DRAFT FINAL GROUNDWATER MANAGEMENT PLAN

Lower Platte South Natural Resources District

Revision of 1995 GWMP

October 30, 2026

LOWER PLATTE SOUTH
natural resources district

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Acronyms and Abbreviations

µg/L	Micrograms per Liter
AEM	Airborne Electromagnetic
AFFF	Aqueous Film Forming Foam
AGF	Aqua-Geo Frameworks
CAFO	Confined Animal Feeding Operation
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cfs	cubic feet per second
CPA	Crete-Princeton-Adams Groundwater Reservoir
CSD	Conservation and Survey Division
CWSPA	Community Water System Protection Area
DAK	Dakota Aquifer
DV	Dwight-Valparaiso Groundwater Reservoir
DVB	Dwight-Valparaiso-Brainard
DWR	Nebraska Department of Water Resources
ENWRA	Eastern Nebraska Water Resources Assessment
EPA	United States Environmental Protection Agency
FEMA	Federal Emergency Management Agency
GIS	Geographic Information System
GMA	Groundwater Management Area
gpd/ft	gallons per day per foot (transmissivity)
gpm	gallons per minute
GWMP	Groundwater Management Plan
HCA	Hydrologically Connected Area
HMP	Hazard Mitigation Plan
IMP	Integrated Management Plan
IPA	Improvement Project Area
LB	Legislative Bill
LLCHD	Lincoln-Lancaster County Health Department
LP3D	Lower Platte River Three District
LPRBWP	Lower Platte River Basin Water Management Plan
LPSNRD	Lower Platte South Natural Resources District
LSC	Lower Salt Creek Groundwater Reservoir
LUST	Leaking Underground Storage Tank
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
MG	Million Gallons
mg/L	Milligrams per Liter
MGD	Million Gallons per Day
MRV	Missouri River Valley

NASS	National Agricultural Statistics Service
DHHS	Nebraska Department of Health and Human Services
DWEE	Nebraska Department of Water, Energy, and Environment
NEMA	Nebraska Emergency Management Agency
ng/L	Nanograms per Liter
NGPC	Nebraska Game and Parks Commission
NHD	National Hydrography Dataset
NO_3-N	Nitrate-Nitrogen
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
NRD	Natural Resources District
PDSI	Palmer Drought Severity Index
PFAS	Per- and Polyfluoroalkyl Substances
POTW	Publicly Owned Treatment Works
ppb	parts per billion
ppm	parts per million
ppt	parts per trillion
PRV	Platte River Valley Groundwater Reservoir
PWS	Public Water System
RA	Remaining Area
RCRA	Resource Conservation and Recovery Act
RWD	Rural Water District
SAC	Stakeholder Advisory Committee
SDWA	Federal Safe Drinking Water Act
SMA	Special Management Area
TDS	Total Dissolved Solids
UBBNRD	Upper Big Blue Natural Resources District
UNL	University of Nebraska–Lincoln
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
USGS	United States Geological Survey
VOC	Volatile Organic Compound
WHPA	Wellhead Protection Area
WMP	Water Management Plan
WQMP	Water Quality Management Plan

Definitions of Groundwater-Related Terms

Aquifer. A water-bearing stratum of rock or sediment capable of yielding supplies of water.

Aquifer, Confined (or Artesian). An aquifer overlain by a low permeability layer or layers, in which pressure head will force water to rise above the aquifer in which it is contained.

Aquifer, Perched. An aquifer containing unconfined groundwater separated from an underlying body of groundwater by an unsaturated zone.

Aquifer, Principal. The aquifer or combination of related aquifers in a given area, which is the important economic source of water to wells—has been used, perhaps inaccurately, as synonymous with groundwater reservoir.

Aquifer, Secondary. Any aquifer other than the principal aquifer that is not the main source of water to wells in a given area, e.g., includes perched aquifers, the Dakota Sandstone in some areas, and several Paleozoic units.

Aquifer, Unconfined (or Water Table). An aquifer in which the upper limit is the water table rather than an impermeable layer.

Bedrock. Sequences of consolidated rock, which outcrop at the surface or which underlie unconsolidated earth materials.

Chemigation. The application of crop nutrients or pesticides through an irrigation system.

Groundwater. Water occupying voids within the saturated zone of a geologic stratum. This saturated zone is to be distinguished from an unsaturated or aeration zone where voids are filled with water and air.

Groundwater Model. A model designed to represent a simplified version of an actual, complex groundwater system; may be mathematical or physical.

Hardness. The amount of certain dissolved minerals in water. Carbonate hardness refers to the hardness caused by calcium and magnesium bicarbonate; noncarbonate hardness is caused by calcium sulfate, calcium chloride, magnesium sulfate, and magnesium chloride in water.

Head. The height of a column of water, supported by static pressure, above a standard datum (usually mean sea level).

Hydraulic Conductivity. The capacity of a porous material to transmit water under a unit hydraulic gradient through a unit area. A measure of an aquifer's ability to transmit water.

Hydrograph. A graph that illustrates a specific hydrologic parameter such as water elevation, discharge, or velocity as a function of time.

Irrigation Efficiency. The ratio of irrigation water beneficially used by the crop to the total amount of water applied.

Leaching. The downward transport of dissolved minerals in a soil by percolating water.

Loess. A wind-deposited silt having little or no stratification.

Net Irrigation Requirement. The amount of irrigation water needed for crop production, in excess of precipitation and natural soil moisture contributions.

Non-Point Source Pollution. Pollution from diffuse sources where no single point of release can be identified.

Operator. That person having the most direct control over the day-to-day farming operation of the land concerned.

Parts Per Million (ppm). A measure of the concentration of dissolved material in terms of a weight ratio. Equivalent to milligrams per liter (mg/L).

Percolation. The downward movement of water through soil or other earth materials.

pH. A logarithmic measure of the relative acidity of water. Below 7 is increasingly acidic, 7 is neutral, and above 7 is increasingly alkaline (basic).

Piezometric (Potentiometric) Surface. The upper level to which a water elevation rises in a tightly cased well.

Point Source Pollution. Pollution from discrete, identifiable locations, which can usually be measured directly or otherwise quantified.

Pollution. The process of contaminating air, water, and land with impurities to a level that is undesirable.

Porosity. The proportion, commonly stated as a percentage, of the total volume of a rock material that consists of pore space or voids.

Precipitation. Water in the form of hail, mist, rain, sleet, or snow that falls to the earth's surface.

Pressure Head. The height of a column of water that can be supported by the pressure at a given point.

Recovery of a Pumped Well. The rise of a water level in a well toward its pre-pumping elevation, which occurs after pumping ceases.

Reservoir (Groundwater). For any given area, the subsurface storage space between the potentiometric surface and the base of the principal aquifer includes one or more

aquifers and any associated fine-grained material (usually excludes any perched aquifer).

Soil. The upper layer of earth that can be cultivated and in which plants grow.

Static Water Elevation. The water elevation in a well before pumping occurs.

Subirrigation (Subirrigated Land). The natural occurrence of a groundwater table within the root zone of agricultural vegetation, not exceeding 10 feet below the surface of the ground.

Transmissivity. A rate that quantifies the ability of an aquifer to transmit water.

Unsaturated Zone. Porous earth materials that contain both air and water in their pore spaces. Sometimes called the vadose zone.

Vadose Zone. The unsaturated zone below the land surface and above the water table.

Water Table. The elevation below which the subsurface is saturated with water and at which the pressure head equals atmospheric pressure. A parameter associated with unconfined aquifers.

Zone of Saturation. Porous earth materials in which all pore spaces are filled with water.

1 INTRODUCTION

The Lower Platte South Natural Resources District (LPSNRD) recognizes the value of quality groundwater in sufficient quantities, perhaps more acutely than many other areas of the state where groundwater is abundant. The groundwater reservoirs in LPSNRD are limited in size, distribution, and, in some areas, use is limited by quality. As a result, LPSNRD is actively participating in programs designed to protect the limited groundwater supplies outlined in this Groundwater Management Plan (GWMP).

The Nebraska Groundwater Management and Protection Act was passed in 1975, and later amended in 1982, 1984, 1986, 1991, 1994, 1996, 2003, 2004, 2006, 2009, and 2014. In 1991, the Nebraska Legislature enacted Legislative Bill (LB) 51, which was subsequently amended in 1994 by LB 480, which required the following actions by LPSNRD:

> "… prior to July 1, 1996, each district shall amend its groundwater management plan to identify to the extent possible the levels and sources of groundwater contamination within the area, groundwater quality goals, long-term solutions necessary to prevent the levels of groundwater contaminants from becoming too high and to reduce high levels sufficiently to eliminate health hazards, and practices recommended to stabilize, reduce, and prevent the occurrence, increase, or spread of groundwater contamination."

This document is presented as an update of the 1995 plan adopted by the Board of Directors and approved by the Nebraska Department of Water Resources (DWR). The LPSNRD Board of Directors contracted with HDR Engineering, Inc. to assist with updating the existing plan.

For this new revision of the 1995 GWMP, discussion of the geology and groundwater supplies in LPSNRD has been reorganized, updated, supported by maps and tables compiled from the best available data, and presented as a foundation for the Plan portion of this document. Updated information and recommendations provided as part of this GWMP reflect the latest plans and studies completed for LPSNRD over the past 30 years. Such groundwater plans or studies incorporated as part of this plan are documented below in Table 1-1.

This update of the 1995 Plan was completed and submitted to the Nebraska Department of Water, Energy, and Environment (DWEE or Department) for review and approval in August 2026. The Draft GWMP was reviewed by DWEE, the Nebraska Game and Parks Commission (NGPC), and the University of Nebraska-Lincoln (UNL) Conservation and Survey Division (CSD), and all comments were provided to DWEE. DWEE added its comments and submitted a letter of approval of the Plan Update to LPSNRD on XXXX.

This GWMP update herein acknowledges and responds to the written and verbal comments of the state agencies and incorporates additional data on groundwater quantity and quality derived from studies and monitoring. Comments from public review at Public Open Houses, were reviewed and considered by LPSNRD. On XXXXX, the LPSNRD Board of Directors adopted this update to the 1995 Groundwater Management Plan. A glossary defining groundwater-related terms is provided for reference.

Table 1-1. Groundwater Plans and Studies Incorporated

LPSNRD Plans or Studies	Description	Referenced in GWMP
Integrated Management Plan (IMP)	LPSNRD's voluntary IMP took effect in 2014 and is reviewed annually in collaboration with DWEE. The three goals in the IMP are to achieve a sustainable water supply, to manage the supply and make it available whenever and wherever needed, and to support water use and conservation that optimizes benefits.	Section 1.3
Lower Platte River Basin Water Management Plan (Lower Platte River Basin-Wide Plan or LPRBWP)	The first increment of the LPRBWP was completed for the Lower Platte River Basin Coalition in 2017. Its purposes include: • Providing guidance and a framework for Lower Platte River Basin Coalition members to develop water use policies and practices that contribute to the protection of existing surface and groundwater uses, while allowing for future water development. • Assisting in the development and maintenance of a water supply and use inventory, based on the best available data and analysis. • Providing consistency and information for incorporation into individual Natural Resource District (NRD) Integrated Management Plans. A second increment of the LPRBWP was initiated in 2021.	Section 1.3
Lower Platte River Drought Contingency Plan	The original Lower Platte River Drought Contingency Plan was completed in 2019 for the Lower Platte River Drought Consortium and later updated in 2024. The updated plan includes drought monitoring and forecasting tools, new proposed drought mitigation activities, and an improved drought communication strategy.	Section 3.6
Drought Emergency Response Plan	Prepared in 2015 along with LPSNRD's IMP to develop strategies to respond to and manage the impacts of multi-year drought.	Section 3.6
Multi-Jurisdictional Hazard Mitigation Plan (HMP)	The 2025 LPSNRD Multi-Jurisdictional HMP was approved by the Nebraska Emergency Management Agency (NEMA) and the Federal Emergency Management Agency (FEMA). It is a community-guided plan that identifies vulnerability to natural and man-made hazards and mitigation projects to reduce or eliminate such risks.	Section 2.6
Eastern Nebraska Water Resources Assessment (ENWRA)	Multiple reports covering Airborne Electromagnetic (AEM) surveys were conducted in 2022, 2020, 2018, 2016, 2015, 2014, 2013, 2009, and 2007. Reports were prepared by U.S. Geological Survey (USGS), University of Nebraska Conservation and Survey Division (UNL-CSD), XRI, and Aqua-Geo Frameworks (AGF).	Section 3.1, 3.2, and 6.1
Water Quality Management Plan (WQMP)	The WQMP was prepared in 2019 and updated in 2024 to guide LPSNRD in developing and implementing future projects to improve water quality, hydrology, and aquatic resources. The plan makes the LPSNRD and all Public Water Systems (PWS) in the District eligible for Section 319 funding and may serve as a basis for seeking financial support for such projects. PWS Wellhead Protection Areas (WHPAs) are considered Special Priority Areas in the WQMP.	Section 2.3

1.1. GROUNDWATER MANAGEMENT PLAN PURPOSE AND ORGANIZATION

In Nebraska Rev. Statute § 46-702, the Nebraska Legislature finds that:

- Ownership of water is held by the state for the benefit of its citizens. Groundwater is one of the most valuable natural resources in the state, and that adequate supply of groundwater is essential to the general welfare of the citizens of this state and to the present and future development of agriculture in the state.
- Every landowner is entitled to the reasonable and beneficial use of the groundwater underlying his or her land subject to the provisions of the Nebraska Groundwater Management and Protection Act and the correlative rights of other landowners when the groundwater supply is insufficient to meet the reasonable needs of all users.
- Nebraska Natural Resources Districts have the legal authority to regulate certain activities and, except as otherwise specifically provided by statute, as local entities are the preferred regulators of activities which may contribute to groundwater depletion.

Given this intent by the state, the purpose of this GWMP is to extend groundwater reservoir life in LPSNRD to the greatest extent practicable, consistent with reasonable and beneficial use of the groundwater and the latest knowledge and information. Each NRD's groundwater management plan shall also identify, the levels and sources of groundwater contamination within the district, groundwater quality goals, long-term solutions necessary to prevent the levels of groundwater contaminants from becoming too high and to reduce high levels sufficiently to eliminate health hazards, and practices recommended to stabilize, reduce, and prevent the occurrence, increase, or spread of groundwater contamination (Nebraska Rev. Statute § 46-709).

Nebraska Rev. Statute § 46-709 identifies the items that must be included in GWMPs that are prepared by NRDs and reviewed and approved by the Department. Table 1-2 lists the specific requirements of the plan and provides a cross-reference to the location of the content in this GWMP.

Table 1-2. Groundwater Management Statutes and Content Location Cross-Reference

Nebraska Revised Statute	Description of Required Content	Content Location in GWMP
46-709(1)	Groundwater supplies within the district including transmissivity, saturated thickness maps, and other groundwater reservoir information	Sections 3.1 and 3.2; Appendix A, Figures 1-1, 9, 11, 15
46-709(2)	Local recharge characteristics and rates from any sources	Sections 2.2, 3.1, 3.2, and 3.6; Appendix A, Figure 2
46-709(3)	Average annual precipitation and the variations within the district	Section 2.2; Appendix A, Figure 2
46-709(4)	Crop water needs within the district	Sections 2.4 and 2.6; Appendix A, Figures 4 and 5
46-709(5)	Current groundwater data-collection programs	Sections 1.3, 3.4, 3.5, 4, and4.2; Appendix A, Figures 13 and 17
46-709(6)	Past, present, and potential groundwater use within the district	Sections 2.6, 3.3, and 3.6; Appendix A, Figures 5 and 6
46-709(7)	Groundwater quality concerns within the district	Section 4.4; Appendix A, Figures 16 and 17
46-709(8)	Proposed water conservation and supply augmentation programs for the district	Sections 6 and 6.1
46-709(9)	The availability of supplemental water supplies, including the opportunity for groundwater recharge	Section 3.6; Appendix A, Figures 2 and 14
46-709(10)	The opportunity to integrate and coordinate the use of water from different sources of supply	Section 3.6
46-709(11)	Groundwater management objectives, including a proposed groundwater reservoir life goal for the district	Sections 5, 5.3, and 6.1
46-709(12)	Existing subirrigation uses within the district	Sections 2.4 and 3.6; Appendix A, Figure 13
46-709(13)	The relative economic value of different uses of groundwater proposed or existing within the district	Section 2.5
46-709(14)	The geographic and stratigraphic boundaries of any proposed management area(s)	Sections 1.3, 7.5, and 7.6; Appendix A, Figure 1-2
46-709	The levels and sources of groundwater contamination within the district	Sections 4.2 and 4.3; Appendix A, Figures 16 and 17
46-709	Groundwater quality goals	Sections 5.4 and 6.2
46-709	Long-term solutions necessary to prevent the levels of groundwater contaminants from becoming too high and methods to reduce high levels sufficiently to eliminate health hazards, and practices recommended to stabilize, reduce, and prevent the occurrence, increase, or spread of groundwater contamination	Sections 6.2, 7.2, 7.4, and 7.6

1.2. GROUNDWATER MANAGEMENT PLAN AUTHORITY AND STATUTORY REQUIREMENTS

Natural Resources Districts are given a wide variety of responsibilities for the management of groundwater quantity and quality by Nebraska statutes. Those authorities can be found mostly in Chapter 46, Section 7 of the Nebraska Revised Statutes, known as the Groundwater Management and Protection Act.

As required by law in 1985, LPSNRD developed and adopted a GWMP to govern its groundwater management programs (LPSNRD 1995). With the goal of meeting the intent of LB 51 in 1991 and LB 480 in 1994, LPSNRD staff and directors modified the 1985 plan in 1995 to address groundwater quality concerns and improvement strategies.

As of the date of this GWMP, LPSNRD has adopted Groundwater Rules and Regulations to implement the GWMP as per the authority granted in statutes. In addition, should the District establish or amend Groundwater Management Areas (GMAs), there are requirements for public notice, public hearings, and district powers and duties in Neb. Rev. Statute § 46-712 and 46-743.

1.3. EXISTING GROUNDWATER MANAGEMENT

The purpose of the latest LPSNRD Rules and Regulations adopted pursuant to the Nebraska Groundwater Management and Protection Act is to implement LPSNRD's GWMP by developing procedures for the implementation of management practices to:

- Conserve and protect groundwater supplies;
- Prevent the contamination or inefficient or improper use of groundwater; and
- Prevent and resolve conflicts between users of groundwater and appropriators of hydrologically connected surface water.

Across the entire LPSNRD, the existing rules and regulations require any new or replacement water well (> 50 gallons per minute [gpm]) to receive approval for a water well permit from the District prior to construction or installation of the well. Any new or replacement water well must also be equipped with a flow meter as a condition of the water well permit.

The current LPSNRD Rules and Regulations designates specific areas of groundwater management (see Appendix A, Figure 1-1 and 1-2) including:

1. Crete-Princeton-Adams (CPA) Groundwater Reservoir;
2. Dwight-Valparaiso (DV) Groundwater Reservoir;
3. Lower Salt Creek (LSC) Groundwater Reservoir;
4. Missouri River Valley (MRV) Groundwater Reservoir;

5. Platte River Valley (PRV) Groundwater Reservoir;
6. Remaining Area (RA); and
7. Community Water System Protection Areas (CWSPA), herein after referred to as Wellhead Protection Areas (WHPAs).

