbus, and Platte River East of Columbus). The delivered loads were calculated based on distances to the Louisville station and decay and travel time assumptions described below. The original load for each of the 22 12-digit HUCs within Model Region 1 was next back-calculated from the net delivered load at the Louisville station. The back-calculated loading model accounted for travel time, decay and land use assumptions as described below.
- **Model Region 2** – This represents the 45 12-digit HUCs located in the Salt River Basin. Bacteria loadings to this region are characterized by the Salt River near Ashland station. Loadings to each of the 45 12-digit HUCs within the basin were back-calculated from the delivered load at the Ashland Station using the same travel time, decay and land use assumptions referenced in Model Region 1. Although the LPRCA study area only includes six of the 45 HUCs, it is necessary to model the entire Salt River Basin in order to correctly apportion bacteria loadings.
- **Model Region 3** – This represents the six HUCs located downstream of the Platte River at Louisville station. Monitoring data are not available to characterize existing bacteria loadings in these HUCS. Therefore, bacteria yields derived from Model Region 1 were applied to this region.

Model assumptions regarding bacteria die-off, travel time, and attributing sources to land use are described below.

Bacteria Die-off Rate

The spreadsheet model was used to back-calculate bacteria loading contributions from 12-digit HUCs located upstream of the Platte River at Louisville and the Salt River near Ashland stations. Since bacteria are living organisms, die-off was accounted for in the modeling process through the following first-order kinetics decay equation, most commonly expressed as Chick's Law:

$$N_t = N_0 \exp(-k_d t)$$

where N_t is the bacteria population at time t, N_0 is the initial population, and $k_d[T^{-1}]$ is a decay constant.

Many factors influence bacteria die-off rates and literature values widely vary. An EPA study of 30 separate in-situ studies identified fresh water decay rates ranging from 0.12 to 26 d^{-1} with a median of 1.0 d^{-1} (Iudiecello 2012). Therefore, for purposes of assessing bacteria loadings a decay rate of 1.0 d^{-1} at 20°C was assumed. In order to correct for temperature the decay rate was adjusted using the Arrhenius-van't Hoff equation:

$$k_T = k_{20}\Phi_T^{(T-20)}$$

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where Φ = 1.07 (Thomann and Mueller 1987). Stream temperatures during the recreational season (May through September) average approximately 24°C at the Louisville Platte River USGS station. Therefore, based on the Arrehenius-van't Hoff equation a temperature corrected decay rate of 1.3 d^{-1} was assumed for modeling purposes.

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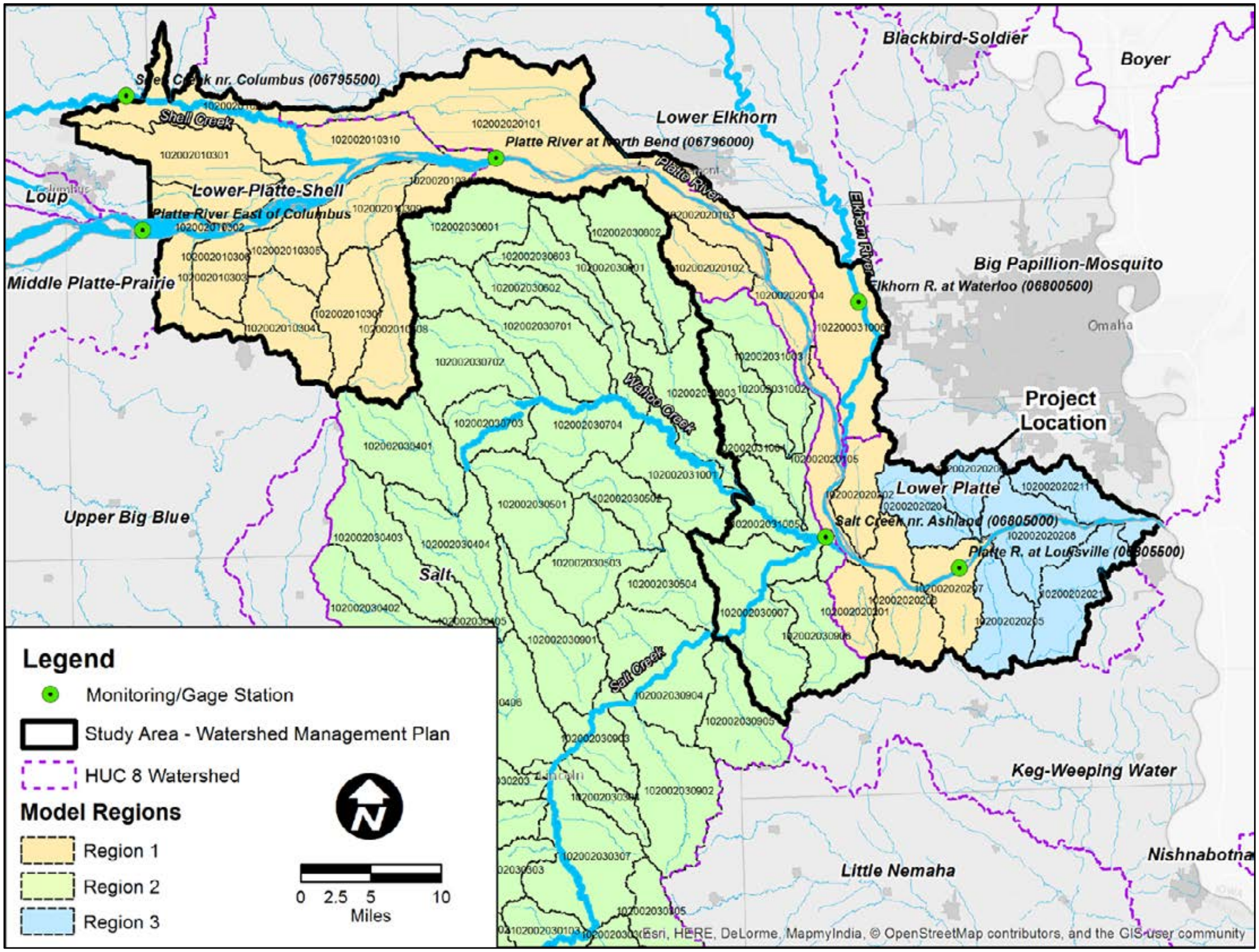

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Figure 3. Bacteria Model Regions

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Travel Time

Bacteria die-off is a function of both the decay rate (k_d) and travel time, which depends on stream velocity. Stream velocity is primarily a function of flow and slope, which vary considerably throughout thousands of stream reaches located in the model regions. In order to reduce model complexity, two different stream velocities were assumed for the spreadsheet model – one for the Lower Platte River and one for all other tributary streams. The average stream velocity in the Platte River was assumed to be 2.1 feet per second (fps) based on data collected in the Lower Platte River (USGS 2008). The average velocity from the tributary streams was estimated from the following equation developed by Boning (1974) for riffle-pool reaches:

$$U = 0.38*Q^{0.4}*s^{0.2}$$

where U is velocity (feet per second [fps]), Q is discharge (cubic feet per second [cfs]), and s is slope (ft/ft).

A representative flow and slope was selected based on the Salt River. The Salt River has an overall slope of 0.0008 ft/ft and a median flow of 329 cfs. However, for purposes of estimating a representative velocity for all tributary reaches, the median flow value was divided in half. Based on this slope and flow, average tributary stream velocities were assumed equal to 0.7 fps.

Attributing Sources to Land Use

The methodology for attributing sources to land use is similar to that used in the Wahoo Creek Watershed Plan, which correlated results from a fecal source tracking study within a rural Nebraska watershed (Plum Creek Watershed) to pastureland, cropland and urban land uses (Vogel et al. 2007). This methodology assumes that bacteria loading from other land uses (e.g., forest) are negligible. While Vogel et al. (2007) does not explicitly link sources to land use, reasonable assumptions may be applied to make this correlation.

Vogel et al. (2007) attributed *E. coli* contributions within the Plum Creek Watershed to known sources within the recreational season (May through September) as follows:

- Cattle: 43%
- Horse: 5%
- Human: 5%
- Wildlife: 19%
- Unknown: 28%

However, these findings do not account for other livestock sources, which likely represent a significant bacteria source in both the Plum Creek and Lower Platte River Watersheds. For example, according to U.S. Department of Agriculture (USDA) National Agricultural Statistics Service census data the hog inventory in the Middle Platte River Watershed is roughly 16% that of the cattle inventory in the Middle Platte River Watershed, which includes the Plum Creek Watershed. Additionally, the density of hogs in the Lower Platte River Watershed is approximately 3.9 times that in the Middle Platte River Watershed. Based on these findings it was assumed that the "unknown" source is predominantly represented by hogs and other livestock. After accounting for other livestock source and aggregating all livestock into a single category, the breakdown of bacteria sources was assumed as follows:

- Livestock – 75%
- Human – 5%
- Wildlife – 20%

In order to correlate bacteria sources to land uses, the following assumptions were applied:

- Livestock sources were assumed to originate from pastureland and cropland. Pastureland was assumed to have twice the livestock loading rate of cropland because livestock likely have access to pastureland year-round, whereas manure is generally only applied to cropland during certain times of the year. Additionally, pastureland provides livestock direct access to streams which potentially represents a significant bacteria loading source.
- Human sources were assumed to originate from pastureland, cropland and urban land. Pastureland and cropland were weighted at 0.5% the loading rate of urban land. The small contribution from pastureland and cropland reflects the fact that municipal biosolids are applied on less than 1% of the nation's agricultural land (EPA 2017).
- Wildlife sources were assumed to originate from pastureland, cropland and urban land at equal rates and proportionate to acreage.

Taking these assumptions into account, the relative contribution of bacteria sources distributed by land use may be derived (Table 3).

Table 3. Relative Contribution of Bacteria Sources Distributed by Land Use[1]

	Plum Creek Watershed Acres[2]	Wildlife	Livestock	Human	Total
Pastureland	64	12.8 (18%)	58.9 (81%)	1.1 (1%)	72.8
Cropland	35	7.0 (30%)	16.1 (68%)	0.6 (2%)	23.7
Urban[3]	1	0.2 (6%)	0 (0%)	3.5 (94%)	3.5
Total		20	75	5	100

[1] Values in table represent the relative contribution of bacteria normalized to 100.
[2] Acres in the Plum Creek Watershed are normalized to 100 acres.
[3] Urban land use represents all other land use types.

The total relative bacteria contribution for each land use type was subsequently divided by the respective acreage to derive a relative yield. For example, pastureland has a relative bacteria yield of 1.1 per acre based on dividing 72.8 by 64 acres. After normalizing the relative bacteria yield of pastureland to 1, relative contributions per acre are as follows for each land use type:

- Pastureland: 1.0/acre
- Cropland: 0.6/acre
- Urban Land: 3.1/acre

POINT SOURCE CONTRIBUTIONS

The proposed methodology does not explicitly account for point sources. Point sources, which primarily refers to wastewater treatment facilities (WWTFs) and permitted confined animal feeding operations (CAFOs), are not expected to be a significant source of *E. coli* loading. According to the EPA approved Lower Platte River TMDL, WWTFs in segments in segments LP1-10000 and LP1-20000 of the Lower Platte River have a combined flow of 7.23 cubic feet per second (cfs). The EPA approved TMDL also

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indicates that the Lower Platte River has a recreational season 7Q10 (the lowest 7-day average flow that occurs on average once every 10 years) of 920 cfs. Therefore, WWTFs sources just represent 0.8% of the critical low flow. Additionally, WWTFs have a wasteload allocation of 126 cfu/100 mL, which is significantly less than the observed recreation season geometric mean of 314 cfu/100 mL reported in the EPA approved TMDL. CAFOs are designed for "zero" discharge. Therefore, in terms of loading, the contribution from point sources is less than 0.8% even during critical low flow conditions. Although the proposed method does not explicitly account for point sources, human sources are accounted for based on the fecal tracking study presented in the previous study. Human sources could potentially be attributed to a number of different point and nonpoint sources such as wastewater treatment facilities, septic systems, sanitary sewer exfiltration, and biosolids application.

RESULTS

LDCs developed in Step 1 of the proposed methodology suggest bacteria loadings are high relative to the *E. coli* criterion of 126 cfu/100 mL throughout most flow conditions (Appendices A and B). Elevated loadings during high flow conditions suggest storm water runoff issues. Conversely, elevated loadings observed during low flow conditions typically suggest the influence of point sources such as wastewater treatment facilities. However, wastewater treatment facilities likely do not represent significant sources in the study area as most facilities currently use disinfection processes. Therefore, direct deposit of manure from livestock with access to streams represents the most likely source of bacteria during low flow conditions. Other sources of bacteria during low flow conditions may include failing septic tanks and exfiltration from sanitary sewer systems.

In Step 2 of the proposed methodology, bacteria loadings calculated at key locations were apportioned to the LPRCA study area 12-digit HUCs by land use type (Attachment C). Model results suggest that approximately 54% of the bacteria loading originate from cropland due to it being the dominant land use (Figure 4). Based on the breakdown of bacteria sources presented in Table 3, approximately 61% of the bacteria loading is estimated to originate from livestock (Figure 4). Wildlife is the next largest source at approximately 22%.

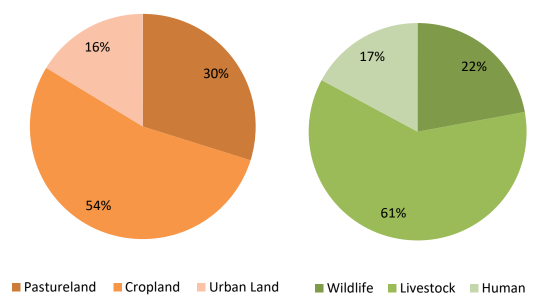

Figure 4. Percent Contribution of Bacteria Loadings in the LPRCA Study Area by Land Use and Source

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DISCUSSION

The proposed methodology suggests that bacteria loadings come from multiple sources and land use types under a range of flow conditions. To best target and prioritize management practices, it is critical to understand the different possible delivery pathways for each of the different sources included in the spreadsheet model. Delivery pathways associated with each of the three model sources are discussed below.

- **Livestock** – Model results suggest 61% of the bacteria loading is from livestock manure, which is predominantly represented by cattle. Bacteria from livestock manure can enter streams and rivers through a number of different pathways including:
  - *Manure application* - Livestock manure may be applied to cropland and pastureland as a fertilizer, where it is susceptible to runoff during stormwater conditions.
  - *Deposition runoff* - Livestock manure deposits are susceptible to stormwater runoff.
  - *Direct deposit* – Direct deposits of manure from livestock with access to streams and rivers can represent a significant source of bacteria loading. Unlike livestock manure deposited on pastureland, direct deposits are not subject to bacteria die-off prior to entering the stream or river.
  - *Waste lagoons* - Irrigation runoff from livestock waste lagoons represents a potential pathway. Waste lagoons are also susceptible to leakage or overflow during major precipitation events (Burkholder et al. 2007).
- **Wildlife** – Preliminary model results suggest 22% of the bacteria loading is from wildlife. Wildlife represents a diffuse bacteria source present in all land uses. Delivery pathways can include both direct deposit and runoff during storm events.
- **Human** – Preliminary model results suggest 17% of the bacteria loading are from human sources. Human sources of bacteria could potentially enter streams and rivers through a number of different pathways including:
  - *Wastewater treatment facilities* – Effluent from wastewater treatment facilities can represent a source of bacteria loading. However, the Lower Platte River TMDL indicates most wastewater treatment facilities in the study area disinfect, so this likely does not represent a significant source of bacteria loading.
  - *Septic systems* – Failing septic systems allow sewage to leave the property and can be a contributor of bacteria contamination to surface water and ground water. However, attempts to quantify bacteria loadings from septic systems suggest this represents a relatively insignificant source of bacteria loading.
  - *Sanitary sewer exfiltration* – Sanitary exfiltration occurs when untreated sewage is discharged from a sanitary sewer into the surrounding geology. Exfiltration may occur due to cracks and defects in pipes, manhole defects, defective laterals and other sources within a sanitary sewer system.
  - *Biosolids application* – The land application of municipal biosolids is susceptible to runoff during stormwater conditions.

