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Lower Platte South Natural Resources District 2021 Groundwater Management Plan Review

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LOWER PLATTE SOUTH NATURAL RESOURCES DISTRICT
GROUNDWATER MANAGEMENT PLAN
2021 ANNUAL REVIEW

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Foreword

The following report fulfills the Lower Platte South Natural Resources District's responsibility to conduct a review each calendar year assessing the District's actions, activities, and effectiveness under the Rules and Regulations for implementation of the Groundwater Management Plan approved by the Nebraska Department of Water Resources on June 26, 1995. This report is issued in a format which will hopefully make it easy for the reader to gain information about groundwater quality and quantity within the District. The 2021 Annual Review was presented to the Water Resources Subcommittee on March 14, 2022 and to the Board of Directors on March 16, 2022.

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Please Note: This report is organized by major groundwater program areas. The applicable rules and regulations governing those program areas are cited in the text for each area where appropriate. These rules and regulations were substantially revised effective January 15, 2020; the applicable sections cited in this document reflect those updates.

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LIST OF ACRONYMS

AEM	Airborne electromagnetic
BMP	Best management practice
CPA	Crete-Princeton-Adams
CWSPA	Community Water System Protection Area; equivalent to Wellhead Protection Area (WHPA)
DV	Dwight-Valparaiso
DVB	Dwight-Valparaiso-Brainard
ENWRA	Eastern Nebraska Water Resources Assessment
gpm	Gallons per minute
GWMA	Groundwater Management Area
GWMP	Groundwater Management Plan
GWR	Groundwater Reservoir
HCA	Hydrologically Connected Area
IMP	Integrated Management Plan
IWMPP	Interrelated Water Management Plan Program
LSC	Lower Salt Creek
MCL	Maximum Contaminant Level
mg/ℓ	Milligrams per liter; equivalent to parts per million (ppm)
MR	Missouri River
MW	Monitoring well
NDEE	Nebraska Department of Environment and Energy (formerly Nebraska Department of Environmental Quality)
NDNR	Nebraska Department of Natural Resources
NDHHS	Nebraska Department of Health and Human Services
ppb	Parts per billion; equivalent to micrograms per liter (ug/ℓ)
ppm	Parts per million; equivalent to milligrams per liter (mg/ℓ)
PR	Platte River
QA/QC	Quality Assurance/Quality Control
RA	Remaining Area
RPD	Relative percent difference
RWD	Rural Water District
SID	Sanitary Improvement District
SMA	Special Management Area
SOP	Standard operating procedure
TDS	Total dissolved solids
ug/ℓ	Micrograms per liter; equivalent to parts per billion (ppb)
UNL	University of Nebraska-Lincoln; these are UNL subdivisions: CSD: Conservation and Survey Division SNR: School of Natural Resources WSL: Water Sciences Laboratory
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
WHPA	Wellhead Protection Area; equivalent to Community Water System Protection Area (CWSPA)
WQMP	Water Quality Management Plan
WMA	Wildlife Management Area
WSF	Water Sustainability Fund

Phase Determination Criteria

Groundwater Quality Triggers

Phase I: Entire NRD

Phase II: contaminants in ≥50% of network wells are ≥50% of the MCL (5 ppm for nitrate-nitrogen)

Phase III: contaminants in ≥80% of network wells are ≥80% of the MCL (8 ppm for nitrate-nitrogen)

(Note: the MCL for nitrate-nitrogen is 10 ppm)

Groundwater Quantity Triggers

Phase I: Entire NRD

Groundwater Quantity Triggers for CPA, DV, MR, and PR GWRs, and RA

Phase II: saturated thickness in ≥30% of network wells is ≥8% below average

Phase III: saturated thickness in ≥50% of network wells is ≥15% below average

Groundwater Quantity Triggers for LSC GWR

Phase II: saturated thickness in ≥30% of network wells is ≥15% below average

Phase III: saturated thickness in ≥50% of network wells is ≥30% below average

Equations

Relative Percent Difference (RPD):

$$RPD = \left[\frac{(Sample1 - Sample2)}{(Sample1 + Sample2)/2} \right] \times 100$$

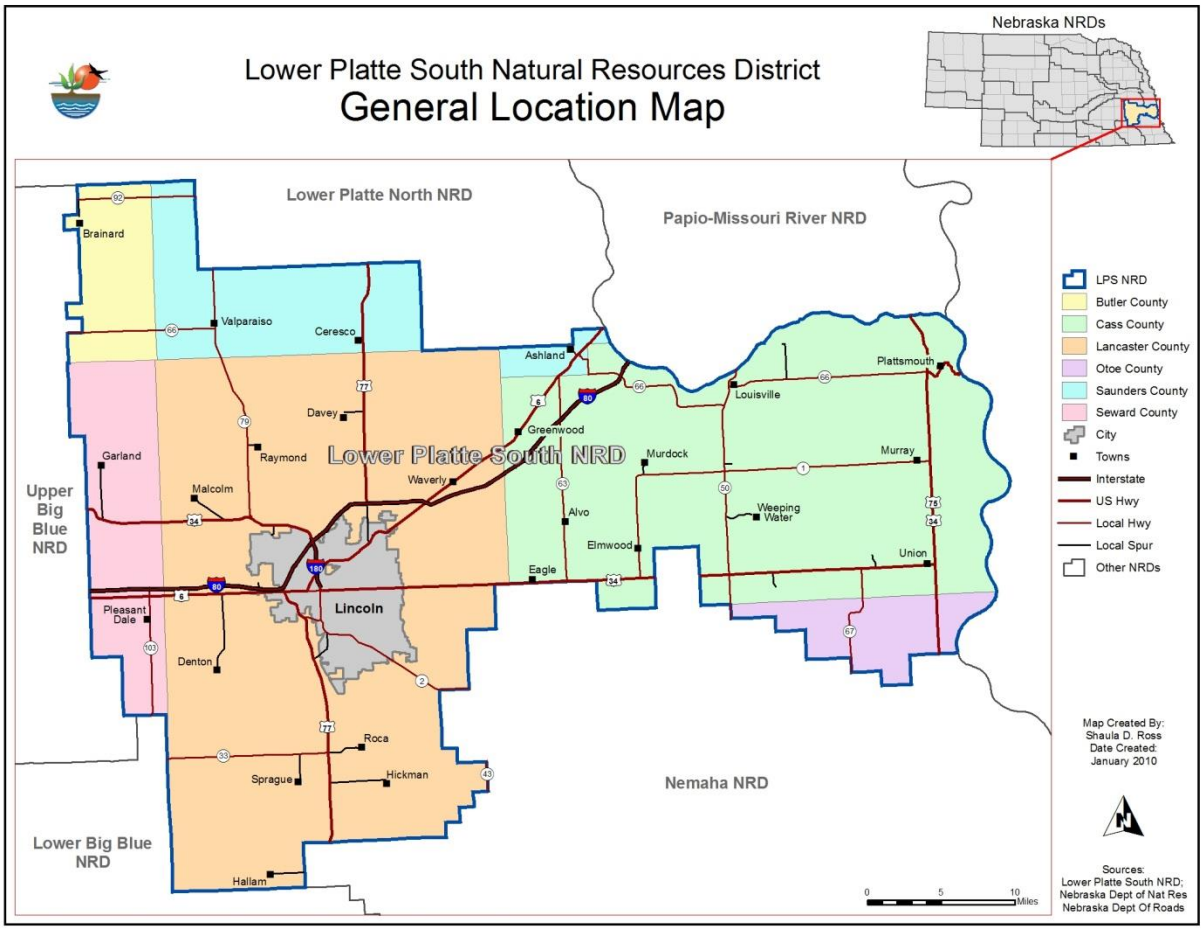
(used to calculate % difference between two samples)

1. INTRODUCTION

1.1. Background

The Lower Platte South Natural Resources District (LPSNRD or District) is one of 23 Natural Resources Districts in Nebraska. When created in the early 1970s, Nebraska's Natural Resources Districts (NRDs) were delineated according to major surface water drainage boundaries, and were given broad responsibilities in conservation and management of natural resources. The LPSNRD is located in the southern portion of the Lower Platte River Basin, and encompasses slightly more than one million acres or more than 1,500 square miles in parts of Butler, Saunders, Seward, Lancaster, Cass, and Otoe Counties in southeast Nebraska (Figure 1).

Figure 1 – General Location Map



One of the primary areas of responsibility delegated to NRDs is the management and conservation of groundwater, both in terms of its quality and quantity (see below). In Nebraska, some 85% of the state's population relies on groundwater as the primary source of drinking water. Many of the state's rivers, streams, and wetlands are fed by

groundwater discharge, and the aquatic and terrestrial plants and animals associated with them depend on groundwater of adequate quality and quantity. Groundwater for irrigation is also fundamental to the state's agricultural economy, and a wide variety of industries depend on its availability and quality. Clearly, groundwater is one of Nebraska's most precious resources, and the Lower Platte South NRD is committed to implementing protective programs for the good of its citizens.

1.2. Authority for Groundwater Programs

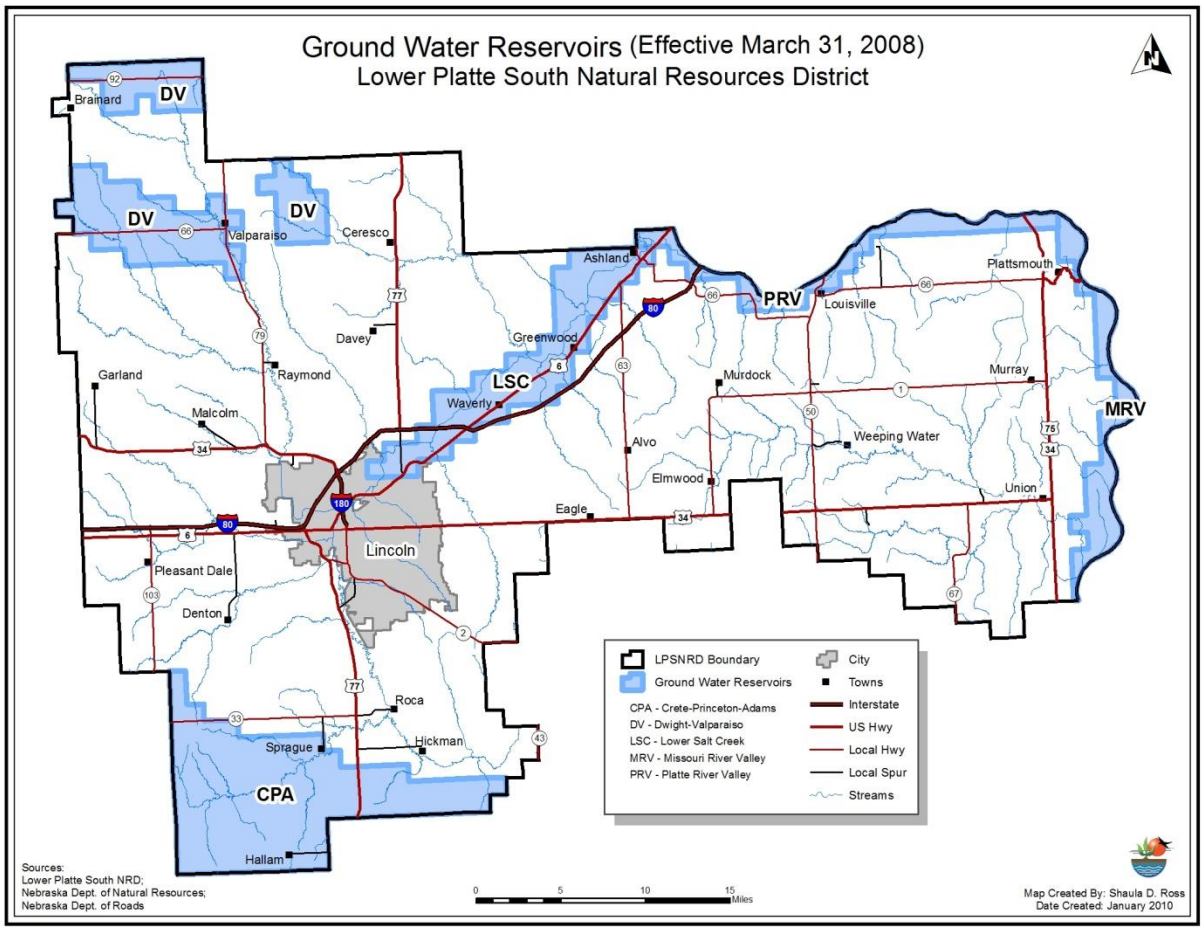
Natural Resources Districts are given a wide variety of responsibilities for the management of groundwater quantity and quality by Nebraska statutes. Those authorities can be found mostly in Chapter 46 of the Nebraska Revised Statutes. As required by law, in 1995 LPSNRD developed and adopted a Groundwater Management Plan (GWMP) to govern its groundwater management programs (LPSNRD, 1995). In addition, LPSNRD has adopted Groundwater Rules and Regulations (Revised Effective Date: January 15, 2020) as per the authority granted in statutes.

1.3. Groundwater Reservoirs

Applicable Regulations: Section B, Rules 2 and 3

As is common in most of eastern Nebraska, the geologic setting of the LPSNRD means that groundwater resources in the District are quite variable from place to place. The District has therefore delineated five major groundwater reservoirs (GWRs) in its jurisdiction. The GWRs represent areas which useable amounts of good quality groundwater are generally available. Typically, the GWRs consist of sand and/or gravel deposits in buried paleovalleys or present-day river valleys. The location of the GWRs can be seen in Figure 2. The remainder of the District has been designated as the Remaining Area (RA), which includes the Dakota Formation aquifer and other small aquifers not designated as part of any GWR. Groundwater in the RA is discontinuous spatially, and variable in both quality and quantity. Figure 2 also shows the location of the RA in LPSNRD (the RA is indicated by the area in white—that is, everything that is not in a GWR).

Figure 2 – Groundwater Reservoirs

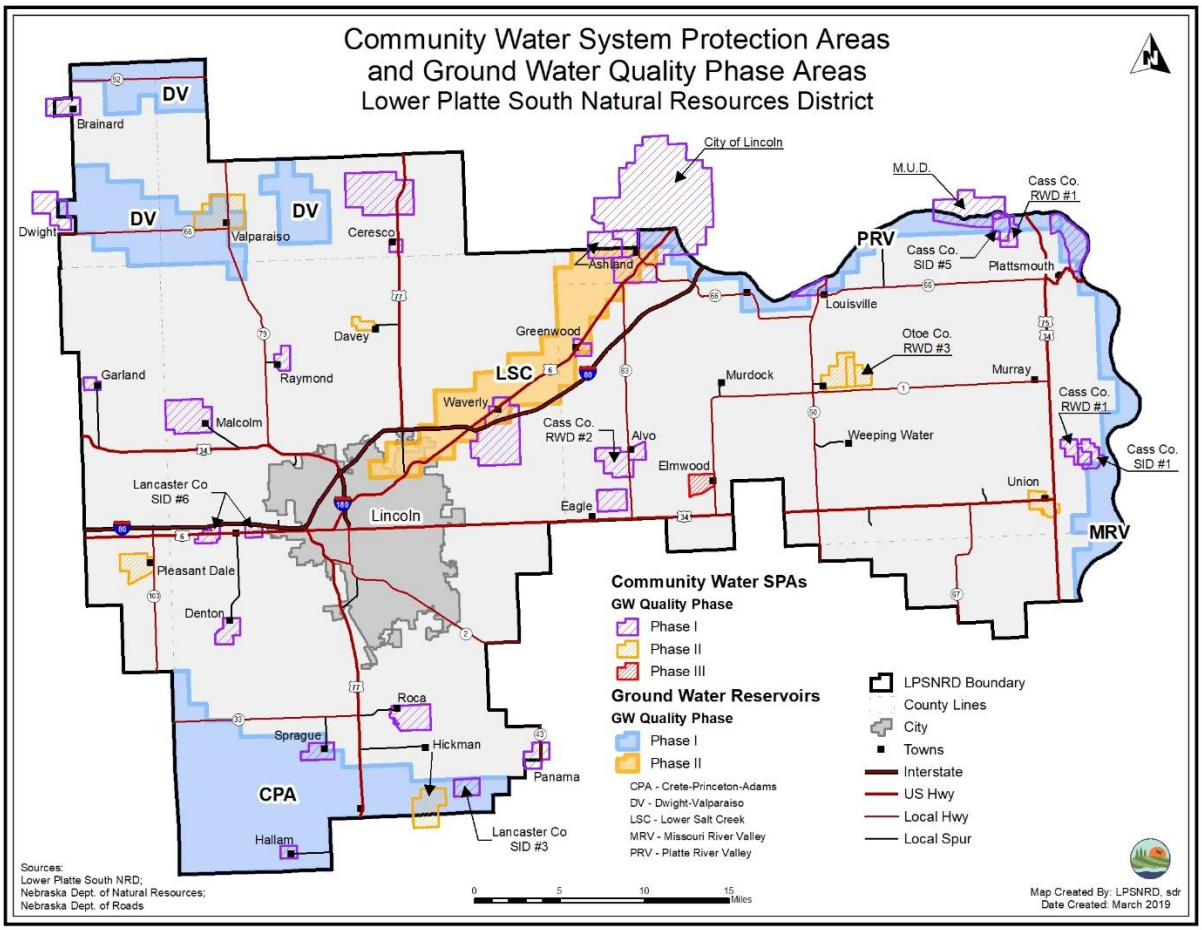


1.4. Community Water System Protection Areas (CWSPAs)

Applicable Regulations: Section B, Rule 2

Drinking water supplies in LPSNRD come primarily from groundwater sources, just like most of the rest of Nebraska. The Nebraska Department of Environment and Energy (NDEE) delineates Wellhead Protection Areas (WHPAs) for all public water supply systems in the state. These WHPAs generally correspond to the predicted 20-year time-of-travel zone for the supply wells in those systems, although recently some communities have designated there WHPAs based on 50-year time-of-travel zones. In other words, the WHPAs represent the area from which groundwater could be expected to be extracted during 20 to 50 years of normal water use for those public water supplies. NDEE has indicated that eventually the 50 year time-of-travel will be used for WHPA delineation. LPSNRD has adopted the boundaries of the delineated WHPAs as additional areas for groundwater management under the current GWMP. In the LPSNRD, these areas are referred to as Community Water System Protection Areas (CWSPAs); the locations of CWSPAs as well as Phase areas (see Section 3) in the District are shown in Figure 3.

Figure 3 – Community Water System Protection Areas



2. REGISTERED WELLS

Applicable Regulations: N/A

As is the case in most of Nebraska, the majority of water for municipal, domestic, irrigation, and other uses comes from groundwater sources. As already described, availability of groundwater across LPSNRD is highly variable, with some areas containing considerable supplies while others have little or almost no groundwater (for more information, see Section 4.1.1). As a result, the distribution of groundwater wells across the District is also variable. Figure 4 shows the locations of registered domestic and public water supply wells in LPSNRD, while Figure 5 shows the locations of registered irrigation wells. Note that, prior to 1993, domestic wells were not required to be registered in Nebraska, and so Figure 4 is only a partial representation of the location of these types of wells. That is, domestic wells completed prior to 1993 may or may not show up on this map.