The groundwater quantity phase triggers in a groundwater reservoir occur when spring static groundwater elevations in monitoring network wells have declined from the established upper elevation of the saturated thickness to an elevation that represents greater than or equal to a specified percentage reduction in the saturated thickness and has remained below that elevation for more than two consecutive years. Groundwater quantity phase triggers in a WHPA shall be the same as the triggers of the groundwater reservoir or RA in which it is located. Currently, the entire geographic area of LPSNRD is designated as a Phase I Groundwater Management Area for quantity. The percentage reduction and number of wells for a groundwater reservoir to receive a Phase II or Phase III designation is shown in Table 1-3.

Table 1-3. Existing Groundwater Quantity Phase Triggers

Groundwater Reservoir	Phase II (30% of the wells)	Phase III (50% of the wells)
Lower Salt Creek	15%	30%
Missouri River	8%	15%
Platte River	8%	15%
Crete-Princeton	8%	15%
Dwight-Valparaiso	8%	15%
Remaining Areas	8%	15%

The groundwater quality Phase II trigger in a groundwater reservoir or WHPA occurs when at least 50 percent of the monitoring wells are at or above 50 percent of the Maximum Contaminant Level (MCL) for more than two consecutive years. Similarly, the groundwater quality Phase III trigger in a groundwater reservoir or WHPA occurs when at least 80 percent of the monitoring wells are at or above 80 percent of the MCL for more than two consecutive years. See Table 1-4.

Table 1-4. Existing Groundwater Quality Phase Triggers

Phases	Percentage of MCL	Minimum Percentage of Wells at or above Percentage of MCL
Phase I	< 50%	N/A
Phase II	50% - < 80%	50%
Phase III	80% - < 100%	80%

The Lower Salt Creek Groundwater Management Area was designated as Phase II in 2001. Currently, 7 of 32 WHPAs are designated as Phase II or Phase III. Designating a Phase II or III area required a 2-year verification study to confirm the levels of groundwater contamination and the occurrence of non-point source pollution. All remaining geographic areas of the District and WHPAs are considered Phase I Groundwater Quality Management Areas (see Appendix A, Figure 1-2).

- Phase II WHPAs: Davey, Hickman, Pleasant Dale, Union, Valparaiso, and Weeping Water/Otoe County Rural Water District (RWD) #3.
- Phase III WHPA: Elmwood.

LPSNRD rules and regulations also implement a Special Management Area (SMA) for the protection of groundwater quantity in a portion or portions of the District where additional controls are necessary to minimize pumping conflicts and protect groundwater supplies for all beneficial uses, public interest, and the health and welfare of the NRD. The only SMA currently designated in LPSNRD is the Dwight-Valparaiso-Brainard (DVB) SMA (see Appendix A, Figure 1-1). This area, which included the DV Groundwater Reservoir and portions of the RA, restricts the approval of any new groundwater-irrigated acres as of March 1, 2014, and establishes a 3-year rolling groundwater use allocation of 21.0 acre-inches per irrigated acre, not to exceed a 9.0 acre-inch annual maximum.

As a requirement of the District and Department's IMP, LPSNRD's rules and regulations also designate the Hydrologically Connected Areas (HCAs) of groundwater and surface water to the Platte River and Lower Salt Creek (see Appendix A, Figure 1-1). The requirements associated with the HCA include a limit on the expansion of irrigated acres, which must be approved by the LPSNRD Board, based on the allowable new stream depletions in each 5-year increment as prescribed by the Lower Platte River Basin Water Management Plan (WMP) (see Table 1-1).

2 DESCRIPTION OF LPSNRD PLAN AREA

2.1 LOCATION

LPSNRD is located in southeastern Nebraska. It shares borders with five other NRDs: the Papio-Missouri River and Lower Platte North NRDs to the north; the Upper Big Blue NRD to the west; and the Lower Big Blue and Nemaha NRDs to the south. Parts of the following six counties comprise the Lower Platte South NRD, Lancaster, Cass, Saunders, Seward, Butler, and Otoe, encompassing a total area of 977,517 acres (1,527.4 square miles). Furthermore, LPSNRD comprises the southern portion of the Lower Platte River Basin and includes areas tributary to the Missouri River, such as Weeping Water Creek, in the southeastern part of the District.

There are 30 municipalities within the District. The largest of these by population (according to the 2020 U.S. Census) are Lincoln (population 291,000), followed by Plattsmouth (population 6,600), Waverly (population 4,280), Ashland (population 3,100), Hickman (population 2,070), Louisville (population 1,320), and Weeping Water (population 1,030).

2.2 CLIMATE

LPSNRD has a humid continental climate. This climate is characterized by great seasonal differences in temperature and precipitation throughout the year. The summers are generally hot with high temperatures often topping 100°F. Winters are generally cold and dry with temperatures as low as -31°F (2021).

The average annual precipitation ranges from 30 to 34 inches, generally from west to east across LPSNRD (see Appendix A, Figure 2-1). Most of the precipitation is in the form of rain (approximately 90 percent of annual precipitation (1991-2020), with the greatest precipitation occurring between April and September. Average groundwater recharge, as shown in Appendix A, Figure 2-1, varies across the District from approximately 2 to 8 inches per year controlled by soil infiltration, slope, land use, and precipitation.

Average annual snowfall is 26 inches according to U.S. Climate Normals from 1991 through 2020 at the Lincoln Municipal Airport. Annual snowfall only accounts for about 10 percent of the average annual precipitation (1991-2020) and can vary widely from year to year. The average length of snow cover in Lincoln is 37 days (1991–2020) (UNL, 2025a). This is eight fewer days than the average of 45 days occurring from 1951 to 1980.

Average monthly temperatures range from a low of 22°F in December and January to a high of 77°F in July (High Plains Regional Climate Center, 2024). The growing season, or the average period between last spring and the first fall frost, is 171 days (Lincoln Weather and Climate, 2025). The relatively high temperatures allow for substantial evaporation, especially during the summer. On average, a small lake or pond will evaporate 45 inches per year in LPSNRD.

Observed changes in Nebraska's climate, as reported in *Understanding and Assessing Climate Change: Preparing for Nebraska's Future* (UNL, 2025b), show an increase in average annual temperatures from 1994 to 2023 (50.9°F) compared to 1895 to 1960 (49.5°F) of 1.4°F for Climate Division 6 encompassing most of LPSNRD. Temperature increases occurred primarily in the

winter and spring months with less difference in the fall and summer months. The average number of frost-free days also increased, with areas in LPSNRD experiencing around 8 to 10 more days per year with minimum temperatures above 32°F from 1951 to 1980 as compared to 1991 to 2020.

A similar increase in overall annual precipitation of 1.59 inches has also been observed in Division 6 when comparing the periods 1895–1960 versus 1994–2023. These observed precipitation increases occurred in spring, fall, and winter with declines in total precipitation during the summer. Since the 1950s, extreme precipitation events (the top 1 percent of heaviest precipitation events) have become more frequent and intense. These changes have contributed to increasing trends in the frequency of large floods and can impact local groundwater recharge.

2.3 SURFACE WATER SUPPLIES

The greatest extent of stream surface water supplies in LPSNRD can be found in the Missouri and Platte Rivers, which form LPSNRD eastern and northeastern boundaries, respectively. Appendix A, Figure 3-1 displays the locations of the individual watersheds within LPSNRD, Table 2-1 reports each watershed's drainage area (acres) and Table 2-2 summarizes stream mileage.

Table 2-1. Watershed Drainage Areas in LPSNRD

Watershed	Drainage Area (acres)
Lower Salt Creek	200,880
Buffalo Creek-Platte River	113,650
Oak Creek	162,700
Weeping Water Creek	159,160
Middle Salt Creek	141,680
Rock Creek	81,060
Middle Creek	64,150
Upper Salt Creek	62,360
Missouri River Tributaries	48,700
Other Drainages	5,600

Table 2-2. Stream Miles within LPSNRD

Stream	2025 Mileage
Antelope Creek	10.1
Bachelor Creek	4.6
Beal Slough	9.5
Big Slough	10.8
Callahan Creek	17.5
Camp Creek	15.5
Cardwell Branch	12.2
Cascade Creek	5.4
Cedar Creek	14.0
Cedar Creek, South	24.1
Cheese Creek	10.6
Dead Man's Run	6.1
Decker Creek	8.7
Deer Creek	11.1
Eight Mile Creek	13.6
Ervine Creek	8.9
Fountain Creek	8.2
Four Mile Creek	15.7
Goose Creek	6.4
Greenwood Creek	9.5
Haines Branch	20.1
Jordan Creek (Lancaster)	8.1
Jordan Creek (Otoe)	4.3
Little Salt Creek	19.8
Middle Creek	25.5
Middle Oak Creek (Butler/Lancaster)	9.5
Middle Oak Creek (Seward/Lancaster)	19.9
Mill Creek	8.6
Missouri River	28.4
North Oak Creek	34.1
Oak Creek	47.8
Olive Branch	13.4
Pawnee Creek	10.6
Platte River	50.7
Rakes Creek	5.3
Rock Creek	36.7
Salt Creek	69.8
Stevens Creek	22.9
Stove Creek	7.2
Wagon Tongue Creek	9.8
Weeping Water Creek	56.6
Weeping Water Creek, South Branch	29.0
West Oak Creek	9.3
Wittstruck Creek	6.8
Wolf Creek	6.3

Source: USGS National Hydrography Dataset (NHD) 2025

Surface water resources are primarily important for livestock, wildlife, and recreational uses. Except during times of heavy precipitation, streams are not filled to capacity and in most places

stream flow is generally low. During parts of the year, many ephemeral and intermittent streams have no flow at all.

Times of low or no stream flow can create several problems: supply of water for domestic, municipal, and industrial consumption may be reduced; water quality can deteriorate as the concentration of pollutants increases with decreased stream flow; fish, wildlife, and vegetation that depend on stream flow can be adversely affected; and recreational activities dependent upon stream flow may also be curtailed.

Pollution is a problem for many streams in LPSNRD. The updated Water Quality Management Plan, accepted by the United States Environmental Protection Agency (EPA) in October 2024, lists the impaired stream segments and lakes in LPSNRD. Sources of pollutants are municipal, industrial, and agricultural discharges. Municipal and industrial waste from the urban areas is a major factor in stream pollution when the discharges are not adequately treated before release. Municipal and industrial point sources of pollution are regulated by permit systems.

Agricultural runoff containing fertilizers, nutrients, and pesticides also degrade water quality and has a negative effect on surface water uses downstream. Certain agricultural discharges are controlled as point sources under the National Pollution Discharge Elimination System (NPDES) permit programs (i.e., feedlot runoff) administered by DWEE.

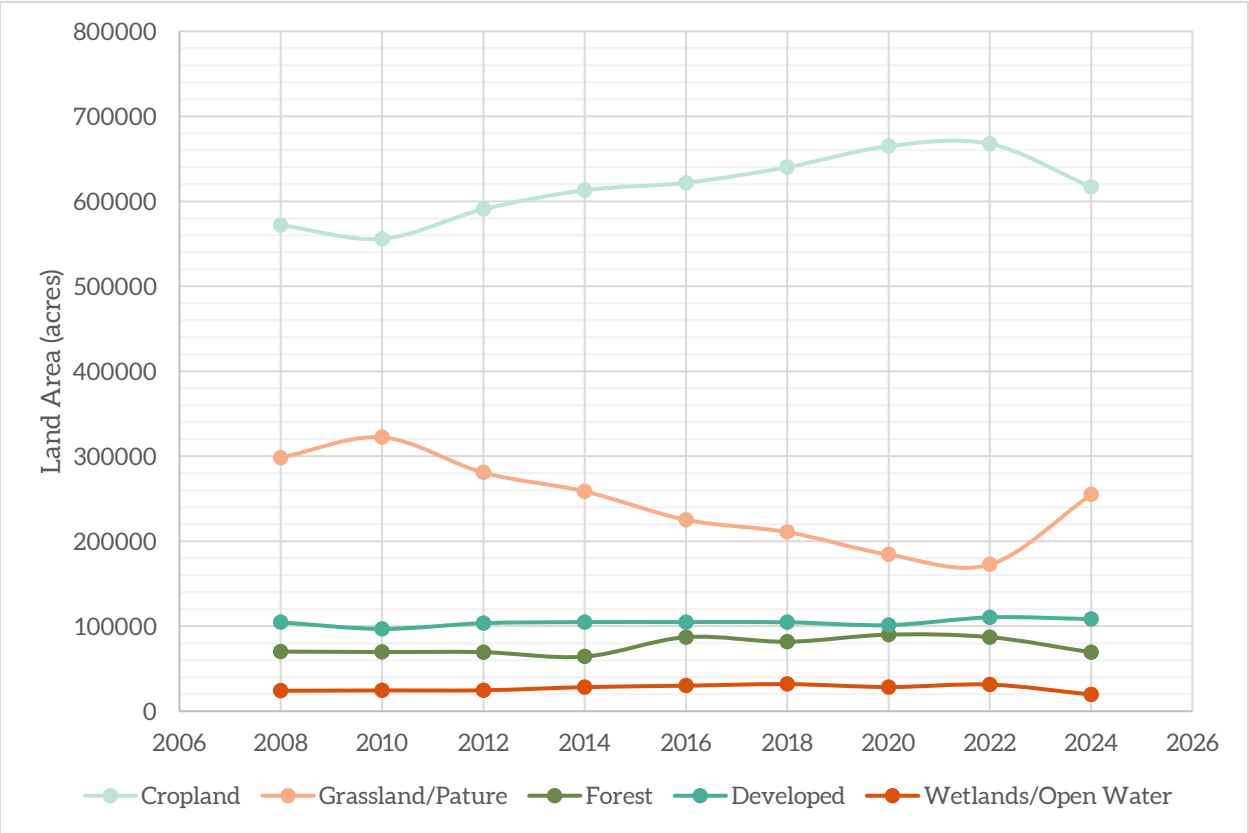
Flood risk reduction reservoirs have been constructed on several of the tributaries of Salt Creek. Ten United States Army Corps of Engineers (USACE) reservoirs provide a total of 4,368 surface water acres at the conservation pool level and an additional 140,000 acre-feet of temporary flood storage. The water stored in these reservoirs serves both wildlife and recreational needs. Numerous other smaller flood control reservoirs and farm ponds are scattered throughout LPSNRD and provide water for livestock, wildlife, recreation, irrigation needs, and possibly flood reduction.

2.4 TOPOGRAPHY, SOILS, AND LAND USE

Topography, soils, and land use are directly related to the distribution and quality of groundwater supplies in LPSNRD. Therefore, they are also discussed in greater detail later in this document.

In the agricultural sector, the major activities are commercial grain farming, cattle and hog feeding, and poultry and dairy production. Dryland corn, sorghum, soybeans, wheat, and alfalfa are the major crops. Land use data from 2008 through 2024 show that cropland has accounted for approximately 52 to 62 percent of the total land area within the District. Figure 2-1 shows that as cropland has increased in acreage, grassland and pasture have decreased, while developed and forested area show only slight increases over the prior 16-year period (United States Department of Agriculture National Agricultural Statistics Service [USDA NASS], 2024). As of 2024, LPSNRD has certified 28,624 irrigated acres, approximately 3 percent of the total land area. Appendix A, Figure 4 depicts the 2024 land use across LPSNRD.

Figure 2-1. LPSNRD Historic Land Use

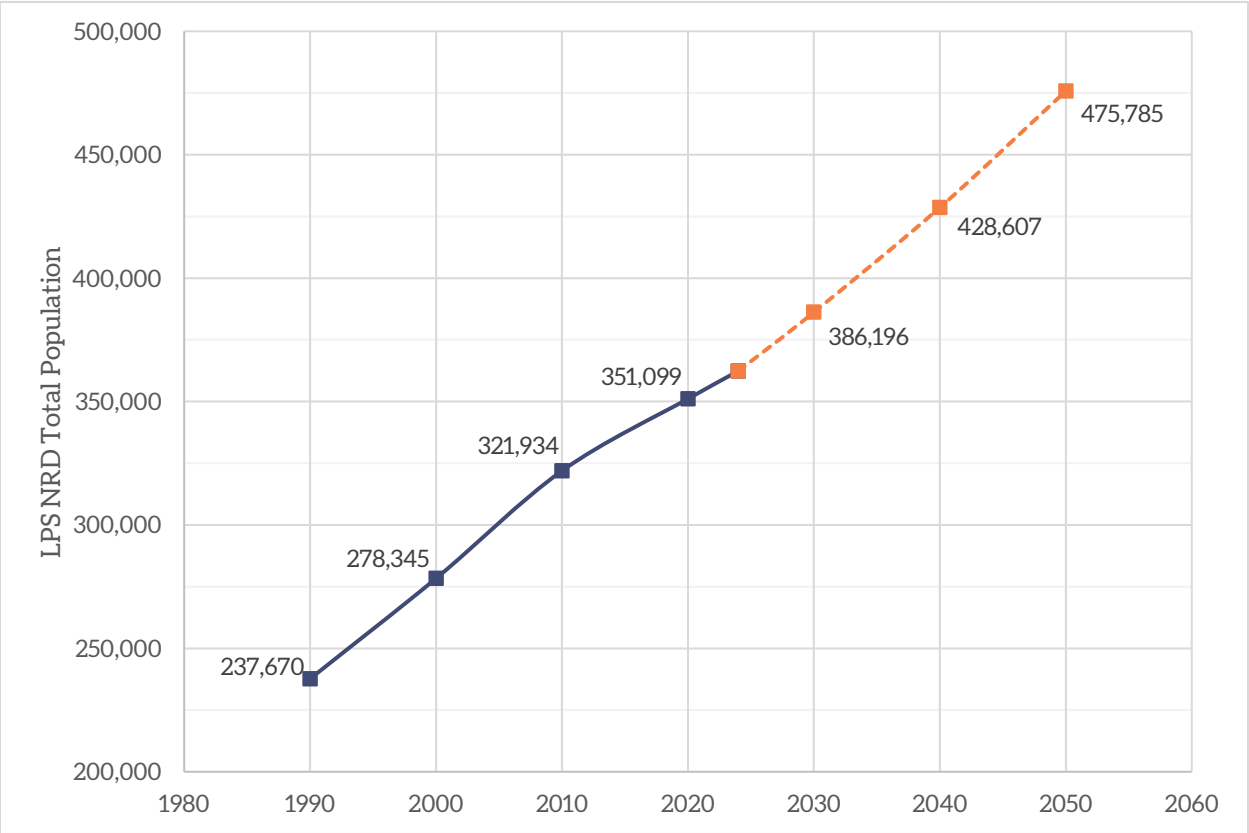


2.5 POPULATION AND ECONOMIC BASE

The population of LPSNRD in 2020 was estimated to be 351,000, a roughly 13 percent increase over the 2010 Census. In 2020, Lancaster County provided approximately 90 percent of LPSNRD's population, Cass County provided 7 percent, and the remaining 3 percent was provided by parts of Saunders, Seward, Butler, and Otoe Counties. Lincoln is the largest community in LPSNRD, with a population of 291,700 in 2020, providing approximately 83 percent of LPSNRD's population. Plattsmouth is the second largest community with a population of 6,600. Figure 2-2 documents the estimated historical population of LPSNRD dating back to 1990 and provides population projections from 2024 through 2050.

LOWER PLATTE SOUTH
natural resources district

Figure 2-2. LPSNRD Total Population



While the agricultural sector accounts for only a small percentage of the direct personal income in LPSNRD, it is nevertheless a major factor influencing the growth of the other economic sectors. Lancaster and Cass County combined for a total market value of agricultural products sold in 2022 of nearly $464.4 million (USDA NASS, 2022 Census of Agriculture). Therefore, to sustain a viable economy in LPSNRD, sound resource management practices that maintain agricultural production are essential.