Ultimately, results from the spreadsheet model should only be considered approximations for purposes of guiding the identification and prioritization of different management practices. A local understanding of agricultural operations and practices will be critical in targeting specific BMPs. Additionally, assumptions underlying the spreadsheet model may need to be refined as more information becomes

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available. Therefore, this approach should be considered iterative and assumptions may need to be refined at a later date.

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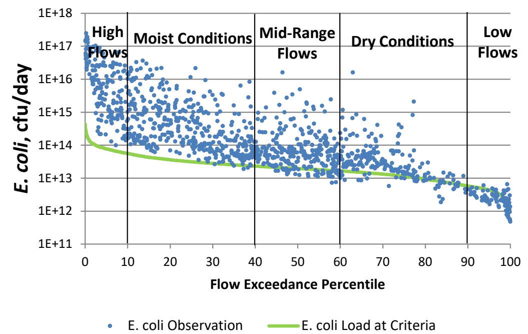
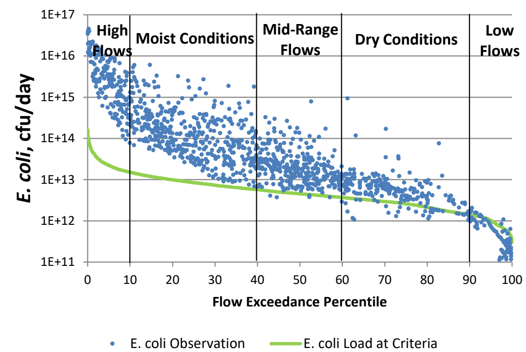
ATTACHMENT A

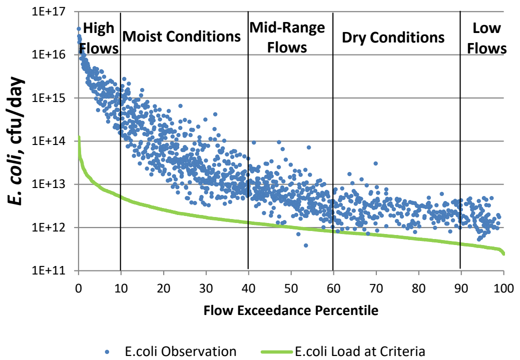
Load Duration Curves



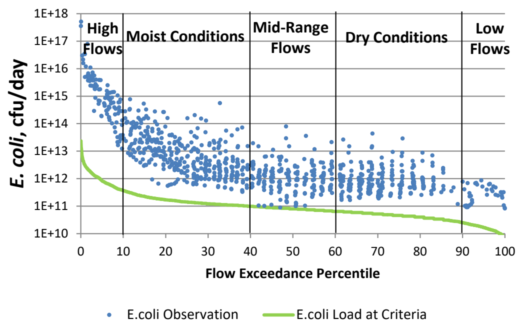
LDC for Platte River at Louisville (*E. coli* observations based on turbidity regressions derived by USGS (Schaepe et al. 2014))



LDC for Elkhorn River at Waterloo (*E. coli* observations based on turbidity regressions derived by USGS (Schaepe et al. 2014))



LDC for Salt River near Ashland (*E. coli* observations based on turbidity regressions derived by USGS (Schaepe et al. 2014))



LDC for Shell River near Columbus (*E. coli* observations based on turbidity regressions derived by USGS (Schaepe et al. 2014))

ATTACHMENT B

Bacteria Loading Tables from Key Monitoring Locations

Recreational Season *E. coli* Loading Calculations for the Platte River at Louisville

Hydrological Condition Class	Flow Duration Interval	Median Flow, cfs	*E. coli* Geomean, cfu/100 mL	Recreational Season Load, cfu/yr
High Flows	0-10%	25,150	8,989	8.41E+16
Moist Conditions	10-40%	10,200	1,355	1.54E+16
Mid-Range Conditions	40-60%	6,360	449	2.12E+15
Dry Conditions	60-90%	3,710	306	1.27E+15
Low Flows	90-100%	1,425	90	4.76E+13
			Total Recreational Season Loading	1.03E+17

Notes: *E. coli* concentrations based on turbidity regressions derived by USGS (Schaepe et al. 2014). Recreation season *E. coli* load = (median flow) x (*E. coli* geomean) x (unit conversion factor [24,465,525 ml•s/ft³•day]) x (# of days in recreation season for hydrological condition class).

Recreational Season *E. coli* Loading Calculations for the Elkhorn River at Waterloo

Hydrological Condition Class	Flow Duration Interval	Median Flow, cfs	*E. coli* Geomean, cfu/100 mL	Recreational Season Load, cfu/yr
High Flows	0-10%	7,190	11,352	3.04E+16
Moist Conditions	10-40%	2,740	1,723	5.27E+15
Mid-Range Conditions	40-60%	1,470	522	5.71E+14
Dry Conditions	60-90%	842	256	2.41E+14
Low Flows	90-100%	329	67	8.19E+12
			Total Recreational Season Loading	3.64E+16

Notes: *E. coli* concentrations based on turbidity regressions derived by USGS (Schaepe et al. 2014). Recreation season *E. coli* load = (median flow) x (*E. coli* geomean) x (unit conversion factor [24,465,525 ml•s/ft³•day]) x (# of days in recreation season for hydrological condition class).

Recreational Season *E. coli* Loading Calculations for the Salt River near Ashland

Hydrological Condition Class	Flow Duration Interval	Median Flow, cfs	*E. coli* Geomean, cfu/100 mL	Recreational Season Load, cfu/yr
High Flows	0-10%	2,782	23,973	2.48E+16
Moist Conditions	10-40%	665	2,822	2.09E+15
Mid-Range Conditions	40-60%	329	689	1.69E+14
Dry Conditions	60-90%	198	528	1.17E+14
Low Flows	90-100%	117	567	2.46E+13
			Total Recreational Season Loading	2.72E+16

Notes: *E. coli* concentrations based on turbidity regressions derived by USGS (Schaepe et al. 2014). Recreation season *E. coli* load = (median flow) x (*E. coli* geomean) x (unit conversion factor [24,465,525 ml•s/ft³•day]) x (# of days in recreation season for hydrological condition class).

Recreational Season *E. coli* Loading Calculations for Shell Creek near Columbus

Hydrological Condition Class	Flow Duration Interval	Median Flow, cfs	*E. coli* Geomean, cfu/100 mL	Recreational Season Load, cfu/yr
High Flows	0-10%	275	137,245	1.40E+16
Moist Conditions	10-40%	46	5,369	2.76E+14
Mid-Range Conditions	40-60%	26	1,633	3.16E+13
Dry Conditions	60-90%	15	1,899	3.18E+13
Low Flows	90-100%	6	1,949	3.99E+12
			Total Recreational Season Loading	1.44E+16

Notes: *E. coli* concentrations based on turbidity regressions derived by USGS (Schaepe et al. 2014). Recreation season *E. coli* load = (median flow) x (*E. coli* geomean) x (unit conversion factor [24,465,525 ml•s/ft³•day]) x (# of days in recreation season for hydrological condition class).

Recreational Season *E. coli* Loading Calculations for the Platte River East of Columbus

Hydrological Condition Class	Flow Duration Interval	Median Flow*, cfs	*E. coli* Geomean†, cfu/100 mL	Recreational Season Load‡, cfu/yr
High Flows	0-10%	13,125	293	1.43E+15
Moist Conditions	10-40%	5,374	199	1.19E+15
Mid-Range Conditions	40-60%	3,404	152	3.85E+14
Dry Conditions	60-90%	2,085	116	2.70E+14
Low Flows	90-100%	824	79	2.41E+13
			Total Recreational Season Loading	3.30E+15

*Median flow values derived from USGS gage stations 06796000 (Platte River at North Bend) and 06795500 (Shell Creek near Columbus).

†*E. coli* geometric mean calculated for each hydrologic condition class assuming an overall *E. coli* geometric mean of 152 cfu/100 mL, a lognormal distribution, and a log standard deviation of 0.4.

‡Recreation season *E. coli* load = (median flow) x (*E. coli* geomean) x (unit conversion factor [24,465,525 ml•s/ft³•day]) x (# of days in recreation season for hydrological condition class).

ATTACMENT C

Bacteria Loadings by Land Use Type

Bacteria Loadings by Land Use Type

HUC	Name	Recreational Season *E.coli* Loading (cfu/season)			
		Cropland	Pastureland	Urban	Total
102002030906	Callahan Creek	6.67E+15	1.78E+15	0.00E+00	8.45E+15
102002030907	Dee Creek-Salt Creek	1.45E+16	4.22E+15	2.42E+15	2.12E+16
102002031002	Johnson Creek	5.20E+15	1.96E+15	7.16E+14	7.88E+15
102002031003	Headwaters Clear Creek	9.08E+15	1.22E+15	8.34E+14	1.11E+16
102002031004	Clear Creek	3.57E+15	4.18E+15	0.00E+00	7.75E+15
102002031005	Wahoo Creek	6.45E+15	2.64E+15	1.62E+15	1.07E+16
102200031006	Big Slough-Elkhorn River	1.46E+16	8.17E+15	2.16E+16	4.44E+16
102002020102	Headwaters Otoe Creek	1.53E+16	1.61E+15	9.56E+14	1.79E+16
102002020103	Elm Creek-Platte River	7.42E+15	9.63E+15	7.06E+15	2.41E+16
102002020104	Otoe Creek-Platte River	7.45E+15	7.69E+15	6.93E+15	2.21E+16
102002020105	102002020105	3.98E+15	9.71E+15	6.30E+14	1.43E+16
102002020201	Pawnee Creek	8.32E+15	4.13E+15	2.00E+15	1.44E+16
102002020202	Western Sarpy Ditch-Platte River	9.72E+15	4.83E+15	1.53E+16	2.98E+16
102002020203	Decker Creek-Platte River	1.66E+16	8.30E+15	3.19E+15	2.81E+16
102002020207	Mill Creek-Platte River	1.55E+16	5.31E+15	9.30E+14	2.17E+16
102002020101	Rawhide Creek-Platte River	6.56E+16	1.93E+16	9.98E+15	9.49E+16
102002010305	Outlet Bone Creek	1.05E+16	8.99E+15	1.66E+15	2.11E+16
102002010306	Tomek Island-Platte River	1.09E+16	9.69E+15	9.66E+14	2.15E+16
102002010307	City of Abie	1.44E+16	1.13E+16	2.43E+15	2.81E+16
102002010308	Headwaters Skull Creek	1.88E+16	1.03E+16	1.23E+15	3.04E+16
102002010309	Outlet Skull Creek	1.26E+16	1.25E+16	1.73E+15	2.69E+16
102002010310	Lost Creek-Platte River	1.72E+16	8.91E+15	1.12E+16	3.73E+16
102002010311	102002010311	4.18E+15	3.92E+15	1.87E+15	9.97E+15
102002010301	Shonka Ditch	2.74E+16	7.58E+15	4.06E+15	3.90E+16
102002010303	Deer Creek-Platte River	1.16E+16	1.12E+16	2.00E+15	2.48E+16
102002010304	Headwaters Bone Creek	1.21E+16	1.63E+16	1.13E+15	2.95E+16
102002010302	Headwaters Lost Creek	6.12E+15	9.74E+15	6.52E+14	1.65E+16
102002010209	Brewery Hill-Shell Creek	2.24E+16	1.18E+16	4.61E+15	3.88E+16
102002020204	Buffalo Creek	1.44E+16	4.27E+15	6.72E+15	2.54E+16
102002020205	Cedar Creek	9.16E+15	7.68E+15	6.22E+15	2.31E+16
102002020210	Eightmile Creek	2.06E+16	6.56E+15	3.37E+15	3.05E+16
102002020208	Turkey Creek-Platte River	1.49E+16	8.19E+15	4.55E+15	2.77E+16
102002020206	Turtle Creek	9.49E+15	2.30E+15	4.98E+15	1.68E+16
102002020211	Zwiebel Creek-Platte River	9.50E+15	7.21E+15	4.62E+15	2.13E+16
	SUM	2.53E+17	4.56E+17	1.38E+17	8.47E+17

Stakeholder Meeting Summary

Lower Platte River CORRIDOR ALLIANCE
LEAD. ORGANIZE. INSPIRE. The voice of the Lower Platte.

Meeting Notes – LPRCA Strategic Planning Meeting

Attendees

LPRCA: Gerry Bowen, P-MRNRD; Steve Gaul, NDNR; Carey Grell, NGPC; John Hannah, LPNNRD; Patrick Hartman, NDEQ; Rachael Herpel, UNL/UNO; Glenn Johnson, LPSNRD; Michelle Koch, NGPC; John Miyoshi, LPNNRD; Melissa Mosier, LPRCA; Tom Mountford, LPNNRD; Marlin Petermann, P-MRNRD; Meghan Sittler, LPRCA; Scott Sprague, DHHS; Larry Vrtiska, NEARNG; John Winkler, P-MRNRD; Paul Zillig, LPSNRD

HDR: George Hunt, Theresa McClure, Matt Pillard, Stephen Sykes

Agenda

Lower Platte River Corridor Alliance
Strategic Planning Meeting
Thursday, April 4, 2013
Lower Platte South NRD

10:00 a.m. Opening/Introductions
10:15 a.m. Overview of current LPRCA programs
Discussion of member agency programs & priorities
11:15 a.m. Watershed Management Plan
- Overview – Nine Elements of a Watershed Management Plan
- Watershed Management Plan Goals

12:00 a.m. Lunch
12:30 p.m. Watershed Management Plan (Continued)
- Watershed Characterization

1:30 p.m. Next Steps for Watershed Management Plan
2:00 p.m. Next Steps for the LPRCA
- Long Range Planning
- Website update
- Update outreach and education strategy

3:00 p.m. Adjourn

Meeting Notes

LPRCA overview and review
Following brief introductions, Sittler began the meeting by providing an overview of LPRCA accomplishments since the last Strategic Planning meeting in 2010:

- Baseline accomplishments included:
  - Branding
  - Website updates
  - Public opinion survey
  - ESA/LSA complete and continues to be updated
  - Expansion of the water quality monitoring network
  - Watershed management plan

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  - New collaborations; expanding partnerships with partners and stakeholders
  - River clean up; identified in public survey as a priority
  - The need to identify new funding: 319 & environmental trust grants

Agency Updates
LPRCA partners provided an update on current events and challenges from the perspective of their agency or organization. The following is a summary of the discussion by each representing partner:

LPNNRD
Staff from LPNNRD described the most pressing issues that the NRD has been addressing lately which included:
- The district is still in need of water due to drought conditions. They are trying to determine sensitive areas in the drought.
- The district has expanded outreach with cities
  - Schuyler has indicated the need for a levee east and north of the city to take a significant amount of the community out of the floodplain.
- Lake Wanahoo is opening for the second season
- The Fremont levee at Highway 30 is still an option
- The district has been focusing on hazard mitigation plans
- The district has been focusing on ongoing efforts in Shell Creek. The creek may be the first stream delisted for Atrazine.