Figure 4 – Locations of Registered Domestic and Public Water Supply Wells

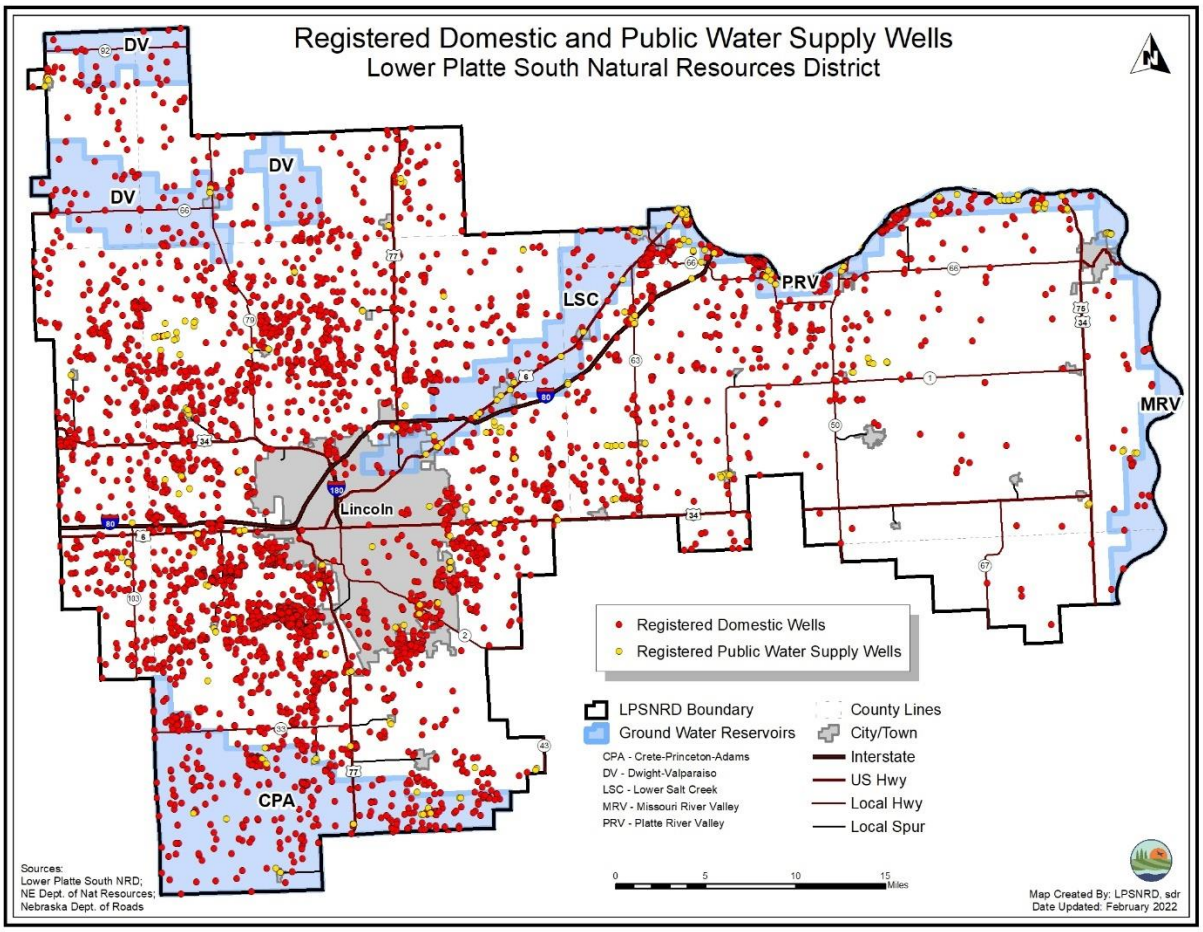
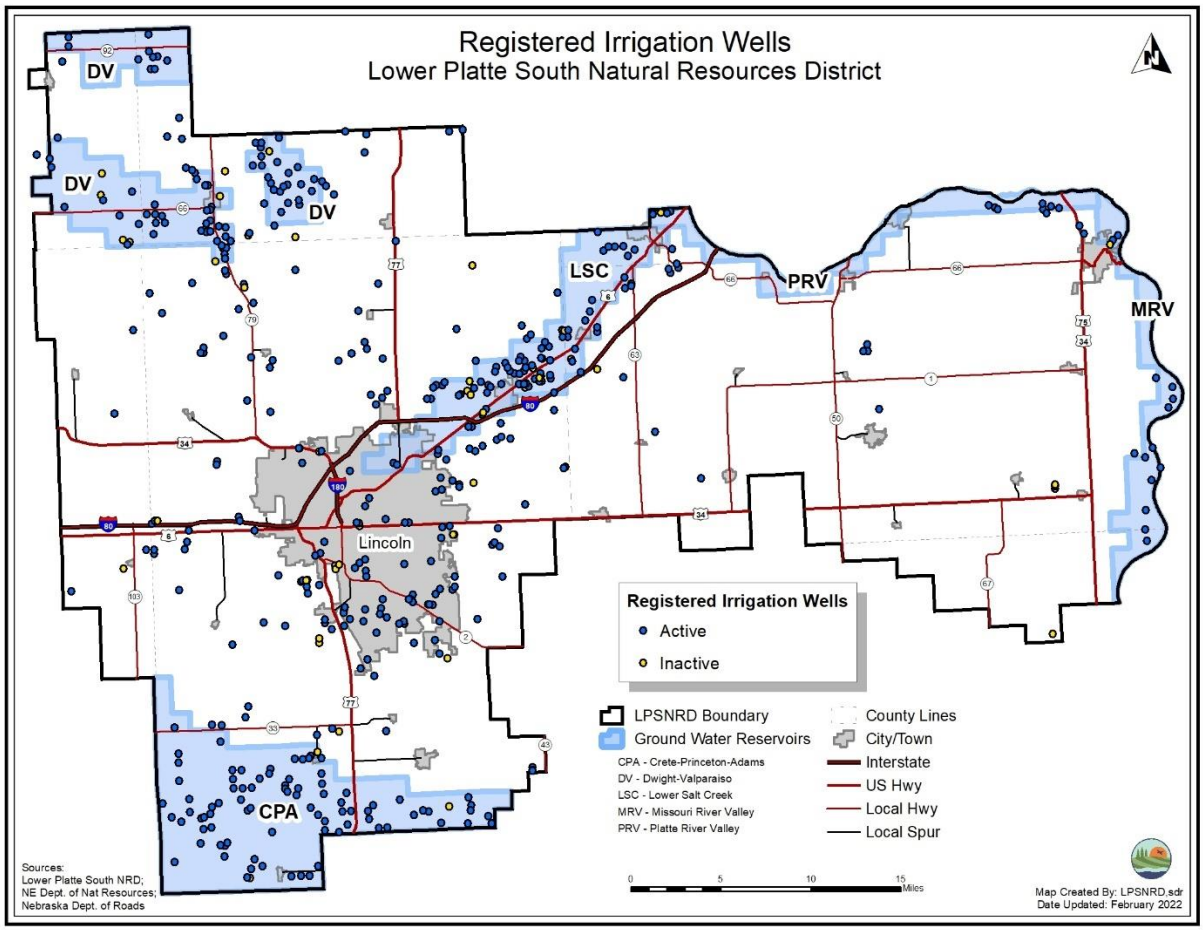


Figure 5 – Locations of Registered Irrigation Wells



3. GROUNDWATER MONITORING NETWORK

Applicable Regulations: Sections F, G

The District's groundwater monitoring networks are designed to provide a grid-like network of monitoring sites for each of the Groundwater Reservoirs and the Remaining Area, and to provide additional information about each CWSPA. LPSNRD's GWMP allows for the designation of various phases to deal with increasing groundwater contamination and/or decreasing groundwater levels. The entire NRD is currently in at least a Phase I Groundwater Management Area (GWMA), and in this phase the District establishes various information and education programs, and requires permits for all new wells which pump more than 50 gallons per minute (gpm) in a GWR or CWSPA, and 20 gpm for non-domestic wells in the RA. Higher levels of phased management have been implemented in some parts of the District to deal with concerns over groundwater quality and quantity (see below). Progress in developing LPSNRD's monitoring well network is shown in Table 1.

Groundwater Reservoir	# Network Wells Needed	# Quality Network Wells/% Complete	# Quantity Network Wells/% Complete
Crete-Princeton-Adams	33	31/94%	26/79%
Dwight-Valparaiso	23	22/96%	24/104%
Lower Salt Creek	19	16/84%	25/131%
Missouri River Valley	10	5/50%	3/30%
Platte River Valley	12	7/58%	4/33%
Remaining Area	58	42/72%	58/100%

Table 1 – Status of Groundwater Monitoring Networks

For groundwater quality, if levels of a contaminant exceed 50% of the federal maximum contaminant level (MCL) for that contaminant in 50% of the District's groundwater monitoring network wells for two consecutive years, the NRD can designate a Phase II GWMA, and adopt rules and regulations for management of that contaminant. If contaminant levels exceed 80% of the MCL in 80% of the NRD's network wells, again for two consecutive years, the NRD can designate a Phase III GWMA, and adopt additional, more stringent rules and regulations for dealing with the situation. Currently, the Lower Salt Creek GWR and the Valparaiso, Otoe County RWD #3/Weeping Water, Davey, Hickman, Pleasant Dale, and Union CWSPAs are in Phase II management, and the Elmwood CWSPA is in Phase III management for groundwater concerns due to elevated nitrate levels (see Figure 3).

For groundwater quantity, LPSNRD's GWMP lays out a similar procedure for designating phased management areas to deal with groundwater declines. If spring static water level elevations in 30% of the District's groundwater monitoring network wells have declined from the established upper elevation of the saturated thickness by 8% (15% in the Lower Salt Creek GWR), the NRD can designate a Phase II GWMA, and adopt rules and regulations to manage groundwater declines. If spring static water level elevations in 50% of the District's network monitoring wells decline by 15% (30% in the Lower Salt Creek GWR), the NRD can designate a Phase III GWMA, and again can adopt additional and more stringent rules and regulations for management of groundwater declines. Currently, there are no Phase II or III GWMAs for groundwater quantity in the LPSNRD, but due to concerns over seasonal declines, LPSNRD is implementing management actions in a Special Management Area in the Dwight-Valparaiso-Brainard area (see Section 4.2).

3.1 Groundwater Quality Monitoring Program

Staff collected 274 samples and 57 quality assurance/quality control (QA/QC) samples from 242 different wells in 2021. Samples that were collected were obtained from monitoring network wells, CWSPA wells, irrigation wells, and other wells that the District samples on an annual basis. Samples were analyzed for a variety of parameters, including nitrate-nitrogen, major ions, pH, specific conductance, hardness, alkalinity, and total dissolved solids. Since 2005, pesticide analyses have been rotated annually between different GWRs, and in 2010, the District adopted a similar rotation for major ions. Community water supply wells and CWSPA monitoring wells were tested for arsenic in addition to the basic parameters.

3.1.1 Nitrate-Nitrogen Results

Nitrates in drinking water have been a concern for many years in many parts of Nebraska, the United States, and the world. Nitrate (often expressed by the term "nitrate as nitrogen" or "nitrate-nitrogen") is naturally present in groundwater at low levels, usually less than 2 parts per million (ppm; this is essentially equivalent to milligrams per liter or mg/ℓ), and at such levels typically does not present any health concerns. However, nitrogen fertilizers, manure, or other nitrate-containing material applied to farm ground or lawns and gardens can supply additional nitrate which can infiltrate with natural recharge and lead to higher than natural levels of nitrate in groundwater. Nitrate in drinking water at elevated levels of several tens of ppm can cause acute health problems especially in infants by causing a condition in which the oxygen-carrying capacity of the blood is inhibited. High nitrate levels have also been associated with health and gestational problems in livestock, and may have long term chronic effects on humans as well. The United States Environmental Protection Agency (USEPA) has established an MCL of 10 ppm for nitrate-nitrogen in drinking water.

All wells sampled by the District in 2021 were analyzed for at least nitrate-nitrogen. Nitrate concentrations were variable across the District (Figures 6 and 7). Based upon this data, Phase II and Phase III determinations for the GWRs are shown in Table 2. Three of 16 samples (19%) from network wells in the LSC GWR exceeded 50% of the MCL for nitrate-nitrogen in 2021. The LSC GWR average was below the Phase II trigger in 2011 through 2020, although in some cases it was only slightly below that trigger. Thus, it appears that overall nitrate levels in groundwater in the LSC GWR are not increasing and may be declining somewhat. As a result of the nitrate levels being consistently below the Phase II trigger for several years, in its implementation plan for Fiscal Year 2020 LPSNRD included an action item to continue to evaluate whether to suspend Phase II in the LSC GWR; this process is ongoing. No other GWRs exceeded a Phase trigger in 2021. More specific information for each GWR can be found in Section 4.

Figure 6 – Nitrate Results – Groundwater Monitoring Network

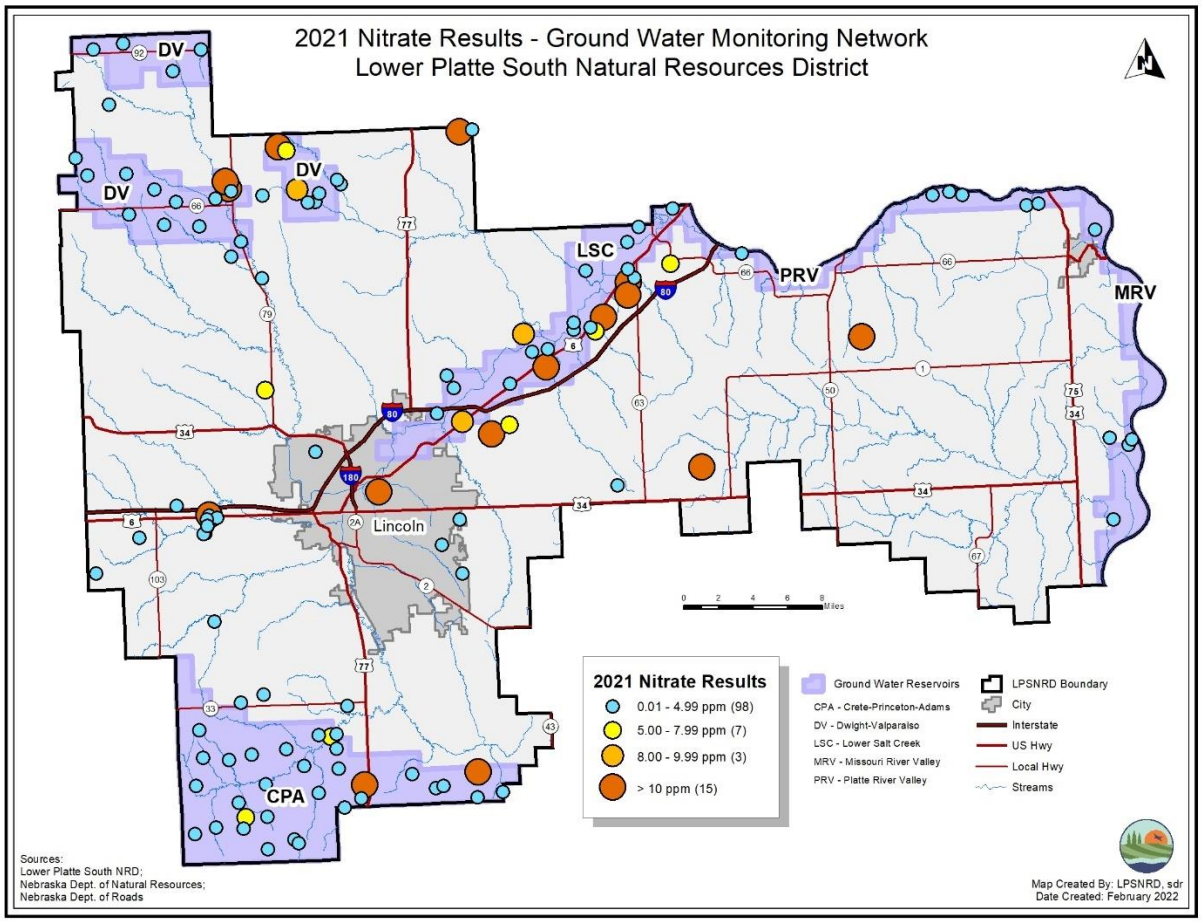
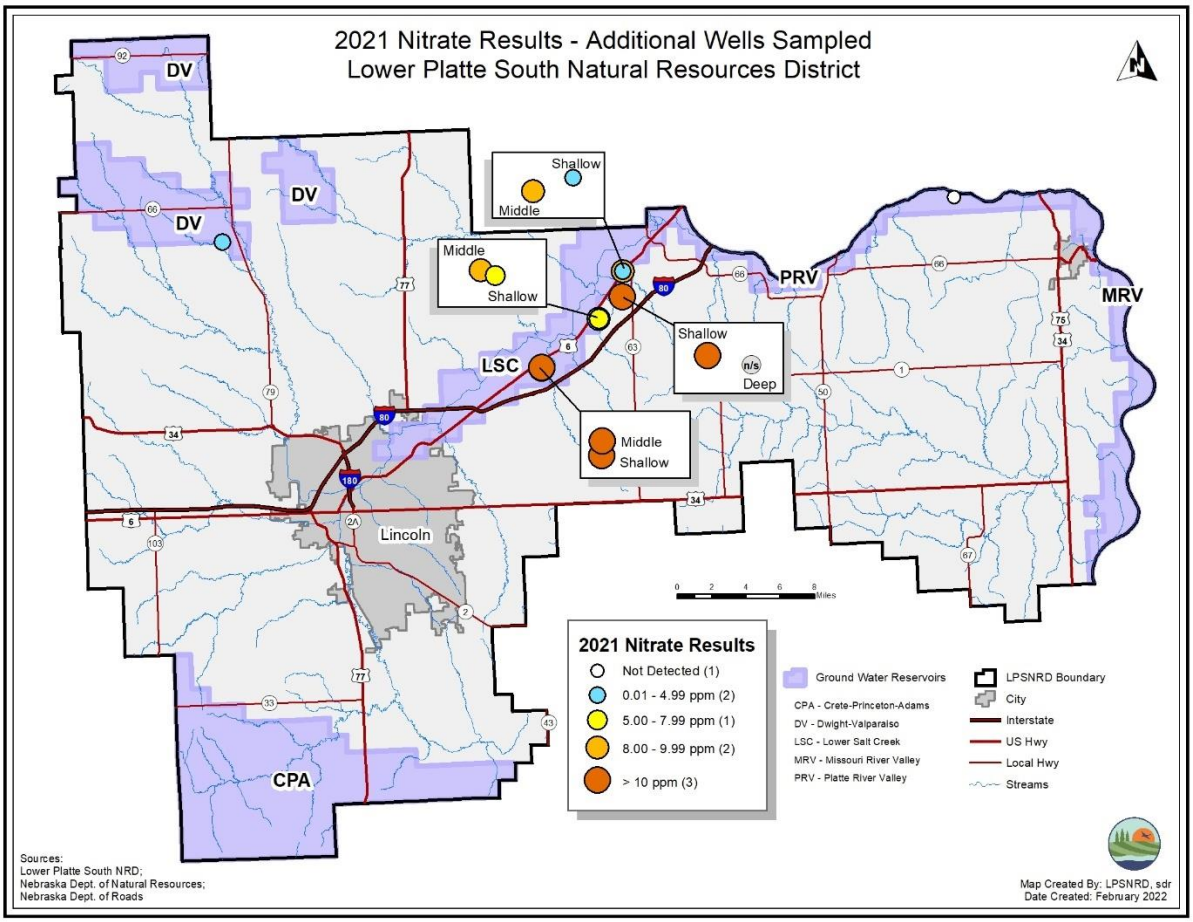


Figure 7 – Nitrate Results – Additional Wells Sampled



Groundwater Reservoir	# Network Wells Sampled	Network Samples ≥ 50% of MCL*	Network Samples ≥ 80% of MCL*
Crete-Princeton-Adams	31	13%	6%
Dwight-Valparaiso	22	18%	14%
Lower Salt Creek	16	**19% (Phase II Area)**	19%
Missouri River Valley	5	0%	0%
Platte River Valley	7	0%	0%
Remaining Area	42	33%	24%

* MCL = Maximum Contaminant Level; the MCL for nitrate-nitrogen is 10 parts per million
Phase II trigger is 50% of network wells ≥ 50% of MCL
Phase III trigger is 80% of network wells ≥ 80% of MCL

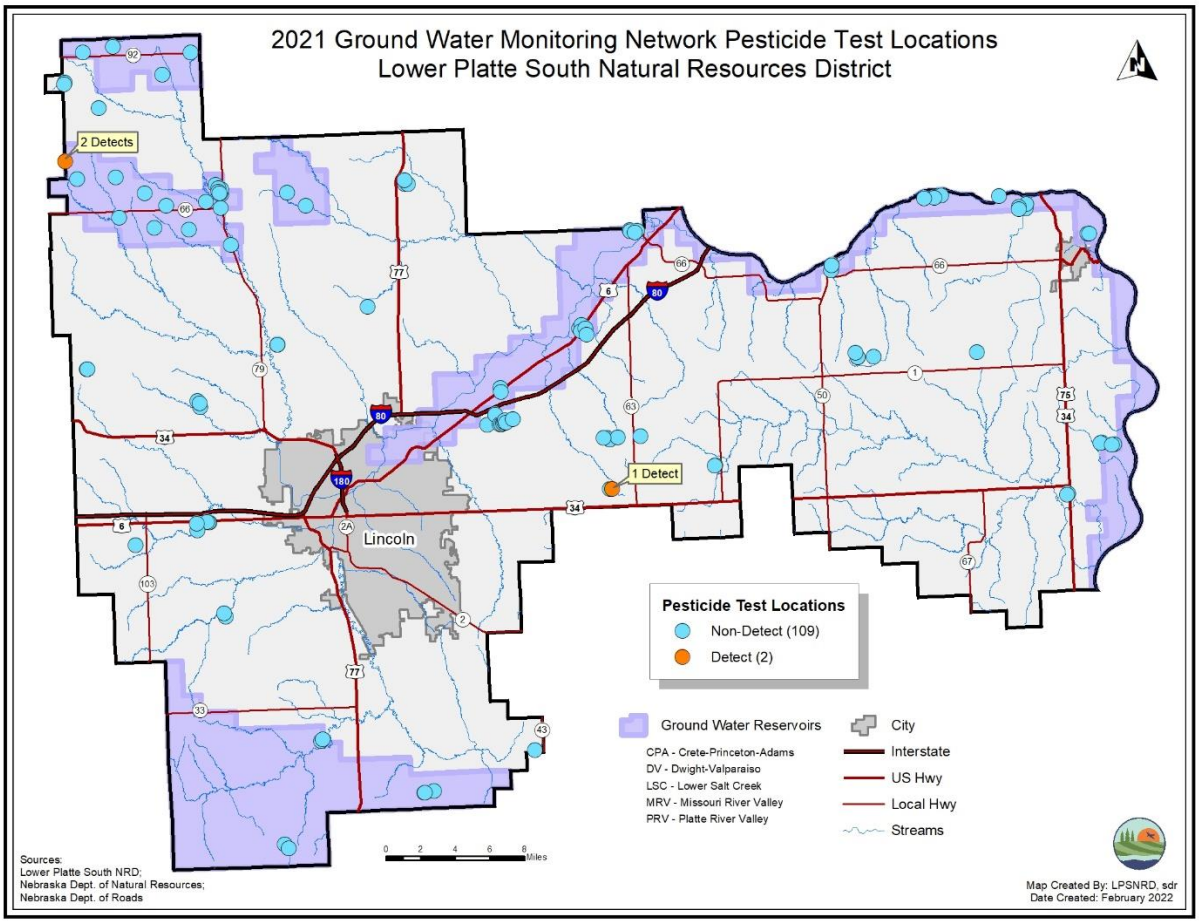
Table 2 – Phase Determinations for Nitrate-Nitrogen

3.1.2 Pesticide Results

Pesticides are compounds that are designed to control pests. Most common of these are herbicides (used to control undesirable plants) and insecticides (use to control undesirable insects). Other commonly used pesticides include fungicides, algicides, rodenticides, and grain fumigants. Residues from pesticides applied to crop ground, buildings, or lawns and gardens, or concentrated amounts from leaks and spills can move into the ground with infiltration and may eventually find their way to groundwater. The possible health effects of pesticides vary widely depending upon the compound and concentration, but as a general rule it is obviously desirable to keep such compounds out of groundwater and drinking water altogether, or at least to keep the levels of pesticides below any applicable health limits.