Lincoln is the primary trade and manufacturing center within LPSNRD, and is the seat of Nebraska's State government. Industries such as pharmaceuticals, milling, printing and publishing, cement production, insurance, finance, and technology and transportation equipment production can be found in the community. The economic outlook for the Lincoln area is good. There are some mining activities in portions of LPSNRD. Sand, gravel, limestone, and clay are the primary materials quarried. Mining operations are most prevalent in Cass County. The combination of transportation access, geographic location, a growing labor force and a major university serve to spur economic growth in LPSNRD.

2.6 WATER DEMANDS

The use of water in LPSNRD is limited by both quantity and quality of water available. The number of registered active wells (7,685 as of 2025 compared to 1,060 in 1995) and surface water permits (440 as of 2025 compared to 98 in 1995) have increased significantly (DWEE 2026). Table 2-3 lists the number of registered active wells by use.

Table 2-3. List of Active Registered Wells by Use in LPSNRD

Well Use	Number of Active Registered Wells
Irrigation	457
Monitor	1,134
Public Water Supply with Spacing Protection	204
Domestic	4,218
Other (incl. Geothermal)	1,260
Commercial/Industrial	79
Observation	111
Recovery	56
Public Water Supply without Spacing Protection	110
Injection	61
Livestock	95
TOTAL	7,685

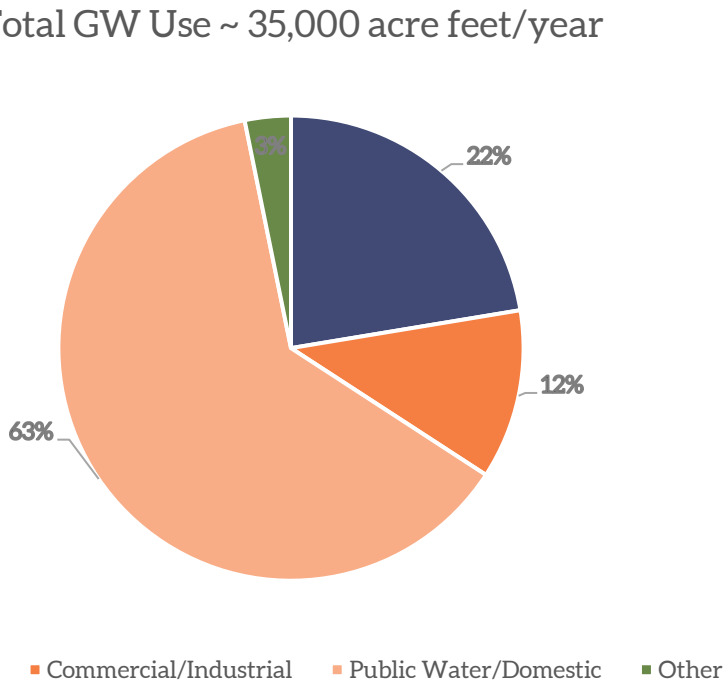
Source: Nebraska Department of Water, Energy, and Environment, Nebraska Registered Wells Inventory, 2025

A representative summary of estimated groundwater use in LPSNRD based on water meter data collected in 2024 is presented in Figure 2-3. Generally, the primary use of water in LPSNRD is for municipal/domestic with irrigation and commercial/ industrial use second and third, respectively. The value presented for Public Water/ Domestic supply in Figure 2-3 does not include groundwater used by any private domestic wells as they are unmetered.

Irrigation water use is generally from groundwater and is primarily concentrated in the LSC, DV, and CPA groundwater reservoirs (Appendix A, Figure 1-1). The development of registered wells serves as an indicator of water use. Table 2-3 lists the number of registered active wells by use, and Appendix A, Figure 5 highlights the location of registered high-capacity wells (>50 gpm), domestic wells, and monitoring wells in the District.

Irrigation well development was most extensive in the 1950s and again in the 1970s, with secondary development in the 1960s and 1980s. Generally, the LSC groundwater reservoir appears to have been developed earliest with a large concentration of 1950s vintage wells. From Raymond north to Valparaiso, a high concentration of irrigation wells was developed in the 1950s and 1960s. Most of the other groundwater reservoirs had intensive well development in the 1970s and 1980s.

Figure 2-3. Approximate Groundwater Use in LPSNRD



Natural subirrigation, where the groundwater elevation would be within the root zone of natural or seasonal vegetation (approximately 5 feet from the surface), is considered a very limited use of water within LPSNRD. Only certain riparian areas in hydrologically connected alluvial valleys would be considered areas of potential subirrigation and these areas would still receive precipitation and be near surface water supplies.

The dramatic increase in the number of registered wells since 1991 is due to the passage of LB 131, which required all new water wells to be registered with the Department. Previously, domestic, monitoring, livestock, observation, recovery, injection, other, and public water supply without spacing protection were not required to be registered.

The major crops grown in LPSNRD are corn, soybeans, sorghum, and lesser amounts of wheat and alfalfa. Irrigation is utilized to supplement rainfall during dry spells on land with an available water source and distribution system. Listed below in Table 2-4 is the seasonal crop water use (evapotranspiration) of the major crops grown in LPSNRD (UNL, 1990). The net irrigation requirement refers to the amount of irrigation water needed for crop production, in excess of precipitation and natural soil moisture contributions. Appendix A, Figure 5 illustrates the net irrigation requirement for corn across LPSNRD ranging from 2 to 4.5 inches per year.

An analysis of reported annual water use over the past 10 years (2014–2024) from irrigation wells throughout LPSNRD with flow meters indicated an average annual irrigation pumping of more than 2.5 billion gallons, which is an average of 4 inches per irrigated acre per year.

Table 2-4. Seasonal Water Use by Crop in LPSNRD

Crop	Inches/Year
Corn	25–28
Soybeans	22–25
Sorghum	20–23
Alfalfa	34–36
Wheat	16–18

Groundwater is the principal source of drinking water supply for public drinking water systems in LPSNRD. However, in many areas of LPSNRD, water must be obtained via private domestic wells or brought from a source area (sometimes outside LPSNRD) to serve the population. This is best illustrated in Appendix A, Figure 6, which depicts the distribution of private domestic wells and the coverage of land area by rural water districts (RWDs), which were formed in response to a common need for a reliable supply of good quality water. Data available from the Nebraska Drinking Water Watch (n.d.), DWEE Nebraska Registered Wells Inventory (2025), and LPSNRD Multi-Jurisdictional Hazard Mitigation Plan (2025) was used to estimate populations relying on private domestic wells in each county and the estimated number of those wells that are registered or unregistered (as of 2025) presented in Table 2-5.

Table 2-5. Public and Private Drinking Water Supply Population and Approximate Number of Private Wells

County	Estimated Population on Public Water Supply	Estimated Population on Private Domestic Water Supply	Active Registered Domestic Wells*	Appox. Unregistered Domestic Wells	Approx. Total Domestic Wells
Butler	590	317	77	76	153
Cass	21,175	3,287	552	718	1,270
Lancaster	310,675	15,326	2,977	3,200	6,177
Otoe	240	160	7	55	62
Seward	415	1785	352	362	714
Saunders	4,915	1,595	253	385	638
TOTAL	**338,010**	**22,470**	**4,218**	**4,826**	**9,014**

*Source: DWEE, Nebraska Registered Wells Inventory, 2025

A large portion of LPSNRD's population obtains its water from outside LPSNRD boundaries and some water must be transported via pipeline a long distance. For example, the City of Lincoln obtains its water from near Ashland and pumps the water approximately 25 miles to Lincoln. This well field is located partially in the Lower Platte South NRD, Lower Platte North NRD, and Papio-Missouri River NRD. Several of the RWDs are presently searching for groundwater supply sources for expansion, and the City of Lincoln is planning to expand the capability of its well field to meet future needs.

Existing industrial and commercial demands for water are centered around power production, food and grain processing, ethanol, mining, livestock production, and diverse manufacturing. Water supply for these demands can be provided by public water supplies or separate, private wells. As of 2026, a rapidly growing use of power, and therefore water, involves data centers and recent advancements in artificial intelligence.

2.7 ENVIRONMENTALLY SENSITIVE RESOURCES

LPSNRD contains an abundance of natural resources, some of which are considered rare and possibly threatened by human activity, including a type of wetland that is rare and unique in Nebraska, the saline wetlands. Saline wetlands in Nebraska are few in number, essentially limited to the floodplains of Salt Creek and its tributaries in Lancaster and Saunders Counties.

The source of water for these wetlands is the streams that originate from or flow through the sandstone units of the Dakota Group; however, the ultimate source of the saline waters lies deeper, in ancient shales and limestones laid down in Cretaceous times, when much of central North America was covered by a vast inland sea called the Western Interior Seaway. Eastern Saline wetlands are made up primarily of sulfate and/or chloride-based salts, like table salt, from the groundwater that feeds them. Appendix A, Figure 7 shows the location of known saline wetland complexes and displays an estimated depth to saline groundwater based on AEM resistivity values as determined by Aqua Geo Frameworks (a subconsultant to HDR).

The Eastern Saline wetlands are the last habitat in the world to support the Salt Creek tiger beetle (*Cicindela nevadica lincolniana)*, a state and federally listed endangered species. These wetlands also support saltwort, a state listed endangered plant. The Eastern Saline wetlands are within the Saline Wetlands Biologically Unique Landscape (Schneider, 2011). Estimates show that over 90 percent of the original saline wetlands within this landscape have been lost or highly degraded.

In the 1860s, the salt resources were commercially mined. However, the extent of the resource was limited for commercial production and mining was abandoned. Historically, human draining and filling have impacted the saline wetlands. Today, the marshes are considerably fewer in number and smaller in size. The channelization of Salt Creek has impacted the wetlands by downcutting Salt Creek and its tributaries, which has indirectly drained many of the wetlands. Other stresses affecting the habitat and species of the Saline Wetland Complex include livestock grazing and haying, invasive plant species, urban development, light pollution, and sedimentation.

The District is continuing to cooperate with the Saline Wetlands Conservation Partnership to operate two wells producing saline water for restoration of wetlands at the Marsh Wren Saline Wetlands north of Lincoln and has continued applying salt water to various portions of the wetlands complex to further this restoration effort.

In addition to the Salt Creek tiger beetle, other animal species listed on the NGPC Threatened or Endangered Species List (NGPC 2023) with possible range and habitat within the LPSNRD include the:

- Endangered Whooping Crane (Grus americana) – historic fall sitings in Lancaster County
- Endangered Interior Least Tern (Sternula antillarum athalassos)
- Endangered Northern Long-eared Bat (Myotis septentrionalis)

- Endangered Pallid Sturgeon (Scaphirhynchus albus)
- Endangered Sturgeon Chub (Macrhybopsis gelida)
- Threatened Piping Plover (Charadrius melodus)
- Threatened Southern Flying Squirrel (Glaucomys volans)

The NGPC has also identified a plant residing in LPSNRD that is on the threatened and endangered species list (NGPC 2023). There are confirmed records of the federally and state threatened western prairie-fringed orchid (*Platanthera praeclara*) within the jurisdictional boundaries of LPSNRD. The western prairie-fringed orchid, a federally and state threatened plant, is an inhabitant of native tallgrass wet meadows and mesic tallgrass prairies. Typical habitats are moderate to high quality meadows and prairies that have not been subjected to large-scale disturbance such as plowing, extreme overgrazing, or heavy herbicide use. Potential habitats may have a history of light disturbance such as haying and/or grazing. Fluctuations in groundwater elevations could significantly impact the hydrology of local habitats occupied by the orchid.

In addition, potential habitat for the western prairie-fringed orchid may occur elsewhere within LPSNRD. Potential orchid habitat would require further investigation to determine the presence of this plant. Habitat requirements and surveying methods for the western prairie-fringed orchid are described below.

Other plant species listed on the NGPC Threatened or Endangered Species List (NGPC 2023) with possible range within the LPSNRD include the:

- Endangered Saltwort (Salicornia rubra)
- Threatened American Geinseng (Panax quinquefolius)

The LPSNRD recognizes:

1. The existence and/or potential existence of threatened and endangered species that may be affected by groundwater elevations and groundwater quality.
2. That general protection of groundwater quantity and quality has many benefits including protecting the habitats of the species listed above.
3. That any groundwater management activities proposed in the plan may have some impact (positive or negative) on threatened species listed above.
4. Should specific adverse effects on threatened species listed in the plan from changing groundwater levels or quality be identified, LPSNRD acknowledges the potential need to modify its groundwater management plan in the future. Such modifications should include actions within control or management areas consistent with the Nebraska Groundwater Management and Protection Act that could be taken by LPSNRD to reduce adverse effects on species by maintaining groundwater elevations that will help sustain these species.

3 GROUNDWATER SUPPLIES

3.1 GEOLOGY

The State of Nebraska is located in the Central Region of North America and lies atop the ancient stable craton of the continent, which has experienced relatively little influence from large-scale tectonic crustal movements or volcanism throughout the Phanerozoic Eon. The state falls within the southern extension of the Canadian Shield, which represents Nebraska's Precambrian basement rocks, but they are deeply buried and do not outcrop anywhere. The basement rocks in LPSNRD consist of basalts, granites, and gabbros. The surface of the basement rock is generally characterized by broad uplifts and basins and is relatively stable.

Overlying the basement rocks are bedrock units consisting of limestones, shales, and sandstones. These bedrock deposits dip gently to the west and may be over 500 feet thick in LPSNRD. The first bedrock units encountered below the ground surface are displayed in a map produced by data from UNL-CSD in Appendix A, Figure 8.

Unconsolidated deposits of sand, gravel, silt, and clay (known as Quaternary age sediments) rest upon the bedrock. These materials were deposited by glaciers and rivers and their thickness is variable. Glacial tills (a mixture of sediments ranging in size from clay and silt particles up to large boulders) mantle the unconsolidated sediments or bedrock. Glacial tills are thickest in the uplands and have been eroded away in many of the stream and river valleys. Windblown loess commonly lies atop the till in much of LPSNRD. The saturated thickness of Quaternary sediments above bedrock and the static groundwater elevations used to determine these saturated thicknesses are shown in Appendix A, Figure 9.

Most groundwater wells in LPSNRD are screened in Quaternary age unconsolidated sand and gravel deposits or in the Cretaceous Dakota Group. Due to the presence of sufficient supplies of useable water in these materials, investigation of the potential for deeper bedrock aquifers has been limited. While some small-capacity wells have been developed in older limestone units, most potential limestone aquifers are usually in excess of several hundred feet deep within LPSNRD and water quality can be poor.

The mapping and geologic characterization presented in this GWMP was greatly aided by geophysical AEM data collected by LPSNRD as part of the Eastern Nebraska Water Resources Assessment (https://enwra.org/). AEM data collection occurred in LPSNRD in 2007, 2009, 2013, 2014, 2015, 2016, 2018, 2020, and 2022. All available AEM data were compiled into a 3D geologic model as part of the Lower Platte River Three District (LP3D) Groundwater Modeling Project.

Full north-to-south and west-to-east geologic cross sections were developed using AEM resistivity data to represent layers of aquifer and coarse aquifer material as well as marginal and non-aquifer material. These cross sections are included in Appendix A as Figures 3.1-1, 3.1-2, and 3.1-3.

3.1.1 BEDROCK DEPOSITS

Most bedrock units in eastern Nebraska are not considered a reliable source of groundwater. The oldest bedrock units in LPSNRD are from the Paleozoic Era and were deposited as long as 300 million years ago. A few low-capacity wells are developed in limestone units, for example, the Highway 77 Rest Area (3.5 miles north of Princeton) in Southern Lancaster County, and reportedly some domestic wells near Roca and industrial uses near Weeping Water. Most wells completed in Paleozoic bedrock have elevated levels of dissolved solids and other problematic constituents.

One bedrock unit that does provide large quantities of useable groundwater in some areas of LPSNRD, however, is the Dakota Aquifer deposited as part of the Dakota Group in the early Cretaceous period around 100 million years ago. The Dakota Aquifer can be referred to as the Upper Maha Aquifer of the Great Plains Aquifer System as proposed by USGS in 1993. However, in eastern Nebraska the aquifer is still referred to colloquially as the Dakota Aquifer with little confusion because it consists solely of the undivided Dakota Group (Divine, 2017). The Dakota Aquifer is an important aquifer to those landowners lacking unconsolidated deposits capable of yielding groundwater at sufficient quantities.

The Dakota Group is composed of interbedded sandstones, shaley sandstones, sandy shales, clayey shales (some carbonaceous), and siltstones. Unconsolidated to semi-consolidated sand, gravel, clay, and silt also occur, and thin beds of ironstone occur at some horizons. Concretions of ironstone and siltstone are common. Strata are unpredictable, owing to their origin as deposits in stream channels or near-shore marine environments. This results in inconsistent and unpredictable well yields and complex water quality conditions.

The Dakota Group underlies most of LPSNRD except for the southeastern portion of Cass County, below the LSC, PRV, and MRV reservoirs, and the entire portion of Otoe County that is within LPSNRD (Appendix A, Figure 8 and Figure 10-1). In these areas, the Dakota Group has been removed by erosion. The thickness of the formation ranges from absent on the eastern side, to more than 400 feet on the western side of the District (Appendix A, Figure 10-1 and Figure 10-2).

3.1.2 SAND AND GRAVEL DEPOSITS

The most extensively used groundwater supplies in LPSNRD are found in the surficial unconsolidated sand and gravel deposits. Three types of unconsolidated Quaternary age saturated sand and gravel deposits have been identified (shown in Appendix A, Figure 11, along with paleovalley deposits), and include:

- Significant thicknesses of sand and gravel in buried bedrock channels;
- Small sand and gravel lenses adjacent to or beneath glacial tills; and
- Coarse-grained sands in modern stream valleys.

These deposits exist sporadically across the District, with the possibility of any combination of them at a given location. Aquifers may be interconnected, and where two or more intersect, larger volumes of groundwater generally are available.

3.1.3 SAND AND GRAVEL IN BURIED BEDROCK STREAM CHANNELS (PALEOVALLEYS)

The locations of current river valleys do not necessarily reflect the locations of the older, buried river valleys, known as paleovalleys. Appendix A, Figure 11 shows the saturated thickness of sand and gravel layers across LPSNRD, including paleovalleys. The bedrock surface consists of broad hills and valleys with variations in the surface elevation of over 200 feet (Goodenkauf, 1978; Holly, 1980). Coarse-grained stream/river sediments were deposited in the main bedrock channels and some of the tributary channels. These deposits range in thickness from less than 20 feet in some areas to approximately 300 feet in others. The widths and lengths of the deposits are also variable, with some areas being over a mile wide and several miles long. The sands and gravels have greater transmissivity than surrounding materials and are generally considered to be an excellent source of useable groundwater in the region. These aquifers may have transmissivity values of up to 150,000 gallons per day per foot (gpd/ft) (Ginsberg, 1983). Wells with transmissivities greater than 100,000 gpd/ft can typically pump 1,000 gpm or more with acceptable drawdown.

3.1.4 SAND AND GRAVEL LENSES

Sand and gravel lenses in the till and small stream valley sand deposits are quite variable in their vertical and lateral extent and can also vary in yield (Appendix A, Figure 11). Often existing closer to the surface than the previously described paleovalleys, they can be depleted relatively quickly when drought conditions arise. In many cases, volumes produced are sufficient for domestic wells but are limited for uses that require large amounts of water. These shallow aquifers are also more susceptible to nitrate and pesticide contamination than deeper aquifers. These deposits are of limited extent and are often surrounded by finer-grained materials, which limits their recharge rates compared to other sand and gravel aquifers in LPSNRD, and causes them to be able to store only small quantities of water. Due to these factors, the lenses generally have transmissivities of less than 20,000 gpd/ft (UNL-CSD, 1984) and usually are not sufficient for any purpose other than domestic use.