P-MRNRD
Staff from P-MRNRD described the most pressing issues that the NRD has been addressing lately which included:
- The district is focused on major flood control efforts
- Focus on western Sarpy Deer Creek levees
- Planning for and around the Omaha well fields
- IMP planning; this is a voluntary effort
- The priority remains drinking water supply from the Platte for public consumption
- The district is advocating for and working on new opened access to the Elkhorn
- The district is looking for new access and improved trail systems on the river
- Invasive species control is an important focus; coordination with other NRD's and weed management authorities
- The district is working on a cost sharing program for weed removal
- Tributaries have major Phragmites and need to be controlled by all NRDs
- Staff are seeing more Phragmites and Purple Loosestrife in areas not previously identified

LPSNRD
Staff from LPSNRD described the most pressing issues that the NRD has been addressing lately which included:
- Recent focus on Plattsmouth wells in hydrologically sensitive areas
- The district has been addressing stream bank stabilization
- The district has been working on IMP planning with a focus on public supply systems
- Sandbar studies have been undertaken

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- The district is interested in a discussion about regulating development along the Platte River
- Lincoln drought issues from 2012 and 2013 are being discussed
- The district is interested in conservation easements on the lower Platte

NDNR
Gaul from NDNR provided context on some of the water management issues in the Corridor by briefly discussing the following:

- Review of the river appropriation process
  - Input from NRD's is expected regarding appropriation of flows
- NDNR has been in discussions about a state level programmatic agreement for water supply and administration
- A hydrologic analysis of eastern NE is on the web

NDEQ
Hartman shared updates from NDEQ that included the following topics:

- An overview of the 319 grant program
  - Greater funding needs to be spent on programs for watershed management
  - 319 funded projects need to be focused on water quality & ground water
  - The program maintains flexibility to include protection
- Recent program changes relate to non-point source management
- There is an increased agency focus on nutrients
- Dedicated funding for watershed planning will be maintained
  - Small projects have to be funded competitively
    - Projects have not exceeded $100,000
  - No cap on the number of projects
  - NDEQ is also funding an extension liaison

Game & Parks
Koch and Grell of NGPC shared agency updates including the following:

- NGPC underwent a recent agency reorganization
- The 2011-2016 Strategic Plan is being implemented
- Looking to renew their in stream flow permit - for renewal in 2014
  - Representatives from P-MRNRD asked questions about the timeline and process for this renewal. NRD staff said they would like to be in contact with NGPC staff when a renewal is planned.
- NGPC has an interest in developing more water recreation trails
- NGPC is promoting education through river permit and retention youth programs
- NGPC staff have been promoting Project Wild which provides interdisciplinary conservation and environmental education

NE ARNG
Vrtiska of NE ARNG provided a variety of updates related to revenue, Camp Ashland, and natural resource management and included:

- Camp Ashland experiences fiscal uncertainty during federal appropriations process

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  - Camp Ashland is the base of operations for O&M
  - Camp Ashland receives a small amount of appropriations
  - Staff are constructing a small waste water treatment plant
- NE ARNG is looking for water projects to improve water quality in the Corridor
- NE ARNG is looking at land use development around Camp Ashland
  - Access to Camp Ashland is being reviewed in light of development
- Natural Resources Management Issues
  - NE ARNG is interested in levee monitoring on Platte
  - NE ARNG is interested in a UNL partnership on fish surveys
  - East side fire hazards near training sites are being addressed
  - NE ARNG is working on controlled burning of Red Cedar trees
  - NE ARNG is working on an updated Integrated Natural Resources Management Plan
  - Proposed construction of a new north facility

HHS
Sprague of HHS introduced himself as the new HHS representative on the LPRCA and provided a few updates on:

- Community water systems and water restrictions jumped from 6 to 180 over a year
  - HHS is prioritizing communities with only one well
- Confirms restrictions are in place for restrictive management
- Focus is on educating the public and elected officials on water supply management

UNL
Herpel provided a variety of updates from the University of Nebraska system which included:

- Water for food institute has undergone a reorganization
- Funding for Corridor related projects only comes to teams working on big issues
- There are system wide interests for collaboration across University
- There is an extreme focus on student productivity post graduation
- New opportunities for new collaborative relationships with NRD's are of high interest
- Rural Futures Institute Update
  - Four research grants are available on a rotating basis
  - Six teaching and outreach grants are also available

Watershed Management Plan Discussion
Pillard and Hunt introduced the Watershed Management Plan portion of the agenda by providing an overview of the EPA's "Nine Elements of Watershed Plans":

1. Identification of causes of impairment and pollutant sources…that need to be controlled to achieve needed load reductions and other goals in the plan.
2. An estimate of the load reduction expected from management measures.
3. A description of the nonpoint source management measures that will need to be implemented to achieve load reductions…
4. Estimate of the amounts of technical and financial assistance needed…and authorities that will be relied upon to implement this plan.
5. An information and education component used to enhance public understanding of the project…

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6. Schedule for implementing the nonpoint source management measures identified in this plan that is reasonably expeditious.
7. A description of interim measurable milestones for determining whether nonpoint source management measures or other control actions are being implemented.
8. A set of criteria that can be used to determine whether loading reductions are being achieved over time…
9. A monitoring component to evaluate the effectiveness of the implementation efforts over time…

General Discussion
Following the "Nine Elements of Watershed Plans" presentation, the group asked questions and generally discussed elements of the plan and the process including a focus on the scope of the 319 program and whether this plan would consider water quantity issues along with water quality issues:

- Are 319 plans typically non-point source?
  - The 319 process looks to develop local projects for implementation
  - A comprehensive analysis looks at both point and non-point sources
- For Antelope Creek; E. Coli was identified and a point source was not identified
- Looking at nutrients and sediment is the goal
- Wahoo Creek Water Quality Management Plan addresses both quality and quantity
  - More focus was on quality
  - Quantity could be addressed in future studies
- Will this plan address water quantity?
  - There was discussion that a watershed management plan should include all elements of a watershed. A 319 Watershed Management Plan typically focuses on water quality, but does not preclude other elements.
  - Including other factors expands the scope outside of what the grant was applied for.
  - Should consider renaming "Lower Platte River Watershed Water Quality Management Plan?"
  - Pillard provided that
- A general question was asked regarding how this plan addresses proposed state legislation. No comments or opinions were offered at the time.
  -

Goals Discussion
Following the general discussion around the focus of the plan and the 319 program, Sykes referred the group to examples of watershed management plan goals that have been used in other regional plans. The members were then asked to work in pairs over the lunch break and develop at least two goals, or goal topics, that should be considered for inclusion in this watershed management plan. Specific direction was provided that asked the group to focus on general goals and avoid listing more specific objectives that would be used to implement the goals. The list of goals, or goal areas, developed by the group included the following:

- How does sediment affect all habitats?
- Identify appropriate sediment balance in the Lower Platte for the pallid sturgeon. Reduce sediment / reduce phosphorous / improve water quality, but…
- Consider how to manage sediments but not eliminate habitat building materials in the river

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- Consider how management of upland riparian areas, stream stability, affects maintaining water quality for wildlife
- Enclosing aquatic assessment communities
- Collaborate with all appropriate zoning jurisdictions to develop and uniformly implement comprehensive, consistent and suitable development ordinances in the Lower Platte corridor
- Comprehensive and uniform planning can be an objective
- How can this plan be utilized to develop a local plan?
- Identify potential water quality issues and treatment measures to address projected changes in watershed land use
- How do you define goals that are easily implemented?
- Partnering with NRC's on upland areas; look at riparian area and stream stability
- Ensure the watershed plan can be implemented and used locally
- Make goals attainable
- Should we have a goal that says no net impact from the time water enters the corridor to the time it leaves?
- Should we add that there should be a net improvement?
- Identify sources for E. Coli and develop treatment programs and set numeric treatment goals
- Identify and manage pollutant sources
- Plan for a variety of uses
  - Municipal
  - Rural
  - Recreational
- Will this plan also address ground water / surface water?
  - What are the influences on ground water?
  - Discussion reflected that ground water would not be excluded but surface water would be the primary focus
  - Hartman: The 319 has particular requirements but the watershed plan that we are going to develop can be more comprehensive (as long as the requirements are met)
- Determine surface water quality effects on drinking water
  - Needs to consider EPA water quality regulations
  - Users on private wells, future contamination
  - What are the water quality parameters impacting surface water?
- Identify funding partners and tools available to address water quality issues
- Develop specific parameters to measure / monitor water quality parameters
- Rank and prioritize
  - Identify differences in water quality and focus on priorities for implementation
  - Identify changes in water quality parameters during wet, dry, and normal years
  - Tie this to survey results
- Develop programs and plans that reduce sediment loads in target streams above 200 cfs. This should include both (sic) structural measures in the farm practice. (discussed changing this to 2 cfs)
- What are other plan goals?

Watershed Characterization

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Sykes and Pillard asked the group to share examples of data sources and resources for partnering projects in the Corridor. The group shared a variety of ideas that included:

- NRCS related activity includes
  - They provide funding
  - They update their inventory
  - Structural BMP's can be incorporated and/or referenced
- Extension offices have resources related to
  - Water climate / environment
  - Ag team is a resource
  - Community partnerships
  - BMP's, info and education
  - On-farm research
    - Saunders County
    - Data capture
- Johnson Creek stabilization project
  - Federal monitoring requirements
  - 404 permitting requirements
  - Challenge of adjacent landowners (NRD can help)
- USGS Instream flow monitoring
- MS4 Stormwater permits (communities 10,000+)
- Farmstead / septic identification and cost sharing programs (BMP)
- DEQ state nutrient management plan
- DEQ basin management plans and soil water conservation fund
- NRD funded BMP's: Ag, structural / practice / stream bank erosion protection programs / waterways
- Wellhead protection areas
- Source water protection grants
- Urban storm water grants
- State revolving loan funds
- Conservation easements
- Farm & ranch protection programs
- Fertilizer management
- Gravity to center pivot cost share programs
- LID strategies / demonstration projects
- Community clean-up's / hazardous waste elimination
- Health departments: funding, advocacy
- NPDES permitting

Discussion of Next Steps for Watershed Management Plan

Sykes and Pillard closed the discussion of the Watershed Management Plan by summarizing the topics of the day and briefly reviewing next steps which include:

- Develop a Plan outline based on discussion and recommended goals
- Identify data collection next steps
- Share the draft plan / goals with LPRCA for comment

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Discussion of Next Steps for the LPRCA

Sittler provided some general updates that provided perspective on the direction of the LPRCA over the coming year. Feedback was solicited from the group related to the ongoing pier removal program. Highlights of this discussion include:

- LPRCA is in a transition phase; important information has been gathered to date, now it's being applied in WMP, programs, and education.
- Web update to fill a gap with users / constituents, try to reduce mailing. Contacts from a broader demographic of people have resulted.
- Outreach & Education: NRD's doing free water quality testing. Newman Grove got national attention for incorporating youth in water quality sampling. Schuyler science clubs to reach kids. Kids can bring parents in for science club type meetings that NRD meetings couldn't attract before.
- UNO / UNL on campus - Time lapse video with USGS data to go with it for educational purposes. 4H participating as well.
- Is the pier removal project still worth funding for another consideration? Three of twelve sets of piers have been removed as part of the program.

The following strategies for successful outreach and public education were solicited from the group:

- Water quality testing meetings
- Tapping into science clubs / school programs
- Girl scout / Boy scout programs
- Camp Ashland access
- Time lapse photo project
  - Youth program / accessibility
  - Partner with USGS monitoring
- DEQ brown bag luncheons
- DNR
- Continuing education credits
- UNL clubs
- 4H, FFA
- Billboard marketing
- Mobile applications that collect feedback from resource users (hikers, hunters, kayakers, etc.) – NGPC has a similar resource
- Water trail development to promote Platte River use
- Outdoor activities 'finder' application
  - Game & Parks collaboration

LPRCA Goals Exercise

Question/Issue	Answer
Lower Platte River Corridor Needs	• Collaboration • A comprehensive plan that identifies goals, objectives for priority areas identified within the corridor for the immediate and long range future. • More research on species needs / requirements

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Question/Issue	Answer
(*Comment mentioned more than once)	• Re-evaluation of water laws and regulations • Integrated water management • Continued obstruction removal* • Non-point source identification and control* • Invasive species control • River clean-up efforts • Maintain and improve wildlife and aquatic habitat* • Conserve and enhance aesthetic value • Conserve and enhance ecologic values • Preserve and enhance native communities • Lower E. Coli levels in streams (sic) to PH standards • More education on river ecosystem function and benefits • More water storage, runoff reduction • More info and education on protecting water quality • Provide programs to conserve SW and GW quality • Provide appropriate bank stabilization and sediment control • Improvement in levees and bank stabilization points • Provide appropriate levels of flood protection and mitigation • Restrict development in floodplains and behind levees to appropriate uses* • Uniformity of floodplain regulations • Consistent development ordinances and control throughout the corridor, including floodplain development controls • Provide for and encourage appropriate economic development and activities on corridor • Better land management • Improved farm management – keep farm problems on the farm • More wild areas or better publicity of wild areas. Programs to get people in them. • Uniformity of gaming regulations • Enhance and develop recreational opportunities while preserving aesthetics and ecologic value • Water recreation access (boating, fishing)* • Increased recreational opportunities • Better understanding / what does that mean to the military • How does this plan integrate into new legislation?
Lower Platte River Corridor Partners (*Organization mentioned more than once)	• USFWS*, DU*, USACE* • All residents within the corridor • All communities, counties and other entities* • Natural Resource Districts • State & Federal agencies • Non-profit organizations • Local, state & federal elected representatives • Youth groups / community organizations • NRD's* • DNR • NDEQ*

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Question/Issue	Answer
	• Universities/Schools • NGPC* • DOR / FHWA • Hunter / Angler Groups • MAPA • Road Planners • UNL Cooperative Extension • NRCS* • Nebraska Homebuilders • Nebraska Wildlife Federation • National Audubon Society • Sierra Club • Izaak Walton League • NOCO • MUD • Lincoln Water • Irrigation interests • Landowners • SID* / Associations • USGS • Defense department • USDA • NDUK • NDOH • Volunteer groups
Untapped resources that could benefit the Lower Platte River Corridor	• If we improved access / access control, maybe more opportunities • Increased county & community involvement • Schools / science clubs / monitoring efforts • Youth groups-Boy / Girl scouts-FFA • Locally led landowner / citizen groups • UNL "Institutes" • New DEQ liaison • Aquatic habitat funds • Stream stability • Cities and counties • Environmental trust (or already tapped) • Schools largely are locally centered. Could be pooling of resources to drive educational efforts • Increase higher education research in watershed, community college based research
What does the Lower Platte River Corridor look like in 2030 without a Watershed Management Plan? (*Comment mentioned more than once)	• Water restriction, potable water (lack of) • River may be much drier / less flow • More battles and litigation over water issues • Straightened, channelized, stabilized rivers • Invasive species issues • Loss of biodiversity* • Loss of recreational opportunities

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Question/Issue	Answer
	• More money spent on flooding issues if floodplain development continues • Increased development in sensitive areas • Scuttes-shot development"(sic) • Sandpit lakes & housing development • Potentially a much degraded river with hodge podge development with reduced or impaired water quality and degraded habitat. A much less natural river and degraded amenity.* • Unrestricted development degrades land use and creates runoff problems • Flooding impacts on structures • Deteriorated water quality* • Decreased riparian health* • Habitat loss • Increase in T&E species • "More sediment and erosion of banks* • Degraded aesthetics, rec values, water quality, ecologic values • Water deficiencies-intractable* • Deforestation and grass land disappearance • Increased competition for resources-be it recreation, water, open space • Loss of military readiness • A plan that will keep the corridor moving in well inputted directions involving all corridor partners. Without a plan, opportunities for moving in most important directions may be missed.

APPENDIX D – MANAGEMENT MEASURES

The intent of this Appendix is to present an array of practical management alternatives for consideration during the project planning phase for all water bodies across the Study Area. This Appendix outlines upland, stream, lake, and groundwater management practices, both structural and non-structural, that are feasible within the Study Area to achieve the water management goals and objectives identified in this Plan. BMPs presented in this Appendix have been identified due to their capability to reduce nutrients, sediment, and bacteria loading to water bodies. BMPs will ultimately be selected based upon their effectiveness to address a specific issue or issues at the project level and their suitability to field scale conditions. The effectiveness of implemented BMPs is highly dependent on watershed characteristics, the position of the BMP in the watershed, drainage area, storage volumes, other BMPs in the watershed, maintenance of existing BMPs, and a host of other factors. BMP selection and expected efficiencies (as presented in Section 4 of the Plan) are best determined (and often aided by watershed models) during specific project planning.