The District analyzes samples for 31 separate pesticide compounds on a rotating basis; in some cases existing agreements with public water suppliers specify annual pesticide sampling. In 2021, samples were collected from 111 wells and analyzed for these compounds. Of the wells sampled in 2021, only two wells (one public supply well and one irrigation well) had any detections of a pesticide. The public supply well showed a detection of phorate at 0.6 parts per billion (ppb; this is essentially the same as micrograms per liter or ug/ℓ). Phorate is a pesticide commonly used for the suppression of insects and nematodes in a variety of crops. There is currently no federal MCL for phorate but the lifetime health advisory recommendation is 1.1 ppb , so the level of this contaminant are well below that health advisory. The irrigation well showed detections of acetochlor at 0.51 ppb and phorate at 1.1 ppb. Acetochlor is a selective herbicide used to control weeds in corn and other crops. The federal MCL for acetochlor is currently 2 ppb, so this detection was approximately one quarter of that level, while as mentioned above the lifetime health advisory for phorate is 1.1 ppb, which is the level shown in this sample. As in the past, the owners of the wells will be notified of these detections, and further sampling will be performed to evaluate any changes in these detections. Figure 8 shows the locations of the wells that were sampled in 2021 along with the location of the two pesticide detections.

Figure 8 – Pesticide Sample Locations



3.1.3 Other Parameter Results

Although nitrate and pesticides are often cited as groundwater concerns, LPSNRD also monitors groundwater for additional parameters. In 2021, District staff collected additional groundwater samples which were analyzed for major ions and arsenic.

3.1.3.1 Major Ions

Analysis of major ionic species in groundwater gives a general indication of water chemistry and hydrogeologic conditions. In 2021, LPSNRD had 126 groundwater samples analyzed for the following ions: calcium, iron, magnesium, manganese, potassium, silicon, sodium, chloride, fluoride, and sulfate. Alkalinity and hardness expressed as calcium carbonate were also included, as was measurement of total dissolved solids (TDS). Based on previous years' monitoring, LPSNRD began a rotational system for monitoring major ions in 2011; in 2021 samples from the Dwight-Valparaiso GWR as well as several public water supplies (depending upon the NRD's agreement with those municipalities) were analyzed for these compounds. Samples from

the other GWRs and the Remaining Area will be analyzed on this rotational basis in coming years, and those from all PWS wells will continue to be analyzed.

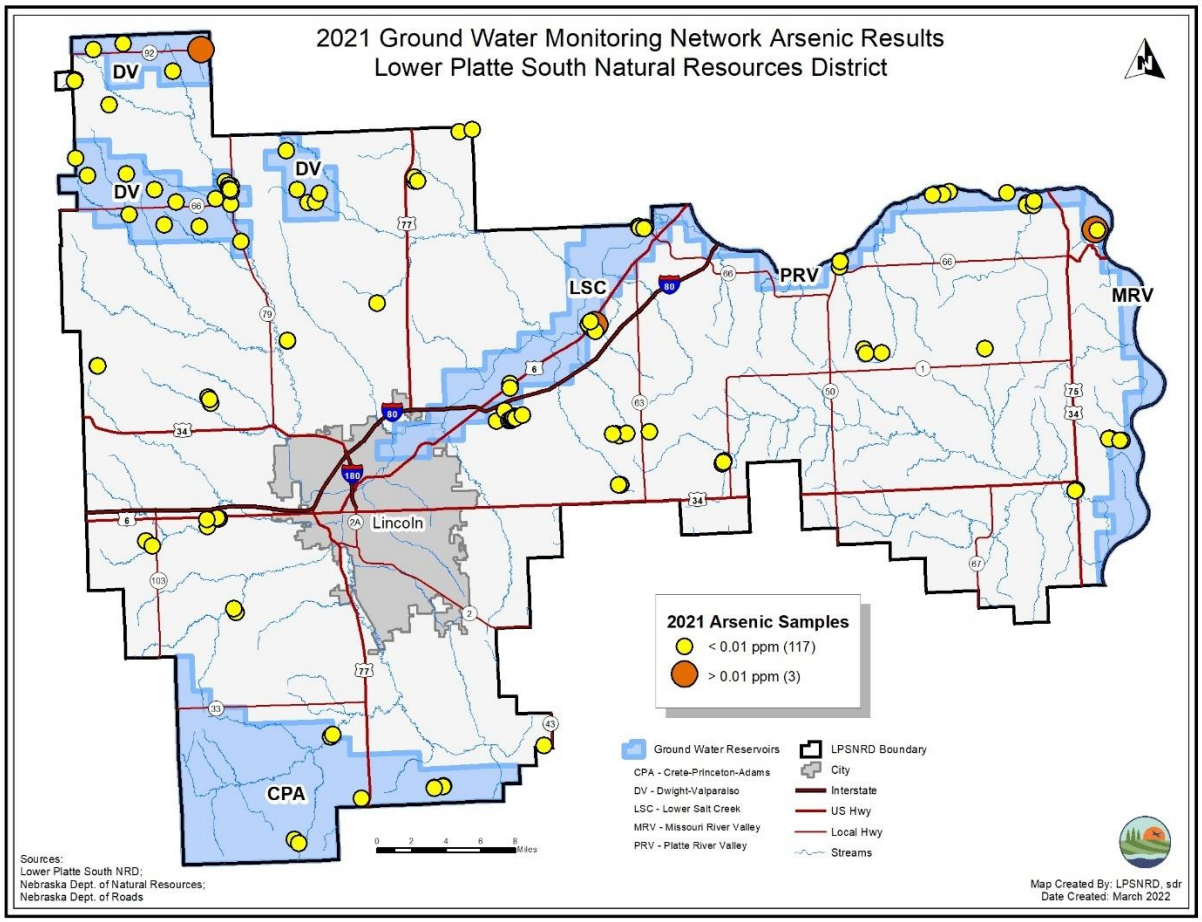
For the most part, analysis of major ions provides information regarding general water quality, and can also be used to evaluate changing groundwater conditions or to help identify concerns. For example, groundwater influenced by animal waste or septic tank effluent may exhibit elevated levels of sodium and/or chloride. In parts of the District, groundwater contained in lower portions of the Dakota Formation may also be elevated in sodium, chloride, and TDS, and pumping of shallow groundwater or various natural conditions may cause saline water to move toward the surface. Monitoring of major ions can give important information on situations such as these.

3.1.3.2 Arsenic

Arsenic is a semi-metallic element that can be found naturally in various kinds of rock and sediment, and can also be produced in agricultural and industrial processes. Acute effects from arsenic can occur at high levels of ingestion, and long-term exposure to arsenic has been linked to various forms of cancer. The USEPA has established an MCL for arsenic in drinking water of 10 parts per billion (ppb), which is equivalent to 0.01 ppm. LPSNRD collects groundwater samples for arsenic analysis as a service to several community water suppliers in the District. Although arsenic is a regulated contaminant for public water supplies, in Nebraska its occurrence is most commonly as a result of naturally-occurring sources, and as such is beyond the NRDs' regulatory authority to manage.

In 2021, LPSNRD staff collected 121 samples from that number of different wells in the District. The results of that sampling are shown in Figure 9. All but three of the samples had arsenic results at either non-detectable levels or levels below the MCL; this number is comparable to past years. The three wells in which arsenic levels exceeded the MCL included one public water supply well (Plattsmouth), one irrigation well, and one CWSPA monitoring well (Greenwood). Such detections of arsenic at slightly elevated levels are thought to be a result of naturally-occurring conditions involving a variety of sediment deposits. District personnel communicated the results to all cooperators, and will continue to provide information as requested.

Figure 9 – Arsenic Detections



3.1.3.3 Radon

Radon is a colorless, tasteless, odorless gas that is produced by the natural breakdown of uranium in rocks and sediments. The main health concern from radon is exposure through inhalation, as high levels of radon in indoor air have been linked with lung cancer. Most radon in indoor air comes from the soil and rock surrounding buildings, but a small amount can be released from water used indoors. In addition, there is some possibility that concentrations of radon in drinking water might increase the likelihood of stomach and other digestive cancers. However, the USEPA has not established an MCL for radon in drinking water. LPSNRD staff did not collect any radon samples in 2021 but will consider such sampling on a case-by-case basis as needed.

3.1.4 Quality Assurance/Quality Control (QA/QC)

The District continued to implement its QA/QC program in 2021. The QA/QC results are used to monitor the performance of a laboratory's analyses. There were four types of

QA/QC checks performed by District staff-- inter-lab comparability, precision, accuracy, and cross-contamination. The relative percent difference (RPD) is computed for each of the first three types of QA/QC sample, and the results are averaged for each type of QA/QC check. Ideally, the RPD should be 0% for each of the QA/QC checks. Generally, an average difference of 10% or less is acceptable, but 5% or less is preferred.

The inter-lab comparability was checked by 'splitting' some samples into two different bottles. The 'split' samples are analyzed by separate laboratories. One sample was sent to Midwest Labs (which is the primary lab for District sample analysis) and the other to the Nebraska Health and Human Services (NHHS) Lab. In 2021, 39 split samples were taken. On average, there was a -14.62% RPD in the results reported by these two labs; in other words, results from Midwest Labs were, on average, 14.62% lower than those of the NHHS Lab. This is outside of the NRD's acceptable range of difference, which is ±10%. However, this number was greatly affected by the results of only one sample, where Midwest Labs documented a concentration of several ppm while NDHHS showed a non-detect. If this anomalous result is removed, the RPD was -9.50%, which is within the acceptable range, although not preferred. Also, it should be noted that the median value for the RPD was -2.58%, which is well within LPSNRD's preferred range. LPSNRD staff is communicating with laboratory staff to establish the reason for the large anomaly in the one sample mentioned above, and will continue to work with both labs to maintain and improve data quality.

The precision, or ability to reproduce similar results, was checked by taking 'duplicate' samples for analysis by Midwest Labs. Duplicates are similar to split samples, but both samples are sent to the same lab – Midwest Labs. Twenty-three samples were duplicated in 2021. The results of this QA/QC check averaged -12.49%. Again, this number is outside of the District's acceptable range of RPDs, but like above, this number was greatly affected by one sample, where the parent sample showed a result of a fraction of a ppm, while the duplicate showed non-detect. These types of results generate high percentage differences, but actually represent only a fraction of a ppm difference in real results. Once this anomalous result was removed, the RPD was -1.38%, which is well within the District's preferred range. Again, the median value for the RPD was 0%, which of course is well within the preferred range. Likewise, NRD staff is working with laboratory personnel to determine the reason for some of these difference, but it appears that procedures in place have resulted in proper laboratory precision, which maintains confidence in the results produced.

In order to demonstrate the accuracy of results from the main contract lab (Midwest Labs), District staff employed analysis of documented reference samples. Reference samples are samples with a predetermined concentration of a certain constituent, prepared beforehand, and sent to the lab concerned to see if that lab can accurately determine that documented concentration. LPSNRD contracted with the University of Nebraska-Lincoln Water Sciences Laboratory (UNL-WSL) to produce nitrate samples of four documented nitrate-nitrogen concentrations, unpreserved: low (1mg/ℓ), medium (5 mg/ℓ), high (10 mg/ℓ), and very high (20 mg/ℓ). UNL-WSL staff prepared these samples using standard laboratory methods, and documented the concentrations of each sample by

analyzing them in duplicate via autoanalysis employing the cadmium-reduction method. LPSNRD sent eight total reference samples (two of each of the concentrations listed above) to Midwest Labs. On average, Midwest Lab's results showed a -0.52% RPD from the UNL documented concentration. These results are well within the preferred ±5% range, and as a result, LPSNRD considers these results to document excellent accuracy from the primary contract lab.

The final type of QA/QC check utilized by the District is the employment of field blanks. A field blank is a sample of distilled or deionized water which is prepared in the field using the same techniques as all other samples. These blanks are then sent to the primary contract lab. The expected result is that all parameters will come back with non-detectable results. If any parameters are detected in any field blank, this is an indication that some operation in sampling, transport, processing, and/or analysis is introducing some sort of outside contamination into the sample. However, in all blank samples taken in 2021 as in almost all years preceding, there were no detections of any contaminant. This is an indication of proper sampling, transport, processing, and analysis.

The results of the calculations for the QA/QC samples with returned detections are summarized in Table 3. Given that a few anomalous results greatly affected the RPDs of the District's QA/QC, and that the median values for those RPDs are well within LPSNRD's preferred range of values, the District considers the results for 2021 to be acceptable. LPSNRD will continue to work with all labs in coming years to maintain and where necessary improve this high level of QA/QC and to improve procedures if necessary.

Relative Percent Difference

Quality Assurance/Quality Control Check	Midwest Labs (Primary Lab)	NDHHS/UNL-WSL (QA/QC Lab)	Comments
Inter-lab comparability	9.50%	-9.50%	Acceptable comparability
Precision	-1.38%	N/A	Acceptable; excellent precision
Accuracy	0.52%	-0.52%	Acceptable; excellent accuracy

Table 3 - Results of Quality Assurance/Quality Control Sampling

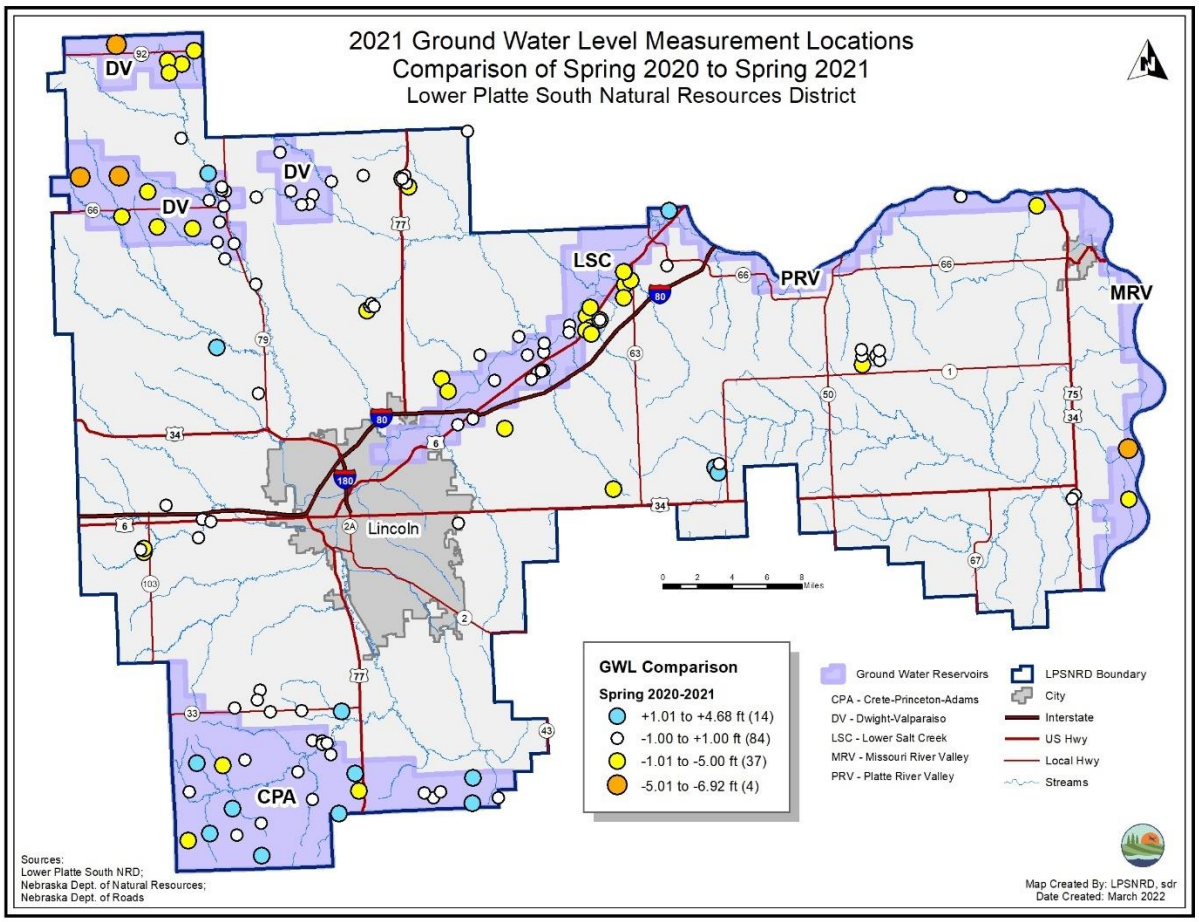
3.2 Groundwater Quantity Monitoring Program

District staff measured a total of 289 water levels in 140 different wells in 2021. For purposes of quantity calculations, the NRD was able to use measurements from all 140 of

these wells. The results have been reported to the U.S. Geological Survey and the District's cooperators. Water levels are measured in the spring (usually February and March) and fall (usually October and November). For purposes of this report and as specified in the District's Groundwater Management Plan, levels are compared from spring to spring measurements, as the spring measurement is considered to be more indicative of static aquifer conditions. Fall measurements are taken within a few months of the cessation of the irrigation season, and some aquifer units are likely still affected by that activity. Spring measurements represent aquifer conditions after the units have had several months to equilibrate, and are used for the purpose of annual comparison. However, in specific cases, comparison of spring to fall water levels can give an indication of how aquifer units are responding to comparatively intense use over the summer months.

Groundwater level fluctuations are variable across the District (Figure 10). From spring 2020 to 2021, water level decreases in the measured quantity network wells were more common than increases, with 92 wells showing a decrease and 47 wells recording an increase. The maximum decline in an individual well's water level was 6.92 feet, while the maximum increase was 4.68 feet between spring 2020 and 2021. The majority of water level changes in the NRD's monitoring wells are on the order of a few hundredths of a foot to a few feet (see Figure 10). District-wide, no Phase II or III triggers were exceeded in any of the District's GWRs (see Table 4). Taken as a whole, the average static water level across the District decreased by 0.71 feet from spring 2020 to spring 2021; individual GWR changes can be seen in Table 4. It's important to realize that this number is only provided for a general comparison from year to year, and doesn't apply to any individual well. As can be seen from Figure 10, water level changes in any well or GWR are quite variable, so a District-wide average does not accurately represent actual changes in groundwater levels.

Figure 10 – Groundwater Level Measurement Locations



Groundwater Reservoir	Percentage of wells below Phase II %* reduction in average saturated thickness	Percentage of wells below Phase III%* reduction in average saturated thickness	Average change in Water levels, Spring 2020-2021 (ft.)
Crete-Princeton-Adams	0%	0%	0.42
Dwight-Valparaiso	0%	0%	-1.97
Lower Salt Creek	0%	0%	-1.01
Missouri River Valley	0%	0%	-4.72
Platte River Valley	0%	0%	0.43
Remaining Area	0%	0%	-0.49

*Phase II trigger for Lower Salt Creek Groundwater Reservoir is 30% of wells showing 15% reduction; for all others it is 30% of wells showing 8% reduction. Phase III trigger for Lower Salt Creek is 50 % of wells showing 30% reduction; for all others it is 50% of wells showing 15% reduction.