3.1.5 COARSE-GRAINED SANDS IN MODERN DAY VALLEYS

Recent erosion in river valleys has produced the current topography of southeastern Nebraska. River sands are often too fine-grained or interbedded with clays to yield large volumes of water to wells. However, at some locations in the larger valleys, coarser-grained sediments can be found that yield large water quantities suitable for most uses.

The sand and gravel deposits in the present-day Lower Salt Creek and the Platte and Missouri River Valleys can yield large amounts of useable groundwater (Appendix A, Figure 11). These valleys are being used by Lincoln, Omaha, Plattsmouth, and Cass County RWD # 1 for their water supplies. These aquifers are 50 to 100 feet thick and are primarily recharged by the adjacent rivers. Thus, quantities are sufficient for large-scale withdrawals with transmissivities in these aquifers up to 100,000 gpd/ft or greater (UNL-CSD, 1984). Water quality, however, is often tied to the season and changes in the stream or river water quality.

3.2 GROUNDWATER RESERVOIRS

There are five major groundwater reservoirs identified by LPSNRD that supply useable amounts of groundwater. These five groundwater reservoirs consist of sand and gravel deposits in buried paleovalleys or in present-day river valleys. The locations of the groundwater reservoirs are shown in Appendix A, Figure 1-1 and Figure 11, and their water bearing characteristics are summarized in Table 3-1.

Table 3-1. LPSNRD Groundwater Reservoirs or Aquifers

Groundwater Reservoir or Aquifer	Geologic Material	Aquifer Type	Saturated Thickness (feet)	Transmissivity (gpd/ft)	Range of Depth to Water (feet)
Crete-Princeton-Adams (CPA)	Interbedded sand and gravel, silts and valleys	Generally semi- or unconfined paleovalley	100–300	20,000–200,000	20–150
Dwight-Valparaiso (DV)	Interbedded sand, sand and gravel, silts and clays	Confined and unconfined paleovalley	100–200	20,000–150,000	10–200
Lower Salt Creek (LSC)	Interbedded sand, sand and gravel, silts and clays	Unconfined or semi-confined	<100, some 100–200	20,000–100,0000	0–50
Missouri River Valley (MRV)	Sand and gravel	Generally unconfined alluvium	50–100	0–400,000	0–15
Platte River Valley (PRV)	Sand and gravel	Generally unconfined alluvium	40–80	20,000–100,000	0–15
Dakota Aquifer (DAK)	Sandstone, siltstone and unconsolidated to semi-consolidated sand, gravel, clay, silt and limestone	Generally confined	0–500	N/A	0–600
Other Bedrock aquifers (Limestone)	Siltstone and unconsolidated to semi-consolidated sand, gravel, clay, silt and limestone	Generally confined	0–100	0–50,000	N/A
Other	Sand and gravel lenses in glacial till or along streams	Variable	Highly variable	<20,0000	Highly variable

Smaller, isolated aquifers include the usable portion of the Dakota Aquifer and the RA within the District. The RA (Appendix A, Figure 3) includes other small, often isolated, aquifers not designated as part of any of the aforementioned groundwater reservoirs. The RA is discontinuous in areal distribution and variable in water quantity and quality. For these

reasons, LPSNRD has grouped all areas not identified as "groundwater reservoirs" into the RA. Further small-scale well development is expected in the RA and LPSNRD will delineate any additional areas or groundwater reservoirs as better information becomes available.

3.2.1 CRETE-PRINCETON-ADAMS (CPA)

An area in the southwestern portion of Lancaster County makes up what is referred to as the Crete-Princeton-Adams Groundwater Reservoir (Appendix A, Figure 1-1 and Figure 11). This Groundwater Reservoir is so named because it follows a paleovalley that extends from west of LPSNRD in Saline County near Crete through Lancaster County near Princeton and continues southeast into Gage County around Adams. A typical geologic cross-section showing the geologic sequence of materials deposited below the land surface is included as Appendix A, Figure 3.2.1-1 to illustrate the subsurface. Most wells screened in this groundwater reservoir encounter interbedded clays and sands with the sand layers providing most of the water entering a well. These sand layers can be overlain by thick units of silt and clay causing portions of the CPA Groundwater Reservoir to be "confined" or "semi-confined' and under hydraulic pressure (Appendix A, Figure 12).

3.2.2 DWIGHT-VALPARAISO (DV)

The Dwight-Valparaiso Groundwater Reservoir follows paleovalleys extending from the northwestern part of the District, in Butler County near Dwight and Brainard to the east, near Valparaiso (Appendix A, Figure 1-1 and Figure 11). It also includes the North Oak Creek Valley north of Valparaiso and extends south of Valparaiso toward Raymond. The Dwight-Valparaiso Groundwater Reservoir also extends north and east of Valparaiso and includes portions of the Rock Creek Township. Although the reservoir appears to be representative of aquifer systems from multiple surface water bodies, the majority of the area has hydraulically connected sand and gravel deposits (Appendix A, Figure 11).

In LPSNRD, the north and south portions of the Dwight-Valparaiso Groundwater Reservoir are split by remaining Carlile and Greenhorn-Graneros bedrock units, but both paleovalley reservoirs are underlain by the Dakota Group bedrock unit. The reservoir is composed of saturated sand and gravel units that are occasionally interbedded with finer-grained materials. The DV is mostly classified as confined, as it is overlain with a significant thickness of non-aquifer material (Appendix A, Figure 12). These deposits overlying the bedrock are as much as 455 feet thick in the uplands over the paleovalley (Ginsberg, 1983). Typical geologic cross-sections showing the sequence of materials deposited below land surface are included in Appendix A as Figure 3.2.2-1 and Figure 3.2.2-2.

3.2.3 LOWER SALT CREEK (LSC)

The Lower Salt Creek Groundwater Reservoir extends from northeast Lincoln in Lancaster County to the Ashland area in northwest Cass County (Appendix A, Figure 1-1 and Figure 11) where Salt Creek flows into the Platte River. Development of the LSC Groundwater Reservoir for irrigation occurred generally during the 1950s and 1960s. The LSC Groundwater Reservoir is the most intensively developed groundwater reservoir in LPSNRD. The two dominant bedrock units that form the base of the groundwater reservoir are Pennsylvanian age bedrock and the

Dakota Group. Much of the usable groundwater in the Waverly area occurs above these bedrock formations, although the Dakota aquifer is a source of water south of Waverly.

The axis of a major bedrock paleovalley enters the area south of Malcolm, extends through northern Lincoln to Waverly, and then exits Lancaster County (Holly, 1980). The LSC Groundwater Reservoir is composed of layers of saturated sands and sand and gravel interbedded with silts and clays which have been deposited in this paleovalley. A typical geologic cross-section showing the sequence of materials deposited below land surface is included in Appendix A as Figure 3.2.3-1.

The LSC Groundwater Reservoir is considered an "unconfined" or "semi-confined" groundwater reservoir. Unconfined means that the water table defines the upper limit of the aquifer and there is no artesian pressure created by an impermeable overlying layer above the aquifer. Hydraulic pressure in the aquifer is therefore equal to atmospheric pressure. Semi-confined means there may be some areas where small pressures above atmospheric exist in the aquifer.

In addition to the large paleovalley aquifer in the LSC Groundwater Reservoir, minor sand and gravel aquifers also occur. In some areas, the well yields are normally sufficient only for domestic uses. Marginal aquifers also occur in inter-till sands and gravels throughout the groundwater reservoir; however, their yields are unpredictable.

3.2.4 MISSOURI RIVER VALLEY (MRV)

The MRV Groundwater Reservoir extends from the confluence of the Platte and Missouri Rivers to approximately 4 miles north of Nebraska City, Nebraska in northeast Otoe County (Appendix A, Figure 1-1 and Figure 11).

The base of the MRV Groundwater Reservoir is bedrock composed of various Paleozoic age interbedded limestones and shales that act as a lower confining layer. Between bedrock and the nearly flat floodplain of the Missouri River Valley are unconsolidated sand and gravel deposits that represent the aquifer. The horizontal boundaries of the reservoir start at a centerline in the river and extend westward to the base of the bluffs. The MRV Groundwater Reservoir is an unconfined aquifer, so there is no pressure head in the aquifer. Presently, the MRV Groundwater Reservoir has not been intensively developed for irrigation, due to the availability of surface water in the river that is generally more economical to obtain.

3.2.5 PLATTE RIVER VALLEY (PRV)

The boundaries of the PRV Groundwater Reservoir are that portion of the Platte River Valley that borders LPSNRD (Appendix A, Figure 1-1 and Figure 11). This Groundwater Reservoir begins just northeast of Ashland, at the NRD boundary shared with the Lower Platte North NRD and continues eastward to the mouth of the Platte River near Plattsmouth.

The base of the PRV Groundwater Reservoir is bedrock composed primarily of Paleozoic age limestone and shale. Between the bedrock and the nearly flat floodplain surface lies between roughly 30 and 60 feet of unconsolidated saturated sand and gravel deposits. Although lenses of fine-grained sediment are present in places, these deposits are, for the most part, coarse-grained and are capable of yielding large amounts of water to high-capacity wells. The cities of Lincoln and Omaha both utilize the PRV Groundwater Reservoir for their public water supply

needs. All the available groundwater in the PRV Groundwater Reservoir is considered to be under water table (or unconfined) conditions even though it may be locally confined in some areas. Since the PRV Groundwater Reservoir is shared with the Papio Missouri River NRD, LPSNRD portion is defined as extending from the middle of the river to the base of the bluffs on the south side of the Platte River Valley. The Platte River Valley covers approximately 12.5 square miles. The average valley width is 1 to 2 miles. A typical geologic cross-section showing the sequence of materials deposited below land surface is included in Appendix A as Figure 3.2.5-1.

3.2.6 DAKOTA AQUIFER (DAK)

The Dakota Group underlies a large part of LPSNRD (Appendix A, Figure 10-1). Although quantity and quality of groundwater from this bedrock formation vary, it is an asset to landowners with no other source of water economically available (Lawton et al., 1984). At the present time, numerous wells extend down into this formation, including some higher yielding municipal and irrigation wells.

Recent work has been done in LPSNRD to understand the Dakota Aquifer using AEM data collection techniques (AGF, 2022). Using AEM data, aquifer characteristics including saturated thickness, material classification, and salinity content have been defined for areas of the District where data collection has occurred. Where present, saturated coarse-grained material of the Dakota Aquifer can exceed 400 feet of thickness, making it a potentially crucial source of groundwater where more surficial aquifers are not prevalent.

The quality of the groundwater in the Dakota Aquifer can be variable; however, as highly saline waters in the Dakota Aquifer and deeper Paleozoic age units have been identified with the AEM (Appendix A, Figure 7). These saline conditions can be encountered at shallow depths in areas surrounding Lincoln and extending northeast toward Raymond and Ceresco.

The extents of the portions of the sand/sandstone-dominant portions of the Dakota Group in LPSNRD that can be used for water supply needs are variable, but AEM suggests that significant thicknesses of saturated, coarse-grained material in the Dakota Group exist in northwestern portions of the District around Valparaiso, to the south and west of Lincoln, and also to some degree south of the Platte River in the northeastern area of the District (Appendix A, Figure 10-2). It should be noted that the AEM data collection and interpretation described here has not been performed in the entirety of the District. The extents of the AEM data collection and related study limits are shown in Appendix A, Figure 10-2 (areas without AEM data are shown as “AEM Exclusion Areas”).

3.2.7 REMAINING AREA (RA)

The remaining portion of LPSNRD consists of unconsolidated deposits located between the land surface and the bedrock, and in bedrock layers where the Dakota Group does not exist. The groundwater supplies throughout the remainder of LPSNRD do not occur in quantities equal to that of the five identified groundwater reservoirs and vary from having a limited supply to virtually no supply of groundwater.

The five major groundwater reservoirs, excluding the Dakota Aquifer, underlie approximately one-third of the total land area in LPSNRD. The majority of the RA is underlain by the Dakota Group (Appendix A, Figure 8) and limestone or shale bedrock deposits. The Dakota Group was discussed previously in Section 3.2.6, and the limestone rocks are generally considered a poor source of groundwater. Most wells tapping into bedrock limestone likely take advantage of fractures or voids but usually have low yields, and the groundwater is generally of poor quality.

Some other areas where useable amounts of water may be found are the area north of Lincoln to Davey, and in sand deposits near streams. In these areas, groundwater occurrence and use is greater than the rest of the RA, but large volumes of groundwater generally do not occur in supplies equal to those of the previously described groundwater reservoirs. Smaller intermittent sand deposits may, however, supply adequate water for domestic, livestock, and some industrial purposes.

Approximately one-half of the RA is devoid of reliable useable water supplies, which explains the coverage of RWDs, which were formed to meet the needs of water users in these areas (Appendix A, Figure 6). Many of the wells in the areas covered by the RWDs are not a reliable source of water during dry periods because the quantities of groundwater obtained are unpredictable and of variable quality.

3.3 FUTURE GROUNDWATER USE (DEMAND)

From 1995 to 2025, overall groundwater demands have moderately increased. The number of irrigation wells has increased by about 1 percent each year (from 347 wells to 457 wells or ~4 wells per year), commercial wells have increased around 5 percent each year (~1.5 wells per year), and the number of public water supply wells has risen by about 2.5 percent, or approximately 4.5 wells per year. This increase in number of wells reflects the growing demand in LPSNRD, especially for public and private domestic supplies and commercial/industrial water use.

According to the 1995 GWMP, the City of Lincoln was planning for a population of approximately 261,200 by the year 2020 and a peak summer usage that could approach 122.5 MGD (million gallons per day). However, the actual 2020 population of Lincoln was approximately 291,000, the average well field pumpage was 46 MGD, and the maximum peak summer usage approached 180 MGD (City of Lincoln, 2020). From 2000 to 2018, Lincoln's average annual usage was approximately 13,000 million gallons (MG), or 35.5 MGD.

In the future, Lincoln projects a 2050 population of approximately 418,000 and a maximum peak hour usage of 235 MGD. The average day usage in 2050 is projected to rise to 52 MGD, or approximately 19,000 MG per year. Historically, Lincoln has met its increasing demand for public water supplies by expanding its existing well field along the Platte River near Ashland. Lincoln's existing municipal groundwater transfer permits allow a maximum daily withdrawal of 110 MGD. The latest projections for Lincoln's Water System show peak demand exceeding this daily maximum by approximately 2048 following the construction of their sixth horizontal collector well (City of Lincoln, 2023).

Starting in 2022, Lincoln commissioned a Water Source Advisory Council to address securing a second source of water supply to meet the projected water capacity needs of Lincoln through

2075. The final recommendation of the advisory council was to add a 40 MGD well field and treatment facility along the Missouri River with direct transport of treated water to Lincoln (City of Lincoln, 2023).

In 1994, Lincoln prepared a WMP to promote water conservation and enact water use restrictions. This plan has been revised, with the latest update in 2022. The purpose of the plan is to keep water use in Lincoln within pumping capacity and delivery capability of the system and to define procedures and communication plans when demand exceeds pumping and delivery capacity. Lincoln's plan addresses a four-phase action plan to curtail summer water use when use would exceed the capability of the water system. The WMP also has a Water Supply Restriction Plan to be implemented in emergency situations. This three-level plan addresses the actions necessary to sustain life and maintain the health of the community under severe emergency conditions.

Most other communities have not identified additional sources for their water supply or prepared written contingency plans. Those communities that have identified supplemental water sources mention drilling new wells or possibly purchasing water from a larger nearby community or RWD. Communities such as Waverly, Greenwood, and Ashland are near the City of Lincoln's existing water transmission line, but there is no existing infrastructure to allow these communities to receive supplemental water from Lincoln.

LPSNRD does not currently own or operate any RWDs or regional water systems. Other NRDs that have established and operate RWDs have generally done so under the improvement project area authority granted to NRDs in Nebraska Revised Statute 2-3252. Improvement Project Areas (IPAs) can be established within an NRD for the purpose of carrying out projects authorized by law that result in special benefits to lands and property within such improvement project areas. The cost of any construction, capital improvements, or operation and maintenance involved in such special benefit portions of a project shall be recovered by the NRD by collecting special assessments or fees. In the case of RWDs or regional water systems, those receiving water supplies will typically repay the total cost of the project via hook-up fees and payments for water deliveries.

Commercial and industrial economic growth is expected to increase the demand for groundwater use throughout LPSNRD, including water needs for power production, technology, transportation, manufacturing, mining, and grain and food processing.

3.4 GROUNDWATER ELEVATIONS (HISTORIC)

Since 2014, the groundwater elevations in most wells that were measured consistently have remained relatively stable. A total of 132 wells were measured in 2014 and, of those, 89 exhibited slight declines and 43 exhibited slight increases over time. Of the wells considered here, the average groundwater elevation change has been a decrease of 0.36 foot. This was calculated by comparing the groundwater level in each well as measured in 2014 and the most recent measurement. The average decline of the 91 wells that have exhibited lower groundwater elevations since 2014 is 2.11 feet, and the average increase in the 41 wells that have exhibited higher groundwater than in 2014 is 3.28 feet. These statistics for all of LPSNRD's

groundwater reservoirs are available in Table 3-2. Static groundwater elevations and the estimated depth to groundwater are shown in Appendix A, Figure 13.

Table 3-2. LPSNRD Principal Groundwater Reservoirs Groundwater Elevation Change Since 2014 Summary

Groundwater Reservoir or Aquifer	Number of Analyzed Wells (Number of Declining Wells/Number of Increasing Wells)	Average of All Measurements in feet (standard deviation)	Average of Declines in feet (standard deviation)	Average Percent of Sat. Thick. Decline (Avg. Sat. Thick. feet)	Maximum Decline (Well ID)	Maximum Increase (Well ID)
Crete-Princeton-Adams (CPA)	29 (22/7)	Decline of 1.05 (3.78)	2.3 (2.97)	-1.44% (160)	15.42 (56169)	10.39 (128565)
Dwight-Valparaiso (DV)	17 (6/11)	Increase of 1.53 (1.79)	0.41 (0.21)	-0.27% (150)	0.66 (173052)	5.56 (204449)
Lower Salt Creek (LSC)	23 (16/7)	Increase of 0.06 (5.25)	2.37 (4.1)	-3.13% (75)	17.98 (105654)	9.58 (1324)
Missouri River Valley (MRV)	2 (2/0)	Decline of 3.1 (2.59)	3.1 (2.59)	-4.16 (75)	5.68 (83028)	No Increases
Platte River Valley	3 (2/1)	Increase of 0.53 (1.76)	0.66 (0.64)	-.87% (76)	1.29 (75249)	2.91 (59421)
Dakota Group (DAK)	25 (18/7)	Decline of 1.5 (4.44)	2.7 (4.46)	-1.58% (115)	20.49 (113767)	7.43 (128615)
Remaining Area (RA)	33 (23/10)	Decline of 0.06 (3.87)	1.78 (1.97)	-1.77% (100)	8.13 (128609)	15.44 (195706)

3.5 GROUNDWATER ELEVATION MONITORING

Since 1994, LPSNRD has collected at least one depth to water measurement in 236 wells across the district. Of these, 163 have had at least one measurement recorded in the last 10 years. All wells are measured at least twice annually in spring and fall, and 30 have dataloggers installed for continuous monitoring. These are maintained by LPSNRD staff in conjunction with the CSD of the University of Nebraska, as well as ENWRA.