MANAGEMENT PRACTICE SUMMARY

A wide variety of management practices are available in this Appendix that might be used by project sponsors when planning at the project level. These management practices have been identified due to their capability to reduce pollutant loading to water resources. Projects will encourage the NRCS 'systems approach' to address priority natural resource concerns. The main point of this approach is that a variety of BMPs in sequence often work better than individual BMPs. A variety of BMPs can be implemented that reduce pollutants by Avoiding, Controlling, or Trapping, or "ACT" (NRCS 2013). The concept of ACT (NRCS 2013) is defined as:

- **Avoiding (A)** – Avoidance helps manage nutrients and sediment source control from agricultural lands, including animal production facilities. Practices such as nutrient management, cover crops, and conservation crop rotation help producers avoid pollution by reducing the amount of nutrients available in runoff or leaching into priority water bodies and watersheds.
- **Controlling (C)** – Land treatment in fields or facilities that prevents the loss of pollutants includes practices such as conservation tillage practices and residue management, which improve infiltration, reduce runoff, and control erosion. Specific practices such as no-till/strip till/direct seed and mulch tillage are foundation practices to recommend to producers in priority watersheds.
- **Trapping (T)** – The last line of defense against potential pollutants at edge of field, or in facilities to trap or treat. Practices such as filter strips, wetland forebays, bioretention areas, water quality basins, and the suite of wetland practices to enhance and/or restore wetlands all serve to trap and uptake nutrients before entering water bodies.

NONPOINT SOURCE CONTROL EFFECTIVENESS

The impact of urban and agricultural practices on water quality has received considerable attention during the last two decades, with a number of studies indicating that agricultural chemicals are one of the main sources of nonpoint source pollution (Gilley and Risse 2000). Intensive agricultural practices are identified to release significant amounts of nutrients, especially nitrogen and phosphorus, fecal bacteria, and sediment to receiving water bodies (Monaghan et al. 2005).

The effectiveness of individual BMPs in reducing nonpoint source pollution loads can be highly variable based on a number of site-specific factors. Additionally, the installation or use of one BMP is rarely sufficient to completely control the pollutant of concern. Combinations of BMPs that control the same pollutant are generally more effective than individual BMPs. These combinations, or systems, of BMPs can be specifically tailored for particular agricultural and environmental conditions, as well as for a particular pollutant (Osmond et al. 1995). To most effectively control nonpoint source pollution, BMP systems should be designed based on the following:

- Pollutant type, source, and cause;
- Agricultural, climatic, and environmental conditions;

- Farm operator's economic situation;
- System designer's experience;
- Acceptability by the producer of the BMP components.

Even though various BMPs have been shown to reduce losses of nonpoint pollutants and improve water quality at the scale of implementation (i.e., field/farm scales), their effectiveness in improving water quality at a watershed scale is less clear. Some BMPs may be effective in controlling one pollutant while, at the same time, may adversely affect the losses of other pollutants (Merriman et al. 2009). This should be considered when the selection is being made rather than after a new problem arises. However, even properly designed BMP systems constitute only part of an effective land treatment strategy. For a land treatment strategy to be really effective, properly designed BMP systems must be placed in the correct locations in the watershed (critical areas) and the extent of land treatment must be sufficient to achieve water quality improvements. Generally, 75% of the critical area must be treated with the appropriate BMP systems. If the problem derives from livestock, generally 100% of the critical area within the watershed must be treated with BMP systems (Meals 1993).

RESPONSE TO NONPOINT SOURCE CONTROLS

Nonpoint source watershed projects sometimes fail to meet expectations for water quality improvement because of lag time—the time elapsed between adoption of management changes and the detection of measurable improvement in water quality in the target water body (Meals 2010). Even when management changes are well-designed and fully implemented, water quality monitoring efforts may not show definitive results if the monitoring period, program design, and sampling frequency are not sufficient to address the lag between treatment and response.

The main components of lag time include the time required for an installed practice to produce an effect, the time required for the effect to be realized in the water body, the time required for the water body to respond to the effect, and the effectiveness of the monitoring program to measure the response. Important processes influencing lag time include hydrology, vegetation growth, transport rate and path, hydraulic residence time, pollutant sorption properties, and ecosystem linkages. The magnitude of lag time is highly site- and pollutant-specific, but may range from months to years for relatively short-lived contaminants such as indicator bacteria, years to decades for excessive phosphorus levels in agricultural soils, and decades or more for sediment accumulated in river systems.

Groundwater travel time is also an important contributor to lag time and may introduce a lag of decades between changes in agricultural practices and improvement in groundwater quality. Approaches to deal with the lag between implementation of management practices and water quality response include characterizing the watershed, considering lag time in BMP selection, siting, and monitoring, selecting appropriate indicators, and designing effective monitoring programs to detect water quality response.

UPLAND STRUCTURAL PRACTICES

Structural practices, such as terraces, ponds, and sediment forebays, are effective in retaining pollutants at or near the source. Structural practices, while more expensive, are longer-term solutions that are less likely to be abandoned. Benefits of these practices for controlling, trapping and attenuating pollutants increase when used in combination with non-structural practices. **Table D-1** displays the structural upland practices likely to be utilized in the Study Area based upon the ACT approach as described in the Nebraska State Nonpoint Source Management Plan (NDEQ 2015). Pollutant reduction estimates for each practice have been provided based upon available literature.

Table D-1. Upland Structural Practices and Pollutants Addressed

Upland Practice	Practice Mode of Action			Pollutants Addressed			
	Avoid	Control	Trap	*E. coli*	Atrazine	Sediment	Nutrients
Constructed wetland		X	X	X		X	X
Wet detention basin		X	X	X	X	X	X
Dry detention basin*		X	X	X	X	X	X
Sediment control basin		X	X	X		X	X

*Source: ACT criteria not reported in Nebraska State Nonpoint Source Management Plan

Constructed Wetlands

Constructed wetlands are treatment systems that control and trap pollutants using natural biological processes involving wetland vegetation, soils, and their associated microbial assemblages to improve water quality. Constructed wetlands are often used as a nonpoint source management practice to reduce sedimentation and nutrient loading to reservoirs by water mechanically filtering and trapping sediment within the wetland, rather than traveling to the waterbody. Wetland systems are unique because of their ability to uptake nutrients, provide natural attenuation, and provide solar disinfection. Constructed wetlands are designed specifically to a size and depth to maximize pollutant removal efficiencies. STEPL reports 85% reduction in sediment, 69% reduction in phosphorous, and 55% reduction in nitrogen (Tetra Tech 2011). However, nutrient reduction efficiencies can be reduced as the wetland community accumulates nutrients in plant biomass and ultimately releases them back into the system upon senescence. The removal (harvesting) of plant biomass (and nutrients contained in the plants) can be required to meet removal goals as wetlands age. *E. coli* reduction efficiency was assumed at 70% based on analysis of data provided by the International Stormwater BMP Database (UWRRC 2014; Wright Water Engineers and Geosyntec 2012).

Wet Detention Basins

Wet detention basins, also referred to as wet ponds, farm ponds, or retention basins, control and trap pollutants by holding runoff and allowing settling of particles. The retention pond has a permanent pool of water that fluctuates in response to precipitation and runoff from the contributing areas. Maintaining a pool reduces re-suspension and assists in keeping deposited sediments at the bottom of the holding area. Natural attenuation of pollutants occurs through breakdown of contaminants by soil microorganisms or other biological processes, especially nutrients and bacteria. This is a key benefit to retention facilities. The renovation of existing structures is a practice to be utilized as part of this Plan, and can be a more cost effective practice than constructing new ponds. STEPL reports pollutant reduction using wet ponds at 86% for sediment, 69% for phosphorus, and 55% for nitrogen (Tetra Tech 2011). In a 2012 study published on the International Stormwater BMP Database, a collaborative study between Wright Water Engineers and Geosyntec found that wet detention basins reduced *E. coli* by 70%.

Dry Detention Basin

Dry detention ponds also control and trap pollutants and are similar to retention basins, but do not permanently hold water, and can serve as infiltration or bioretention features. They are designed to remain dry except during or after rain or snow melt, which allows for agricultural use to continue on a regular basis above the structure. Their purpose is to slow down water flow and hold it for a short period of time to allow natural treatment of pollutants, for stormwater to infiltrate into the ground, or to settle out of the water during retained times rather than flow into a waterbody. The average depth at the peak water level after a rainfall event will be dependent on the frequency of event for the facility is designed. For example, a facility designed for a 2-year event won't be as deep at the maximum detention pool as a facility designed for a 10-year event. A reasonable estimate would be six to 10 feet, with a drawdown time of approximately three days. STEPL reports pollutant reduction estimates of 58% for sediment, 26% for phosphorus, and 30% for nitrogen. According to the Massachusetts Stormwater Handbook, *E. coli* reduction efficiency in dry detention basis is less than 10%, for this study efficacy is assumed to be 10% (MassDEP 2017).

Sediment Control Basin

Sediment control basins can be used to control and trap pollutants, mainly by storing sediment produced by agricultural or urban activities, or serve as flow detention facility for fields with irregular topography. Sediment traps are much smaller than a retention or detention basin and can reduce runoff and sediment, prevent gullies, controls erosion on hilly uniform land, and improves the farm-ability of irregular cropland. A sediment control basin is constructed by excavation or by placing an earthen embankment across a low area or drainage swale. They may include a riser and pipe outlet with a small spillway. The Minnesota BMP Guidebook records sediment reduction between 60 to 90% (a mean value of 75% was used), phosphorus at 34 to 73% (a mean value of 53% was used), nitrogen reductions at 30%, and bacteria reductions at 70% (Miller et al. 2012).

Grassed Waterways

Grassed water ways are vegetated channels through fields that provide a means for concentrated flows to drain from a field without causing erosion. They can be installed on most fields but are especially effective in controlling gully erosion on steeper slopes. Grassed waterways are commonly used to convey runoff from terraces and diversions but are an important BMP when concentrated flows occur (Miller et al. 2012). For the purposes of this study, pollutant load reductions for grassed waterways are considered to be similar to streambank stabilization: 75% load reduction for sediment, phosphorous, and nitrogen (Tetra Tech 2011). *E. coli* reduction efficiency is conservatively estimated to be 50%. This is much lower than removals cited by the University of Minnesota Extension for a simulated study of bacteria removal in grass filter strips, which ranged from 75 to 92% for fecal coliforms and 68 to 74% for streptococci (Coyne et al., 1995).

UPLAND NON-STRUCTURAL PRACTICES

Non-structural practices are less expensive and easier to implement, but often require a change in landowners' operations in order to be successful. While there are a host of practices available to producers to address specific or multiple issues, there are core practices that have either been widely accepted or have a high potential to benefit water resources. The Other practices listed below would apply to stream restoration projects. Common practices are shown in **Table D-2** and further explanation of these practices are provided.

Crop to Grass Conversion

Crop to grass conversion is a highly effective practice to avoid pollutants from entering water bodies. Significant environmental gains can be achieved by converting row crop back into grass including: decreased soil erosion, reductions in pollutant loading, reduced greenhouse gas emissions, reduced fertilizer usage, wildlife habitat, and many others. Since 2009, commodity prices have dropped significantly and many producers are again considering a non-row crop option such as the Conservation Reserve Program (CRP). Since 2009, over 160,000 acres have been converted into

Table D-2. Upland Non-Structural Practices and Pollutants Addressed

Practice	Practice Mode of Action			Pollutants Addressed			
	Avoid	Control	Trap	*E. coli*	Atrazine	Sediment	Nutrients
Cropland							
Crop to grass/CRP	X				X	X	X
Cover crop	X	X		X		X	X
Irrigation management	X	X				X	X
No-till farming		X	X			X	X
Nutrient management	X	X					X
Soil sampling*	X						X
Terraces**		X	X			X	X
Diversions		X	X			X	X
Contour farming*		X	X			X	X
Livestock							
Manure and Land Application Management**	X	X		X			X
Reduced nutrients in feed*	X						X
Pasture management/ Prescribed grazing	X	X		X		X	X
On-site waste water management system*	X	X	X	X		X	X
On-site runoff management*		X	X	X		X	X
Livestock Exclusion**	X			X		X	X
Other							
Riparian buffer**		X	X	X	X	X	X
Saturated buffers		X	X	X	X	X	X
Soil Health Management	X			X		X	X

*Source: ACT criteria not reported in Nebraska State Nonpoint Source Management Plan

** Used for determinations of load reductions in this Plan. Other practices are potential for implementation and load reductions would be considered at the time of implementation.

row crop from either grasslands or pasture in the Study Area. This conversion was driven mainly by a desire to increase crop production during a time when agricultural markets were very strong. Commodity prices can drive the attractiveness of CRP contracts.

Cover Crops

Cover crops are an important tool for promoting healthy soils and trapping pollutants. They are designed to naturally absorb excess nutrients after crop harvest and to prevent erosion when the field would otherwise be fallow, therefore improving water quality be reducing nutrients and sediment in agricultural runoff. Cover crops are typically planted in the late-fall and increase infiltration of rainfall and snowmelt. A cover crop is not typically harvested, but is grown to benefit the topsoil and or other crops. If the length of the growing season permits, however, it can be harvested prior to planting a summer crop. Crops such as turnips, radishes, and collards are the most common cover crop in NE. Other cover crops include cereal rye, oats, sweet clover, winter barley, and winter wheat are planted to temporarily protect the soil from wind and water erosion during times when cropland is not adequately protected. Cover crops also increase the organic matter and improve soil health, and are also referred to as green manure. STEPL reports pollutant reduction of 70% for sediment. According to the Pennsylvania Department of Environmental Protection (PA DEP), cereal cover crops provide between 30 and 45% load reduction for nitrogen (2006). PA DEP also reports phosphorous efficiencies at 15% for early-application and 7% for late-application when conventional-till methods are used. When conservation-till methods are used, PA DEP reports efficiencies of 0% phosphorous efficiency for both early and late-applications. The USEPA (2014) reported that combined soil conservation practices that included cover crops reduced *E. coli* runoff concentrations up to 46%.

Irrigation Management

Irrigation management techniques can prevent excessive runoff of pollutants by avoiding the over application of irrigation water. Irrigation scheduling is a practice that can reduce total water use and results in less nitrogen leaching from the root zone. Funding assistance through the P-MRNRD for data loggers, evapotranspiration gauges, watermark sensors, and irrigation water flow meters represent valuable tools for optimal irrigation strategies.

Pivot irrigation is considered more efficient than furrow irrigation and can reduce leaching of nitrates by applying water in a more timely manner. Replacing furrow irrigation with a pivot irrigation system decreases water consumption and reduces infiltration of nutrients to groundwater.

Application of fertilizer through a pivot, referred to as both chemigation and fertigation, can help ensure that nitrogen is utilized by the plant. This practice encourages the use chemigation for a portion of their crop's fertilizer needs, thus reducing pre-plant applications that are more prone to runoff or infiltration to groundwater.

Variable Rate Irrigation (VRI) is a newer technology designed to control irrigation water application depths and rates. VRI takes into account soil types, topography, fertility levels, soil texture and quality, and past yields. VRI has multiple benefits, including reduced pumping costs, water conservation, and reduced infiltration, thus limiting nitrogen leaching.