Table 4 – Phase Determinations for Quantity

The District continues to monitor long-term groundwater level trends from representative wells from each GWR (Figures 11 and 12). Some areas of the District have experienced a decrease in groundwater levels since the early 1980s, even though trigger levels as reflected in LPSNRD's GWMP have not been exceeded. As already mentioned, the difference in spring water levels serves as the trigger for management actions in the District's current GWMP. Figure 11 provides a general sense for how these spring levels have varied over time. Given the unusual drought conditions that prevailed for much of the summer in 2012 and the latter portion of the summer in 2013 (see below), the District paid special attention to groundwater levels late in the summer and throughout the fall and winter of 2012 and 2013. Figure 12 shows the changes in fall water levels for the representative wells depicted in Figure 11. Note that, even with the drought of 2012 and 2013, water levels in both the spring and fall were not below some of the corresponding measurements from earlier years, particularly in the mid-1990s and mid-2000s. In addition, given the return to more normal precipitation patterns since 2014, water levels in all these wells show anywhere from a few inches to several feet of recovery. However, increasing concern over seasonal water level declines in the northwestern portion of the District has prompted the initiation of a Special Management Area to deal with well interference concerns in that portion of LPSNRD (see Section 4.2). The District has taken additional water level measurements in the past few years to gain more data regarding changes in groundwater levels, and has deployed several continuous water level measuring devices in selected dedicated monitoring wells to provide additional information. All of this data will be considered carefully as the District evaluates management actions in the future.

Figure 11 – Representative Spring Groundwater Level Graphs from Each Groundwater Reservoir

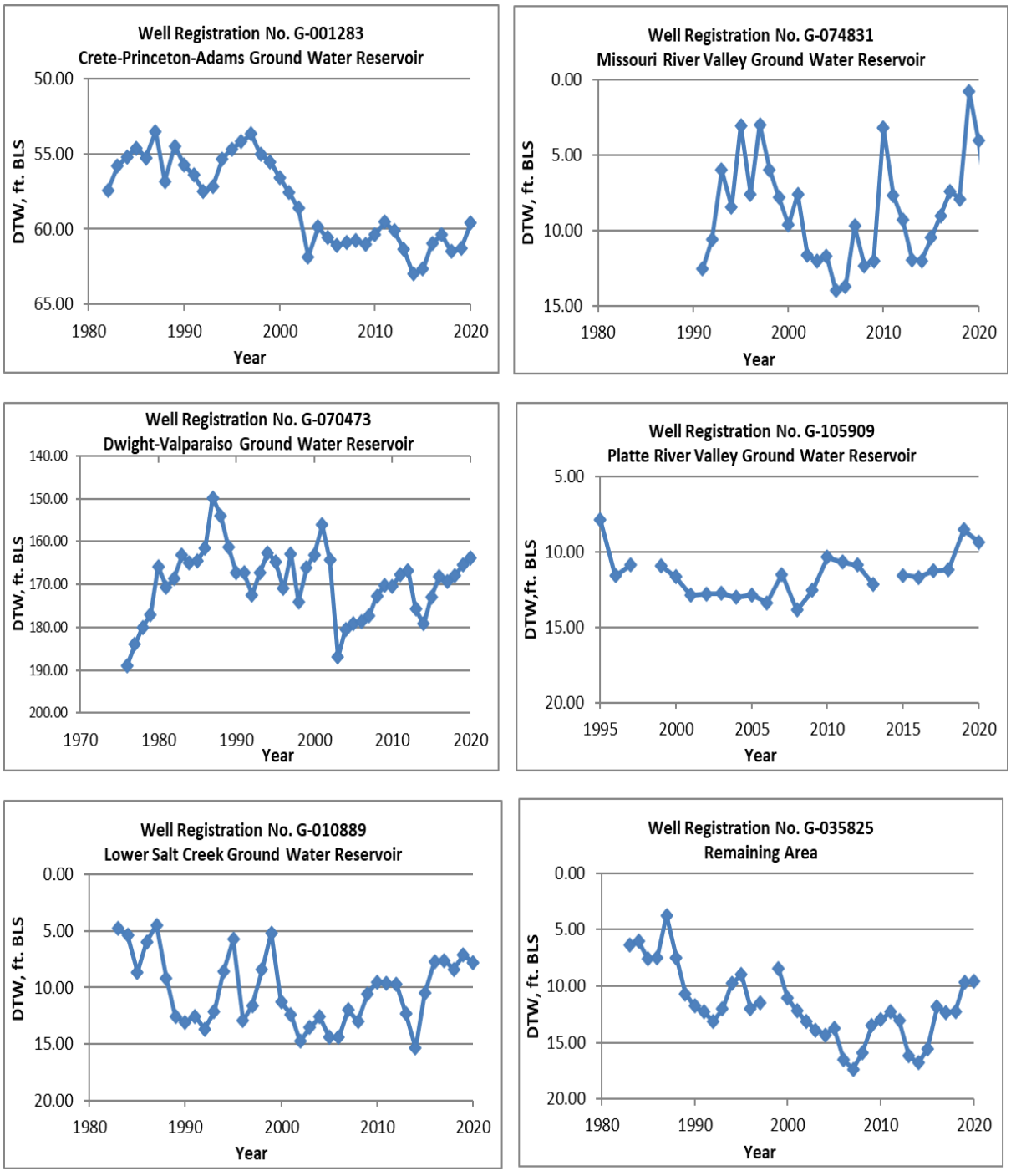
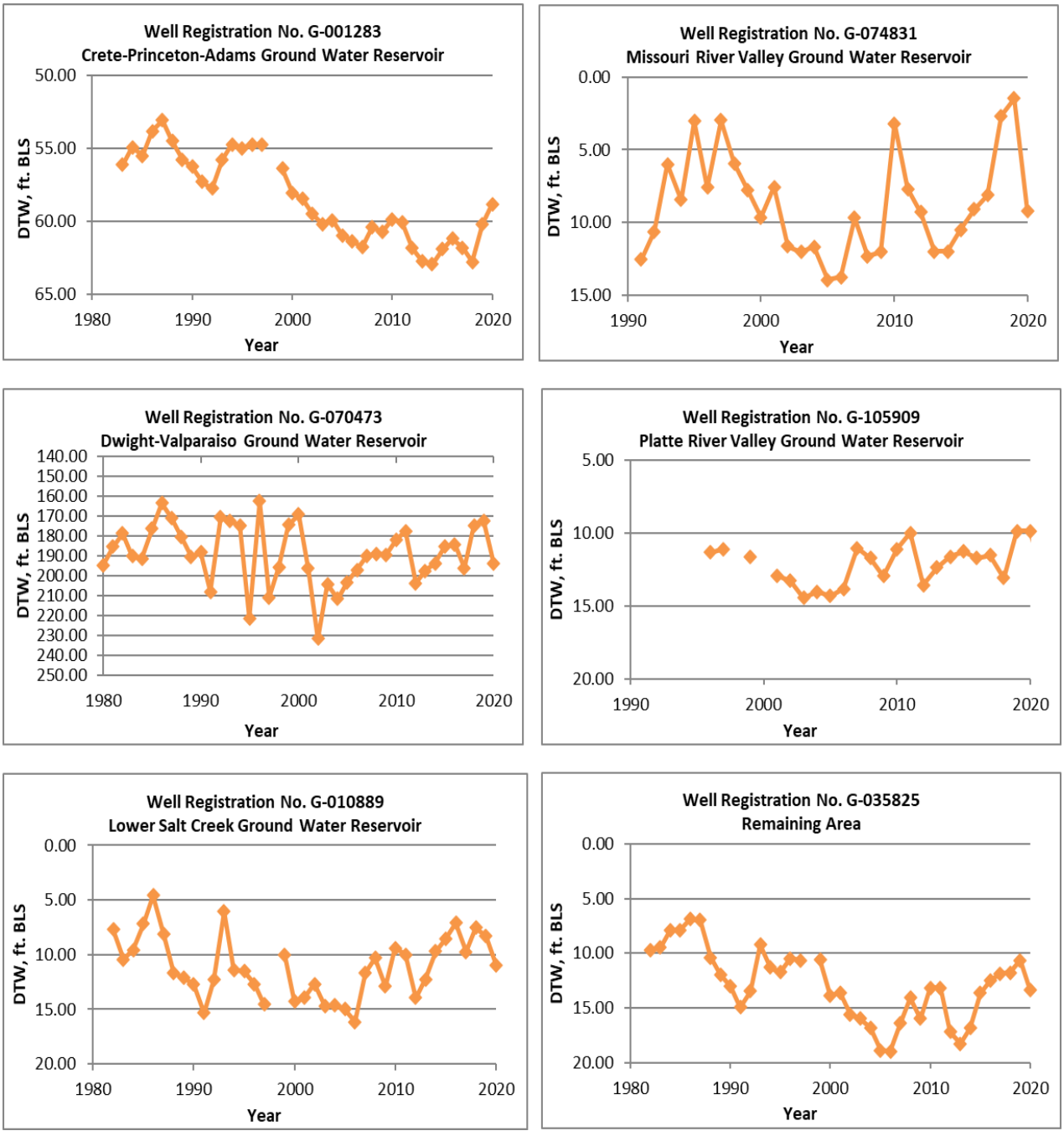


Figure 12 – Representative Fall Groundwater Level Graphs from Each Groundwater Reservoir



3.3 Data Management

LPSNRD's groundwater database continued to be developed and maintained in 2021. The District has been working with a contractor on database improvements and revisions and these tasks were expanded upon in 2021.

In 2021, the District continued to utilize the information site created in 2017 that allows cooperators to view existing data for their wells and to enter new meter information based upon a preassigned login.

District staff continued to utilize the mobile database collection tools that were recently developed. Staff utilizes tablet computers for many aspects of data collection including water level data, water meter inspections, and retrieval of historical sampling information while in the field. These tools have aided staff in ensuring quality data entry and providing tools to better communicate with landowners while in the field.

4. DESIGNATED AREAS OF MANAGEMENT

Applicable Regulations: Sections B, E, F, G, I, J, K, L

The District's 1995 GWMP specifies three types of areas in which LPSNRD can pursue various management activities to deal with concerns in groundwater quality and quantity. These three types of areas are Groundwater Reservoirs (GWRs), the Remaining Area (RA), and Community Water Supply Protection Areas (CWSPAs). The following sections highlight NRD activities in each area in regard to both groundwater quality and quantity.

4.1 Groundwater Quality

4.1.1 Groundwater Reservoirs

Note: for more information on LPSNRD's Groundwater Reservoirs, see Druliner and Mason, 2001.

4.1.1.1 Crete-Princeton-Adams

The Crete-Princeton-Adams (CPA) GWR is located in the southwestern portion of LPSNRD (see Figure 2). The aquifer in CPA is generally semi-confined to confined, and consists of a complex sequence of glacial till, loess, sand, and gravel. Saturated thickness of sediments ranges from 50 to 250 feet, and depth to groundwater ranges widely from a few feet to about 250 feet below the land surface. Results of groundwater monitoring for nitrate, pesticides, and other components in the CPA GWR are summarized in Figures 6-9 and Table 2. In addition to this routine monitoring, several important actions in CPA

were undertaken as part of the Eastern Nebraska Water Resources Assessment (ENWRA). These activities are described in Section 17. Also, in addition to these activities, the District is continuing administration of a Phase II nitrate management area in the Hickman CWSPA (see Figure 3). Activities for the Hickman CWSPA in 2021 are described in Section 4.1.2.16. Finally, in 2020 a major water user applied for a water well permit for industrial use in the CPA GWR, and three new well permits were issued in 2021 for that use. Basic information in this regard is summarized in Section 5.

4.1.1.2 Dwight-Valparaiso

The Dwight-Valparaiso (DV) GWR occupies the northwestern portion of the District (see Figure 2). The DV aquifer is mostly semi-confined to confined, and is made up of sand and gravel deposits underlying thick glacial till and loess. Saturated thickness of these sands and gravels is about 40-100 feet, and depth to water again ranges from a few feet to about 250 feet below the land surface. Due to the confining units present, significant variations in water levels can result from changes in head pressure due to groundwater withdrawals, and as a result in 2014 the District established the Dwight-Valparaiso-Brainard Special Management Area to help address these in-season declines. Further information about this activity can be found in Section 4.2. Results of groundwater quality monitoring for nitrate, pesticides, and other components in the DV GWR are summarized in Figures 6-9 and Table 2. In addition to this routine monitoring, the District continues to administer a Phase II nitrate management area in the Valparaiso CWSPA (see Figure 3). Activities for the Valparaiso CWSPA in 2021 are described in Section 4.1.3.28.

4.1.1.3 Lower Salt Creek

Applicable Regulations: Section K(1)

The Lower Salt Creek (LSC) GWR is located in the north-central portion of the LPSNRD, roughly between Lincoln and Ashland (see Figure 2). The LSC aquifer is semi-confined to confined, and consists mostly of sand and gravel deposits overlying older bedrock units. Saturated thickness of these sand and gravel deposits is about 40 to 65 feet, and depth to water ranges from a few feet to about 50 feet below the land surface. Results of groundwater monitoring for nitrate, pesticides, and other components in the LSC GWR are summarized in Figures 6-9 and Table 2.

In 2002, the LSC GWR was designated as a Phase II management area in response to nitrate levels which were determined to be above the NRD's trigger levels for that phase. As a result of this designation, a local advisory committee was formed to advise the District on adoption of rules and regulations to deal with the nitrate issue. The regulations subsequently adopted by the District required nitrogen certification training for those who apply nitrogen fertilizer to agricultural fields in the GWR, and established cost-share programs to implement Best Management Practices (BMPs) aimed at reducing nitrate in groundwater. Practices for which cost-share is available (in addition to the District-wide cost-share items) include fertilizer meters and manifolds, and soil sampling

and analysis for fertilizer carryover credits. More information on District cost-share in the LSC GWR as well as the remainder of the NRD can be found in Sections 6-10. However, as described above, nitrate levels in groundwater in the LSC GWR have been below the Phase II trigger for the past several years. Thus, it's apparent that nitrate levels in the Lower Salt Creek GWR appear to be decreasing at least somewhat over time. In recent revisions of the District's Groundwater Rules and Regulations (Effective Date: January 15, 2020), a procedure was included for suspending Phase II and moving back to Phase I if nitrate levels dropped below appropriate triggers for a period of not less than three years. In 2021, LPSNRD continued to evaluate steps to suspend the Phase II designation for the LSC GWR, and will continue to consult with landowners and other interested parties in LSC to get their input on future directions for the GWR. However, recent data suggests that nitrate levels within the Waverly, Greenwood, and Ashland CWSPAs, each of which is partially contained within the LSC GWR, have exceeded the Phase II trigger. LPSNRD is cooperating with the City of Waverly, NDEE, and UNL-WSL to implement a comprehensive drinking water protection plan to protect the City's water supply for the foreseeable future. In 2021, LPSNRD worked with Waverly to install dedicated pumps in five preexisting monitoring wells in the vicinity of the City's south wellfield, and with UNL to install one more dedicated monitoring well on the eastern margin of the CWSPA. Part of this project includes determination as to whether the nitrate levels in the Waverly CWSPA meet LPSNRD's criteria for a Phase II GWMA; upon completion of this project the NRD will determine whether to designate the Waverly CWSPA as a Phase II area. Similarly, in 2018 LPSNRD initiated a Phase II Verification Study for the Greenwood CWSPA also to determine if it should be designated as a Phase II GWMA, and these study activities were completed in 2020. In 2021, LPSNRD initiated the public input phase of this study to advise the District on future actions by meeting with the Village of Greenwood, and this process is ongoing. In addition, the District retained a private consulting firm to begin Phase II verification study activities in Ashland, and soil sampling was completed in 2020. It is anticipated that study activities will be completed in 2021. More detail on activities in these CWSPAs can be found in Section 4.1.2 below. Finally, several vadose zone samples have been taken from sites within the LSC GWR to further evaluate the likelihood of groundwater quality concerns. These efforts are also described in Section 4.1.2 below.

4.1.1.4 Missouri River Valley

The Missouri River Valley (MRV) GWR is located along the Missouri River at the eastern margin of the District (see Figure 2). The MRV aquifer is mostly unconfined, and consists of fluvial sand, gravel, and silt deposits with some local clay lenses, all overlying older bedrock formations. Aquifer thickness is on the order of 80 feet, and depth to water is generally around 5 to 10 feet below the land surface. Results of groundwater monitoring for nitrate, pesticides, and other components in the MRV GWR are summarized in Figures 6-9 and Table 2.

4.1.1.5 Platte River Valley

The Platte River Valley (PRV) GWR is located in the northeastern portion of the District, along the southern edge of the Platte River (see Figure 2). The PRV aquifer is an

unconfined alluvial aquifer that consists of fluvial sand, gravel, and silt overlying older bedrock. The aquifer is on the order of 70 feet thick, and depth to water also ranges from about 5 to 10 feet below the surface. Results of groundwater monitoring for nitrate, pesticides, and other components in the PRV GWR are summarized in Figures 6-9 and Table 2.

4.1.1.6 Remaining Area

The Remaining Area (RA) includes all the land in the District which is not included in a GWR (see Figure 2). In the RA, the occurrence of groundwater bearing units is highly variable; in some portions, practically no groundwater is available. As a result of this variability, no specific GWRs are identified within the RA. In those areas where groundwater does occur, it usually comes from small, intermittent sand bodies within silt and clay deposits, or from underlying bedrock units such as the Dakota Formation, or even older limestone units. Groundwater from these sand units may be of acceptable quality, but the small quantity available limits its use. Conversely, significant amounts of groundwater may occur within the Dakota Formation, but salinity and mineral content of this water increases rapidly with depth, and thus the quality is a limiting factor. Groundwater from limestone bedrock is usually limited to small quantities, and this water is also highly mineralized, therefore these older bedrock units are not generally considered as significant aquifers. Results of groundwater monitoring for nitrate, pesticides, and other components in the RA are summarized in Figures 6-9 and Table 2.

In addition to this routine monitoring, the District continues to administer Phase II management areas in the Davey, Hickman, Pleasant Dale, Otoe County RWD #3/Weeping Water, Valparaiso, and Union CWSPAs and a Phase III management area in the Elmwood CWSPA (see Figure 3). However, recent data suggests that the Hickman, Union, and Valparaiso CWSPA nitrate levels have dropped below the Phase II trigger, so LPSNRD is evaluating if and when these Phase II areas should be suspended. However, the data from Pleasant Dale suggests that nitrate levels might have exceeded the Phase III trigger, so in 2018 LPSNRD undertook additional studies in that CWSPA to determine if Phase III designation is necessary. Additional shallow and deep soil sampling toward this end was conducted in 2019, and the District has completed these studies with installation of one additional dedicated monitoring well in 2020. In 2021, the District determined that the Phase III trigger had not been exceeded for Pleasant Dale, and so after meeting with the Village has continued its Phase II implementation. Also in 2018, LPSNRD initiated a Phase II Verification Study for the Raymond CWSPA, as District groundwater sampling indicated that this trigger may have been exceeded. In 2021, three additional dedicated monitoring wells in the CWSPA were installed and sampled. The final report with recommendations was nearing completion at the end of 2021. Finally, nitrate levels in the Sprague CWSPA, which had been very near the Phase II trigger for the past several years, have increased to the point where they are consistently above the trigger, so LPSNRD will initiate designation of that CWSPA as a Phase II area in 2022. More detail on the activities in these CWSPAs can be found under the section for each in Section 4.1.2 below.