3.6 GROUNDWATER QUANTITY CONCERNS

The quantity of groundwater available for extraction by wells across LPSNRD is affected by local geology and hydrogeologic properties, groundwater flow, alluvial interaction with streams and rivers, and the climate's impact on surface water supplies and groundwater recharge.

The groundwater reservoirs described in Section 3.2 reflect which geologic units are typical sources of groundwater. As shown in Appendix A, Figure 5, very few active wells exist in Cass and Otoe Counties outside of the LSC, PRV, and MRV Reservoirs. This is primarily due to the lack of saturated sediments above bedrock (shown in Appendix A, Figure 9) and the extent of the bedrock units (shown in Appendix A, Figure 8). The Pennsylvanian bedrock units, roughly east of 96th Street and south of McKelvie Road in LPSNRD, have minimal or no saturated

sediments above them, limiting or fully preventing the installation of low-producing wells in the RA. North of McKelvie Road and west of 96th Street in Cass County, opportunities for limited groundwater supplies exist within the sandstones of the Cretaceous Dakota Group (Appendix A, Figure 10-2).

Other limitations to available groundwater supplies due to geology can occur when well interference within confined or partially confined areas of saturated sand and gravel aquifers forces groundwater elevations to drop significantly. The elevation of non-aquifer material above or in the same layer as the water table was used to identify confined, potentially confined, or likely unconfined aquifers (Appendix A, Figure 12).

Continuous recording monitoring wells in the DV Reservoir have reported seasonal declines of 50 to 80 feet during the summer irrigation season. As these declines have previously caused some wells to decline below their operational level, LPSNRD designated an SMA, known as the Dwight-Valparaiso-Brainard Area, to minimize pumping conflicts and protect groundwater supplies for all beneficial uses. The requirements of this SMA are described in Section 1.3. It is possible that other confined aquifer areas within the District (Appendix A, Figure 12) may also experience well interference issues in the future.

Estimated annual groundwater recharge ranges between approximately 2 inches in western areas of the District, to 7 inches or more in the eastern areas of the District and along the Platte River (Appendix A, Figure 2). This geographic distribution of recharge is not only consistent with precipitation patterns (Appendix A, Figure 2), but also with soil infiltration capacity based on AEM-derived interpretation of materials present near the land surface (Appendix A, Figure 14). Groundwater recharge is also seasonal with less recharge during the growing season when photosynthesis is active, versus excess soil moisture becoming recharge during the non-growing season (Cherry, 2020).

In contrast, groundwater flow rates (specific discharge) follow a different pattern within LPSNRD. Estimated flow rates vary widely between less than 1 foot per day up to more than 100 feet per day. Groundwater reservoirs in Saunders, Butler, Seward, and Lancaster Counties generally have higher transmissivity and groundwater flow rates than upland aquifers in Cass and Otoe Counties (Appendix A, Figure 15).

The Lower Platte River, its tributaries, and aquifers serve approximately 80 percent of Nebraska's population comprising thousands of businesses and industries and more than 2 million irrigated acres and provide stream flows for threatened and endangered species. Flows in the Platte River are monitored by the City of Lincoln as part of its Water Management Plan (Rev 2022) and the Lower Platte River Drought Contingency Plan (DWEE, 2024). As flows decrease, Lincoln implements water conservation phases, which include actions such as mandatory designated outdoor watering days or indoor water use only. Members of the Lower Platte River Consortium monitor drought conditions through an online dashboard and have established drought triggers as shown in Table 3-3.

Table 3-3. Lower Platte River Drought Contingency Plan Drought Triggers

Category	U.S. Drought Monitor Level	Palmer Drought Severity Index (PDSI)	Platte River Flow at Ashland (cfs)	Standardized Precipitation Index (SPI)
Abnormally Dry	0	-1.0 to -1.99	>3,000	-0.5 to -0.7
Moderate Drought	1	-2.0 to -2.99	1,500 to 3,000	-0.8 to -1.2
Severe Drought	2	-3.0 to -3.99	500 to 1,500	-1.3 to -1.5
Extreme Drought	3	-4.0 to -4.99	< 500	-1.6 to -1.9
Exceptional Drought	4	-5.0 and below	Negligible Flow	-2.0 or less

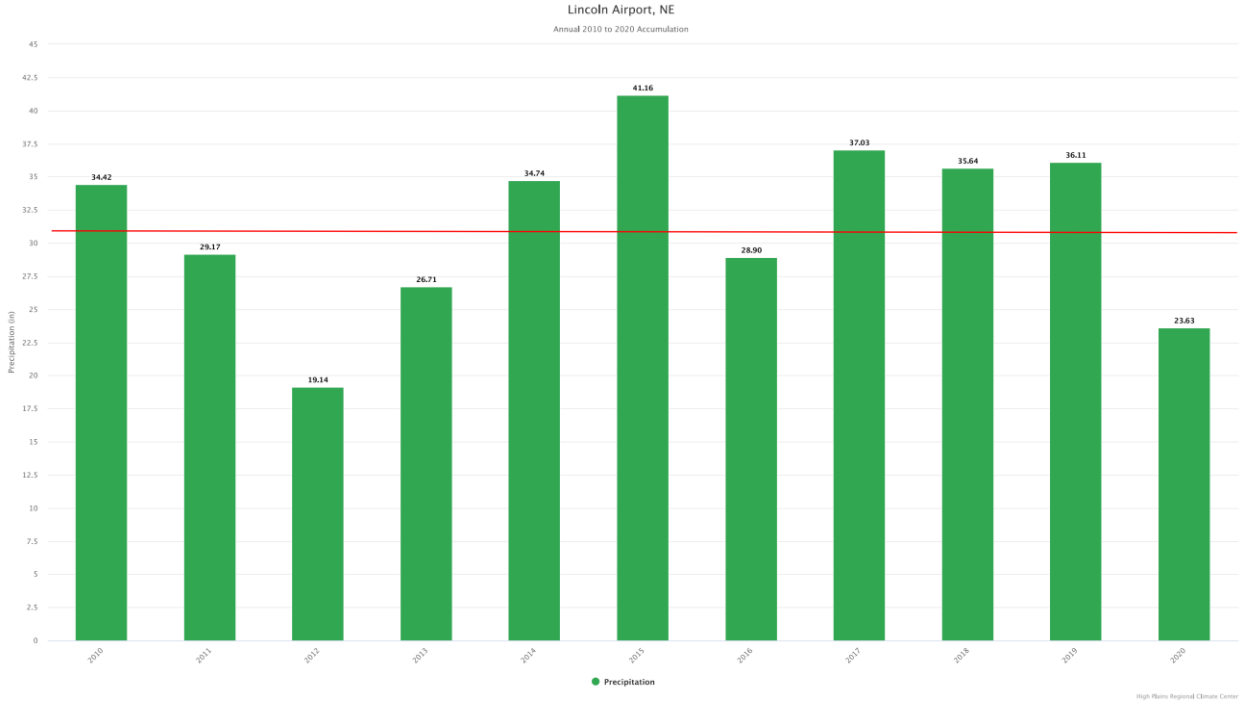
Overall, it is anticipated that short and long-term droughts have the greatest potential of negatively impacting groundwater quantity by reducing total groundwater recharge, from reduction in both precipitation infiltration, and from stream infiltration. Surface water supplies are also significantly reduced during drought conditions, leading to equal or less discharge into hydrologically connected gaining streams and rivers, and further reducing alluvial groundwater elevations. An assessment of future climate impacts on estimated groundwater supplies and elevations during dry, normal, and wet conditions is included in the next section.

3.6.1 FUTURE CLIMATE ASSESSMENT ON GROUNDWATER QUANTITY

In wet years, more water is available for aquifer recharge and less supplemental irrigation water is pumped from aquifers, resulting in modest groundwater elevation increases that coincide with increased baseflow discharge to receiving surface waters. Conversely, in extremely dry years, less water is available for recharge, more water is pumped for both urban and agricultural irrigation, and some baseflow discharge to streams and rivers still occurs, resulting in net declines in groundwater elevations. As a result, groundwater elevation declines during years of drought tend to be more substantial than recoveries in extremely wet years. For example, following the extreme flooding across Nebraska in 2019, statewide average depth to water in wells experienced an average rise of 1.6 feet. Following the extreme drought of 2012, the average depth to water in wells declined by over 2.5 feet (UNL 2025b).

Groundwater elevations in 15 continuously monitored wells in various groundwater reservoirs across LPSNRD were evaluated along with historic net recharge data from the LP3D Groundwater Model. These wells generally began continuous monitoring in 2012 or 2014 and recharge data from the groundwater model is available through 2020. Shown in Figure 3-1, the annual precipitation for these years was generally above the 31 inch 30-year normal average precipitation in Lincoln.

Figure 3-1. Annual Precipitation at the Lincoln Airport (2010–2020)



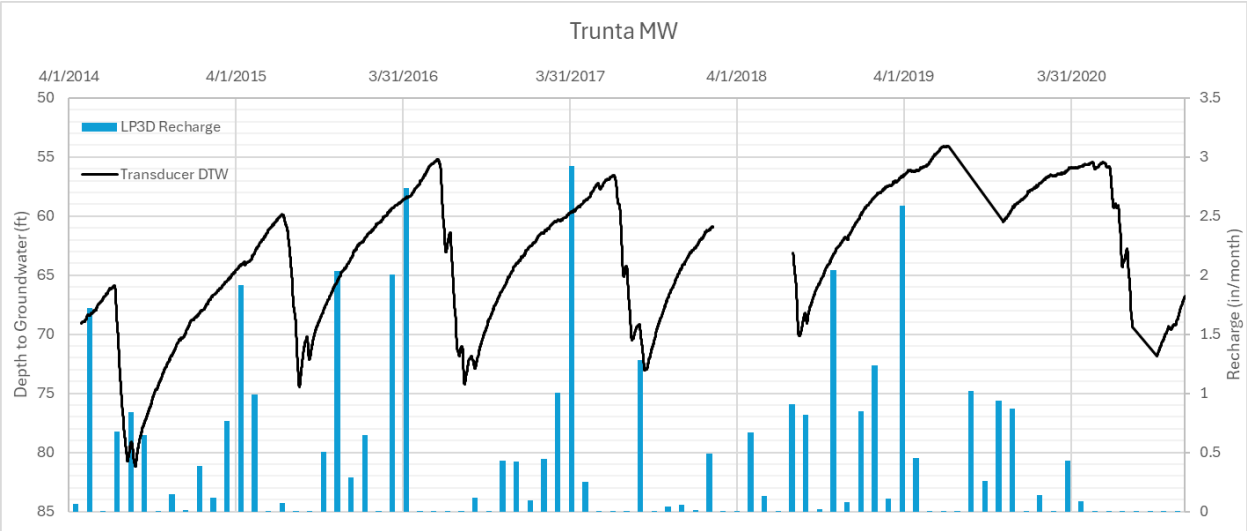
While this period, from 2012 to 2020, did include an extreme dry period, the groundwater elevation data show recovery from the 2012 drought and short-term responses to projected periods of minimal recharge. In fact, declines and recovery in the groundwater elevation data vary by reservoir, and react differently to various conditions, including:

- Confined versus unconfined;
- Irrigation season pumping;
- Time periods with and without estimated recharge; and
- Hydrologic connection with surface water.

Six of the 15 monitoring wells are located in the DV Reservoir. Several of these wells are located within confined or semi-confined aquifers and can show large declines ranging from 10 to over 50 feet during the summer irrigation season. Groundwater elevations in the wells generally recover in the fall and winter depending on the amount of recharge that occurred in the non-growing season. However, this reservoir is in the northwest corner of LPSNRD where infiltration rates through the soil are generally lower, several confining layers exist, it is not within the hydrologically connected area, and it receives lower average annual rainfall. Overall, the DV Reservoir only receives an average of 2 to 4 inches of net recharge per year. The graph below, Figure 3-2, shows an example of this data comparison from 2014 to the end of 2020.

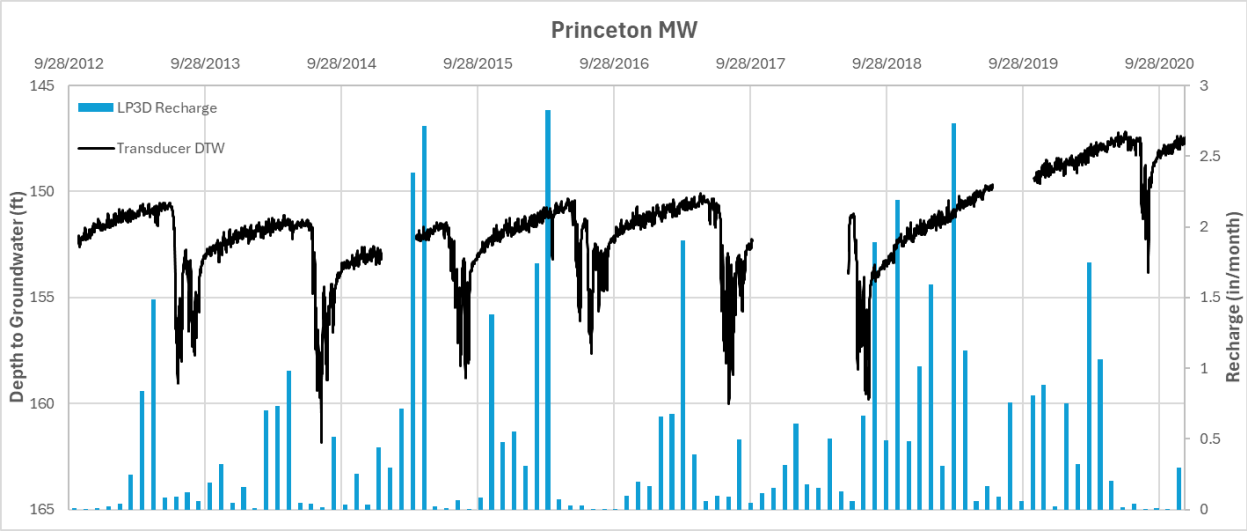
LOWER PLATTE SOUTH
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Figure 3-2. DV Monitoring Well Depth to Groundwater and Monthly Recharge



Another three of the continuous monitoring wells are located in the CPA Reservoir, see data below in Figure 3-3 comparing estimated recharge to continuously recorded groundwater elevations. The majority of the CPA Reservoir is not confined but may be semi-confined. Surface soils and geology above this aquifer generally have high infiltration potential, see Appendix A, Figure 14, and total average net recharge is between approximately 3 and 5 inches with more consistent recharge occurring in all months of the year.

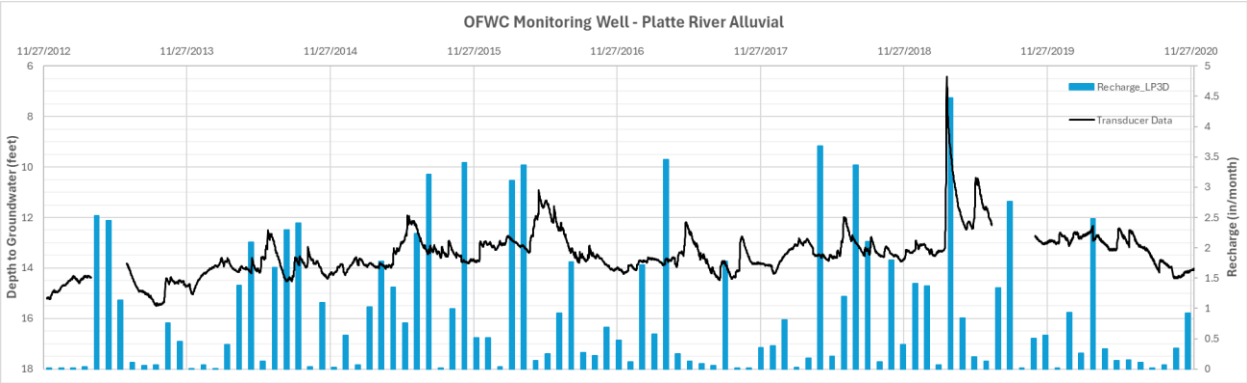
Figure 3-3. CPA Monitoring Well Depth to Groundwater and Monthly Recharge



Four of the remaining six continuous monitoring wells are located in alluvial aquifers in the LSC, PR, and MR Reservoirs, while the other two are wells in the DAK Reservoir. The four alluvial aquifers are hydrologically connected to surface water, and the decline or rise of their groundwater elevations is responsive to changes in surface water elevations and discharges. This can be seen in the example Figure 3-4 from a monitoring well along the Platte River.

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Figure 3-4. PRV Monitoring Well Depth to Groundwater and Monthly Recharge



Groundwater elevation changes react to climatic conditions based on recharge, surface water supplies, and changes in groundwater needs and withdrawals. Evaluating the groundwater quantity changes by reservoir in relation to the current climate changes reported in Section 2.2 can provide insights into how these aquifers may react to future wet, dry, and normal climate conditions in the future.

Overall, future climate changes are anticipated to impact water resources across LPSNRD in the following ways (based on information from UNL 2025b):

- A generally warmer atmosphere allows for more moisture and potentially more precipitation. However, it is anticipated that precipitation will fall in heavier, more intense and extreme, storm events throughout the year. This, plus an overall increase in total annual precipitation, may lead to more surface water runoff and the same or slightly less groundwater recharge.
- Seasonal shifts are likely to result in less precipitation and a longer vegetation growing season during the summer. Temperatures in summer and fall are projected to warm more than winter and spring. The number of consecutive dry days per year (one indicator of drought) may also increase by the end of the century, especially across the eastern portion of the state. All combined, this has the potential to increase the difference between vegetation water needs (crops and lawns) and the available soil moisture from precipitation, ultimately resulting in higher demand for irrigation.
- The shift to more precipitation in the spring and fall, and an overall increase in frost-free days, could lead to additional soil moisture that may be available for groundwater recharge during the non-growing season.

Applying these anticipated climate change impacts with the groundwater elevation change evaluation for the major groundwater reservoirs in LPSNRD, the following conclusions may be inferred:

- Significant seasonal groundwater elevation declines are likely to continue to occur in the DV Reservoir due to confined conditions and declining or stagnant recharge. During dry or drought conditions, declines in

groundwater levels may continue to exceed 50 feet as pressurized conditions in confined areas of the aquifer can become unpressurized while groundwater is extracted. During extended periods of drought, greater than 1 year, the groundwater quantity stored in the DV Reservoir would be expected to decline with year-over-year decreases of approximately 3 to 5 feet. As data from the recent time period shows in Figure 3-2, normal to wet years can increase groundwater elevations between 1 and 3 feet. Groundwater declines resulting from drought events tend to have roughly double the impact on groundwater levels compared to years with above average annual precipitation (UNL, 2025b).

- The CPA Reservoir has a higher probability of being affected by climate change due to its higher soil infiltration capacity and observed groundwater elevation reactions to changes in available recharge. Even though the typical saturated thickness of the CPA Reservoir is greater than 150 feet, if flash or long-term droughts significantly curtail recharge and forced greater groundwater use, groundwater elevations could potentially decline by as much as 2 to 4 feet per year. Conversely, groundwater elevation gains of only 1 to 2 feet were recorded during the wet years of 2018 and 2019.
- Alluvial aquifers in LPSNRD are likely to reflect the highs, lows, and timing of surface water flows during fluctuations between extreme drought or flooding. Long-term changes to climatic conditions are expected to make these fluctuations greater in magnitude and occur more often. Groundwater elevations in the LSC, PR, and MR Reservoirs will certainly vary during these significant changes but are not expected to decline more than 1 to 2 feet each year and should quickly recover as soon as the dry period has ended and surface water flows return to near normal. Only minimal increases in groundwater elevations are expected during wetter than normal periods, as this typically leads to increased baseflow discharge to receiving streams or rivers.