No-Till Farming

No-till farming can reduce soil erosion by 90 to 95% compared to conventional tillage practices, and continuous no-till can make the soil more resistant to erosion over time. Phosphorus naturally binds to sediment, therefore, a reduction in sediment loading equates to a reduction in phosphorus loading. In fact, Baker and Laflen (1983) documented a 97% reduction in sediment loss in a no-till system as compared with conventional tillage practices. Fawcett et al. (1994) summarized natural rainfall studies covering more than 32 site-years of data and found that, on average, no-till resulted in 70% less herbicide runoff, 93% less erosion and 69% less water runoff than moldboard plowing, in which the soil is completely inverted. STEPL lists reduction of 75% for sediment, 45% for phosphorous, and 55% for nitrogen (Tetra Tech 2011).

Nutrient Management

Nutrient management is an avoiding practice for the management of the amount, method, and timing of application of fertilizer, manure, and other soil amendments. This practice is one of the most effective ways to improve water quality. Nutrient loss can be reduced by implementing general nutrient application guidelines that have been developed for voluntary or regulatory use (Miller et al. 2012). The Pennsylvania

Department of Environmental Protection (2006) indicates an 18% reduction in nitrogen and a 22% reduction of phosphorous. A compilation of guidelines recommended in Nebraska and surrounding states can be used to direct voluntary efforts. General fertilizer application guidelines can include:

- Apply nutrients during the spring to avoid fall and winter runoff
- Apply nutrients in split applications
- Always apply nutrients at agronomic rates
- Maintain soil phosphorus concentrations at peak production levels
- Do not apply nutrients directly to surface water
- Do not apply nutrients to saturated ground
- Do not apply nutrients to ground that is frequently flooded or when flooding is expected
- Do not apply nutrients to frozen or snow covered soils

Split nitrogen applications consist of applying nitrogen in two batches at two different times rather than one. This is a common practice when total fertilizer recommendations exceed 100 lbs. Side dressing or chemigation is common for the final application.

Nitrogen inhibitors are chemicals that reduce the rate at which ammonium is converted to nitrate by killing or interfering with the metabolism of Nitrosomonas bacteria. The loss of nitrogen from the root zone can be minimized by maintaining applied nitrogen in the ammonium form during periods of excess rainfall prior to rapid nitrogen uptake by crops. Data has shown that fields with only spring application of fertilizer show less nitrogen below the root zone. This is due to the differences in application timing, leaching rates, and crop utilization rates.

Record keeping is a non-structural BMP where producers that keep track of agronomic applications to ensure good crop production and protect water from leaching or runoff. Typical records include field based information such as residual soil nitrogen, nitrates in irrigation water, applied fertilizers, water applied, yield goals, and actual goals. Producers who more closely manage nitrogen applications typically apply less than those who do not.

Soil Sampling

Soil testing can be considered the basis for all nutrient management plans and should be practiced regularly by all producers. By following recommendations of an agronomist, fertilizer is applied at an agronomic rate based upon what exists in the soil, so the total quantity of fertilizer needed can be reduced in most cases, leading to improvement in groundwater and surface water quality. As commodity prices drop, managing input costs becomes an increasing concern to producers, making nutrient management even more important.

Soil sampling is a practice that may save a producer a considerable amount of money by reducing fertilizer inputs, yet maintaining a strong yield, without economic incentives to encourage implementation.

Terraces

Terraces are a controlling practice that consist of an earthen embankment, channel, or a combined ridge and channel built across the slope of the field and are generally used in moderate to steep sloping land. Terraces intercept and store surface runoff, trapping sediments and pollutants. In some types of terraces, underground drainage outlets are used to collect soluble nutrient and pesticide leachates, reducing the risk of movement of pollutants into the groundwater, and improving field drainage. However, the waterbody receiving runoff directly via tile drains can be impacted by high pesticide and dissolved nutrient concentrations. They may reduce the sediment load and content of associated pollutants in surface water runoff. STEPL lists pollutant reductions as 85% for sediment, 70% for phosphorus, and 20% for nitrogen (Tetra Tech 2011). *E. coli* load reductions are estimated at 25%. One method of incorporating terraces that is used by the Lower Platte NRD with success is called "Lands for Conservation Practice". Under this method, landowners are provided a payment for setting aside land for constructing conservation practices such as terraces during the summer months (June, July & August).

Diversions

A diversion is very similar to a terrace, but its purpose is to direct or divert surface water runoff away from an area, or to collect and direct water to a pond. Filter strips should be installed above the diversion channel to trap sediment and protect the diversion. Similarly, vegetative cover should be maintained in the diversion ridge. Any associated outlets should be kept clear of debris. STEPL reports pollutant reduction using diversions at 35% for sediment, 30% for phosphorus, and 10% for nitrogen (Tetra Tech 2011).

Contour Farming

Contour farming includes tillage, planting, and other farming operations performed with the rows on or along the contour of the field slope. It helps to reduce sheet and rill erosion and the resulting transport of sediment and other waterborne contaminants (Tetra Tech 2011). STEPL reports pollutant reductions for contour farming at 41% for sediment, 55% for phosphorous, and 49% for nitrogen.

Manure and Land Application Management

Land application of animal manure helps to recycle nutrients in the soil and adds organic matter to improve soil structure, tilth, and water holding capacity. One major concern about this practice is that unintended runoff to surface water and buildup of phosphorus in soils results in nutrient delivery to downstream water resources. Manure management includes methods such as applying manure at agronomic rates, using methods that limit runoff (such as knifing) and applying manure outside of priority area sub-watersheds. Using STEPL, pollutant load reductions can be estimated by reducing the number of months manure applied to fields by 1/3. This resulted in reductions of 5% for phosphorous, 6% for nitrogen, and 33% for *E. coli* (Tetra Tech 2011).

Reduced Nutrients in Feed

Geographic areas with intense livestock production often import more nutrients in the form of feed than is exported in livestock or crop products. When manure is applied intensely to these areas over long periods of time, phosphorus tends to increase in the soils unless the manure is exported. Phosphorus inputs not only include the natural content of feed, but mineral supplements. Careful balancing of livestock rations may allow reductions in added phosphorus, thereby reducing the phosphorus content of manure. Studies have estimated that balancing supplemental phosphorus to dietary intake requirements could reduce phosphorus use by 15% (Fawcett 2009). Providing education to producers to promote feed ration optimization as a means to improve profits is a key component to this practice.

Pasture Management – Prescribed Grazing

Rotational grazing, also called prescribed or managed grazing, is a management-intensive system of raising livestock on subdivided pastures called paddocks. Livestock are regularly rotated to fresh paddocks at the right time to prevent overgrazing and optimize grass growth (Miller et al. 2012). The research portion of the economic, environmental and social analysis by the Land Stewardship Project documented significant water quality benefits when a managed year-round cover scenario (including rotational grazing) is used on working farms to replace intensive row cropping. A scenario identified expected water quality improvements of a 49% reduction in sediment, a 75% reduction in phosphorus, and a 62% reduction in nitrogen (Miller et al. 2012).

On-site Waste Water Management

Animal waste management systems comprise a variety of best management practices (BMPs) or combination of BMPs used at concentrated animal feeding operations (CAFOs) and farms to manage animal waste and related animal byproducts. These systems include engineered facilities and management practices for the efficient collection, proper storage, necessary treatment, transportation, and distribution of waste. The BMPs are designed to reduce the discharge of nitrogen, phosphorus, pathogens, organic matter, heavy metals (such as zinc, copper, and occasionally arsenic, which are present in many animal rations), and odors. Example facilities and management methods are holding ponds, waste treatment ponds, composting, and manure management and land application (Tetra Tech 2011). The Pennsylvania Department of Environmental Protection (2006) cites that waste management systems on feedlots can reduce phosphorous 75% and can reduce nitrogen by 75%. *E. coli* reduction is assumed to be similar to other pollutant reductions, also at 75%.

On-site Runoff Management System

A runoff management system controls excess runoff caused by construction operations at development sites, changes in land use, or other land disturbances like feedlot operations (Tetra Tech 2011). In 2011, the Minnesota Department of Agriculture (Miller et al. 2012) reported that runoff management systems can reduce sediment and phosphorous by 75%. Nitrogen reduction was estimated at 65% and *E. coli* reduction was 50%.

Livestock Exclusion

Livestock producers who restrict or eliminate access to streams and/or farm ponds and convert to an alternative water source can expect increased productivity and improvements in riparian vegetation and in-stream water quality (Zeckoski et al. 2007). Key practice components include providing off-stream watering, livestock comfort, streamside fencing, stream crossings, and buffer strips. Not only does it decrease disturbance, this practice also reduces sediments being stirred up and eliminates livestock from defecating directly in the stream which helps with nutrients and bacteria. Pollutant reduction by livestock exclusion are: 86% for sediment, 65% for phosphorus, 27% for nitrogen, and 70% for *E. coli*.

Riparian Buffer

Riparian buffers, vegetated buffers or filter strips, are planted between fields and surface waters to reduce sediment, organics, nutrients, pesticides pathogens, and other contaminants in runoff. The use of vegetated buffers along streams, and vegetated filter strips in uplands, can provide significant reductions of pollutants to water bodies by reducing sediment to waterways, which equates to less sediment bound phosphorus being discharged to water bodies. Nitrogen and dissolved contaminant reductions are more associated more with infiltration in the buffer. Pollutant removal rates largely depend on buffer width, vegetative make up, and pollutant type. A study for Stevens Creek near Lincoln, NE found that the baseline buffer width recommended for both water quality maintenance and basic habitat is 50 ft (15 m) per side. This number may be modified based on other factors such as slope, soil particle size, adjacent land use, the presence of certain wildlife communities, stream size, and stream order (Bray 2010). Pollutant load reduction estimates noted in the Agriculture BMP Handbook for Minnesota list reductions as: 86% for sediment, 65% for phosphorus, 27% for nitrogen, and 58% for atrazine (MDA 2012). *E. coli* reductions considered to be 70% based on the findings of Koelsch et al. (2006) and Wagner (2010).

Saturated Buffer

Nutrient loss through subsurface drainage systems is a major concern throughout the Midwest. By hydrologically reconnecting a subsurface drainage outlet with an edge-of-field buffer this practice takes advantage of both the denitrification and plant nutrient uptake opportunities that are known to exist in buffers with perennial vegetation as a way to remove nutrients from the drainage water. Nitrate reduction have been proven at 60 to 95%, while studies have shown that there were no consistent trends that indicated that dissolved phosphorus in the tile water was removed by the saturated buffers (Utt 2015).

Soil Health Management

Management of soil health has generated increased interest in recent years. Improvements to soil health can include increasing organic matter and increasing microbial activity. This results in increase water retention and improves nutrient cycling, which reduces the need for chemical fertilizer application, increases drought resiliency, etc., and ultimately reduces runoff and the associated pollutant loads. Chapter 8, Section 8.2 introduces the Nation Corn Growers – Soil Health Partnership that is working to establish demonstration farms to improve soil health. This would be a highly beneficial to bring into the Study Area.

URBAN CONSERVATION PRACTICES

Many communities promote urban conservation practices to protect water quality and reduce runoff. Like agricultural practices, urban practices require a program to build awareness and promote behavioral change that will result in improvement and protection of water resources. In many cases, urban conservation practices can be utilized in public places (e.g., parks, public facilities, private lots, street right of ways, etc.) and serve as demonstration sites. **Table D-3** displays several conservation practices commonly used within municipalities.

Bioswales

Bioswales control and trap pollutants using deep rooted native vegetated drainage courses designed to increase infiltration and strip sediment and other pollutants from storm runoff. They are often installed as an alternative to underground storm sewers and are located within urban drainage ways. The bioswale is engineered so that runoff from frequent, small rains infiltrate into the soil below. When larger storms occur, bioswales slow the flow of runoff while using above ground vegetation to filter and clean the runoff before it ends up in a lake or stream. Bioswales can be a cost effective, low-maintenance replacement for low flow concrete liners in need of expensive repairs. Reduction estimates are 81% for sediment, 34% for phosphorus, and 84% for nitrogen (Winer 2000).

Urban Soil Quality Restoration

Healthy soil is the key to preventing polluted runoff and can avoid, control, and trap pollutants. As buildings and houses are built, top soil is removed and the remaining sub-soil is compacted by grading and construction activity. The owner is left with heavily compacted subsoil, usually with high clay content and little organic matter. Soil quality restoration is simple—start by reducing soil compaction and increasing organic matter content with the addition of compost. Soil quality restoration can be completed on any existing yard, making this one of the easiest and least expensive water quality conservation practices to implement. Reduction estimates for this practice were not widely reported.

Table D-3. Urban Practices and Pollutants Addressed

Practice	Practice Mode of Action			Pollutants Addressed			
	Avoid	Control	Trap	*E. coli*	Atrazine	Sediment	Nutrients
Urban							
Bioswales		X	X	X		X	X
Urban soil quality restoration	X	X	X			X	X
Rain garden/bioretention **		X	X	X	X	X	X
Bioinfiltration systems**		X	X	X		X	X
Rain water harvesting	X	X		X		X	X
Native landscaping	X				X	X	X
No/low–Phosphorus Fertilizer*	X						X
Pet Waste Management	X			X			
Low impact development	X				X	X	X
Green roofs*		X	X				X
Soil Health Management	X			X		X	X

*Source: ACT criteria not reported in Nebraska State Nonpoint Source Management Plan

** Used for determinations of load reductions for this Plan. Other practices are potential for implementation and load reductions would be considered at the time of implementation.

Rain Gardens

Small-scale bioretention features, often referred to as *rain gardens*, are a structural conservation practice commonly used for stormwater quality improvement and reduction of stormwater runoff in urban areas. Rain gardens reduce runoff and allow stormwater to soak into the ground as opposed to flow into storm drains and surface waters which causes erosion, water pollution, flooding, and diminishes groundwater quality. When properly designed for specific soil types and climate, and well maintained, they can offer highly efficient reduction of phosphorus, as well as other pollutants, and are highly aesthetic. Pollutant reduction estimates for rain gardens vary and in some cases nutrient loads may increase. STEPL reports pollutant reduction using rain gardens at 81% for phosphorus, and 43% for nitrogen. *E. coli* reduction is estimated at 70% based on median concentration influent/effluent values reported in the International Stormwater BMP Database 2012 Pollutant Category Summary Addendum (Wright Water Engineers and Geosyntec 2012).

Bioinfiltration Systems

Bioinfiltration systems are shallow, landscaped depressions used to promote absorption and infiltration of stormwater runoff. This management practice is effective at removing pollutants and reducing the volume of runoff. Stormwater ponds in the depression and infiltrates into the soil bed. The filtered runoff infiltrates into surrounding soils through an absorption basin or trenches. These systems are typically designed to treat runoff from relatively small storms (1–2 yr events). STEPL reports pollutant reduction using bioinfiltration at 90% for sediment, 65% for phosphorus, and 50% for nitrogen. Bioinfiltration features reduced *E. coli* 20 to 95% according to median concentration influent/effluent values provided in the International Stormwater BMP Database 2012 Pollutant Category Summary Addendum (Wright Water Engineers and Geosyntec 2012). For this study, *E. coli* reduction efficiency for bioinfiltration systems is assumed at the mean performance, 58%.

Rain Water Harvesting

Rain barrels are a very simple method for collecting roof runoff for beneficial uses such as irrigation of landscaping and gardens. Residential rain barrels typically hold 55 gallons and are connected to a downspout with a faucet and overflow pipe. Rain water is naturally soft, oxygenated, and free of chemicals used to treat most sources of publicly supplied water.

Native Landscaping

Native vegetation enhances a landscape's ability to manage stormwater, and also requires less water to survive by encouraging the growth of plants native to the surrounding area. The goal of low impact landscaping is to use techniques that infiltrate, store, evaporate, and detain runoff close to its source. A diversified habitat with native vegetation encourages use by birds, butterflies, and other wildlife. In most cases, native vegetation doesn't require fertilizer or pesticides for survival. Native landscaping and turf can replace bluegrass and other non-native water sensitive species commonly used in communities.