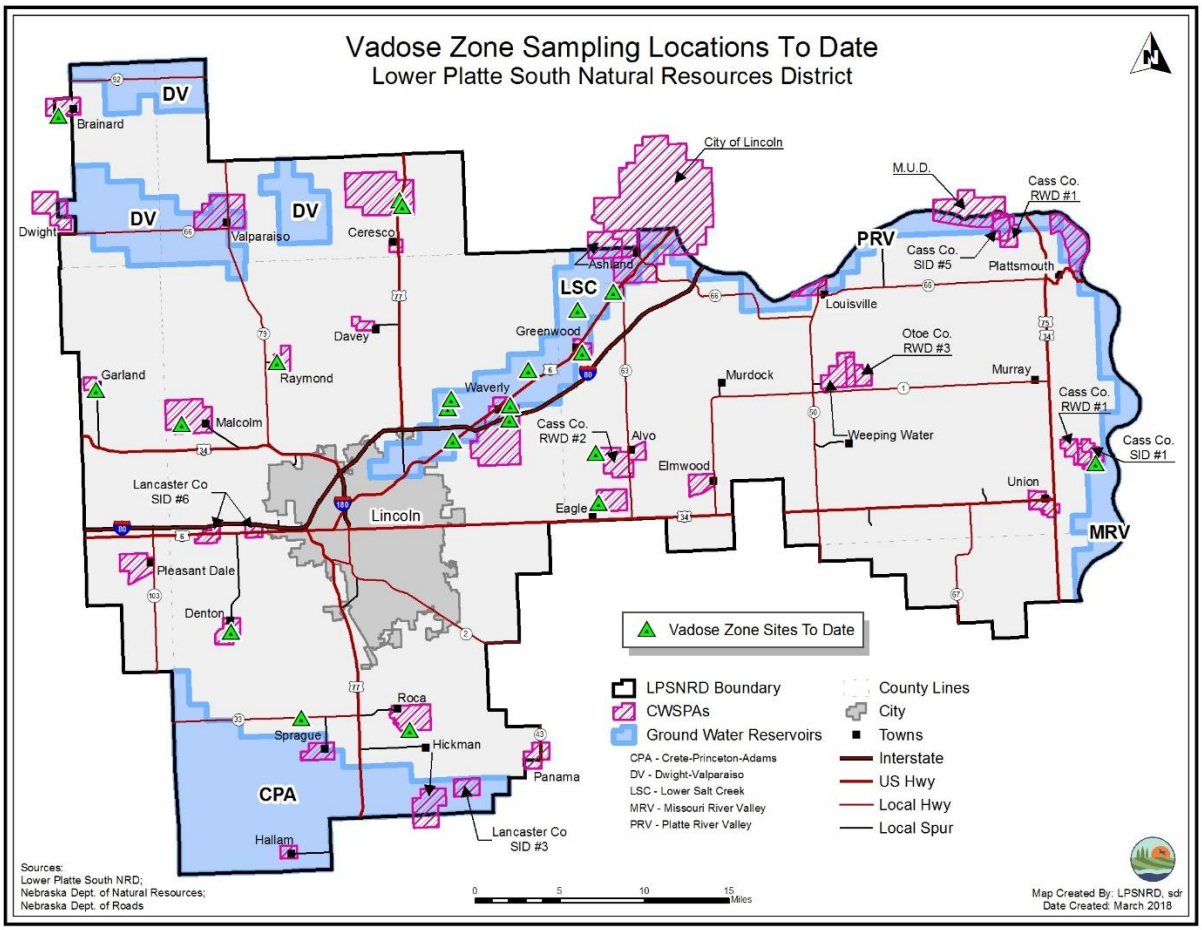
4.1.2 Community Water System Protection Areas (CWSPAs)

LPSNRD focuses a great deal of effort on groundwater which is used for public drinking water supply. This concern has led the District to delineate Community Water Supply Protection Areas around the groundwater supply wells for the 30 public water supplies (PWSs) within its jurisdiction (see Figure 3). CWSPA boundaries correspond with Wellhead Protection Area boundaries as delineated by the NDEE, and are defined as the area which encompasses the 20-year time-of-travel zone around a given wellfield. In other words, the CWSPA is the area around a well or wellfield from which groundwater can be expected to travel in a period of 20 years. NDEE determines these boundaries by entering information on geology, aquifer characteristics, water levels, and well pumping data into a computer model, which then predicts the 20-year time-of-travel zone. Over the past several years, NDEE has begun the process of implementing comprehensive Drinking Water Protection Programs for various WHPAs around the state. An important additional step in this program is that the capture zones of the wellfields are modeled to a 50-year time-of-travel, and more sophisticated modeling techniques are utilized. The City of Waverly project is proceeding under this program structure. Regardless of the individual circumstances, LPSNRD staff continues to work with NDEE staff to ensure that they have the best available geological and groundwater data for this modeling effort, so the boundaries of the CWSPAs are as accurate and defensible as possible.

In general, LPSNRD samples each cooperating PWS well at least annually, and has these samples analyzed for the following components: nitrate-nitrogen, major ions, arsenic, and pesticides. Some of the systems have specific agreements with LPSNRD to perform additional analysis. Also, in 2021, District staff continued implementation of a program to collect unsaturated or vadose zone nitrate data within the confines of the NRD's CWSPAs (as well as locations outside of CWSPAs). This information, which will be similar to that collected during the various verification studies for the Phase II and Phase III delineations, consists of taking soil/sediment samples at approximately 5-foot increments from the land surface downward to the water table, or as deep as the sampling equipment will allow. These samples are analyzed for nitrate-nitrogen content (and any other constituents of concern), and a nitrate profile for the entire vadose zone is constructed. Individual sampling sites will then be re-sampled every few years (the re-sampling may vary depending upon individual results), and the nitrate profiles for each site will be compared over time. In this way, LPSNRD hopes to gain at least some qualitative data to indicate the overall amount of nitrate loading as well as estimates of transport times for various vadose zone settings. Ultimately, this data will help the District evaluate the effectiveness of its management activities, as well as provide some early indication of possible groundwater nitrate problems.

Since 2014, LPSNRD has contacted with different entities to provide vadose zone sampling services. The locations of sites sampled since the inception of the program is shown in Figure 13.

Figure 13 – Vadose Zone Sampling Locations



Vadose zone samples are obtained from shallower depths down to about 75' below the land surface using a small, track-mounted GeoProbe® unit which uses a "direct push" pressure to advance the sampling equipment to the desired depth. For depths greater than about 75', it is necessary to use a more powerful, truck-mounted rotary drilling rig. Both of these units are designed to return continuous core samples of the vadose zone sediments encountered; these samples are in turn analyzed for various compounds such as nitrate-nitrogen, ammonia, and arsenic. Figure 14 shows examples of both of these pieces of machinery.

Figure 14 – Geoprobe® (left) and Rotary Drill Rig (right) Used in Vadose Zone Sampling

In addition, in 2016, LPSNRD began a cooperative effort with UNL-WSL to develop a more comprehensive set of standard operating procedures (SOPs) for vadose zone data collection. This project will aim to address everything from the most basic sample and data collection (e.g. the nitrate-nitrogen and arsenic characterization described above) to more advanced techniques like soil pore-water extraction and analysis, and higher level research parameter collection such as age-dating. In addition, it is anticipated that this project will provide the foundation for establishment of a statewide database or "clearinghouse" for vadose zone data collected by the NRDs, UNL, and other resources agencies. Several sites were sampled in 2017 and 2018. The technical report for this project was completed in September, 2018 (Snow, 2018), and LPSNRD continues to cooperate with UNL-WSL to develop SOPs for vadose zone sampling as well as to help establish the statewide "clearinghouse for vadose zone data. In 2019, the District entered into an additional agreement with UNL-WSL to sample additional sites and analyze vadose zone core samples for additional parameters such as ammonia-nitrogen, pore water content, and isotopic analysis for age-dating. However, due to the COVID-19 pandemic, UNL field activities were severely curtailed and no additional fieldwork was accomplished in 2020. In 2021, six sites (two in the Ceresco and one in the Eagle CWSPAs, two in the LSC GWR, and one at the Cottontail Wildlife Management Area (WMA)) were resampled and as of this writing analysis of the samples and reporting is proceeding.

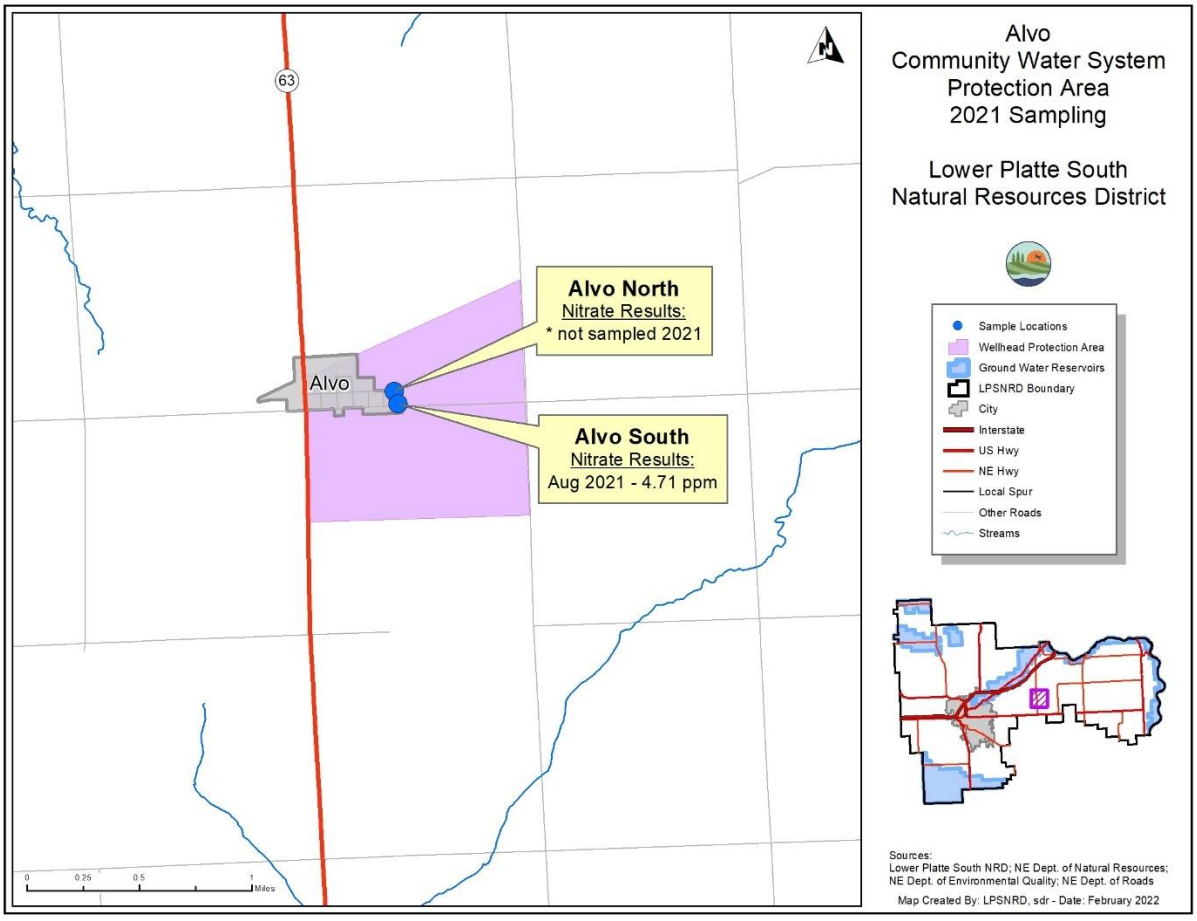
The following sections provide an overview of the District's activities in each of the CWSPAs in 2021. The maps for each PWS show the wells sampled along with the

results for nitrate sampling. Other parameters (typically major ions and pesticides) are described only if they have indicated a cause for concern, otherwise the remaining sample information is communicated to the system for their use.

4.1.2.1 Alvo

The Village of Alvo's CWSPA occupies slightly less than one square mile to the east and north of the village in east-central Cass County. LPSNRD takes annual water samples from two PWS wells for the village, but the District was only able to sample the south well in 2021. The results of that sampling and the locations of Alvo's wells are shown in Figure 15.

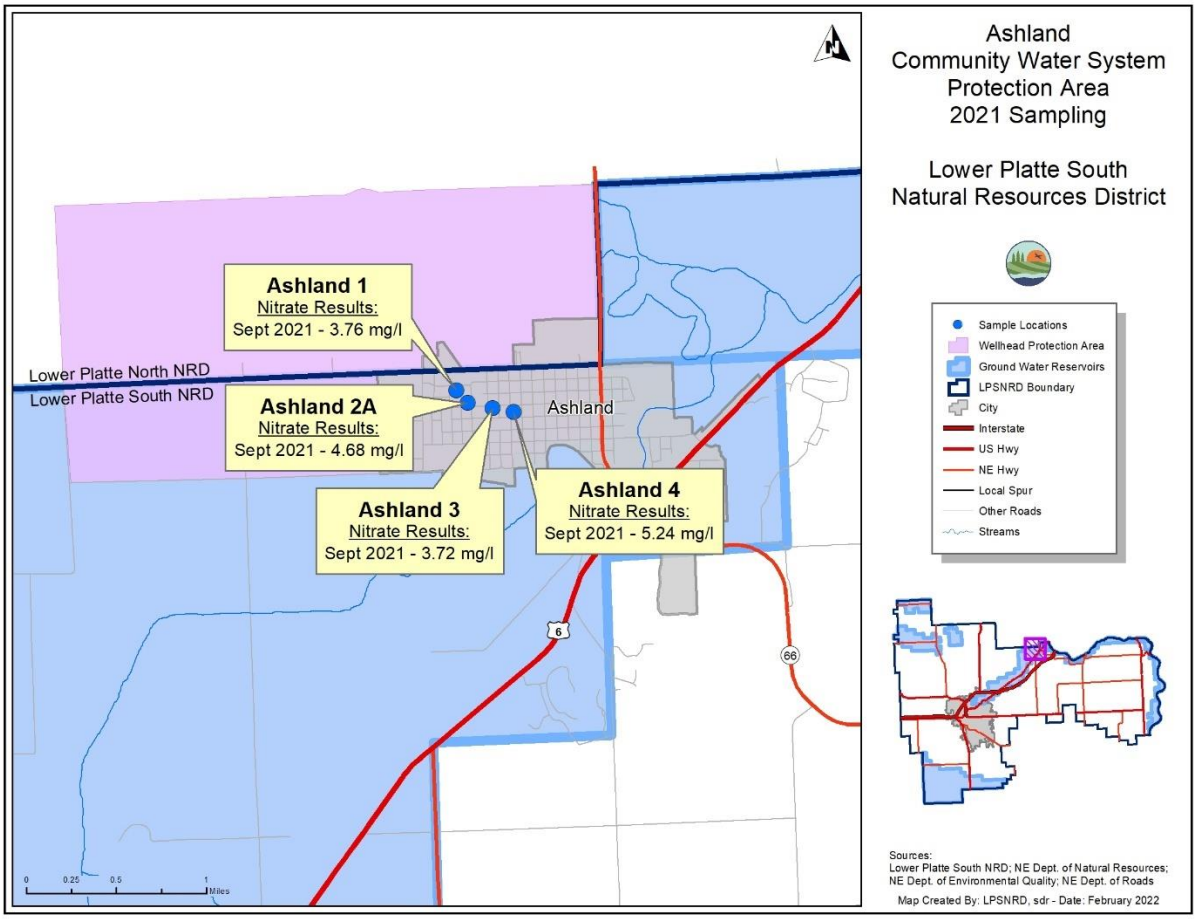
Figure 15 – Alvo



4.1.2.2 Ashland

Ashland's CWSPA encompasses about 4 ½ square miles along the northern edge of the city, located along the Platte River in southeastern Saunders County. This area straddles the boundary between the Lower Platte South and Lower Platte North NRDs; about 1 ½ square miles are located within the LPSNRD. At present, all of Ashland's PWS wells are located in LPSNRD, so the District takes annual water samples from those three PWS wells as part of its regular monitoring. The sample results for the three wells sampled in 2021 are shown in Figure 16 (Note that the LPSRND portion of the Ashland CWSPA is contained within the larger Lower Salt Creek GWR Phase II GWMA). Sampling results from 2018 indicated that nitrate levels in the Ashland CWSPA exceeded the Phase II trigger, and so in 2019 LPSNRD retained a consultant to initiate a verification study for this area. Shallow and deep soil sampling was completed in 2020, and installation of one new dedicated groundwater monitoring well was completed in 2021. Two additional monitoring well sites are planned within the CWSPA and those are anticipated to be completed in 2022, along with the final report and recommendations. Finally, the District amended its interlocal agreement with the Lower Platte North NRD in 2019 to coordinate study efforts and any future Phase implementation.

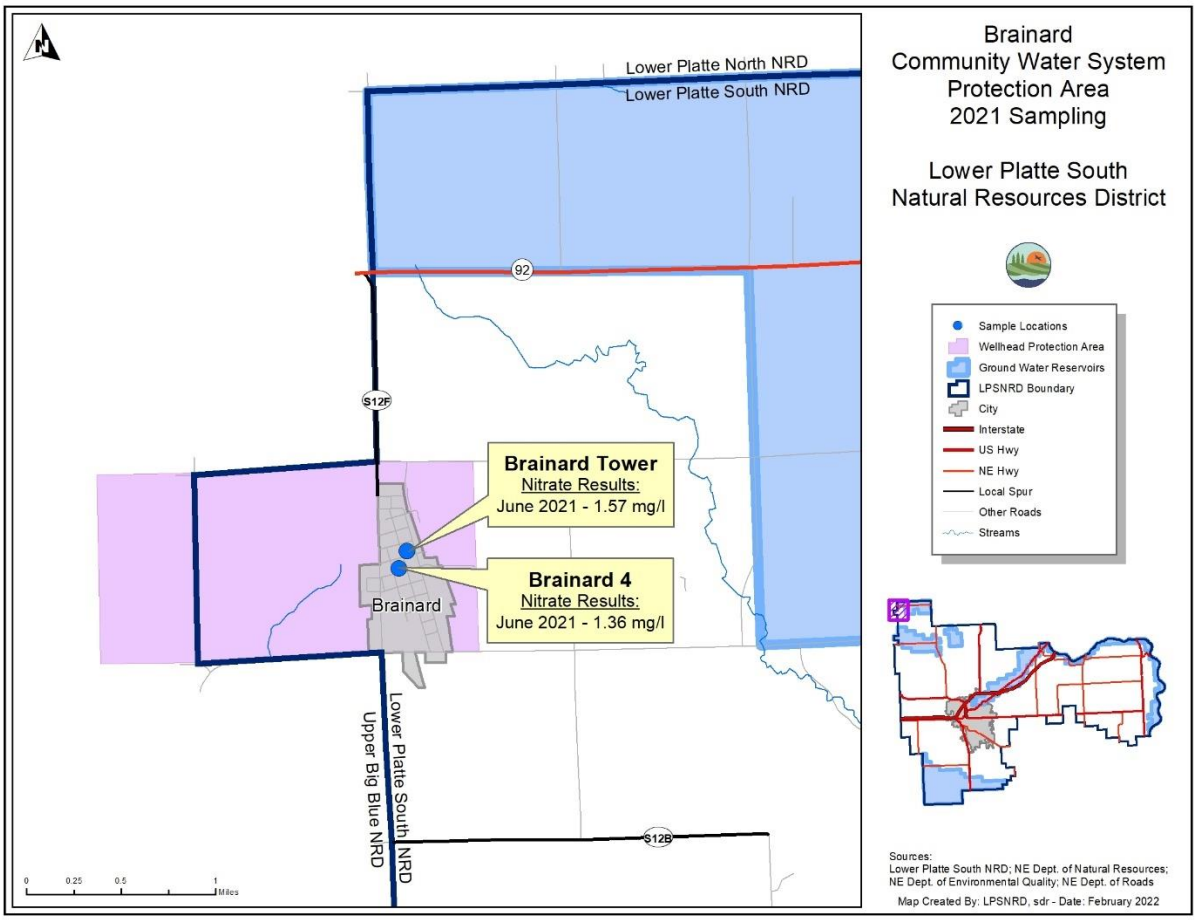
Figure 16 – Ashland



4.1.2.3 Brainard

The CWSPA for the Village of Brainard occupies slightly less than two square miles west of the village in southeastern Butler County. The area straddles the boundary between the Lower Platte South and Upper Big Blue NRDs; about 1 ½ square miles are located in LPSNRD. Both of the Village's wells are located in LPSNRD, and the District has taken annual water samples from these wells. The sample results from the two wells that were sampled in 2021 are shown in Figure 17.