Comparing water quantity impacts from anticipated climate change with estimated groundwater aquifer responses points to possible declines in groundwater elevations in most reservoirs across LPSNRD during extreme drought conditions. For the DV and CPA Reservoirs with average saturated thicknesses of 150 feet, it would likely take a 3-year drought or longer before groundwater levels fell below 8 percent of the saturated thickness and recovery in these reservoirs could take twice as long as the drought period depending on normal or above-normal precipitation. In other alluvial groundwater reservoirs in the NRD with hydrologic connection to surface water, it would be less likely for groundwater elevations to fall below 8 percent of the saturated thickness, ranging between 50 and 75 feet, during anticipated drought conditions over various time periods.

4 GROUNDWATER QUALITY

Water quality in the LPSNRD can be characterized as highly variable due to diverse geology, multiple possible sources of contamination, and a wide range of vulnerability and risk. The use of water in LPSNRD can be limited by not only the availability of the water supply, but where adequate water supplies are present, the quality may not be sufficient for the intended use.

Water quality in the sand and gravel alluvial aquifers and buried paleovalleys is usable for most purposes. The water quality of the Dakota Aquifer is highly variable and may contain relatively large concentrations of dissolved solids, metals, nitrate/nitrogen and salt (specifically in portions of Lancaster County). This difference in background water quality accounts, in part, for the varied groundwater development across the District.

Water quality data have been collected by a number of agencies for various purposes in LPSNRD. A summary of available water quality data is given below:

- *Lower Platte South NRD:* LPSNRD began sampling water wells in 1984. At that time, 14 wells were selected, sampled, and analyzed for 12 major cations and anions including nitrates. In 2024, LPSNRD collected and tested nearly 350 samples for nitrate-nitrite alone, as well as numerous samples tested for other constituents. All other sample results taken during studies are included with datasets from the Nebraska Groundwater Quality Clearinghouse.
- *City of Lincoln:* Extensive water quality data have been collected by the City from its well field located along the Platte River at Ashland and from the Antelope well field in Lincoln. These results are maintained by the City in its own data files and are available to LPSNRD upon request.
- *Lincoln-Lancaster County Health Department (LLCHD):* The County requires yearly sampling for nitrates of all wells located within the City of Lincoln and a one-time sampling of all wells for nitrates located within a 3-mile radius of the City of Lincoln. In addition, nitrate samples collected for real estate transactions are also retained by the County.
- *State Department of Health:* Municipal water supplies are sampled for a variety of parameters as required for the Safe Drinking Water Act. These samples are collected either at the tap or at the entry point to the distribution system. This data is maintained by the State and is available to LPSNRD upon request.
- *DWEE:* The Nebraska State Legislature commissioned a study of Nitrate in Drinking Water across Nebraska in 2023. The study resulted in nearly 3,500 private domestic well nitrate samples statewide (DWEE, 2024)
- *USGS Cooperative Study:* A past 3-year study identified and sampled approximately 46 suitable monitoring network wells (USGS, 1994).

Most of the groundwater quality monitoring data has been archived online in the Nebraska Groundwater Quality Clearinghouse (n.d.). As of 2025, the clearinghouse contains 60,561 sample results in LPSNRD for more than 150 different analytes. Table 4-1 documents the submitting agency, number of samples, and dates for which data in the clearinghouse was collected.

Table 4-1. Groundwater Quality Monitoring Data from the Nebraska Groundwater Quality Clearinghouse

Agency	Number of Samples	Date From	Date To
LPSNRD	53184	1984	2024
DWEE	4391	2010	2024
Lincoln-Lancaster Co Health Dept	454	2013	2015
USGS	52	1984	2009
Nebraska Department of Health and Human Services	1356	1987	1995
Other	1124	1978	1999

4.1 SAFE DRINKING WATER AND PUBLIC HEALTH

According to the latest research, contaminants in groundwater can be linked to a range of health issues, including:

- Gastrointestinal illnesses caused by harmful bacteria or viruses.
- Methemoglobinemia, or blue-baby syndrome, caused by ingesting high nitrate/nitrite concentrations, which interfere with the ability of the body's blood to carry oxygen.
- Preterm birth issues and birth defects.
- Organ damage due to prolonged exposure, as well as damage to immune and reproductive systems.
- Neurological issues when certain contaminants affect the nervous system.
- Certain types of cancer have been linked to long-term exposure of harmful contaminants in groundwater.

The Nebraska Safe Drinking Water Act (Act) establishes regulations to ensure the safety and quality of public drinking water in Nebraska, aligning with standards recommended by the Federal Safe Drinking Water Act (SDWA). Monitoring and compliance of public water systems across Nebraska ensure compliance with standards set for over 90 potential drinking water contaminants. Since the SDWA does not regulate private domestic wells, studies have shown the most at-risk populations for exposure to nitrate contamination are those utilizing private domestic wells located in agricultural areas (Ward, 2018).

In the November 2024 Nebraska Nitrate in Drinking Water Study final report (DWEE, 2024), it states:

> *"A literature review from Ward et al. (2018) of epidemiologic studies involving nitrate intake from drinking water found that the strongest evidence for a relationship between nitrate ingestion from drinking water and negative health outcomes (other than methemoglobinemia) is for colorectal cancer, thyroid disease, and neural tube defects."*

An ongoing EPA reassessment of orally ingested nitrate and nitrite could eventually lead to a revised MCL; however, the current MCL for nitrate in the SDWA is still 10 milligrams per liter (mg/L), which is based on the acute effect of methemoglobinemia in infants and other sensitive populations.

4.2 SOURCES OF POLLUTION

4.2.1 POINT SOURCE POLLUTION

Point source pollution generally impacts the quality of the groundwater in localized areas. However, when these sites overlie potential drinking water supplies or are located adjacent to wells, the impact of a spill or leak can affect larger populations.

A large number of manufacturing facilities, petroleum handling facilities, and agricultural-related businesses, such as grain storage bins and fertilizer and pesticide storage facilities, exist within LPSNRD. Although regulations and generally improved product and waste handling procedures have reduced the chances of a spill or release of contaminants from these types of activities, numerous spills have been documented.

A groundwater quality management area can only be designated for non-point sources of pollution either by an NRD or the State Director of DWEE, per Nebraska Rev. Stat. 46-724. Contamination from point sources must use the procedures authorized in the Environmental Protection Act pursuant to Section 46-723.

Underground Storage Tanks Hydrocarbon Releases

This type of release generally involves a spill or leak from buried tanks at gas stations or industrial sites. Known as Leaking Underground Storage Tanks (LUSTs), they are regulated by the Department according to provisions of Nebraska Titles 118 and 126. Some LUST spills have been traced to locations that are no longer used as gas stations. In these cases, the spills are known as "orphan tanks" and regulated and investigated by DWEE. It is not uncommon to have several LUST sites located within the same block or heavily used highways and streets.

Hazardous Waste Releases

Hazardous waste releases are defined as those sites where contaminants other than petroleum have been found in groundwater. Such sites are often associated with manufacturing, petrochemical, or grain storage facilities. Hazardous waste sites are regulated in Nebraska by either DWEE according to provisions in Nebraska Titles 118 and 126 or by the EPA according to provisions of the Resource Conservation and Recovery Act (RCRA) or the Comprehensive

Environmental Response, Compensation, and Liability Act (CERCLA), commonly referred to as "Superfund."

Public water supplies in the State regularly test for the presence of Volatile Organic Compounds (VOCs). These compounds are generally mobile in groundwater and include many common solvents, degreasers, paint thinners, septic tank cleaners, and grain fumigants.

National Pollution Discharge Elimination System (NPDES) Permit Program

The NPDES Permit Program controls the discharge of pollutants to Waters of the State, including groundwater, through establishment of operational requirements and discharge limitations for municipal, industrial, and commercial wastewater dischargers. In LPSNRD, there are approximately 1,800 facilities, excluding animal confinement operations regulated under this program, with over 1,370 of these located within Lancaster County. See Table 4-2.

Table 4-2. NPDES Permitted Facilities in LPSNRD

County	Number of Facilities
Lancaster	1,376
Cass	302
Saunders	66
Seward	45
Otoe	13
Butler	13

NPDES permits require the construction, operation, and maintenance of wastewater treatment systems. Monitoring and inspections of regulated facilities are required to ensure compliance with permit conditions.

This program has protected and sustained the beneficial uses for the stream segments of the state. It has also assisted in bringing nonattainment areas (water quality limited stream segments) up to their designated beneficial use.

Nebraska Pretreatment Program

The Nebraska Pretreatment Program controls the discharge of industrial wastewater to Publicly Owned Treatment Works (POTWs). Uncontrolled industrial discharges can cause serious problems at POTWs, including hazardous or explosive conditions in the collection system, inhibition of the biological wastewater treatment process, and contamination for wastewater sludge. Industrial pollutants can also pass through a POTW untreated causing problems in the receiving streams.

Livestock Waste Control Facilities

Presently, there are nearly 500 Livestock Waste Control facilities located within LPSNRD that are permitted and regulated by the Department (State of Nebraska GIS Web Portal). See Table 4-3. Of these permitted facilities, approximately 330 are regulated for Confined Animal Feeding Operations (CAFOs). The principal pollutants associated with feedlots are nitrogen, phosphorus, chloride, organic materials, and microorganisms. High levels of livestock waste

pollution may also cause discoloration, odor, and taste problems in drinking water supplies. The potential for groundwater pollution will depend upon the management of animal wastes, application timing on cropland, and infiltration rates of the parent soil material.

Table 4-3. Livestock Waste Control Facilities in LPSNRD

County	Number of Facilities
Lancaster	220
Cass	145
Saunders	51
Seward	41
Otoe	13
Butler	11

Private Septic Systems

A conventional private septic system consists of a septic tank and soil absorption field. Liquid waste flows from household tanks to the soil absorption field where it is treated as it filters through the soil. Soil type is crucial to this process, since only certain types of soil can properly treat the effluent. A soil with large pores allows the effluent to move quickly and does not hold it long enough for complete treatment before it seeps into groundwater. For example, increased installation of septic systems for recreational households along the Platte River, where the water table is shallow and soils are coarse, may pose a potential pollution problem to water supplies. Where soil is too tight, the septic system will not drain adequately and may break down or cause nuisance conditions. Pollutants of concern from septic systems are nitrate, bacteria, viruses, and hazardous chemicals.

The location of septic systems in relation to drinking water supply wells is crucial in determining whether they cause contamination. Many domestic wells are located in close proximity to septic systems and can intercept contaminants. If the well is improperly constructed, the well may even serve as a conduit for pollution. Where local hydrogeology is suitable and the well and septic systems are properly constructed, private septic systems may not cause groundwater contamination problems. Under existing regulations, private domestic wells must be located at least 100 feet from existing or proposed septic systems.

There are roughly 5,000 septic systems in LPSNRD; an approximate breakdown by county is shown in Table 4-4 (State of Nebraska GIS Web Portal). Towns with wastewater collection and treatment plants are less likely to have septic system pollution, although municipal wastewater piping may leak locally and contaminate groundwater. The greatest density of septic systems is found on acreages in the vicinity of Lincoln. Other subdivisions outside the City of Lincoln's service area are being developed using common disposal systems.

Table 4-4. Private Septic Systems in LPSNRD

County	Number of Septic Systems
Lancaster	3,292
Cass	1,186
Saunders	259
Seward	246
Otoe	30
Butler	51

Improperly Abandoned Wells

Abandoned water wells can serve as conduits for groundwater pollution if they are not properly sealed to prevent the infiltration of surface contaminants. Nebraska Statute R.R.S. 46-602 requires the proper decommissioning of illegal water wells. Since 1990, LPSNRD has offered a well-decommissioning cost-share program to assist landowners with proper decommissioning of illegal water wells on their property. The LPSNRD coordinates with county and state authorities to notify landowners of illegal water wells on their property and inform them of their responsibility to decommission those wells in accordance with state regulations.

In accordance with Nebraska Administrative Code Title 178, Chapter 12, wells constructed since 2014 are required to have a primary aquifer seal around the well casing either at: 1) a known aquitard (silt/clay layer) above the production zone, 2) at the top of the gravel pack just above the screened openings, or 3) at or immediately below the static groundwater elevation. This additional aquifer seal helps reduce pollutants and contaminants in the vadose zone from traveling along the outside of the well casing and into the primary aquifer.

4.2.2 NON-POINT SOURCE POLLUTION

Non-point source pollution is generally defined as pollution from diffuse sources where no single point of release can be identified. While non-point source pollution can be related to weathering of minerals or soil erosion, human activities are commonly the originator for non-point source groundwater pollution. The diffuse application of fertilizers, pesticides, and herbicides in agricultural operations account for large areas of land with soils containing these additives. If overapplication occurs, coupled with heavy precipitation or overirrigation, these chemicals can leach into the groundwater and contaminate it.

In Nebraska, nitrate is the most common non-point source pollutant. Water quality studies conducted in LPSNRD (Spalding, 1990) concluded that widespread pesticide and herbicide contamination is not apparent in LPSNRD, but there is evidence that some non-point pollution is present. Section 4.4 discusses and evaluates the extent of non-point contamination in LPSNRD.

4.3 GROUNDWATER QUALITY VUNERABILITY (RISK)

The vulnerability of groundwater to spills and releases of contaminants or the application of fertilizers and pesticides is dependent upon many factors including the volume and type of the potential pollutant as well as the subsurface hydrogeologic features and properties of the area. Groundwater vulnerability across LPSNRD was analyzed by creating a matrix that includes the depth to groundwater across the District and whether the groundwater is classified as confined. This matrix is shown spatially in Appendix A, Figure 16, and the inputs are described below.

4.3.1 DEPTH TO GROUNDWATER

Depth to water can be defined as the distance between the land surface and the elevation of the water table. It is a measurement of the total thickness of the geologic material through which a

contaminant must move before reaching the groundwater. As a rule, the greater the depth to water, the longer the travel time in the unsaturated zone and the greater the opportunity for attenuation and reduced concentration of a contaminant.

Appendix A, Figure 13 shows the relative depth to water within LPSNRD (LRE Water, 2023). This surface was created using depths to water in publicly available registered well logs, LPSNRD static groundwater elevation records, and stream elevations from the National Elevation Dataset.

Depths to water range from less than 5 feet to greater than 250 feet in LPSNRD. Shallow depths to water (<25 feet) occur in the Platte and Missouri River Valleys, and along Salt Creek and its tributaries. Greater depths to water exist in areas moving away from the river and stream valleys with the largest values, >100 feet, occurring in the uplands of Cass and Otoe Counties, the western, southern, and northern parts of Lancaster County, the western parts of Seward and Butler Counties, and the southwestern part of Saunders County.

4.3.2 CONFINING STATUS OF AQUIFER

Whether or not the surficial aquifer within LPSNRD can be considered confined or protected from infiltration of contaminants originating on the surface, was analyzed using AEM resistivity data that have been collected across a majority of LPSNRD. Hydraulic properties of different layers in the subsurface have been extrapolated from the AEM data (JEO, 2026) and were used to identify where material classified as "non-aquifer" exists above the water table described above (Appendix A, Figure 12).

4.3.3 GROUNDWATER VULNERABILITY

This analysis, documented in Appendix A, Figure 16, shows that groundwater is most vulnerable in the Platte and Missouri River Valleys and their tributaries, and in parts of the Lower Salt Creek watershed where confining conditions do not exist and groundwater levels lie close to the surface. There are also many upland areas within LPSNRD described in Section 4.4.1 that also benefit from confining material overlying the water table that acts as additional protection from surficial contamination (Appendix A, Figure 12).

4.3.4 LAND USE AND CHEMICAL APPLICATIONS

The use of land overlying a groundwater reservoir is often an important factor in the condition of the groundwater resource. While many factors interact to determine the pollution potential of a groundwater reservoir, the use of the land above it may directly influence water quality. An analysis of land use patterns in LPSNRD is presented here as a foundation for analysis of its relationship to contamination.

As noted in Section 2.4, the largest percentage of land use in the District is for agricultural purposes. Within this category, cultivated land accounts for approximately 62 percent of the total acreage of the District. Most of the remaining agricultural lands are used as pasture. The distribution of irrigated cropland is a good indicator of the distribution of groundwater reservoirs in LPSNRD because water quantity and quality are sufficient for crop production.

Agricultural land use for crop production is often identified as the primary contributor to non-point source nitrate pollution. Commercial fertilizers applied to crops can leach through the soil profile and enter the groundwater reservoir if physical conditions are favorable to leaching. The source of water that leaches the fertilizers can be from heavy rain, flooding, or overapplication of irrigation water.

Only approximately three percent of LPSNRD land area is irrigated land, so leaching of nutrients or contaminants due to overirrigation is not likely a widespread non-point source pollution problem. The most intensively irrigated area is in the LSC Groundwater Reservoir, with the largest and oldest irrigated area dating back to the 1950s. Irrigation development in the CPA and D-V Groundwater Reservoirs occurred later in the 1970s and 1980s and is not as intense as the LSC Groundwater Reservoir.

4.4 GROUNDWATER QUALITY CONCERNS

4.4.1 NITRATE/NITROGEN

Nitrates can be found in many areas in Nebraska. Sources of nitrates include breakdown of organic material in soils, human or animal wastes, and chemical fertilizers. When exposed to nitrate levels in excess of 10 mg/L in drinking water, infants may develop methemoglobinemia or "blue-baby" syndrome. The MCL for nitrate under the Safe Drinking Water Act is 10 parts-per-million (ppm) as nitrate-nitrogen (NO_3-N).

Non-point source nitrate pollution refers to large areas of elevated nitrate levels, which are generally a result of widespread agricultural fertilizer application. If non-point source nitrate pollution is occurring, it is typically associated with elevated levels of other agricultural chemicals.

Point source nitrate contamination is more localized and is generally associated with fertilizer spills, human or livestock waste migrating into shallow groundwater, or well construction. Poorly constructed or located domestic wells may have nitrate levels that exceed the drinking water limit of 10 ppm. It may be difficult to distinguish between non-point and point source nitrate pollution unless investigation is conducted.

Recent monitoring of NO_3-N within LPSNRD is mapped in Appendix A, Figure 17. Elevated levels of nitrates are scattered throughout the NRD. A number of wells with elevated nitrates are domestic or stock wells, which may be the result of point source contamination.