No/Low-Phosphorus Fertilizers

Nutrients are essential for plant growth, especially nitrogen, phosphorus, and potassium. Fertilizers, pesticides, and animal waste commonly include phosphorus. Excessive phosphorus loading is a leading contributor to algae growth, which lowers water quality and causes several issues in community lakes. No-phosphorus fertilizers (i.e. 30–0–3) are recommended to be used on established lawns, as most soils in Nebraska contain enough natural phosphorus to support a healthy lawn. Similar to Nutrient Management, reductions with this practice are 18% reduction in nitrogen and a 22% reduction of phosphorous.

Pet Waste Management

Pet waste, like livestock manure, contain nutrients and bacteria that can contribute pollution in runoff. Immediate removal and proper disposal of pet waste can help reduce pollutants and bacteria from reaching surface and ground waters. Pollutant load reductions can be estimated by using similar values to the manure management practices previously identified for manure management and land application management. Low Impact Development

Numerous projects in Nebraska have focused on introducing urban stormwater management practices to citizens, community leaders and practitioners in the construction and land maintenance industries. Larger communities have relaxed mandatory curb and gutter standards to allow alternative street designs. Curb cuts draining runoff to rain gardens or bioswales and low-maintenance landscapes are now being encouraged in streetscape designs. Architects and engineers are gaining more experience with roof gardens, low input landscaping and green space as design options for public and private buildings. Permeable pavement is accepted as a common design option for low traffic areas such as parking spaces, trails and walkways. Low/no-phosphate fertilizer is now available through most garden centers and lawn maintenance companies. Landscape designers now promote rain barrels, rain gardens and native plants requiring less water and nutrients. Installation and evaluation of demonstration sites and extensive communication and training for private citizens, community leaders and industry professionals was instrumental in gaining acceptance and creating a market for low impact development practices in Nebraska.

Green Roofs

Green roofs or vegetated roof covers are a thin layer of growing plants on top of a roof. These systems store water in engineered soil, where water is taken up by the plant and transpired into the atmosphere. This results in a decrease in stormwater runoff from the roof and associated pollutants.

Soil Health Management

Soil health management in urban areas is an effort to reduce soil compaction and increase organic matter content with the addition of compost. Lawns with good soil quality reduce the need for watering, and minimize the need for fertilizers and pesticides. Yards with poor, compacted soil contribute to water quality problems due to their inability to infiltrate and absorb water, which increases runoff and the associated pollutant loads.

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Table E-1. Summary of *E. coli* BMP Load Reductions and Costs within Priority 1 Watersheds

Watershed	Existing Load	E. Coli Load Reduction/year	E. coli Reduced Load	E. coli Load Reduction Required to Meet WQS	Percent Effective	Cost
Eightmile Creek	3.05E+16	1.82E+16	1.23E+16	5.50E+15	60%	$23,380,828
Headwaters of Skull Creek	2.91E+16	2.41E+16	5.01E+15	5.24E+15	83%	$33,439,468
Headwaters of Bone Creek	2.84E+16	2.42E+16	4.15E+15	5.11E+15	85%	$35,026,431
Turkey Creek – Platte River	2.76E+16	1.43E+16	1.33E+16	4.98E+15	52%	$18,203,951
Buffalo Creek	2.54E+16	1.60E+16	9.38E+15	4.57E+15	63%	$20,556,180
Zwiebel Creek – Platte River	2.13E+16	1.46E+16	6.77E+15	3.84E+15	68%	$19,447,722
Turtle Creek	1.07E+17	9.15E+16	1.52E+16	1.92E+16	86%	$12,995,171
Priority 1 Watershed Composite	2.69E+17	2.03E+17	6.62E+16	2.21E+17	75%	-

Table E-2. Eightmile Creek *E. coli* Load Reductions

		Pasture[1]	Cropland	Urban	Other[2]	Total
BMP		3,252 acres	17,860 acres	355 acres	2,132 acres	23,599 acres
Constructed Wetland	Treatment Area (acres)[3]	162.6	893	-	-	-
	Treatment Area	5%	5%			
	Reduction Efficiency	70%	70%			
Wet Detention Basin	Treatment Area (acres)[3]	162.6	893	-	-	-
	Treatment Area	5%	5%			
	Reduction Efficiency	70%	70%			
Dry Detention Basin/Terraces	Treatment Area (acres)[3]	-	1786	-	-	-
	Treatment Area		10%			
	Reduction Efficiency		25%			
Sediment Control Basin	Treatment Area (acres)[3]	813	4,465	-	-	-
	Treatment Area	25%	25%			
	Reduction Efficiency	70%	70%			
Grassed Waterways/Cover Crop	Treatment Area (acres)[3]	-	4,465	-	-	-
	Treatment Area		25%			
	Reduction Efficiency		50%			
Manure Application Management	Treatment Area (acres)[3]	-	17,860	-	-	-
	Treatment Area		100%			
	Reduction Efficiency		33%			
Livestock Exclusion	Treatment Area (acres)[3]	-	-	-	-	-
	Treatment Area					
	Reduction Efficiency					

Table E-2. Eightmile Creek *E. coli* Load Reductions (continued)

		Pasture[1]	Cropland	Urban	Other[2]	Total
Riparian Buffer	Treatment Area (acres)[3]	-	13,395	-	-	-
	Treatment Area		75%			
	Reduction Efficiency		70%			
Bioswales	Treatment Area (acres)[3]	-	-	17.8	-	-
	Treatment Area			5%		
	Reduction Efficiency			70%		
Rain Garden	Treatment Area (acres)[3]	-	-	35.5	-	-
	Treatment Area			10%		
	Reduction Efficiency			70%		
Bioinfiltration	Treatment Area (acres)[3]	-	-	35.5	-	-
	Treatment Area			10%		
	Reduction Efficiency			58%		
Totals						
	Current *E. coli* Load, col/year	6.56E+15	2.06E+16	3.37E+15	-	3.05E+16
	Effective Reduction[5]	0.23	0.79	0.15		-
	E. coli Reduction/year	1.52E+15	1.62E+16	5.21E+14		1.82E+16
	E. coli Reduced Load , col/year	5.04E+15	4.41E+15	2.85E+15		1.23E+16
	E. coli Load Reduction Required to Meet WQS	1.18E+15	3.71E+15	6.07E+14		5.50E+15

[1]Pasture land includes CRP land. The land use data was taken with visual imagery and grass CRP was classified with pasture land.

[2]Other land use includes barren, open water, riparian forest and woodlands, road, and wetlands.

[3]Treatment Area acres is assumed to be the area that needs to be treated. This is not the number of acres that each specific BMP needs to be on but rather the number of acres that needs to be treated by the BMP. This could be done by many small treatments scattered or one large treatment.

[4]Bioswales were assumed to have the same effectiveness as wet detention basins and constructed wetlands

[5]Using an effective reduction calculation allows multiple BMP methods to be used without double counting reductions.

Table E-3. Eightmile Creek BMP Cost

BMP		Land Use					Unit	Cost/Unit	Quantity	Cost
		Pasture	Cropland	Urban	Other[1]	Total				
Acres		3,252	17,860	355	2,132	23,599				
Constructed Wetland[2]	Treatment Area (acres)[3]	163	893	-	-	-	each	$260,000	6	$1,668,425
	Treatment Area	5%	5%							
Wet Detention Basin	Treatment Area (acres)[3]	163	893	-	-	-	each	$1,560,000	6	$10,010,553
	Treatment Area	5%	5%							
Dry Detention Basin/Terraces[4]	Treatment Area (acres)[3]	-	1,786	-	-	-	feet	$20	368,363	$7,367,250
	Treatment Area		10%							
Sediment Control Basin	Treatment Area (acres)[3]	813	4,465	-	-	-	each	$65,000	32	$2,085,532
	Treatment Area	25%	25%							
Grassed Waterways/Cover Crop	Treatment Area (acres)[3]	-	4,465	-	-	-	acres	$90	4,465	$401,850
	Treatment Area		25%							
Manure Application Management	Treatment Area (acres)[3]	-	17,860	-	-	-	acres	$50	17,860	$893,000
	Treatment Area		100%							
Livestock Exclusion	Treatment Area (acres)[3]	-	-	-	-	-	-	-	-	-
	Treatment Area									
Riparian Buffer[5]	Treatment Area (acres)[3]	-	807	-	-	-	acres	$1,000	807	$807,099
	Treatment Area		75%							

Table E-3. Eightmile Creek BMP Cost (continued)

BMP		Land Use					Unit	Cost/Unit	Quantity	Cost
		Pasture	Cropland	Urban	Other[1]	Total				
Acres		3,252	17,860	355	2,132	23,599				
Bioswales[6]	Treatment Area (acres)[3]	-	-	17.75	-	-	each	$2,000	5	$10,000
	Treatment Area			5%						
Rain Garden	Treatment Area (acres)[3]	-	-	35.5	-	-	each	$600	66	$39,618
	Treatment Area			10%						
Bioinfiltration	Treatment Area (acres)[3]	-	-	35.5	-	-	each	$19,500	5	$97,500
	Treatment Area			10%						
									Total Cost	$23,380,828

[1]Other land use includes barren, open water, riparian forest and woodlands, road, and wetlands.

[2]Constructed wetland costs include the cost of design and permitting.

[3]Treatment Area acres is assumed to be the area that needs to be treated. This is not the number of acres that each specific BMP needs to be on but rather the number of acres that needs to be treated by the BMP. This could be done by many small treatments scattered or one large treatment.

[4]Terrace Calculation: ((Feet in a mile/Average Terrace width (200))*Length of terrace in a mile (5000))*(Land use acreage/acres in a square mile (640))

[5]Treatment area for riparian buffers was calculated based on the total amount of NHD lines within a watershed. The numbers were not tailored to match the amount of each NHD within a specific land use.

[6]Bioswale costs were not provided. An average was chosen based on cost estimates from the American Society of Landscape Architects. Assumed to be a 200m2 bioswale.

Table E-4. Headwaters of Skull Creek *E. coli* Load Reductions

		Pasture[1]	Cropland	Urban	Other[2]	Total
BMP		5,318 acres	16,348 acres	0 acres	944 acres	22,610 acres
Constructed Wetland	Treatment Area (acres)[3]	265.9	817.4	-	-	-
	Treatment Area	5%	5%			
	Reduction Efficiency	70%	70%			
Wet Detention Basin	Treatment Area (acres)[3]	265.9	817.4	-	-	-
	Treatment Area	5%	5%			
	Reduction Efficiency	70%	70%			
Dry Detention Basin/Terraces	Treatment Area (acres)[3]	-	1,634.8	-	-	-
	Treatment Area		10%			
	Reduction Efficiency		25%			
Sediment Control Basin	Treatment Area (acres)[3]	1,329.5	4,087	-	-	-
	Treatment Area	25%	25%			
	Reduction Efficiency	70%	70%			
Grassed Waterways/Cover Crop	Treatment Area (acres)[3]	1,329.5	4,087	-	-	-
	Treatment Area	25%	25%			
	Reduction Efficiency	50%	50%			
Manure Application Management	Treatment Area (acres)[3]	-	16,348	-	-	-
	Treatment Area		100%			
	Reduction Efficiency		33%			
Livestock Exclusion	Treatment Area (acres)[3]	5,318	-	-	-	-
	Treatment Area	100%				
	Reduction Efficiency	70%				

Table E-4. Headweaters of Skull Creek *E. coli* Load Reductions (continued)

		Pasture[1]	Cropland	Urban	Other[2]	Total
Livestock Exclusion	Treatment Area (acres)[3]	5,318	-	-	-	-
	Treatment Area	100%				
	Reduction Efficiency	70%				
Riparian Buffer	Treatment Area (acres)[3]	3,988.5	12,261	-	-	-
	Treatment Area	75%	75%			
	Reduction Efficiency	70%	70%			
Bioswales	Treatment Area (acres)[3]	-	-	-	-	-
	Treatment Area					
	Reduction Efficiency					
Rain Garden	Treatment Area (acres)[3]	-	-	-	-	-
	Treatment Area					
	Reduction Efficiency					
Bioinfiltration	Treatment Area (acres)[3]	-	-	-	-	-
	Treatment Area					
	Reduction Efficiency					
Totals						
	Current *E. coli* Load, col/year	1.03E+16	1.03E+16	-	-	2.91E+16
	Effective Reduction[5]	0.90	0.90			-
	E. coli Reduction/year	9.31E+15	9.31E+15			2.41E+16
	E. coli Reduced Load , col/year	9.87E+14	9.87E+14			5.01E+15
	E. coli Load Reduction Required to Meet WQS	4.93E+15	4.93E+15			2.50434E+16

[1]Pasture land includes CRP land. The land use data was taken with visual imagery and grass CRP was classified with pasture land.

[2]Other land use includes barren, open water, riparian forest and woodlands, road, and wetlands.

[3]Treatment Area acres is assumed to be the area that needs to be treated. This is not the number of acres that each specific BMP needs to be on but rather the number of acres that needs to be treated by the BMP. This could be done by many small treatments scattered or one large treatment.

[4]Bioswales were assumed to have the same effectiveness as wet detention basins and constructed wetlands

[5]Using an effective reduction calculation allows multiple BMP methods to be used without double counting reductions.

Table E-5. Headwaters Skull Creek BMP Cost

BMP		Land Use					Unit	Cost/Unit	Quantity	Cost
		Pasture	Cropland	Urban	Other[1]	Total				
Acres		5,318	16,348	0	944	22,610				
Constructed Wetland[2]	Treatment Area (acres)[3]	265.9	817.4	-	-	-	each	$260,000	7	$1,712,206
	Treatment Area	5%	5%							
Wet Detention Basin	Treatment Area (acres)[3]	265.9	817.4	-	-	-	each	$1,560,000	7	$10,273,240
	Treatment Area	5%	5%							
Dry Detention Basin/Terraces[4]	Treatment Area (acres)[3]	-	1634.8	-	-	-	feet	$20	337,178	$6,743,550
	Treatment Area		10%							
Sediment Control Basin	Treatment Area (acres)[3]	1,329.5	4,087	-	-	-	each	$65,000	33	$2,140,258
	Treatment Area	25%	25%							
Grassed Waterways/Cover Crop	Treatment Area (acres)[3]	-	4,465	-	-	-	acres	$90	4,087	$367,830
	Treatment Area		25%							
Manure Application Management	Treatment Area (acres)[3]	-	16,348	-	-	-	acres	$50	16,348	$817,400
	Treatment Area		100%							
Livestock Exclusion	Treatment Area (acres)[3]	5,318	-	-	-	-	each	$2,000	5,318	$10,636,000
	Treatment Area	100%								

Table E-5. Headwaters Skull Creek BMP Cost (continued)

BMP		Land Use					Unit	Cost/Unit	Quantity	Cost
		Pasture	Cropland	Urban	Other[1]	Total				
Acres		5,318	16,348	0	944	22,610				
Riparian Buffer[5]	Treatment Area (acres)[3]	-	749	-	-	-	acres	$1,000	749	$748,983
	Treatment Area		75%							
Bioswales[6]	Treatment Area (acres)[3]	-	-	-	-	-	each	$2,000	-	-
	Treatment Area									
Rain Garden	Treatment Area (acres)[3]	-	-	-	-	-	each	$600	-	-
	Treatment Area									
Bioinfiltration	Treatment Area (acres)[3]	-	-	-	-	-	each	$19,500	-	-
	Treatment Area									
								Total Cost		$33,439,468

[1]Other land use includes barren, open water, riparian forest and woodlands, road, and wetlands.

[2]Constructed wetland costs include the cost of design and permitting.

[3]Treatment Area acres is assumed to be the area that needs to be treated. This is not the number of acres that each specific BMP needs to be on but rather the number of acres that needs to be treated by the BMP. This could be done by many small treatments scattered or one large treatment.

[4]Terrace Calculation: ((Feet in a mile/Average Terrace width (200))*Length of terrace in a mile (5000))*(Land use acreage/acres in a square mile (640))

[5]Treatment area for riparian buffers was calculated based on the total amount of NHD lines within a watershed. The numbers were not tailored to match the amount of each NHD within a specific land use.