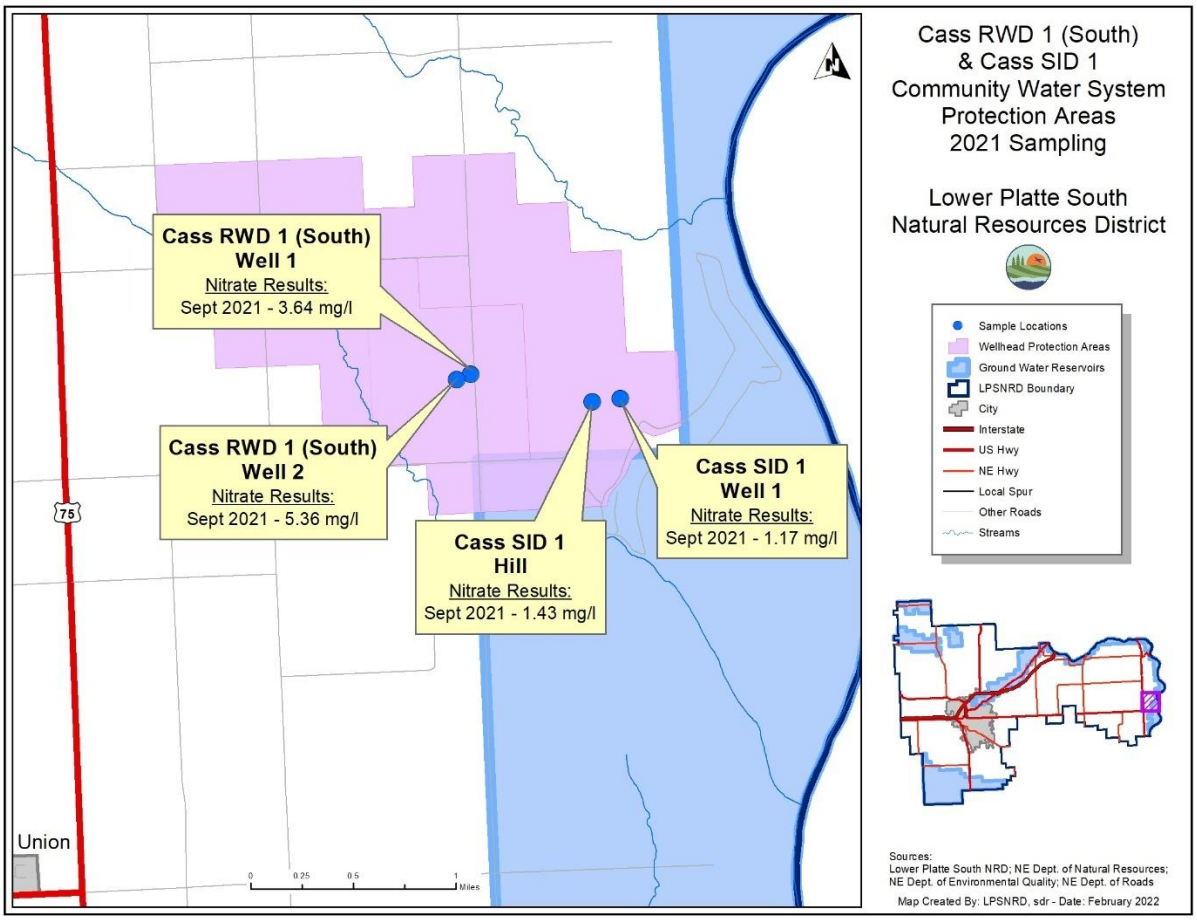
Figure 17 – Brainard



4.1.2.4 Cass County RWD #1/SID #1 (Lake Waconda)

Cass County Rural Water District (RWD) #1 and Sanitary Improvement District (SID) #1 (which serves the Lake Waconda community) are located within about one mile of each other in eastern Cass County, and the CWSPAs overlap each other. The combined area of the two CWSPAs is about 2 ¾ square miles. The NRD takes annual water samples from two PWS wells for the Cass County RWD #1, and two PWS wells for SID #1, and the 2021 results from these well samples are shown in Figure 18. Also, in 2015, Cass County RWD #1 completed a new well along the Platte River near the existing wells for Cass County SID #5/Buccaneer Bay. The results for the new RWD #1 well are shown with those for SID #5 in Figure 20.

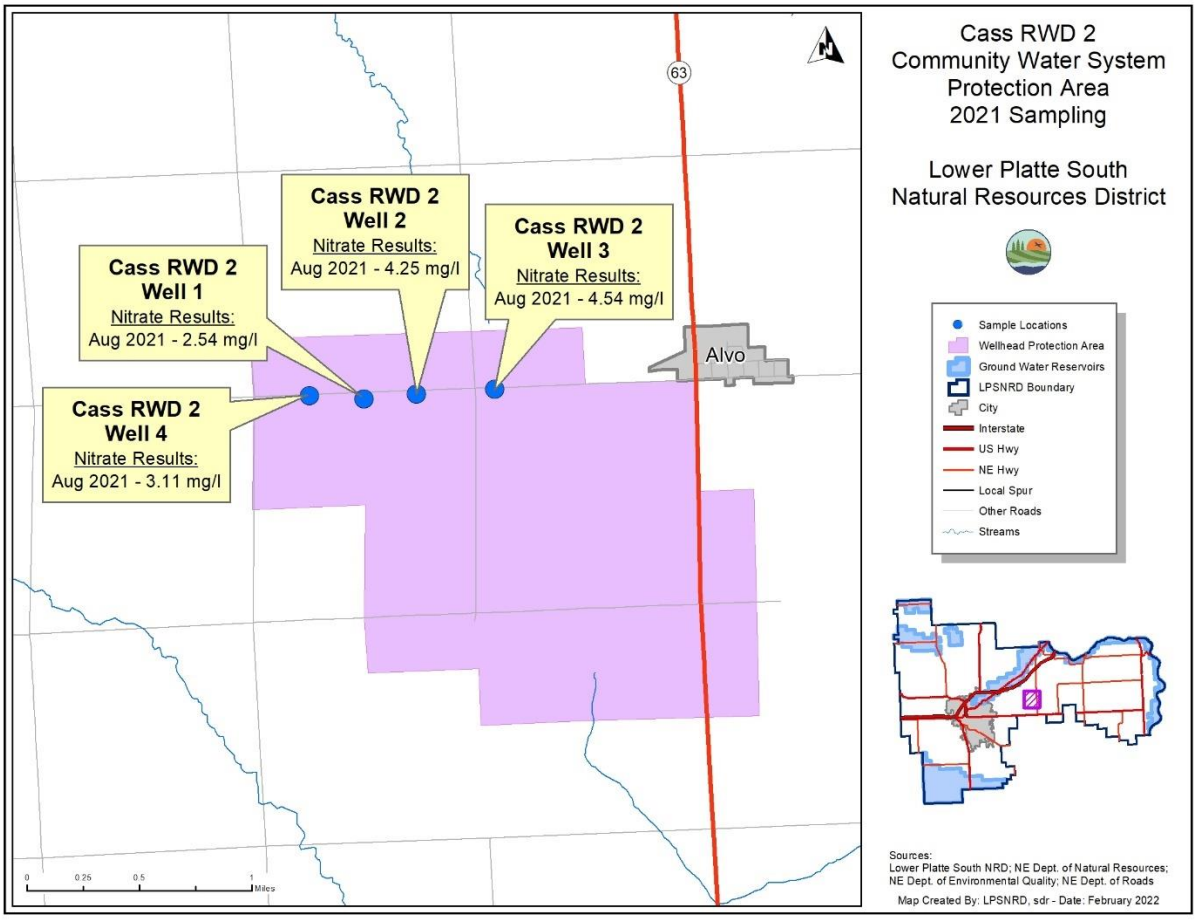
Figure 18 –Cass County RWD #1/SID #1 (Lake Waconda)



4.1.2.5 Cass County RWD #2

The CWSPA for the Cass County Rural Water District #2 takes up about three square miles, just southwest of the Village of Alvo in east-central Cass County. The CWSPAs for the Village of Alvo and the RWD do not overlap each other. LPSNRD takes annual water samples from four PWS wells for the RWD, and the nitrate results of the 2021 sampling are shown in Figure 19.

Figure 19 – Cass County RWD #2



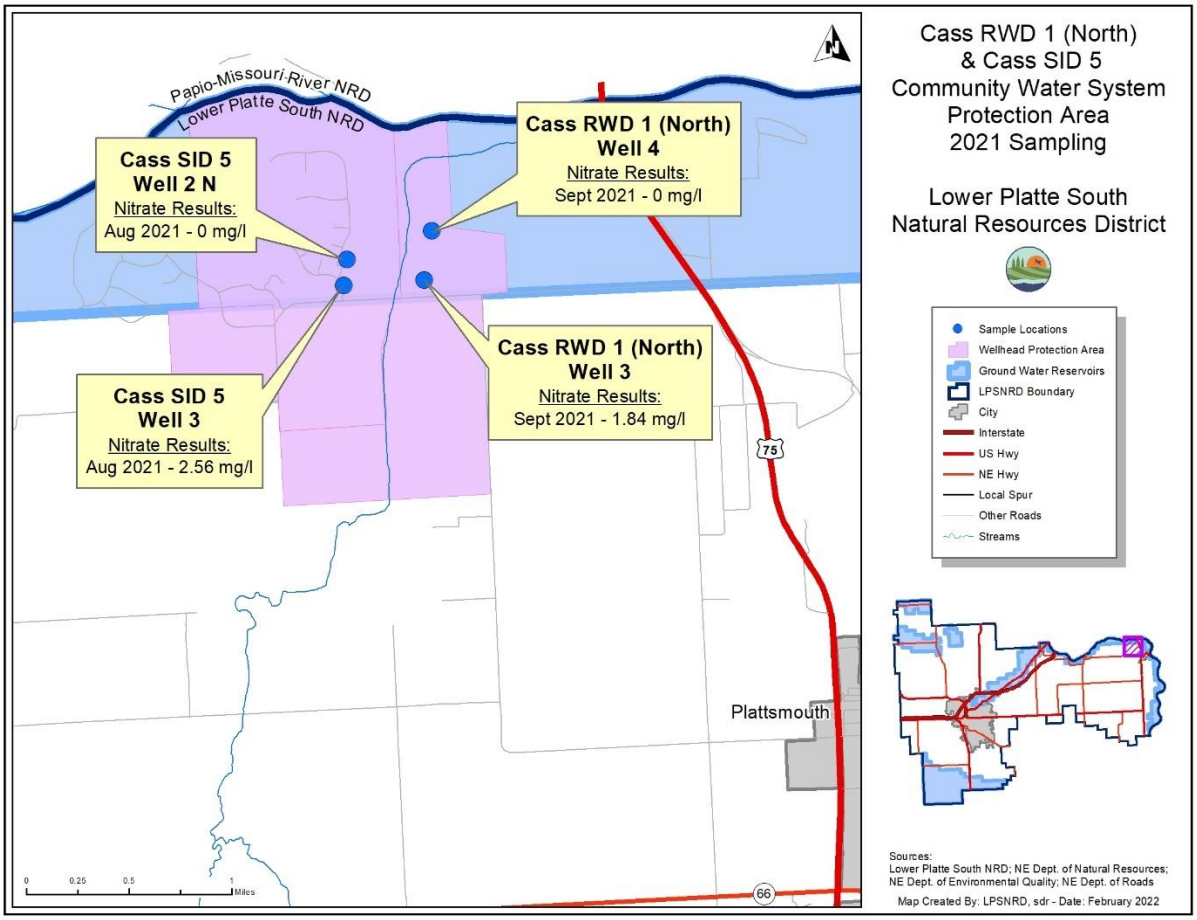
4.1.2.6 Cass County SID #1

See Cass County Rural Water District #1

4.1.2.7 Cass County SID #5/Buccaneer Bay

The Cass County SID #5/Buccaneer Bay development's CWSPA occupies about one square mile northwest of Plattsmouth in northeastern Cass County. The CWSPAs for the SID and Plattsmouth do not overlap. LPSNRD takes annual water samples from two PWS wells for the SID. As noted in Section 4.1.2.4, Cass County RWD #1 completed a new well in 2013 in the vicinity of the SID #5 wells. The 2021 sample results for all four of these wells are shown in Figure 20.

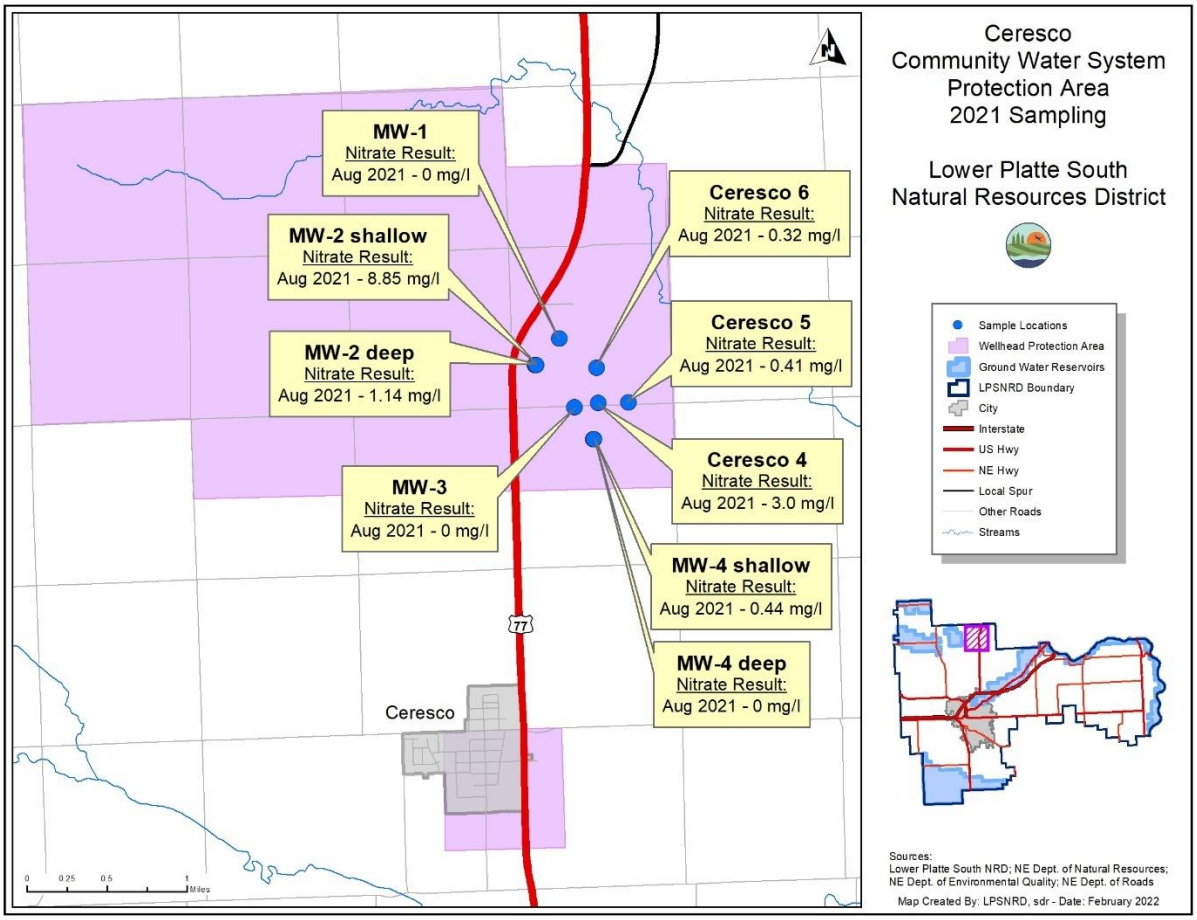
Figure 20 – Cass County SID #5/Buccaneer Bay



4.1.2.8 Ceresco

The Village of Ceresco's CWSPA takes in slightly more than nine square miles north and west of the community in southern Saunders County. In 1997, the District signed an Interlocal Agreement with Ceresco to provide structure for ongoing monitoring and water quality management activities. As a result of this agreement, six dedicated monitoring wells have been installed in the CWSPA. In addition, Ceresco has completed a contaminant source inventory for the CWSPA detailing the locations of possible sources of contamination. The results of the 2021 nitrate sampling are shown in Figure 21.

Figure 21 – Ceresco

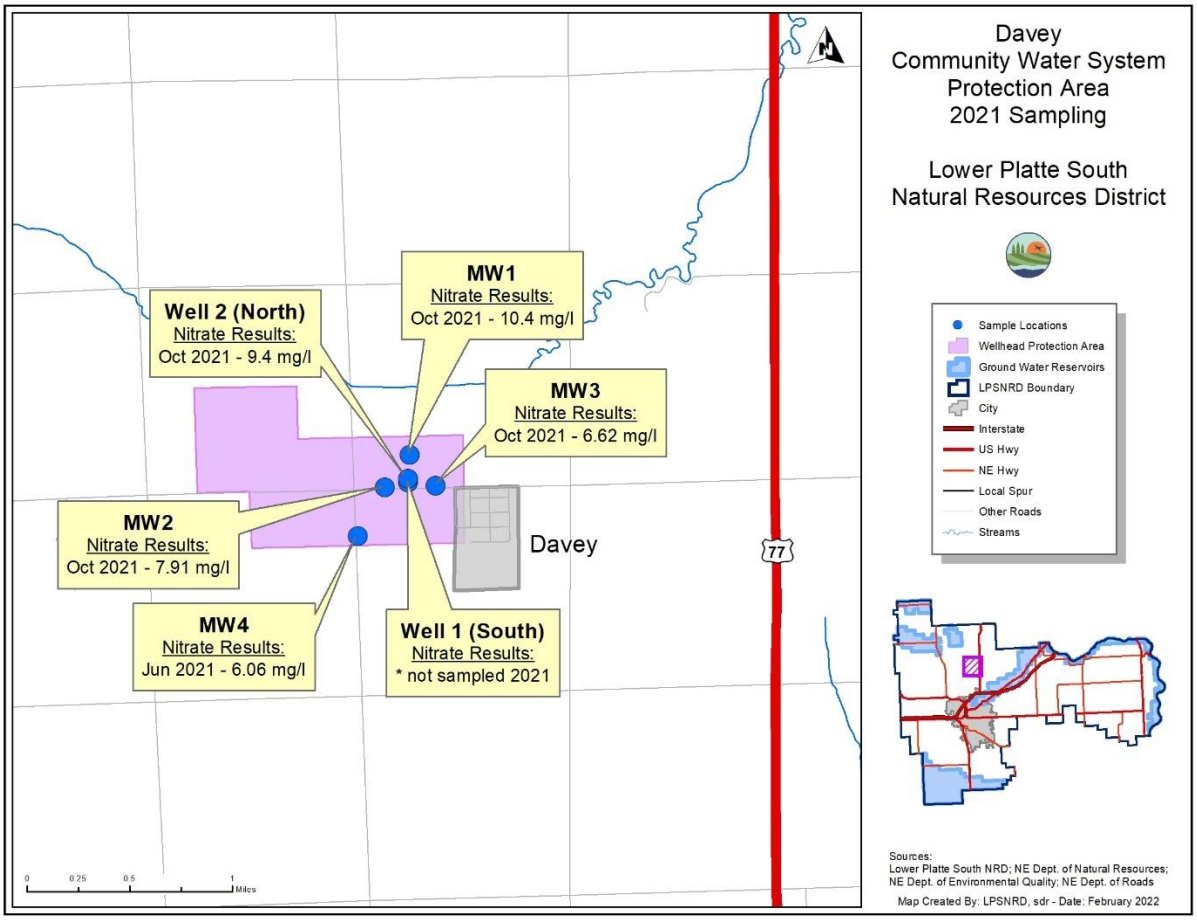


4.1.2.9 Davey

Applicable Regulations: Section K(1)

The CWSPA for the Village of Davey occupies slightly less than ½ square mile west and north of the village in northern Lancaster County. In 2006, District sampling results indicated that the triggers for a Phase II groundwater management area had been exceeded in the CWSPA. As a result, a Phase II Verification Study was initiated and was completed in 2008. This study resulted in the installation of four dedicated monitoring wells in the CWSPA, as well as collection of a great deal of geologic, soil, and other data (EA Engineering, Science, and Technology, 2008a). The nitrate sampling results for the PWS and monitoring wells in 2020 are displayed in Figure 22. As a result of the verification study and subsequent sampling, the LPSNRD designated the Davey CWSPA as a Phase II GWMA in December 2009. In 2012, the NRD began assembling an advisory committee of stakeholders from Davey to advise the District as it develops rules and regulations for the implementation of Phase II, and held the first meeting of that advisory group. Regulations for the Davey Phase II area were adopted in 2013, and became effective in March 2014. As in other Phase II areas, these regulations center on requirement for nitrogen certification for those who apply nitrogen fertilizer, as well as additional promotion of cost-share programs for nitrogen management BMPs. In 2018, the Village began the process of exploring for a possible additional well site to help mitigate the high nitrate levels in the public water supply and those efforts continued in 2019 through2021. The District provided general information for this effort and will continue to assist the Village into the future.