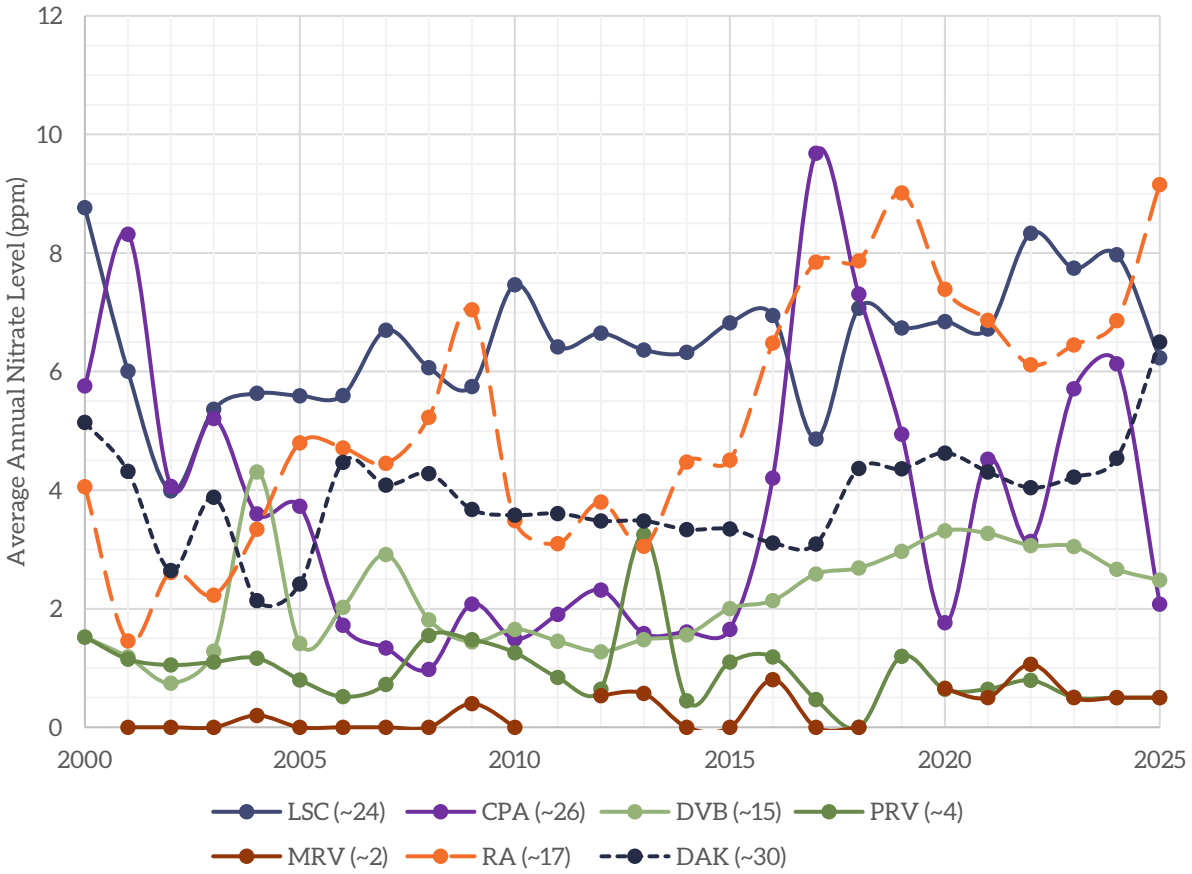
Sampling results in the LSC Groundwater Reservoir show NO_3-N levels exceeding 10 ppm in several irrigation wells (Spalding, 1990). This prompted LPSNRD to designate the Lower Salt Creek Groundwater Management Area, using their own monitoring network data, as Phase II in 2001.

The WHPAs of Davey (December 2009), Hickman (December 2009), Pleasant Dale (December 2009), Union (December 2009), Valparaiso (2004), and Otoe County RWD #3/Weeping Water (January 2010) have been designated as Phase II groundwater quality management areas. The Elmwood WHPA was designated as Phase III (December 2009). Other community water suppliers in LPSNRD, which historically have elevated levels of nitrate, have been able to

significantly reduce nitrate in drinking water by abandoning older wells, installing new ones, and/or mixing water from different wells.

Figure 4-1 summarizes the average NO_3-N level for the total number of samples taken (listed in parentheses) in each groundwater reservoir from 2000 to 2025. Reviewing the average NO_3-N levels provides insight into trends over time, but does not mean that any specific groundwater quality phase trigger has been met or exceeded.

Figure 4-1. Average Annual Nitrate Levels by Groundwater Reservoir



4.4.2 TOTAL DISSOLVED SOLIDS (TDS)

The total concentration of dissolved inorganic material in water is expressed as Total Dissolved Solids (TDS). TDS is a good general indicator of water quality, reflecting in part the sodium content and degree of mineralization of the water. Water containing excessive amounts of TDS may be unsuitable for irrigation use, aesthetically unacceptable for drinking, and limited in its use for industrial purposes. The SDWA sets a secondary limit for public drinking water supplies of 500 ppm for TDS. Generally, water containing more than 1,000 ppm TDS will likely cause a taste or odor problem, or make the water unsuitable for domestic, industrial, or agricultural use.

The distribution of TDS within LPSNRD is dependent upon several factors including the geologic source of the water, the depth and construction of the well, and the rate at which the well is pumped. In general, higher TDS values are found in wells that are screened in the

Dakota Aquifer. There are many areas in LPSNRD where TDS in groundwater exceeds 500 ppm. An area to the north and west of Lincoln as well as in parts of Cass County may produce water in excess of 1,000 ppm TDS.

In some parts of LPSNRD, the intrusion of salt water into fresh groundwater is a concern. This is especially so in areas where the Dakota Group or older Paleozoic bedrock is close to the surface, as some units within the Dakota and older units contain saline water (see Appendix A, Figure 7). Excess pumping of shallow, fresh groundwater can induce intrusion of saline water from deeper geologic units and, therefore, the District continues to monitor for indicators of saltwater intrusion, as well as work with well owners to address such concerns. This condition is monitored by analyzing samples for such parameters as sodium, chloride, and TDS.

4.4.3 OTHER AGRICULTURAL CHEMICALS

Since 1994, LPSNRD has tested approximately 1,850 samples for atrazine. Of these, around 110 samples reported concentrations above 0 micrograms per liter (µg/L). All wells sampled in LPSNRD were below the proposed EPA MCL of 3 parts per billion (ppb). The maximum reported concentration was 1.5 µg/L, 50 percent of the EPA MCL, which only occurred once in 2006 near the Tanglewood Reservoir in southwest Lancaster County. These low concentrations were detected in areas of intensive corn production where atrazine is applied annually, which suggests contamination is non-point source.

Emerging Contaminants of Concern

Arsenic

Arsenic has been detected above the MCL in at least eight wells sampled in LPSNRD. The MCL is listed as 0.010 mg/L in groundwater. Several of the wells indicate an increase in arsenic from below the MCL to above the MCL (e.g., well 186426). The maximum concentrations found were 0.045 mg/L at well ID 38941 just north of Wildwood WMA and 0.044 mg/L in well ID 186420 just southeast of Union.

The MCL of arsenic was reduced from 0.050 mg/L to 0.010 mg/L on January 22, 2001, as part of the Arsenic Rule (66 Federal Register 6976). Long-term exposure to arsenic in drinking water has been linked to several forms of cancer, especially bladder and lung cancer, and to other health problems, such as diabetes and heart disease.

Uranium

The MCL for uranium is 0.030 mg/L. Based on Nebraska Groundwater Clearinghouse data, the 50 wells currently sampled for uranium are located in the CPA reservoir, and several are approaching the MCL. Uranium breaks down to various isotopes of thorium, radium radon, and other metals through alpha and beta decay. The MCL for gross alpha particles is 15 picocuries per liter. It has been determined that bacterial degradation of nitrates can release uranium from soils and sediments under anaerobic conditions (ACS, 2015).

Selenium

The MCL for selenium is 0.050 mg/L. Three groundwater wells located in the CPA reservoir contained selenium above the MCL (193822, 195736, and 205334). It was noted that well number 205334 spiked in 2022 but has since decreased back to previous concentrations near

0.030 mg/L. Selenium is an essential nutrient at low concentrations; however, an excess of selenium can lead to hair loss or nerve damage.

Per- and Polyfluoroalkylated Substances (PFAS)

According to EPA, PFAS is a class of compounds that contain nearly 15,000 different chemical compounds. The MCL for PFAS compounds in drinking water has been established for five of the known PFAS compounds. See Table 4-5.

Table 4-5. Current MCL for PFAS Compounds

Compound	Final MCLG	Final MCL (enforceable)
PFOA – perfluorooctanoic acid	Zero	4.0 ppt (ng/L)
PFOS – Perfluorooctane sulfonate	Zero	4.0 ppt
PFHxS – Perfluorohexanesulfonic acid	10 ppt	10 ppt
PFNA – Perfluorononanoic acid	10 ppt	10 ppt
HFPO – DA – Hexafluoropropylene Oxide Dimer Acid (GenX)	10 ppt	10 ppt

ppt = parts per trillion or nanograms per liter (ng/L); MCLG = Maximum Contaminant Level Goal

A Hazard Index was implemented by EPA in 2025; however, this current approach has been placed on hold and is under review. PFAS compounds are considered emerging chemicals. PFAS was used in firefighting foam (as Aqueous Film Forming Foam [AFFF]), waterproofing (e.g., Gore-Tex), Teflon, Teflon additives to hydraulic oils, and other materials. The primary source of PFAS contamination may be from fire departments training activities. Due to the additional costs, some fire departments used dishwashing soap in place of AFFF. Areas downgradient of training sites should be sampled and analyzed for PFAS to gather a baseline analysis.

The Agency for Toxic Substances and Disease Registry list a number of health effects from PFAS including:

- Increased cholesterol levels;
- Lower antibody response to vaccines;
- Changes in liver enzymes;
- Pregnancy-induced hypertension and preeclampsia;
- Decreased birth weight; and
- Kidney and testicular cancer.

As of January 2025, DWEE has reported PFAS sampling results for 23 public water systems (PWS) in the LPSNRD (PFAS in Public Water Supply Systems | DWEE NE). Additional PWSs are expected to be sampled in the future. Further studies are currently underway to determine potential health impacts to humans and the environment.

Neonicotinoids (Neonics)

Neonicotinoids (Neonics) are a class of synthetic insecticides that are chemically related to nicotine. Neonicotinoid use, particularly as a seed treatment, has become prominent in the

"Corn Belt" states of Iowa, Illinois, Indiana, Michigan, Ohio, Nebraska, Kansas, Minnesota, and Missouri. As of 2020, nearly 50 percent of soybeans (18.2 million hectares), nearly 100 percent of corn (>36.4 million hectares), and 95 percent of cotton (15 million hectares) are treated with neonicotinoids (Berens, 2021).

Neonics are known for their high toxicity to bees and other pollinators, raising concerns about their movement via water and soil in our ecosystems.

Neonics were first and are most prevalently found in surface waters; however, recent studies have documented that the combination of heavy use overlying a hydrogeologic setting vulnerable to surface applied contaminants leads to the transport of neonics into groundwater resources. Despite neonics being documented in water sources and the contamination risks posed to wells, exposure from drinking well water has not been adequately assessed (USGS; Thompson et al., 2021). Based on previous research, it is likely that many shallow rural wells are similarly contaminated with neonics, but additional data are needed to better characterize groundwater contamination by these insecticides and any potential human health implications.

5 GROUNDWATER MANAGEMENT GOALS AND OBJECTIVES

In 1985, LPSNRD developed its first Groundwater Management Plan, designed to satisfy requirements of the Nebraska Groundwater Management and Protection Act (Section 46-673.01-.04 of Nebraska Statutes). The Plan served as a foundation upon which LPSNRD has built goals, programs, and policies to preserve this valuable resource. Since nearly the entire population of LPSNRD depends upon groundwater for its drinking water, developing and maintaining a sustainable plan is important to understanding the supply and its quality, as well as providing a tool for decision-making.

This section provides the framework for LPSNRD's groundwater management goals and objectives. It provides a discussion of its relationship to the overall LPSNRD mission, describes LPSNRD's general strategy for groundwater management and defines the objectives for management of groundwater in LPSNRD.

During the planning process for the 1995 Plan, it was anticipated that the demand for groundwater would increase during the next 20 years in LPSNRD. They anticipated the following development scenario:

- Irrigation use will increase, but so will efficiency of water use.
- Individual domestic use will see little change because RWDs are reaching out to these users and are providing water of better quality and quantity for them.
- Municipal and industrial use will increase.
- Areas and the number of residents served by RWDs will increase.

It has been 30 years since this prediction was made, and some predictions appear to remain on target while others have changed. Irrigation well development has continued to slowly rise as shown by the number of irrigation wells in Table 2-3.

Municipal and Industrial water needs have also increased and are projected to continue to do so, which resulted in the City of Lincoln's drive to diversify its future water supply from the Platte River alluvial aquifer to the Missouri River. While growth in individual domestic use has occurred on the fringes of the Lincoln area and with the development of non-farm acreages, these self-supplied domestic wells or small community water systems tend to have a greater concern for water quality than a large water quantity demand.

Generally, RWDs within LPSNRD have experienced limited increases in population and service connections, primarily due to restricted water supplies and infrastructure.

The reliance of water users in LPSNRD on a sufficient supply of high-quality water, now and in the future, has led to a policy of proactive groundwater management. It is generally recognized that the time and resources required to correct a problem after it occurs or is allowed to continue, is substantial when compared to the cost of prevention and/or quick response.

5.1 STAKEHOLDER INPUT

Two Stakeholder Advisory Committees (SACs) were put together to discuss the Groundwater Management Plan and needed changes. Each SAC met four times during the course of plan development. One SAC met in Elmwood, Nebraska, and one met in Lincoln, Nebraska.

The first round of SAC meetings was held in September 2025. This meeting served as a project kick-off meeting to introduce the SAC to the current GWMP, present new data currently available, and discuss specific concerns in stakeholder areas. Activities for this meeting included group open discussions and an online Mentimeter activity.

The second round of SAC meetings was held in November 2025. The purpose of these meetings was to collect input from the SAC on the groundwater quantity and quality life goals and supporting objectives. Activities for this meeting included a pre-meeting survey and small breakout group discussions during the meeting.

The third round of SAC meetings was held in February 2026. The purpose of these meetings was to review updates to goals and objectives, review potential changes to groundwater quantity and quality triggers, as well as brainstorm management strategies and Best Management Practices. Activities included large group discussions, small group discussions, and a post-it board activity.

5.2 PUBLIC INPUT

The public was presented with materials regarding the updated GWMP in multiple formats.

Project information was kept up to date on a project website (https://www.lpsnrd.org/ground-water-management-plan). Information on the project website included background information, project timeline, and initial information about what was shared by the community.

Multiple public information meetings were held throughout the project. Each meeting was open-house style to allow attendees to speak with project team members, and each meeting was held in multiple locations, sharing the same information, in order to reach the widest span of constituents across the District.

The first public informational meetings were held in June of 2025 in Elmwood, Valparaiso, Lincoln, and Pleasant Dale. This meeting presented background information on the District, the GWMP, why it matters to the public, and the effects of groundwater quantity and quality on things like public health, the economy, and recreation. The public was polled on what topics they would like to learn more about: groundwater quality, public health, groundwater quantity, recreational effects, economic effects, and monitoring data. A survey was also developed to collect public feedback from those that were unable to attend the public meeting.

In May of 2026, a second round of public open houses in Lincoln and Elmwood presented the draft GWMP to the public. It provided a high-level overview of what the plan contains, what has changed since the previous plan update, and to collect any comments on the document before being submitted to DWEE.

The third and final public meeting was held in November of 2026 to present the final version of the GWMP to the public. The meeting highlighted the final changes that were made and how the final plan provides future management strategies to address key issues across the District.

5.3 GROUNDWATER QUANTITY LIFE GOALS

The Goal and Objectives for groundwater quantity include:

GOAL: SUSTAIN THE QUANTITY OF GROUNDWATER IN EACH GROUNDWATER RESERVOIR FOR ANY BENEFICIAL USE IN PERPETUITY.

- *Objective 1: Monitor groundwater quantity elevations in compliance with Nebraska Groundwater Quality Standards and with provisions of the Groundwater Management and Protection Act.*
- *Objective 2: Manage groundwater quantity and encourage sustainable development for effective long-term conservation and utilization.*
- *Objective 3: Implement the policies and strategies in the District's Groundwater Management Plan and update as needed.*
- *Objective 4: Work collectively with other agencies to evaluate groundwater quantity data and groundwater models.*

5.4 GROUNDWATER QUALITY LIFE GOALS

The Goal and Objectives for groundwater quality and drinking water include:

GOAL: MAINTAIN THE QUALITY OF GROUNDWATER FOR ANY BENEFICIAL USE IN CONFORMANCE WITH STATE STANDARDS.

- *Objective 1: Protect groundwater from point and non-point sources of pollutants, including contamination by pesticides and fertilizers, meeting standards set by the State or other agencies with proper authority.*
- *Objective 2: Monitor groundwater quality in compliance with Nebraska Groundwater Quality Standards and with provisions of the Groundwater Management and Protection Act.*
- *Objective 3: Manage groundwater quality and encourage sustainable development for effective long-term conservation and utilization.*
- *Objective 4: Implement the policies in the District's Groundwater Management Plan and update as needed.*
- *Objective 5: Work cooperatively with other agencies and stakeholders to encourage and promote wellhead protection and public health initiatives for drinking water supplies.*
- *Objective 6: Work collectively with other agencies to evaluate groundwater quality data.*

6 GROUNDWATER MANAGEMENT STRATEGIES

LPSNRD has taken a proactive approach to groundwater management. LPSNRD intends to protect groundwater resources from non-point source pollution and groundwater elevation declines by utilizing all its technical, financial, and educational capabilities and its regulatory authorities. LPSNRD will also assist other local entities to protect groundwater from point source pollution.

LPSNRD recognizes the need for a combination of strategies to effectively manage its groundwater resources. Historically, LPSNRD has primarily relied upon non-regulatory approaches, including public education; encouragement of voluntary use of best management practices; governmental inter-agency coordination; monitoring to identify water quality and quantity problems; and inspection and demonstration (training) programs. These voluntary programs will continue even if groundwater quality or quantity problems escalate.

Where problems arise, LPSNRD has offered additional cost-share incentives and increased information and education activities in the affected area. If problems continue to worsen, regulations can be implemented to protect the groundwater resources for all beneficial uses.

To best respond to groundwater quality or quantity problems, LPSNRD has established a Groundwater Management Area (GMA) encompassing the entire LPSNRD. Under a GMA, LPSNRD will manage groundwater by use of any one or a combination of the following means as authorized in the Groundwater Management and Protection Act:

1. Allocating the total permissible withdrawal of groundwater;
2. Rotation of use of groundwater;
3. Well-spacing requirements pursuant to Section 46-673.12;
4. Reduction of irrigated acres;
5. Requiring the use of flow meters on wells;
6. Best management practices;
7. Requiring the analysis of water or deep soils for fertilizer and chemical content;
8. Educational programs designed to protect water quality;
9. Approval of well permits (including requirements for well depth, flow meters, etc.), certified irrigated acres, and transfers;
10. Moratoriums on new well development; and
11. Any other reasonable rules and regulations necessary to carry out the purpose for which a GMA was designated.

LPSNRD has designated areas of management for both groundwater quality and quantity, has established a limit "trigger" to the amount of contamination or decline that is allowed for different phases, and has developed strategies to implement actions in different phases of management.

6.1 GROUNDWATER QUANTITY MANAGEMENT STRATEGIES

The strategies for better understanding and managing groundwater quantity have changed significantly over the last 30 years given LPSNRD's involvement in ENWRA and the ongoing update of regional and subregional groundwater models. This latest hydrogeologic knowledge is reflected in Appendix A in previously described Figures 2, 9, 12, 14, and 15, showing the thickness of saturated Quaternary materials, confined or partially confined aquifers, soil infiltration capacity, average groundwater recharge, and transmissivity. Insights into secondary bedrock aquifers have also improved, including updates to the extent of the saturated thickness of the Dakota Group and partial mapping within the District of those portions of the Dakota Group that are likely sand or sandstone dominant (and classified as Dakota Aquifer).