[6]Bioswale costs were not provided. An average was chosen based on cost estimates from the American Society of Landscape Architects. Assumed to be a 200m2 bioswale.

Table E-6. Headwaters of Bone Creek *E. coli* Load Reductions

		Pasture[1]	Cropland	Urban	Other[2]	Total
BMP		8,394 acres	10,499 acres	0 acres	1,921 acres	20,814 acres
Constructed Wetland	Treatment Area (acres)[3]	419.7	524.9	-	-	-
	Treatment Area	5%	5%			
	Reduction Efficiency	70%	70%			
Wet Detention Basin	Treatment Area (acres)[3]	419.7	524.5	-	-	-
	Treatment Area	5%	5%			
	Reduction Efficiency	70%	70%			
Dry Detention Basin/Terraces	Treatment Area (acres)[3]	-	1,049.9	-	-	-
	Treatment Area		10%			
	Reduction Efficiency		25%			
Sediment Control Basin	Treatment Area (acres)[3]	2,098.5	2,624.8	-	-	-
	Treatment Area	25%	25%			
	Reduction Efficiency	70%	70%			
Grassed Waterways/Cover Crop	Treatment Area (acres)[3]	2,098.5	2,624.8	-	-	-
	Treatment Area	25%	25%			
	Reduction Efficiency	50%	50%			
Manure Application Management	Treatment Area (acres)[3]	-	10,499	-	-	-
	Treatment Area		100%			
	Reduction Efficiency		33%			
Livestock Exclusion	Treatment Area (acres)[3]	8,394	-	-	-	-
	Treatment Area	100%				
	Reduction Efficiency	70%				

Table E-6. Headwaters of Bone Creek *E. coli* Load Reductions (continued)

		Pasture[1]	Cropland	Urban	Other[2]	Total
Riparian Buffer	Treatment Area (acres)[3]	6,295.5	7,874.3	-	-	-
	Treatment Area	75%	75%			
	Reduction Efficiency	70%	70%			
Bioswales	Treatment Area (acres)[3]	-	-	-	-	-
	Treatment Area					
	Reduction Efficiency					
Rain Garden	Treatment Area (acres)[3]	-	-	-	-	-
	Treatment Area					
	Reduction Efficiency					
Bioinfiltration	Treatment Area (acres)[3]	-	-	-	-	-
	Treatment Area					
	Reduction Efficiency					
Totals						
Current *E. coli* Load, col/year		1.63E+16	1.21E+16	-	-	2.84E+16
Effective Reduction[5]		0.90	0.79			-
E. coli Reduction/year		1.47E+16	9.51E+15			2.42E+16
E. coli Reduced Load , col/year		1.56E+15	2.59E+15			4.15E+15
E. coli Load Reduction Required to Meet WQS		2.93E+15	2.18E+15			5.11E+15

[1]Pasture land includes CRP land. The land use data was taken with visual imagery and grass CRP was classified with pasture land.

[2]Other land use includes barren, open water, riparian forest and woodlands, road, and wetlands.

[3]Treatment Area acres is assumed to be the area that needs to be treated. This is not the number of acres that each specific BMP needs to be on but rather the number of acres that needs to be treated by the BMP. This could be done by many small treatments scattered or one large treatment.

[4]Bioswales were assumed to have the same effectiveness as wet detention basins and constructed wetlands

[5]Using an effective reduction calculation allows multiple BMP methods to be used without double counting reductions.

Table E-7. Headwaters Bone Creek BMP Cost

BMP		Land Use					Unit	Cost/Unit	Quantity	Cost
		Pasture	Cropland	Urban	Other[1]	Total				
Acres		8,394	10,499	0	1,921	20,814				
Constructed Wetland[2]	Treatment Area (acres)[3]	419.7	524.9	-	-	-	each	$260,000	6	$1,493,064
	Treatment Area	5%	5%							
Wet Detention Basin	Treatment Area (acres)[3]	419.7	524.9	-	-	-	each	$1,560,000	6	$8,958,383
	Treatment Area	5%	5%							
Dry Detention Basin/Terraces[4]	Treatment Area (acres)[3]	-	1,050	-	-	-	feet	$20	216,542	$4,330,838
	Treatment Area		10%							
Sediment Control Basin	Treatment Area (acres)[3]	2,098.5	2,624.8	-	-	-	each	$65,000	29	$1,866,330
	Treatment Area	25%	25%							
Grassed Waterways/Cover Crop	Treatment Area (acres)[3]	-	2,625	-	-	-	acres	$90	2,625	$236,228
	Treatment Area		25%							
Manure Application Management	Treatment Area (acres)[3]	-	10,499	-	-	-	acres	$50	10,499	$524,950
	Treatment Area		100%							
Livestock Exclusion	Treatment Area (acres)[3]	8,394	-	-	-	-	each	$2,000	8,394	$16,788,000
	Treatment Area	100%								

Table E-7. Headwaters Bone Creek BMP Cost (continued)

BMP		Land Use					Unit	Cost/Unit	Quantity	Cost
		Pasture	Cropland	Urban	Other[1]	Total				
Acres		8,394	10,499	0	1,921	20,814				
Riparian Buffer[5]	Treatment Area (acres)[3]	-	829	-	-	-	acres	$1,000	829	$828,639
	Treatment Area		75%							
Bioswales[6]	Treatment Area (acres)[3]	-	-	-	-	-	each	$2,000	-	-
	Treatment Area									
Rain Garden	Treatment Area (acres)[3]	-	-	-	-	-	each	$600	-	-
	Treatment Area									
Bioinfiltration	Treatment Area (acres)[3]	-	-	-	-	-	each	$19,500	-	-
	Treatment Area									
								Total Cost		$35,026,431

[1]Other land use includes barren, open water, riparian forest and woodlands, road, and wetlands.

[2]Constructed wetland costs include the cost of design and permitting.

[3]Treatment Area acres is assumed to be the area that needs to be treated. This is not the number of acres that each specific BMP needs to be on but rather the number of acres that needs to be treated by the BMP. This could be done by many small treatments scattered or one large treatment.

[4]Terrace Calculation: ((Feet in a mile/Average Terrace width (200))*Length of terrace in a mile (5000))*(Land use acreage/acres in a square mile (640))

[5]Treatment area for riparian buffers was calculated based on the total amount of NHD lines within a watershed. The numbers were not tailored to match the amount of each NHD within a specific land use.

[6]Bioswale costs were not provided. An average was chosen based on cost estimates from the American Society of Landscape Architects. Assumed to be a 200m2 bioswale.

Table E-8. Turkey Creek – Platte River *E. coli* Load Reductions

		Pasture[1]	Cropland	Urban	Other[2]	Total
BMP		3,816	12,957	528	7298	24,599
Constructed Wetland	Treatment Area (acres)[3]	190.8	647.85	-	-	-
	Treatment Area	5%	5%			
	Reduction Efficiency	70%	70%			
Wet Detention Basin	Treatment Area (acres)[3]	190.8	647.85	-	-	-
	Treatment Area	5%	5%			
	Reduction Efficiency	70%	70%			
Dry Detention Basin/Terraces	Treatment Area (acres)[3]	-	1,295.7	-	-	-
	Treatment Area		10%			
	Reduction Efficiency		25%			
Sediment Control Basin	Treatment Area (acres)[3]	954	3,239.3	-	-	-
	Treatment Area	25%	25%			
	Reduction Efficiency	70%	70%			
Grassed Waterways/Cover Crop	Treatment Area (acres)[3]	-	3,239.3	-	-	-
	Treatment Area		25%			
	Reduction Efficiency		50%			
Manure Application Management	Treatment Area (acres)[3]	-	12,957	-	-	-
	Treatment Area		100%			
	Reduction Efficiency		33%			
Livestock Exclusion	Treatment Area (acres)[3]	-	-	-	-	-
	Treatment Area					
	Reduction Efficiency					

Table E-8. Turkey Creek – Platte River *E. coli* Load Reductions (continued)

		Pasture[1]	Cropland	Urban	Other[2]	Total
Riparian Buffer	Treatment Area (acres)[3]	-	9,717.8	-	-	-
	Treatment Area		75%			
	Reduction Efficiency		70%			
Bioswales	Treatment Area (acres)[3]	-	-	26.4	-	-
	Treatment Area			5%		
	Reduction Efficiency			70%		
Rain Garden	Treatment Area (acres)[3]	-	-	52.8	-	-
	Treatment Area			10%		
	Reduction Efficiency			70%		
Bioinfiltration	Treatment Area (acres)[3]	-	-	52.8	-	-
	Treatment Area			10%		
	Reduction Efficiency			58%		
Totals						
Current *E. coli* Load, col/year		8.19E+15	1.49E+16	4.55E+15	-	2.76E+16
Effective Reduction[5]		0.23	0.79	0.15		-
E. coli Reduction/year		1.90E+15	1.17E+16	7.03E+14		1.43E+16
E. coli Reduced Load , col/year		6.29E+15	3.19E+15	3.85E+15		1.33E+16
E. coli Load Reduction Required to Meet WQS		1.47E+15	2.68E+15	8.19E+14		4.98E+15

[1]Pasture land includes CRP land. The land use data was taken with visual imagery and grass CRP was classified with pasture land.

[2]Other land use includes barren, open water, riparian forest and woodlands, road, and wetlands.

[3]Treatment Area acres is assumed to be the area that needs to be treated. This is not the number of acres that each specific BMP needs to be on but rather the number of acres that needs to be treated by the BMP. This could be done by many small treatments scattered or one large treatment.

[4]Bioswales were assumed to have the same effectiveness as wet detention basins and constructed wetlands

[5]Using an effective reduction calculation allows multiple BMP methods to be used without double counting reductions.

Table E-9. Turkey Creek – Platte River BMP Cost

BMP		Land Use					Unit	Cost/Unit	Quantity	Cost
		Pasture	Cropland	Urban	Other[1]	Total				
Acres		3,816	12,957	528	7,298	24,599				
Constructed Wetland[2]	Treatment Area (acres)[3]	190.8	647.9	-	-	-	each	$260,000	5	$1,325,526
	Treatment Area	5%	5%							
Wet Detention Basin	Treatment Area (acres)[3]	190.8	647.9	-	-	-	each	$1,560,000	5	$7,953,155
	Treatment Area	5%	5%							
Dry Detention Basin/Terraces[4]	Treatment Area (acres)[3]	-	1,296	-	-	-	feet	$20	267,238	$5,344,763
	Treatment Area		10%							
Sediment Control Basin	Treatment Area (acres)[3]	954	3,239.3	-	-	-	each	$65,000	25	$1,656,907
	Treatment Area	25%	25%							
Grassed Waterways/Cover Crop	Treatment Area (acres)[3]	-	3,239	-	-	-	acres	$90	3,239	$291,533
	Treatment Area		25%							
Manure Application Management	Treatment Area (acres)[3]	-	12,957	-	-	-	acres	$50	12,957	$647,850
	Treatment Area		100%							
Livestock Exclusion	Treatment Area (acres)[3]	-	-	-	-	-	each	$2,000	-	-
	Treatment Area									

Table E-9. Turkey Creek – Platte River BMP Cost (continued)

BMP		Land Use					Unit	Cost/Unit	Quantity	Cost
		Pasture	Cropland	Urban	Other[1]	Total				
Acres		3,816	12,957	528	7,298	24,599				
Riparian Buffer[5]	Treatment Area (acres)[3]	-	818	-	-	-	acres	$1,000	818	$817,793
	Treatment Area		75%							
Bioswales[6]	Treatment Area (acres)[3]	-	-	26.4	-	-	each	$2,000	5	$10,000
	Treatment Area			5%						
Rain Garden	Treatment Area (acres)[3]	-	-	52.8	-	-	each	$600	98	$58,925
	Treatment Area			10%						
Bioinfiltration	Treatment Area (acres)[3]	-	-	52.8	-	-	each	$19,500	5	$97,500
	Treatment Area			10%						
								Total Cost		$18,203,951

[1]Other land use includes barren, open water, riparian forest and woodlands, road, and wetlands.

[2]Constructed wetland costs include the cost of design and permitting.

[3]Treatment Area acres is assumed to be the area that needs to be treated. This is not the number of acres that each specific BMP needs to be on but rather the number of acres that needs to be treated by the BMP. This could be done by many small treatments scattered or one large treatment.

[4]Terrace Calculation: ((Feet in a mile/Average Terrace width (200))*Length of terrace in a mile (5000))*(Land use acreage/acres in a square mile (640))

[5]Treatment area for riparian buffers was calculated based on the total amount of NHD lines within a watershed. The numbers were not tailored to match the amount of each NHD within a specific land use.

[6]Bioswale costs were not provided. An average was chosen based on cost estimates from the American Society of Landscape Architects. Assumed to be a 200m2 bioswale.

Table E-10. Buffalo Creek *E. coli* Load Reductions

		Pasture[1]	Cropland	Urban	Other[2]	Total
BMP		2,114	12,476	897	1,074	16,561
Constructed Wetland	Treatment Area (acres)[3]	105.7	623.8	-	-	-
	Treatment Area	5%	5%			
	Reduction Efficiency	70%	70%			
Wet Detention Basin	Treatment Area (acres)[3]	105.7	623.8	-	-	-
	Treatment Area	5%	5%			
	Reduction Efficiency	70%	70%			
Dry Detention Basin/Terraces	Treatment Area (acres)[3]	-	1,247.6	-	-	-
	Treatment Area		10%			
	Reduction Efficiency		25%			
Sediment Control Basin	Treatment Area (acres)[3]	528.5	3,119	-	-	-
	Treatment Area	25%	25%			
	Reduction Efficiency	70%	70%			
Grassed Waterways/Cover Crop	Treatment Area (acres)[3]	528.5	3,119	-	-	-
	Treatment Area	25%	25%			
	Reduction Efficiency	50%	50%			
Manure Application Management	Treatment Area (acres)[3]	-	12,476	-	-	-
	Treatment Area		100%			
	Reduction Efficiency		33%			
Livestock Exclusion	Treatment Area (acres)[3]	2,114	-	-	-	-
	Treatment Area	100%				
	Reduction Efficiency	70%				

Table E-10. Buffalo Creek *E. coli* Load Reductions (continued)

		Pasture[1]	Cropland	Urban	Other[2]	Total
Riparian Buffer	Treatment Area (acres)[3]	1,585.5	9357	-	-	-
	Treatment Area	75%	75%			
	Reduction Efficiency	70%	70%			
Bioswales	Treatment Area (acres)[3]	-	-	-	-	-
	Treatment Area					
	Reduction Efficiency					
Rain Garden	Treatment Area (acres)[3]	-	-	89.7	-	-
	Treatment Area			10%		
	Reduction Efficiency			70%		
Bioinfiltration	Treatment Area (acres)[3]	-	-	89.7	-	-
	Treatment Area			10%		
	Reduction Efficiency			58%		
Totals						
Current *E. coli* Load, col/year		4.27E+15	1.44E+16	6.72E+15	-	2.54E+16
Effective Reduction[5]		0.90	0.79	0.12		-
E. coli Reduction/year		3.86E+15	1.13E+16	8.33E+14		1.60E+16
E. coli Reduced Load , col/year		4.09E+14	3.08E+15	5.89E+15		9.38E+15
E. coli Load Reduction Required to Meet WQS		7.69E+14	2.59E+15	1.21E+15		4.57E+15

[1]Pasture land includes CRP land. The land use data was taken with visual imagery and grass CRP was classified with pasture land.

[2]Other land use includes barren, open water, riparian forest and woodlands, road, and wetlands.

[3]Treatment Area acres is assumed to be the area that needs to be treated. This is not the number of acres that each specific BMP needs to be on but rather the number of acres that needs to be treated by the BMP. This could be done by many small treatments scattered or one large treatment.