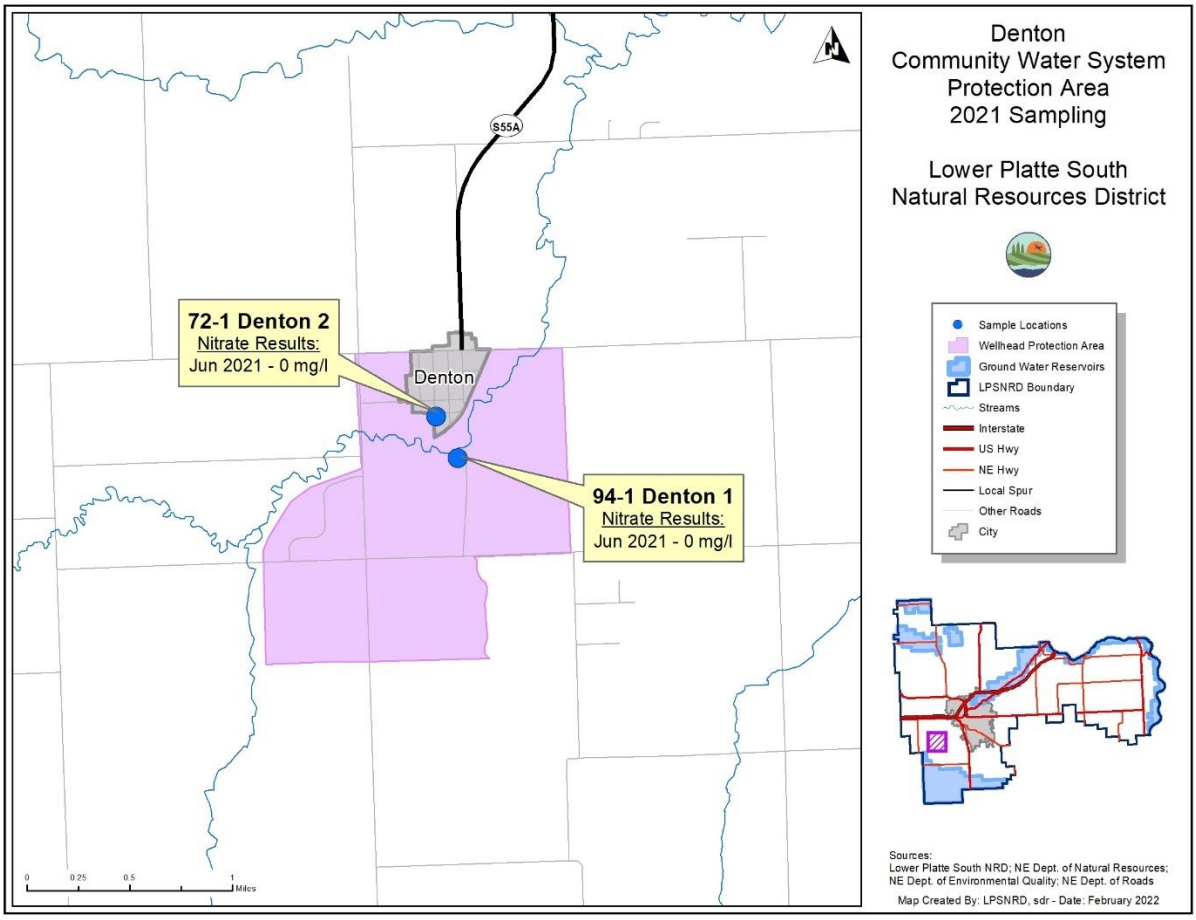
Figure 22 -- Davey



4.1.2.10 Denton

The Village of Denton's CWSPA takes up about 1 ¾ square miles around and to the south of the village in west-central Lancaster County. District staff sample two PWS wells for the village, and the 2021 sample results for Denton's wells are shown in Figure 23.

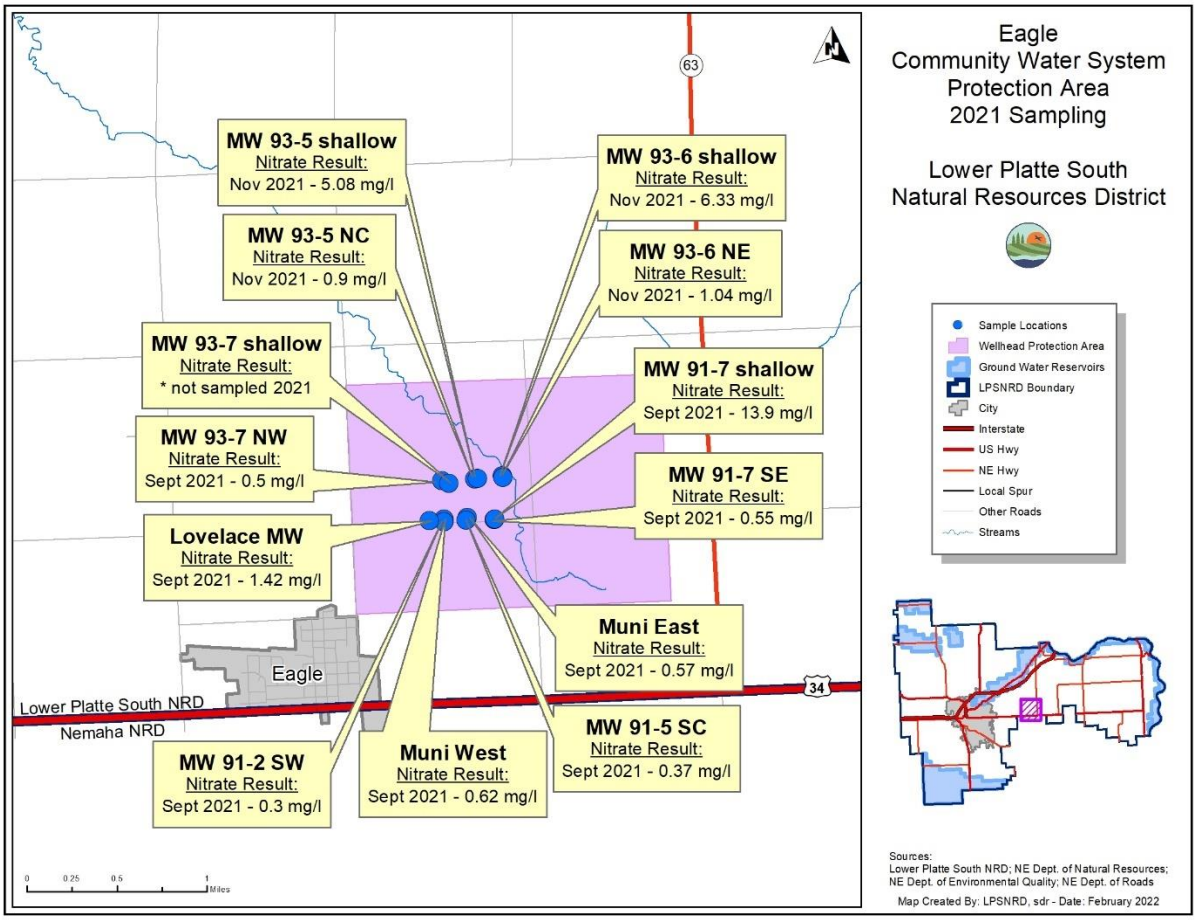
Figure 23 – Denton



4.1.2.11 Eagle

The CWSPA for the Village of Eagle takes in about 1 ½ square miles northeast of the village in southwestern Cass County. As a result of 1998 Interlocal Agreement with Eagle, 11 dedicated monitoring wells have been installed in the CWSPA, and these wells as well as the two PWS wells are monitored by the District. The results of the 2021 nitrate sampling are shown in Figure 24.

Figure 24 – Eagle

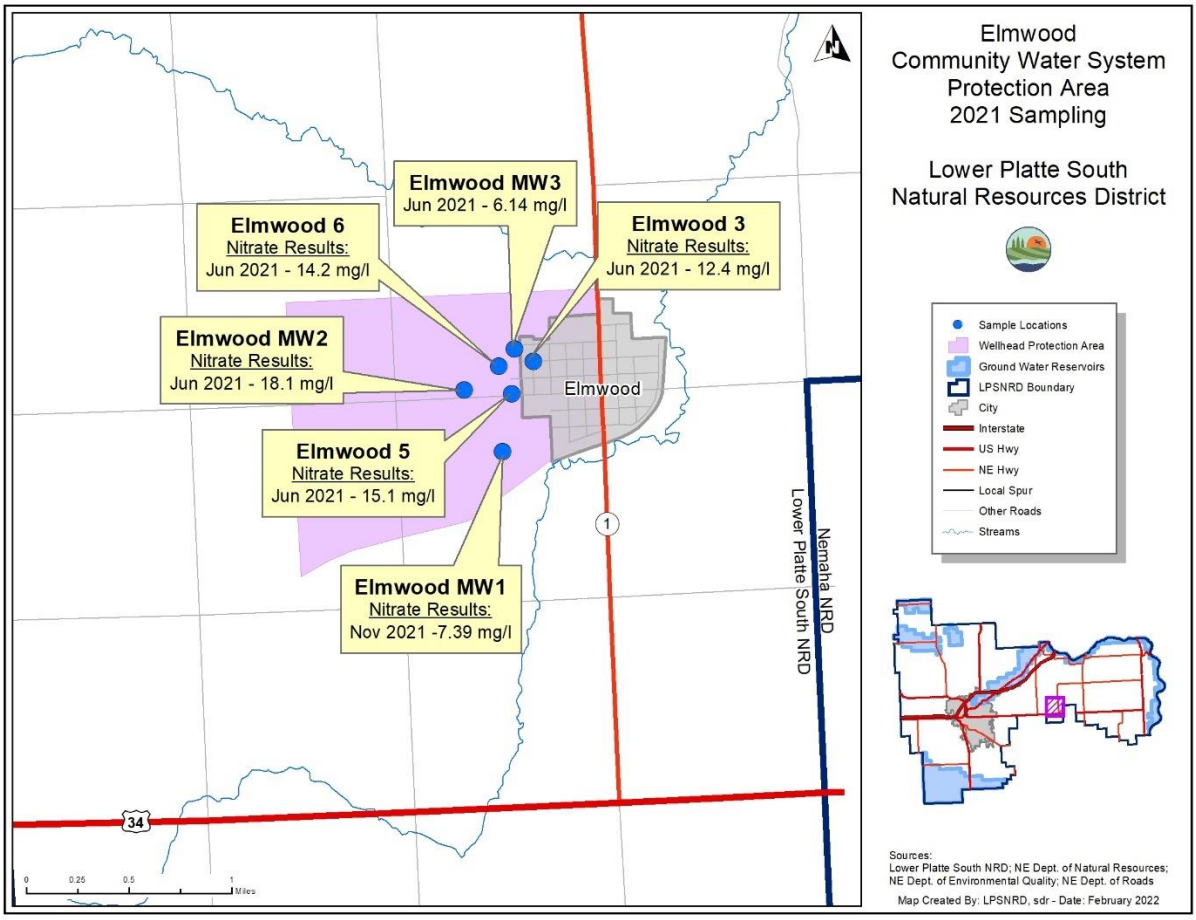


4.1.2.12 Elmwood

Applicable Regulations: Section L(1)

The CWSPA for the Village of Elmwood occupies slightly more than 1 ½ square miles west and south of the village in central Cass County. In 2006, District sampling results indicated that the triggers for a Phase III groundwater management area had been exceeded in the CWSPA. As a result, a Phase III Verification Study was initiated and was completed in 2008. This study resulted in the installation of three dedicated monitoring wells in the CWSPA, as well as collection of a great deal of geologic, soil, and other data (EA Engineering, Science, and Technology, 2008b). The nitrate sampling results for the monitoring wells and three PWS wells in 2021 are displayed in Figure 25. As a result of the verification study and subsequent sampling, the LPSNRD designated the Elmwood CWSPA as a Phase III GWMA in December 2009. In 2010, the NRD assembled an advisory group for the GWMA composed of local residents and officials from the Elmwood area, and held two meetings with that group. Regulations for the Phase III area were developed and adopted in 2011. In 2012 the District began implementation those regulations for the Phase III area, including requirements for nitrogen certification, fall fertilization, and soil sampling, and increased cost-share for best management practices. In early 2012, the District held nitrogen certification classes and certified six nitrogen applicators from the Elmwood CWSPA, and those certifications were renewed in 2017. As part of the Phase III rules and regulations, any producer that intends to apply nitrogen has to conduct soil sampling and must report those results to the LPSNRD. Nitrogen fertilizer can then be applied after the results of the soil sampling have been considered by the landowner, but only after March 1 of any given cropping year (i.e. no fall fertilization is allowed in order to limit the opportunity for nitrates to leach below the crop root zone). In addition, producers must report the amount of nitrogen applied to those fields by the end of each calendar year. LPSNRD will continue to work with all operators within the Phase III area to ensure that its regulations are implemented successfully.

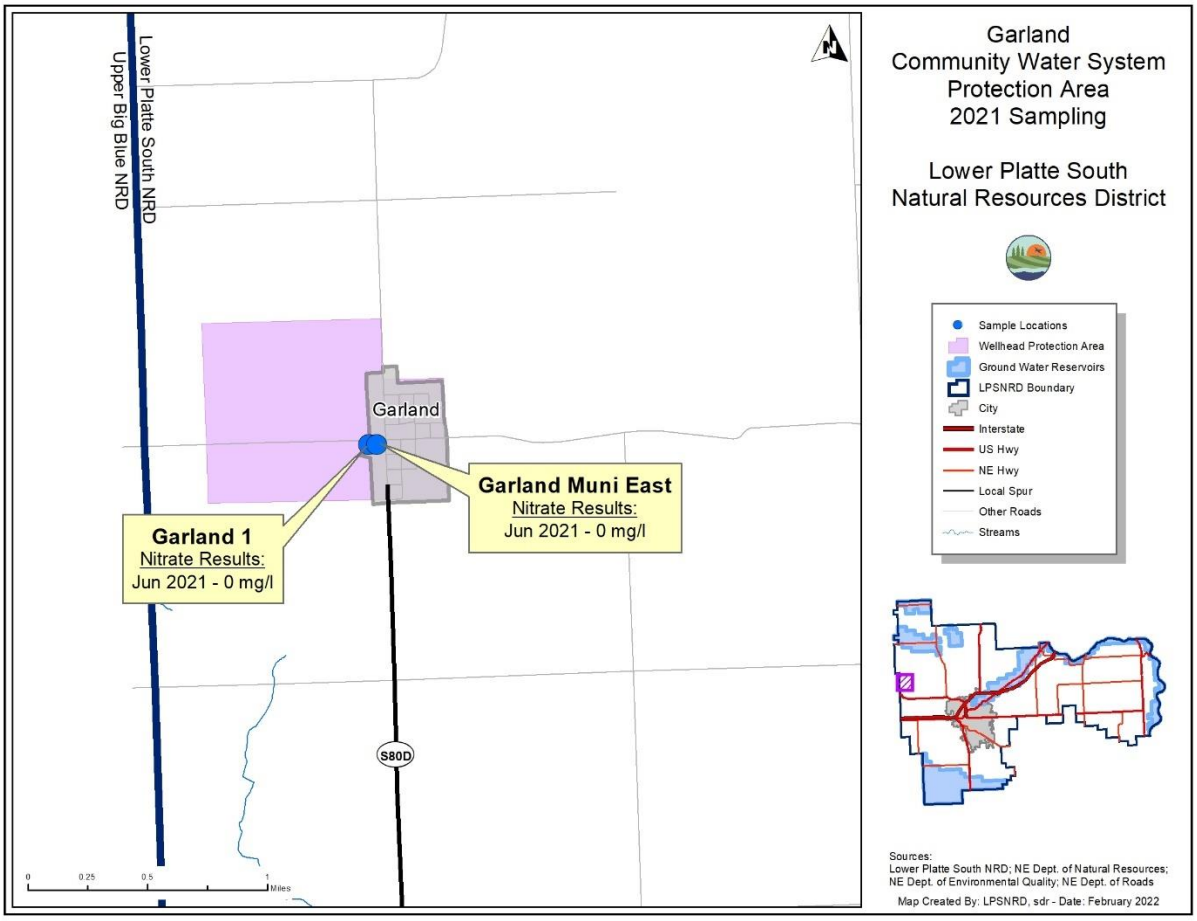
Figure 25 – Elmwood



4.1.2.13 Garland

The Village of Garland's CWSPA takes up slightly less than one square mile around and to the west of the village in northwestern Seward County. District staff sample two PWS wells for the village, and the 2021 nitrate results are shown in Figure 26.

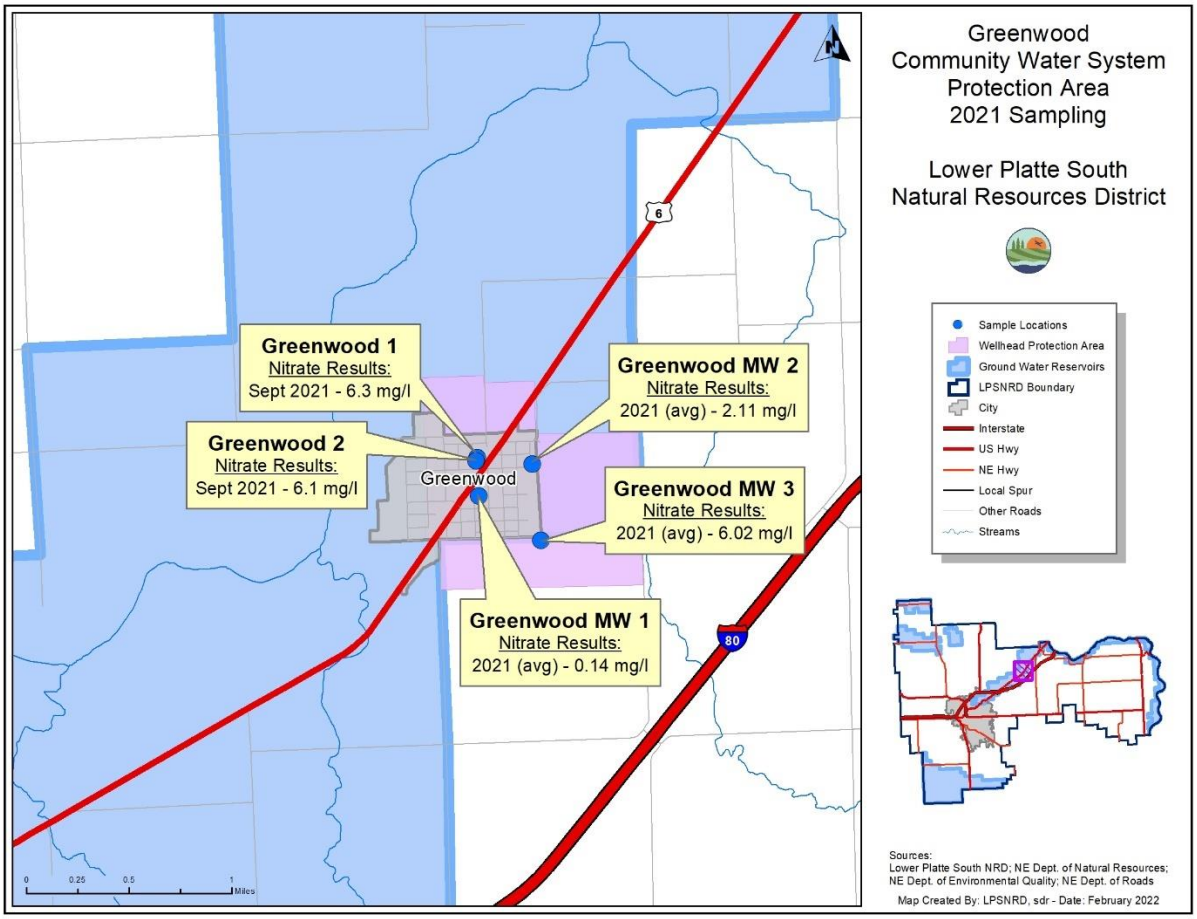
Figure 26 – Garland



4.1.2.14 Greenwood

The CWSPA for Greenwood occupies about one square mile around and to the east and southeast of the village in western Cass County. District staff sample two PWS wells and three dedicated monitoring wells for the village, and the 2021 sample results from Greenwood's wells are shown in Figure 27. This data as well as sample results from past years indicates that the nitrate levels in the CWSPA have exceeded the Phase II (and perhaps the Phase III) trigger, but the majority of Greenwood's CWSPA is already contained within the larger Lower Salt Creek GWR Phase II GWMA. The District has considered suspending the Phase II designation for the LSC GWR and will continue to evaluate whether or not to do so. However, in 2018, the NRD began a two-year Verification Study for the Greenwood CWSPA to see if it merits designation as a Phase II GWMA. Shallow and deep soil sampling have been completed and three dedicated monitoring wells were installed in and around Greenwood in 2019, and the study report was completed in 2020. That report concluded that NPS groundwater contamination is occurring in the CWSPA. In 2021, LPSNRD met with Greenwood to determine future actions regarding Phase II implementation; if the CWSPA is designated as a Phase II area it would add a small area to the south of the Village to Phase II activities.