However, in some areas, questions remain about the quantity and timing of water supply within various groundwater reservoirs. One example of this is: "What serves as the primary source of groundwater recharge for the DV Reservoir?" Limited AEM data exists west of LPSNRD boundary in Butler County (in the Upper Big Blue NRD [UBBNRD]). The resistivity flight lines that are available from the 2015 Reconnaissance report, which followed historic CSD test holes, suggest that most of the paleovalley aquifer is overlain by non-aquifer confining layers. Future inter-agency partnerships with UBBNRD, UNL, USGS, and others could provide research or studies that may determine areas of surface recharge connection or possible connections with other aquifers, including the High Plains Aquifer.

Another significant groundwater quantity question raised during the GWMP update process was the monitoring and management of widely geographically distributed reservoirs such as groundwater-producing pockets in the RA. The limited number of wells available for monitoring and sparse AEM or geologic data do not provide a strong basis for determining if groundwater elevations are declining and, if so, what affected aquifer area may be designated as a Phase II GMA or SMA.

Similarly, the same issue arises when monitoring and possibly managing the bedrock Dakota Aquifer. The Dakota Group formed during the Cretaceous period when sea levels were dramatically higher than today and much of eastern Nebraska was part of the Western Interior Seaway, or was the eastern shoreline/delta area where shallow seawater met drainage from some portion of the Appalachia land mass. This formed geographically dispersed and interbedded layers of sand, silt, and clay, which hardened or cemented to form layers of mostly sandstone, mudstone, or shale. Again, making it potentially difficult to determine what aquifer area is being affected by groundwater elevation fluctuations.

These potential groundwater quantity questions can point to diverse management strategies including:

- Additional hydrogeological data collection and studies.
- Additional 3D geologic or groundwater modeling.
- Additional test hole logs and aquifer pumping tests.
- Soil health investigations (to potentially enhance groundwater recharge or conservation).
- Climate change adaptations.
- Continued outreach and education.
- Evaluation of regionalization of drinking and rural water systems as Improvement Project Areas, see Section 3.3 (Governor's Water Quality and Quantity Task Force, 2026).

Future data and information may provide context for LPSNRD to determine appropriate actions to support management strategies in various phases. Such actions could include, but would not be limited to:

- Enhanced review or additional conditions of new well permits.
- Improved construction of new or replacement wells.
- Improved land use and conservation practices.
- Precipitation, soil moisture, and vadose zone monitoring to assess potential groundwater recharge over varying climatic conditions.
- Additional groundwater elevation monitoring.
- Allocation or restriction of water use (possibly including a new well moratorium).

6.2 GROUNDWATER QUALITY MANAGEMENT STRATEGIES

Groundwater quality improvement strategies primarily focus on preventing further contamination of groundwater from the surface and/or reducing public health risks associated with various pollutants. In most cases, current groundwater quality impairments can only be monitored, avoided as drinking water sources, or properly treated by community or in-home systems. Outreach and education are the typical actions to inform constituents of contamination and potential health risks.

Strategies aimed at reducing public health risks are first, and foremost, aimed at improving research and overall understanding of the potential public health impacts from numerous human-induced or naturally occurring contaminants (Section 4.1). Recently, the University of Nebraska Medical Center, in cooperation with the Daugherty Water for Food Global Institute at

UNL, has developed a Water, Climate, and Health Program to focus on researching potential health risks and providing outreach to educate the public about potential risks and actions they can take to better understand or reduce them.

The educational outreach of the Water, Climate, and Health program is centered around proper testing of water quality, improved understanding of water quality test results and health risks, and future water quality and quantity concerns due to climate change. On an annual basis, water quality testing is required for community water systems but only recommended for private domestic wells. This has prompted an outreach and testing focus on private domestic wells.

Even though municipal domestic groundwater supplies are tested to meet SDWA requirements, existing water quality impairments are present in WHPAs across the District. LPSNRD has long recognized this as part of its existing groundwater management program and has carefully reviewed water quality monitoring data by WHPA. Such testing has prompted some community WHPAs to undergo verification studies and be designated as Phase II or III groundwater quality management areas. As a result, water quality and vadose zone monitoring have increased in those areas.

LPSNRD has also encouraged municipal water suppliers to develop plans for protecting their WHPAs. Public water suppliers with Wellhead Protection or Drinking Water Protection Management Plans in LPSNRD include Cass County RWD #2, the Village of Emerald, and the City of Waverly (Appendix A, Figure 6). LPSNRD is cooperating with the City of Waverly, DWEE, and UNL to implement a comprehensive drinking water protection plan for the Waverly WHPA to protect its water supply for the foreseeable future. More communities in LPSNRD should consider developing Wellhead Protection Plans with future assistance and involvement from the District. All WHPAs in LPSNRD are eligible for Section 319 funding as they are considered Special Priority Areas in the District's WQMP. Existing WHPAs should be updated to reflect a 50-year time of travel based on the most recent groundwater modeling available rather than a 20-year time of travel.

Actions beyond education and outreach, which can support the strategy of reducing public health risks include, but are not limited to:

- Proper, and in some cases enhanced, well abandonment.
- Annual nutrient management planning and reporting, including soil and water sampling.
- Fertilizer and chemical application monitoring or restrictions.
- Increased vadose zone monitoring by LPSNRD.
- Assisting with developing Wellhead Protection Plans for municipal public water suppliers (WHPA Plans).
- Surface water quality improvements through watershed management, wetland enhancement, riparian buffer strips, and other various BMPs benefit groundwater quality.

- Cooperating with other agencies to identify groundwater and monitor potential emerging contaminants.

Another groundwater quality management strategy proposed as part of the GWMP update is to improve soil health, so it can do more to protect groundwater quality. According to the Nebraska Healthy Soils Task Force Report (Nebraska Healthy Soils Task Force, 2020), soil is healthier when organic matter levels are increasing (carbon sequestration), water infiltration rates are improving (reducing erosion, runoff, and flooding), and the soil's biological life is diverse and abundant. The Natural Resources Conservation Service (NRCS) says there are four principles to improving soil health: 1) keep soil covered as much as possible; 2) disturb the soil as little as possible; 3) keep plants growing throughout the year to feed the soil; and 4) diversify as much as possible using crop rotation and cover crops.

Healthier soils infiltrate and retain more soil moisture for longer periods of time, providing vegetation more water for photosynthesis and evapotranspiration. This slightly increased use of water during the growing season is unlikely to affect overall groundwater recharge and helps prevent the leaching of nutrients and other contaminants applied during the crop growing season. In addition, keeping living vegetation in the soil throughout the fall and spring when soil is not frozen, helps maintain root structure and reduce compaction, allowing even greater precipitation infiltration into the soil and more than offsetting limited cover crop water use during these times.

Healthier soils also produce and retain more of their own nutrients, reducing the amount of fertilizer that needs to be applied to dryland or irrigated crops. More organic matter means that more nitrogen is released as ammonium-N through mineralization (UNL EC117, 2023). UNL's Nitrogen Calculator tool (https://cropwatch.unl.edu/nitrogen-tool/) should be used throughout the NRD to help account for nitrogen already available from the soil to accurately estimate how much additional fertilizer may be needed.

Actions beyond education and outreach, which can support the strategy of improving soil health and water quality include, but are not limited to:

- Cover cropping systems.
- No-till and conservation practices.
- Soil moisture monitoring and studies (to help determine when leaching/ recharge is potentially occurring).
- Soil sampling for nitrogen and the presence of other potential contaminants.
- Promoting safe chemigation from pivots and a timely application of fertilizers, herbicides, and pesticides based on plant needs.
- Encouraging urban landscapes to only apply necessary fertilizer, chemicals, or irrigation based on plant and soil needs.

7 GROUNDWATER MANAGEMENT IMPLEMENTATION

7.1 GROUNDWATER QUANTITY TRIGGERS

The entire LPSNRD is currently in a Phase I Groundwater Quantity Management Area (GMA). LPSNRD will continue to take spring groundwater elevation readings from each of the LPSNRD monitoring network wells. For a designated area of management to move into another phase, static spring groundwater elevations in monitoring network wells must decline from the established upper elevation of the saturated thickness to an elevation that represents greater than or equal to a specified percent reduction in the saturated thickness and remain below that elevation for more at least two consecutive years. The saturated thickness will be the vertical distance, measured in feet, between the base of the water bearing formation and the average spring static groundwater elevation.

7.1.1 TRIGGERS FOR SPRING STATIC WATER ELEVATION DECLINE

- **Phase I:** Upon establishment of the Groundwater Management Area.
- **Phase II:** When spring static water elevations in 30 percent of the monitoring wells in that designated GMA have declined from the established upper elevation of the saturated thickness to an elevation that represents a percent reduction in the saturated thickness and have remained below that elevation for a two-consecutive-year period (spring elevations). See Table 7-1 below for the percentage for each designated area of management.
- **Phase III:** When spring static water elevations in 50 percent of the monitoring wells in that designated GMA have declined from the established upper elevation of the saturated thickness to an elevation that represents a percent reduction in the saturated thickness and have remained below that elevation for a two-consecutive-year period (spring elevations). See Table 7-1 below for the percentage for each designated area of management.

Table 7-1. Revised Groundwater Quantity Phase Triggers

Groundwater Reservoir or Aquifer	Phase II Percent Reduction	Phase III Percent Reduction
Missouri River Valley (MRV)	8%	15%
Platte River Valley (PRV)	8%	15%
Lower Salt Creek (LSC)	10%	15%
Dwight-Valparaiso (DV)	6%	12%
Crete-Princeton-Adams (CPA)	6%	12%
Remaining Area (RA)[1]	8%	15%

1. Smaller areas experiencing groundwater elevation declines may be designated within the RA.

7.2 GROUNDWATER QUALITY TRIGGERS

For a designated groundwater quality management area to move into another phase, the following must occur based on samples from the monitoring network:

1. A monitoring network well meets or exceeds the percentage of the MCL for a contaminant that could potentially be from non-point source pollution;
2. A set percentage of the monitoring network wells (percentage listed in Table 7-2) within a designated area of management must be at or above the percentage of the MCL; and
3. An investigation (verification study) of the area where the monitoring network well(s) exceeds the percentage of MCL and percentage of monitoring network wells has been conducted to verify the sample and identify contributing sources of pollution.

7.2.1 PERCENTAGE OF MAXIMUM CONTAMINANT LEVEL (MCL)

The most current Safe Drinking Water Standards as set by the Nebraska Department of Health and the EPA will be the official listing of the MCL. The MCL will be the basis of management. Contaminants include all pollutants that are potentially from a non-point source (nitrate, pesticides, etc.) See Table 7-2 for the percent of MCL trigger and minimum percent of wells for each groundwater quality phase determination.

Table 7-2. Revised Groundwater Quality Phase Triggers

Phases	Percentage of MCL	Minimum Percentage of Wells at or above Percent of MCL
Phase I	< 50%	NA
Phase II	50% - < 75%	50%
Phase III	75% - < 100%	75%
Phase IV	> 100%	75%

7.2.2 PERCENTAGE OF MONITORING WELL NETWORK

In designated groundwater reservoirs, WHPAs, or the RA, at least 50 percent of the wells in the monitoring network must be at/or above 50 percent of the MCL to initiate the verification component. In order for a designated groundwater reservoir, WHPA, or portion of the RA to qualify as Phase III, at least 75 percent of the samples in the monitoring network must be at/or above 75 percent of the MCL. For Phase IV, at least 75 percent of the samples in the monitoring network must be at or above 100 percent of the MCL.

7.2.3 VERIFICATION

When the annual sampling of the monitoring network indicates that an area meets the Phase II, III, or IV requirements in Table 7-2, LPSNRD will conduct an assessment which shall include, but not be limited to:

- Resampling all monitoring wells in the area;
- If nitrate/nitrite is a contaminant, determine if it is organic or inorganic;
- Determine if contaminant(s) are from a point or non-point source; and
- Reevaluate susceptibility of the vadose zone to non-point source pollution.

7.3 GROUNDWATER QUANTITY MONITORING RECOMMENDATIONS

LPSNRD's goal is to monitor 20 percent of the registered large-capacity wells in the RA, and one well per 2-mile grid (4 sq mi) in the five designated groundwater reservoirs. Existing wells to be sampled will be registered large-capacity wells with yields greater than 50 gpm that are screened in the water-bearing formation. In the groundwater reservoirs where existing wells are not available, LPSNRD will install dedicated wells and utilize them for both water quantity monitoring and water quality sampling.

The saturated thickness will be established for each monitoring network well. The saturated thickness will be that vertical distance, measured in feet, between the base of the water-bearing formation and the average spring static water elevation. For newer monitoring wells with less than five years of data, the saturated thickness will be calculated using interpolated elevations based on existing data.

7.4 GROUNDWATER QUALITY MONITORING RECOMMENDATIONS

Different levels of monitoring will be conducted in each designated area of management. Typically, monitoring will be more densely concentrated within the WHPAs and the five designated groundwater reservoirs due to the availability of wells, with less dense monitoring likely in the RA and Dakota Aquifer.

All monitoring wells will be sampled at least annually for phase determination. When more than one sample is taken in any well in a given year, quality results will be averaged. Past LPSNRD sampling efforts have been hampered by wet and dry climatic cycles and wells being rendered temporarily inactive because of the Conservation Reserve Program, land use changes, etc.

7.4.1 WELLHEAD PROTECTION AREAS

For each WHPA, a monitoring well network will be established in cooperation with the community water supplier. At a minimum, this network will include the water supplier's

well(s) and possibly other registered wells, supplemented as necessary by dedicated monitoring wells. LPSNRD will encourage the owner of each PWS to participate with LPSNRD and share in the cost to install and monitor a system of dedicated monitoring network wells.

7.4.2 DESIGNATED GROUNDWATER RESERVOIRS

In the five designated groundwater reservoirs, LPSNRD plans to sample a minimum of one well per 2-mile grid (4 sq mi). Existing wells to be sampled will be registered large-capacity wells with yields greater than 50 gpm that are screened in the water-bearing formation, as well as registered small-capacity wells. In areas where existing wells are not available, LPSNRD will install dedicated monitoring wells to complete the network.

7.4.3 REMAINING AREA AND DAKOTA AQUIFER RESERVOIR

LPSNRD will identify 20 percent of the registered large-capacity wells, as spatially distributed as possible, to monitor long-term trends and phase determinations in the RA. The RA also encompasses the majority of the Dakota Aquifer and any water quality sampling from this aquifer would be considered part of the 20 percent.

7.5 GROUNDWATER QUANTITY MANAGEMENT AREAS

The groundwater resources in LPSNRD vary widely from area to area in both quantity and quality. LPSNRD has established this plan to manage groundwater quantity in groundwater reservoirs and the RA. LPSNRD has designated the following five groundwater reservoirs: MRV, PRV, LSC, DV, and CPA (Appendix A, Figure 1-1).

LPSNRD has also designated the balance of LPSNRD, outside the five groundwater reservoirs, as RA. The best available information indicates that portions of the RA, including portions of the Dakota Formation, can yield usable quantities of groundwater to wells. The natural quality and quantity of the groundwater in the RA is highly variable. Each GMA will be managed separately and have a monitoring network, a set amount of decline that will serve as a trigger for each action, and specific actions for each phase of management.

The groundwater quantity phase triggers in a groundwater reservoir occur when spring static groundwater elevations in monitoring network wells have declined from the established upper elevation of the saturated thickness to an elevation that represents greater than or equal to a specified percent reduction in the saturated thickness and has remained below that elevation for more than two consecutive years. Groundwater quantity phase triggers in a WHPA shall be the same as the triggers of the groundwater reservoir or RA in which it is located. Currently, the entire geographic area of LPSNRD is designated as a Phase I Quantity Groundwater Management Area.

An SMA can be designated when additional controls are necessary to protect groundwater supplies for all beneficial uses, public interest, and the health and welfare of LPSNRD. LPSNRD designated an SMA, known as the Dwight-Valparaiso-Brainard area, to minimize pumping

conflicts and protect groundwater supplies for all beneficial uses. The requirements of this SMA are described in Section 1.3. It is possible that other aquifer areas within the District may also experience well interference issues in the future and require the designation of new SMAs.

7.6 GROUNDWATER QUALITY MANAGEMENT AREAS

DWEE has delineated WHPAs for community water systems within LPSNRD. WHPAs are drawn around time of travel lines, which refer to the path that water or a contaminant takes to reach the wellhead site over a given number of years. Existing WHPAs should be updated to reflect a 50-year time of travel rather than a 20-year time of travel using updated groundwater models. Each designated area of management will be managed separately and have a monitoring network, components that will trigger phase determination, and management tools established to serve as LPSNRD's plan for management.

The WHPAs will automatically assume the phase designation of the groundwater reservoir or RA in which it is located unless the WHPA is in a higher phase of management.

The LSC reservoir was designated as a Phase II Groundwater Management Area in 2001. Currently, 7 of 32 WHPAs are designated as Phase II or Phase III. All remaining geographic areas of the District and WHPAs are considered Phase I Groundwater Quality Management Areas.

- Existing Phase II WHPAs include Davey, Hickman, Pleasant Dale, Union, Valparaiso, and Weeping Water/Otoe County RWD #3.
- Existing Phase III WHPAs include Elmwood.

Any groundwater quality management area previously designated as Phase II shall remain a designated Phase II area in perpetuity. GMAs designated as Phase III or Phase IV may be redesignated as Phase III or Phase II once determined to fall below the required triggers. Actions or regulations associated with groundwater quality management areas are implemented through amendments to the existing Groundwater Rules and Regulations and, as such, would have to be approved by the LPSNRD Board of Directors.

If a sudden issue arises due to groundwater contamination, LPSNRD may designate an SMA to place moratoria on any new groundwater development (for up to 6 months) and restrict groundwater uses in the area until solutions to address the groundwater quality issue may be determined.

8 GROUNDWATER MANAGEMENT PLAN UPDATES

8.1 ANNUAL REVIEW

LPSNRD conducts a review each calendar year assessing the District's actions, activities, and effectiveness under the Rules and Regulations for implementation of the GWMP. The report documents annual groundwater quantity and quality monitoring network results, certified irrigated acres, new well permits, water use reports, SMA allocations, well decommissioning, other cost-share applications, and updates to referenced or associated plans and studies. The designated phase of each GMA is reviewed and documented based on existing groundwater quality and quantity triggers in each annual report.

Annual review reports are an integral procedure in how LPSNRD assesses and communicates its ongoing groundwater management monitoring, strategies, and actions. Such documentation should continue to be provided annually as part of this Groundwater Management Plan.

8.2 CONTINUOUS UPDATES

Numerous datasets and maps are provided each year in LPSNRD's annual review report. Additionally, new geologic and groundwater data from well driller logs, ENWRA, new groundwater models (DWEE), or UNL-CSD are consistently being developed and published. In some cases, it may be appropriate to provide the most recent monitoring or groundwater data in the form of maps or online Geographic Information System (GIS) information on a more continuous basis. It is possible that this new information can be provided as public data through online maps or dashboards.

8.3 LONG-TERM REVIEW AND UPDATES

Nebraska statutes do not require any specific timeframe for NRDs to update or revise Groundwater Management Plans. However, it is generally anticipated that as new data is developed and documented as part of annual or continuous updates, it may be appropriate to revise portions or all of the GWMP. At this time, the general recommendation would be to track and document potential updates or revisions on an annual basis as part of each annual review. Depending on the cumulative need to update the GWMP documented in each annual report, the timing and/or schedule for updating the GWMP should be documented and reviewed with the LPSNRD Board of Directors.

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Appendix A: Additional Figures