[4]Bioswales were assumed to have the same effectiveness as wet detention basins and constructed wetlands

[5]Using an effective reduction calculation allows multiple BMP methods to be used without double counting reductions.

Table E-11. Buffalo Creek BMP Cost

BMP		Land Use					Unit	Cost/Unit	Quantity	Cost
		Pasture	Cropland	Urban	Other[1]	Total				
Acres		2,114	12,476	897	1,074	16,561				
Constructed Wetland[2]	Treatment Area (acres)[3]	105.7	623.8	-	-	-	each	$260,000	4	$1,153,009
	Treatment Area	5%	5%							
Wet Detention Basin	Treatment Area (acres)[3]	105.7	623.8	-	-	-	each	$1,560,000	4	$6,918,055
	Treatment Area	5%	5%							
Dry Detention Basin/Terraces[4]	Treatment Area (acres)[3]	-	1,248	-	-	-	feet	$20	257,318	$5,146,350
	Treatment Area		10%							
Sediment Control Basin	Treatment Area (acres)[3]	528.5	3,119	-	-	-	each	$65,000	22	$1,441,261
	Treatment Area	25%	25%							
Grassed Waterways/Cover Crop	Treatment Area (acres)[3]	-	3,119	-	-	-	acres	$90	3,119	$280,710
	Treatment Area		25%							
Manure Application Management	Treatment Area (acres)[3]	-	12,476	-	-	-	acres	$50	12,476	$623,800
	Treatment Area		100%							
Livestock Exclusion	Treatment Area (acres)[3]	2,114	-	-	-	-	each	$2,000	2,114	$4,228,000
	Treatment Area	100%								

Table E-11. Buffalo Creek BMP Cost (continued)

BMP		Land Use					Unit	Cost/Unit	Quantity	Cost
		Pasture	Cropland	Urban	Other[1]	Total				
Acres		2,114	12,476	897	1,074	16,561				
Riparian Buffer[5]	Treatment Area (acres)[3]	-	528	-	-	-	acres	$1,000	528	$528,389
	Treatment Area		75%							
Bioswales[6]	Treatment Area (acres)[3]	-	-	-	-	-	each	$2,000	-	-
	Treatment Area									
Rain Garden	Treatment Area (acres)[3]	-	-	89.7	-	-	each	$600	167	$100,105
	Treatment Area			10%						
Bioinfiltration	Treatment Area (acres)[3]	-	-	89.7	-	-	each	$19,500	7	$136,500
	Treatment Area			10%						
								Total Cost		$20,556,180

[1]Other land use includes barren, open water, riparian forest and woodlands, road, and wetlands.

[2]Constructed wetland costs include the cost of design and permitting.

[3]Treatment Area acres is assumed to be the area that needs to be treated. This is not the number of acres that each specific BMP needs to be on but rather the number of acres that needs to be treated by the BMP. This could be done by many small treatments scattered or one large treatment.

[4]Terrace Calculation: ((Feet in a mile/Average Terrace width (200))*Length of terrace in a mile (5000))*(Land use acreage/acres in a square mile (640))

[5]Treatment area for riparian buffers was calculated based on the total amount of NHD lines within a watershed. The numbers were not tailored to match the amount of each NHD within a specific land use.

[6]Bioswale costs were not provided. An average was chosen based on cost estimates from the American Society of Landscape Architects. Assumed to be a 200m2 bioswale.

Table E-12. Zwiebel Creek – Platte River *E. coli* Load Reductions

		Pasture[1]	Cropland	Urban	Other[2]	Total
BMP		3,551	8,240	576	3,653	16,020
Constructed Wetland	Treatment Area (acres)[3]	177.6	412	-	-	-
	Treatment Area	5%	5%			
	Reduction Efficiency	70%	70%			
Wet Detention Basin	Treatment Area (acres)[3]	177.6	412	-	-	-
	Treatment Area	5%	5%			
	Reduction Efficiency	70%	70%			
Dry Detention Basin/Terraces	Treatment Area (acres)[3]	-	824	-	-	-
	Treatment Area		10%			
	Reduction Efficiency		25%			
Sediment Control Basin	Treatment Area (acres)[3]	887.8	2,060	-	-	-
	Treatment Area	25%	25%			
	Reduction Efficiency	70%	70%			
Grassed Waterways/Cover Crop	Treatment Area (acres)[3]	887.8	2,060	-	-	-
	Treatment Area	25%	25%			
	Reduction Efficiency	50%	50%			
Manure Application Management	Treatment Area (acres)[3]	-	8,240	-	-	-
	Treatment Area		100%			
	Reduction Efficiency		33%			
Livestock Exclusion	Treatment Area (acres)[3]	3,551	-	-	-	-
	Treatment Area	100%				
	Reduction Efficiency	70%				

Table E-12. Zwiebel Creek – Platte River *E. coli* Load Reductions (continued)

		Pasture[1]	Cropland	Urban	Other[2]	Total
Riparian Buffer	Treatment Area (acres)[3]	2,663.25	6,180	-	-	-
	Treatment Area	75%	75%			
	Reduction Efficiency	70%	70%			
Bioswales	Treatment Area (acres)[3]	-	-	-	-	-
	Treatment Area					
	Reduction Efficiency					
Rain Garden	Treatment Area (acres)[3]	-	-	57.6	-	-
	Treatment Area			10%		
	Reduction Efficiency			70%		
Bioinfiltration	Treatment Area (acres)[3]	-	-	57.6	-	-
	Treatment Area			10%		
	Reduction Efficiency			58%		
Totals						
Current *E. coli* Load, col/year		7.21E+15	9.50E+15	4.62E+15	-	2.13E+16
Effective Reduction[5]		0.90	0.79	0.12		-
E. coli Reduction/year		6.52E+15	7.47E+15	5.73E+14		1.46E+16
E. coli Reduced Load , col/year		6.91E+14	2.03E+15	4.05E+15		6.77E+15
E. coli Load Reduction Required to Meet WQS		1.30E+15	1.71E+15	8.32E+14		3.84E+15

[1]Pasture land includes CRP land. The land use data was taken with visual imagery and grass CRP was classified with pasture land.

[2]Other land use includes barren, open water, riparian forest and woodlands, road, and wetlands.

[3]Treatment Area acres is assumed to be the area that needs to be treated. This is not the number of acres that each specific BMP needs to be on but rather the number of acres that needs to be treated by the BMP. This could be done by many small treatments scattered or one large treatment.

[4]Bioswales were assumed to have the same effectiveness as wet detention basins and constructed wetlands

[5]Using an effective reduction calculation allows multiple BMP methods to be used without double counting reductions.

Table E-13. Zwiebel Creek – Platte River BMP Cost

BMP		Land Use					Unit	Cost/Unit	Quantity	Cost
		Pasture	Cropland	Urban	Other[1]	Total				
Acres		3,551	8,240	576	3,653	16,020				
Constructed Wetland[2]	Treatment Area (acres)[3]	177.6	412	-	-	-	each	$260,000	4	$931,812
	Treatment Area	5%	5%							
Wet Detention Basin	Treatment Area (acres)[3]	177.6	412	-	-	-	each	$1,560,000	4	$5,590,869
	Treatment Area	5%	5%							
Dry Detention Basin/Terraces[4]	Treatment Area (acres)[3]	-	824	-	-	-	feet	$20	169,950	$3,399,000
	Treatment Area		10%							
Sediment Control Basin	Treatment Area (acres)[3]	887.8	2,060	-	-	-	each	$65,000	18	$1,164,764
	Treatment Area	25%	25%							
Grassed Waterways/Cover Crop	Treatment Area (acres)[3]	-	2,060	-	-	-	acres	$90	2,060	$185,400
	Treatment Area		25%							
Manure Application Management	Treatment Area (acres)[3]	-	8,240	-	-	-	acres	$50	8,240	$412,000
	Treatment Area		100%							
Livestock Exclusion	Treatment Area (acres)[3]	3,551	-	-	-	-	each	$2,000	3,551	$7,102,000
	Treatment Area	100%								

Table E-13. Zwiebel Creek – Platte River BMP Cost (continued)

BMP		Land Use					Unit	Cost/Unit	Quantity	Cost
		Pasture	Cropland	Urban	Other[1]	Total				
Acres		3,551	8,240	576	3,653	16,020				
Riparian Buffer[5]	Treatment Area (acres)[3]	-	500	-	-	-	acres	$1,000	500	$500,095
	Treatment Area		75%							
Bioswales[6]	Treatment Area (acres)[3]	-	-	-	-	-	each	$2,000	-	-
	Treatment Area									
Rain Garden	Treatment Area (acres)[3]	-	-	57.6	-	-	each	$600	107	$64,282
	Treatment Area			10%						
Bioinfiltration	Treatment Area (acres)[3]	-	-	57.6	-	-	each	$19,500	5	$97,500
	Treatment Area			10%						
								Total Cost		$19,447,722

[1]Other land use includes barren, open water, riparian forest and woodlands, road, and wetlands.

[2]Constructed wetland costs include the cost of design and permitting.

[3]Treatment Area acres is assumed to be the area that needs to be treated. This is not the number of acres that each specific BMP needs to be on but rather the number of acres that needs to be treated by the BMP. This could be done by many small treatments scattered or one large treatment.

[4]Terrace Calculation: ((Feet in a mile/Average Terrace width (200))*Length of terrace in a mile (5000))*(Land use acreage/acres in a square mile (640))

[5]Treatment area for riparian buffers was calculated based on the total amount of NHD lines within a watershed. The numbers were not tailored to match the amount of each NHD within a specific land use.

[6]Bioswale costs were not provided. An average was chosen based on cost estimates from the American Society of Landscape Architects. Assumed to be a 200m2 bioswale.

Table E-14. Turtle Creek *E. coli* Load Reductions

		Pasture[1]	Cropland	Urban	Other[2]	Total
BMP		1,157	8,235	687	545	10,624
Constructed Wetland	Treatment Area (acres)[3]	57.9	411.8	-	-	-
	Treatment Area	5%	5%			
	Reduction Efficiency	70%	70%			
Wet Detention Basin	Treatment Area (acres)[3]	57.9	411.8	-	-	-
	Treatment Area	5%	5%			
	Reduction Efficiency	70%	70%			
Dry Detention Basin/Terraces	Treatment Area (acres)[3]	-	823.5	-	-	-
	Treatment Area		10%			
	Reduction Efficiency		25%			
Sediment Control Basin	Treatment Area (acres)[3]	289.3	2,058.8	-	-	-
	Treatment Area	25%	25%			
	Reduction Efficiency	70%	70%			
Grassed Waterways/Cover Crop	Treatment Area (acres)[3]	289.3	2,058.8	-	-	-
	Treatment Area	25%	25%			
	Reduction Efficiency	50%	50%			
Manure Application Management	Treatment Area (acres)[3]	-	8,235	-	-	-
	Treatment Area		100%			
	Reduction Efficiency		33%			
Livestock Exclusion	Treatment Area (acres)[3]	1,157	-	-	-	-
	Treatment Area	100%				
	Reduction Efficiency	70%				

Table E-14. Turtle Creek *E. coli* Load Reductions (continued)

		Pasture[1]	Cropland	Urban	Other[2]	Total
Riparian Buffer	Treatment Area (acres)[3]	867.8	6,176.3	-	-	-
	Treatment Area	75%	75%			
	Reduction Efficiency	70%	70%			
Bioswales	Treatment Area (acres)[3]	-	-	-	-	-
	Treatment Area					
	Reduction Efficiency					
Rain Garden	Treatment Area (acres)[3]	-	-	68.7	-	-
	Treatment Area			10%		
	Reduction Efficiency			70%		
Bioinfiltration	Treatment Area (acres)[3]	-	-	68.7	-	-
	Treatment Area			10%		
	Reduction Efficiency			58%		
Totals						
Current *E. coli* Load, col/year		9.23E+16	9.49E+15	4.98E+15		1.07E+17
Effective Reduction[5]		0.90	0.79	0.12		-
E. coli Reduction/year		8.35E+16	7.46E+15	6.17E+14	-	9.15E+16
E. coli Reduced Load , col/year		8.84E+15	2.03E+15	4.36E+15		1.52E+16
E. coli Load Reduction Required to Meet WQS		1.66E+16	1.71E+15	8.96E+14		1.92E+16

[1]Pasture land includes CRP land. The land use data was taken with visual imagery and grass CRP was classified with pasture land.

[2]Other land use includes barren, open water, riparian forest and woodlands, road, and wetlands.

[3]Treatment Area acres is assumed to be the area that needs to be treated. This is not the number of acres that each specific BMP needs to be on but rather the number of acres that needs to be treated by the BMP. This could be done by many small treatments scattered or one large treatment.

[4]Bioswales were assumed to have the same effectiveness as wet detention basins and constructed wetlands

[5]Using an effective reduction calculation allows multiple BMP methods to be used without double counting reductions.

Table E-15. Turtle Creek BMP Cost

BMP		Land Use					Unit	Cost/Unit	Quantity	Cost
		Pasture	Cropland	Urban	Other[1]	Total				
Acres		1,157	8,235	687	545	10,624				
Constructed Wetland[2]	Treatment Area (acres)[3]	57.9	411.8	-	-	-	each	$260,000	3	$742,225
	Treatment Area	5%	5%							
Wet Detention Basin	Treatment Area (acres)[3]	57.9	411.8	-	-	-	each	$1,560,000	3	$4,453,350
	Treatment Area	5%	5%							
Dry Detention Basin/Terraces[4]	Treatment Area (acres)[3]	-	824	-	-	-	feet	$20	169,847	$3,396,938
	Treatment Area		10%							
Sediment Control Basin	Treatment Area (acres)[3]	289.3	2,058.8	-	-	-	each	$65,000	14	$927,781
	Treatment Area	25%	25%							
Grassed Waterways/Cover Crop	Treatment Area (acres)[3]	-	2,059	-	-	-	acres	$90	2,059	$185,288
	Treatment Area		25%							
Manure Application Management	Treatment Area (acres)[3]	-	8,235	-	-	-	acres	$50	8,235	$411,750
	Treatment Area		100%							
Livestock Exclusion	Treatment Area (acres)[3]	1,157	-	-	-	-	each	$2,000	1,157	$2,314,000
	Treatment Area	100%								

Table E-15. Turtle Creek BMP Cost (continued)

BMP		Land Use: Pasture	Cropland	Urban	Other[1]	Total	Unit	Cost/Unit	Quantity	Cost
Acres		1,157	8,235	687	545	10,624				
Riparian Buffer[5]	Treatment Area (acres)[3]	-	370	-	-	-	acres	$1,000	370	$370,171
	Treatment Area		75%							
Bioswales[6]	Treatment Area (acres)[3]	-	-	-	-	-	each	$2,000	-	-
	Treatment Area									
Rain Garden	Treatment Area (acres)[3]	-	-	68.7	-	-	each	$600	128	$76,669
	Treatment Area			10%						
Bioinfiltration	Treatment Area (acres)[3]	-	-	68.7	-	-	each	$19,500	6	$117,000
	Treatment Area			10%						
								Total Cost		$12,995,171

[1]Other land use includes barren, open water, riparian forest and woodlands, road, and wetlands.

[2]Constructed wetland costs include the cost of design and permitting.

[3]Treatment Area acres is assumed to be the area that needs to be treated. This is not the number of acres that each specific BMP needs to be on but rather the number of acres that needs to be treated by the BMP. This could be done by many small treatments scattered or one large treatment.

[4]Terrace Calculation: ((Feet in a mile/Average Terrace width (200))*Length of terrace in a mile (5000))*(Land use acreage/acres in a square mile (640))

[5]Treatment area for riparian buffers was calculated based on the total amount of NHD lines within a watershed. The numbers were not tailored to match the amount of each NHD within a specific land use.

[6]Bioswale costs were not provided. An average was chosen based on cost estimates from the American Society of Landscape Architects. Assumed to be a 200m2 bioswale.