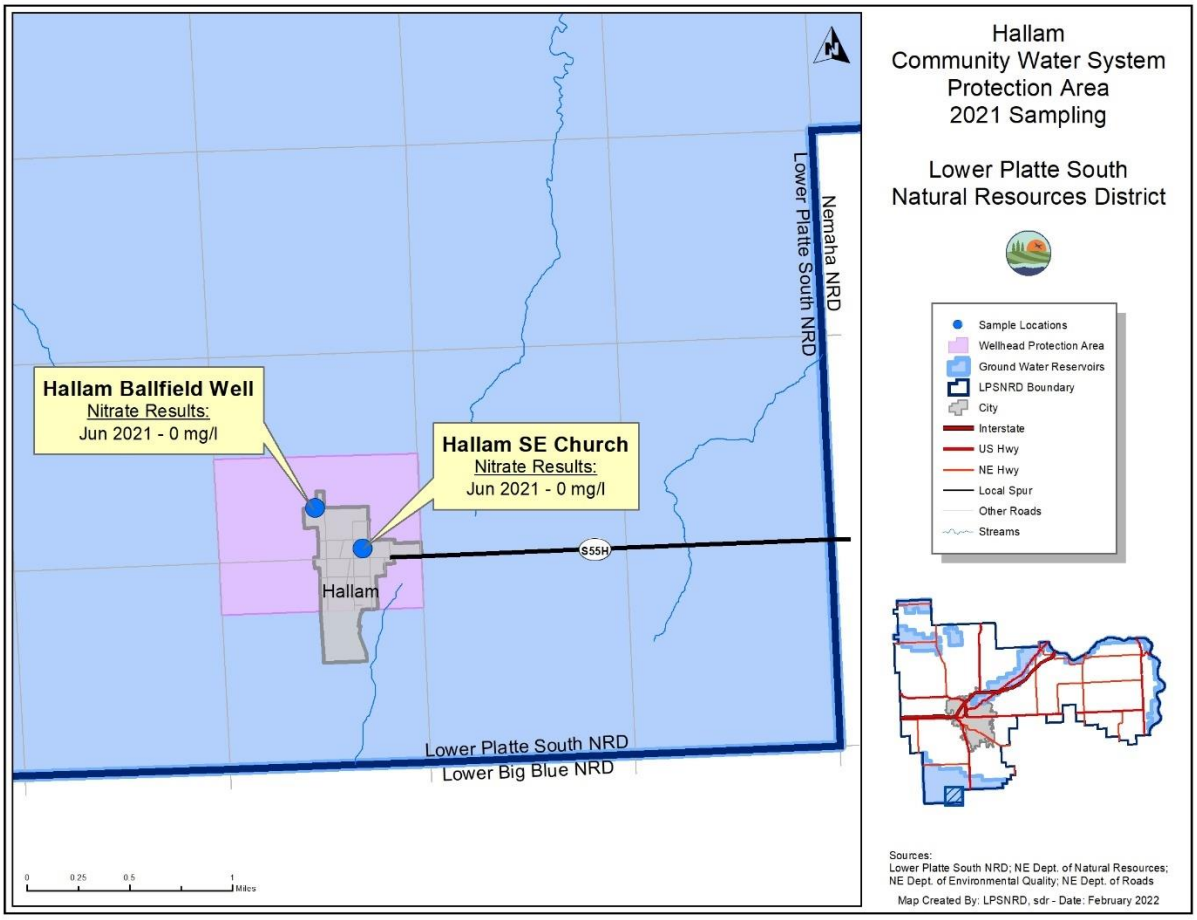
Figure 27 – Greenwood



4.1.2.15 Hallam

The Village of Hallam's CWSPA takes up about ¾ square mile around and to the north of the village in southern Lancaster County. District staff sample two PWS wells for the village, and the 2021 nitrate results are shown in Figure 28.

Figure 28 – Hallam

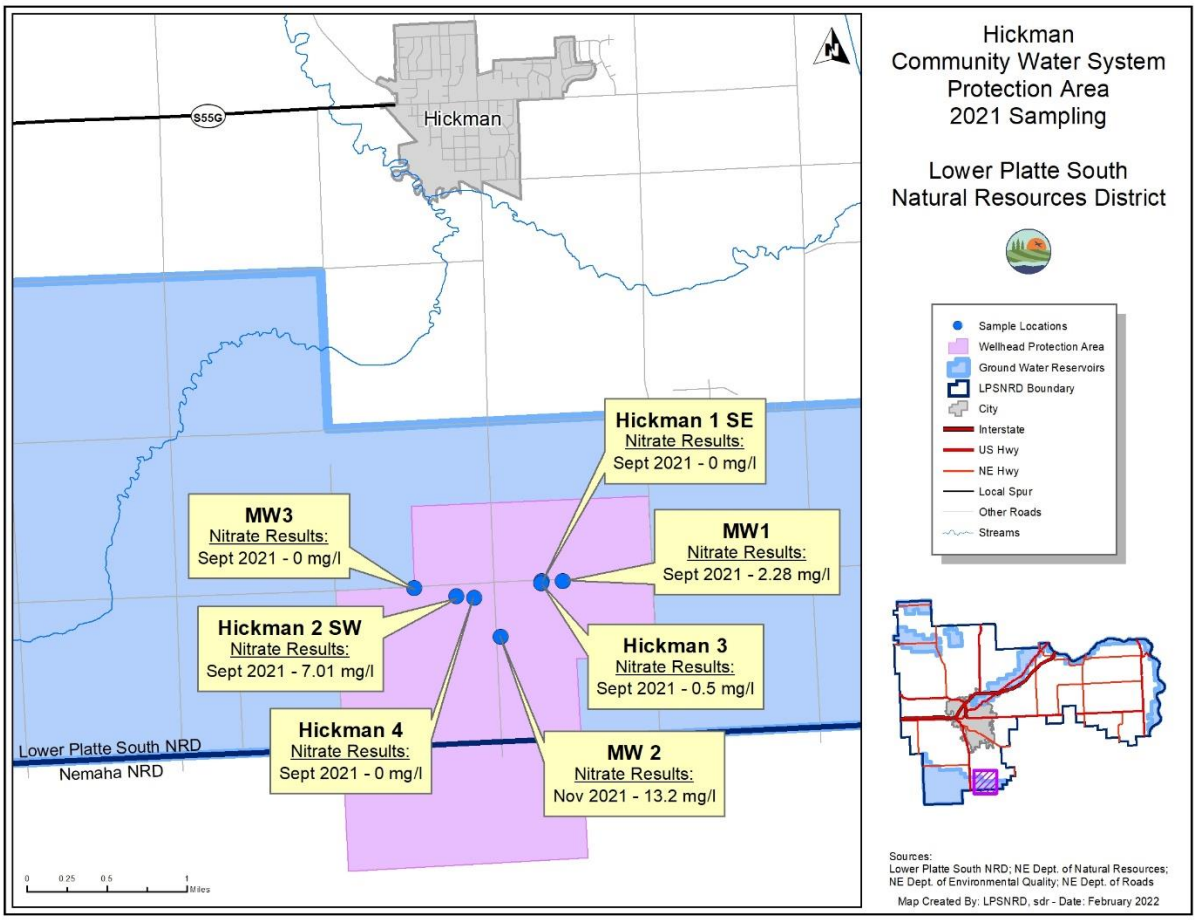


4.1.2.16 Hickman

Applicable Regulations: Section K(1)

The City of Hickman's CWSPA takes in slightly more than 3 ½ square miles south of the city in southern Lancaster County. The CWSPA for Hickman straddles the boundary between the Lower Platte South and Nemaha NRDs; about 2 ½ square miles are in LPSNRD, and the remaining one square mile is in NNRD. In 2006, District sampling results indicated that the triggers for a Phase II groundwater management area had been exceeded in the CWSPA. As a result, a Phase II Verification Study was initiated and was completed in 2009. This study resulted in the installation of three dedicated monitoring wells in the CWSPA, as well as collection of a great deal of geologic, soil, and other data (EA Engineering, Science, and Technology, 2009a). The nitrate sampling results for the PWS and monitoring wells in 2021 are displayed in Figure 29. As a result of the verification study and subsequent sampling, the LPSNRD designated the Hickman CWSPA as a Phase II GWMA in December 2009. In 2012, the NRD began assembling an advisory committee of stakeholders from Hickman to advise the District as it develops rules and regulations for the implementation of Phase II, and the District developed and adopted the Phase II regulations as of November 1, 2013. As already described, these regulations include a requirement for nitrogen certification training and additional promotion of BMP cost-share. In addition, in 2013, LPSNRD signed an addendum to its Interlocal Agreement with the Nemaha NRD to allow LPSNRD to provide BMP cost-share to producers in NNRD's portion of the CWSPA, as long as any of those producers who desire the cost-share first complete LPSNRD's nitrogen certification training requirements. for 2011 through 2021, Hickman's nitrate levels in the NRD's monitoring wells continued to stay below the Phase II trigger. In recent revisions of the District's Groundwater Rules and Regulations (Effective Date: January 15, 2020), a procedure was included for suspending Phase II and moving back to Phase I if nitrate levels dropped below appropriate triggers for a period of not less than three years. Hickman's levels have stayed around the Phase II trigger and some variation in one or more of the wells could result in an exceedance of that trigger. As a result, in 2022 LPSNRD will continue to consider the process of suspending the Phase II requirements for the Hickman CWSPA.

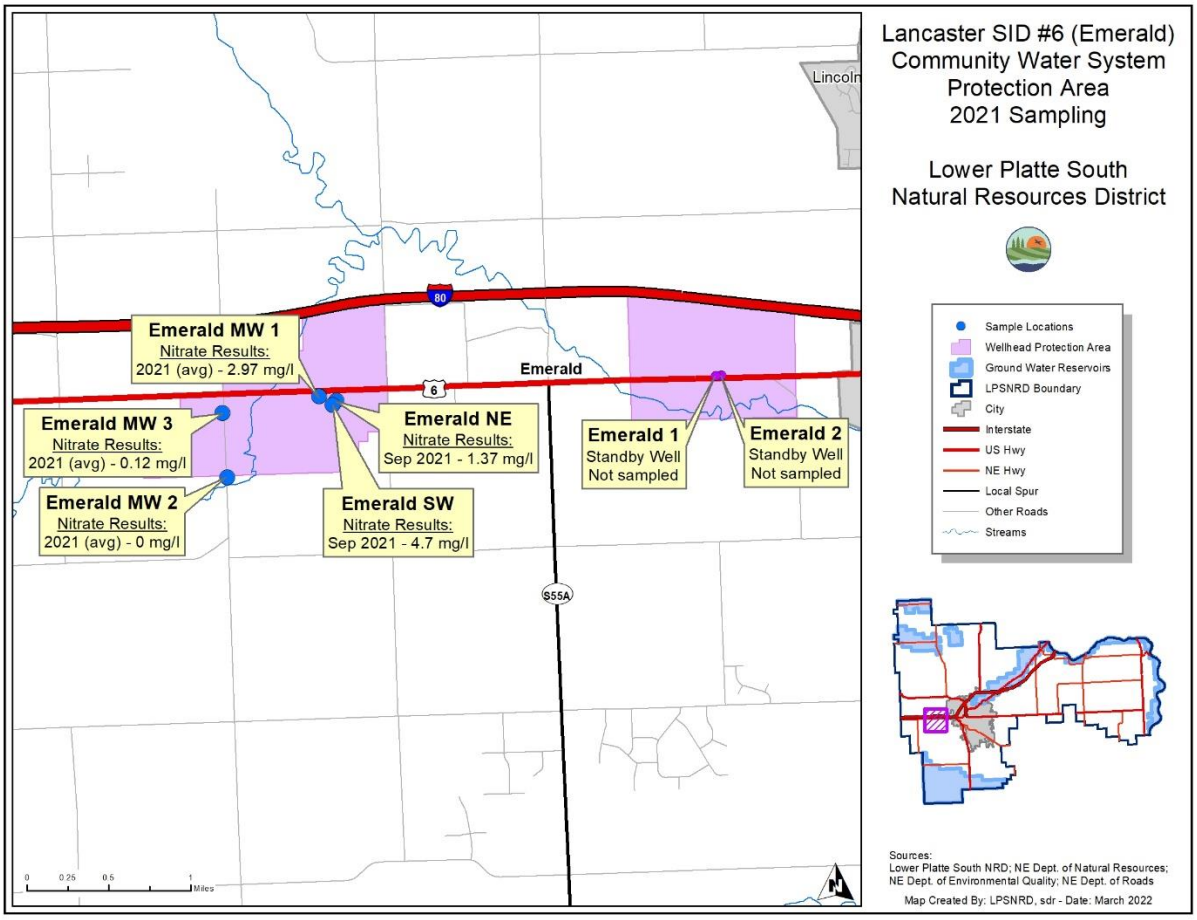
Figure 29 – Hickman



4.1.2.17 Lancaster County SID #6/Emerald

The process of installing a new public water system for the community of Emerald in west-central Lancaster County stretches back for several years. After considerable effort, the system was completed and came online in 2010. In 2011, NDEE completed delineation of the wellhead protection area boundary for the new wellfield, and in 2013 LPSNRD arranged a sampling agreement for it. Figure 30 shows the 2021 sample results. Note that the wells in the eastern portion of the CWSPA are backup wells and are not typically sampled in a given year. Also, the sample results for 2016-2018 indicate that the Phase II trigger had been exceeded for Emerald. In 2018, the District initiated a Phase II verification study to determine if the Emerald CWSPA should be delineated as a Phase II GWMA. Shallow soil sampling was completed in 2018; deep soil sampling and installation of one monitoring well were completed in 2019, and the remaining two monitoring wells were completed in 2020. Study activities are complete and a report was issued in late 2020. With the installation of the dedicated monitoring wells, it appears that the Phase II trigger has not been exceeded, and so Phase II designation is not warranted at this time. In 2021, LPSNRD consulted with the SID to that effect, and both entities agreed to continue monitoring water quality in the SID supply wells and monitoring wells to determine whether additional action will be necessary in the future.

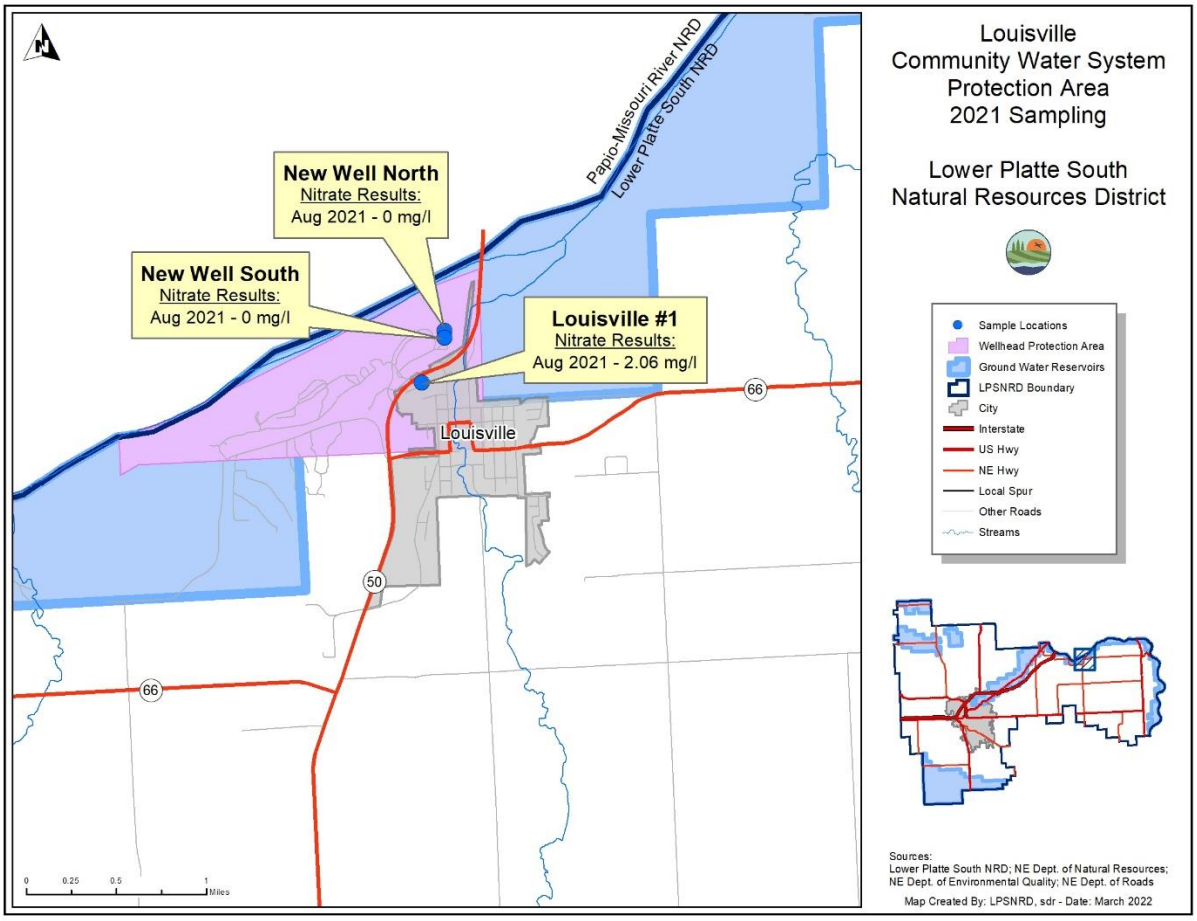
Figure 30 – Lancaster County SID #6/Emerald



4.1.2.18 Louisville

The City of Louisville's CWSPA takes up about1 ¼ square miles to the west of the city along the south side of the Platte River in northern Cass County. District staff sample three PWS wells for the city, and the 2021 nitrate results are shown in Figure 31.

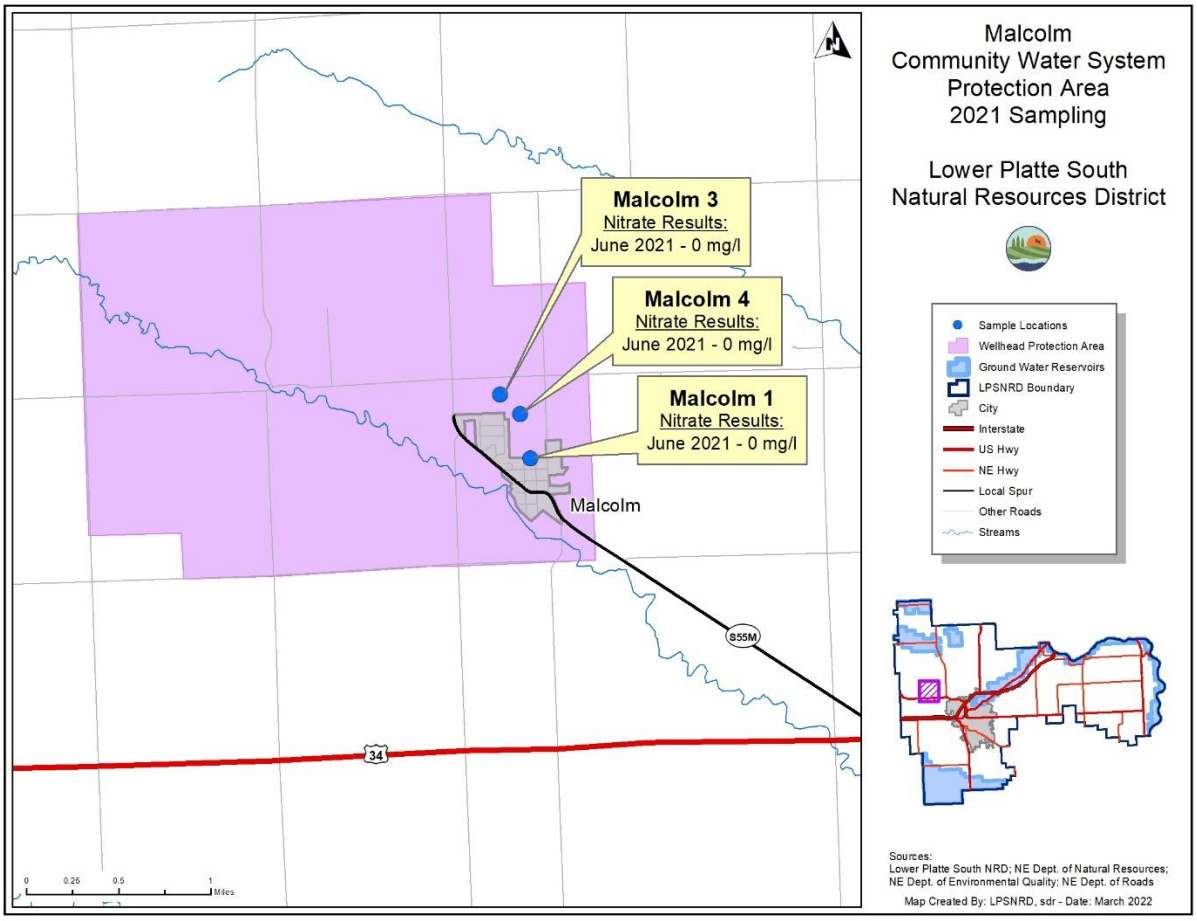
Figure 31 – Louisville



4.1.2.19 Malcolm

The Village of Malcolm's CWSPA covers about 5 square miles north and west of the village in west-central Lancaster County. District staff sample three PWS wells for the village, and the 2021 nitrate results are shown in Figure 32.

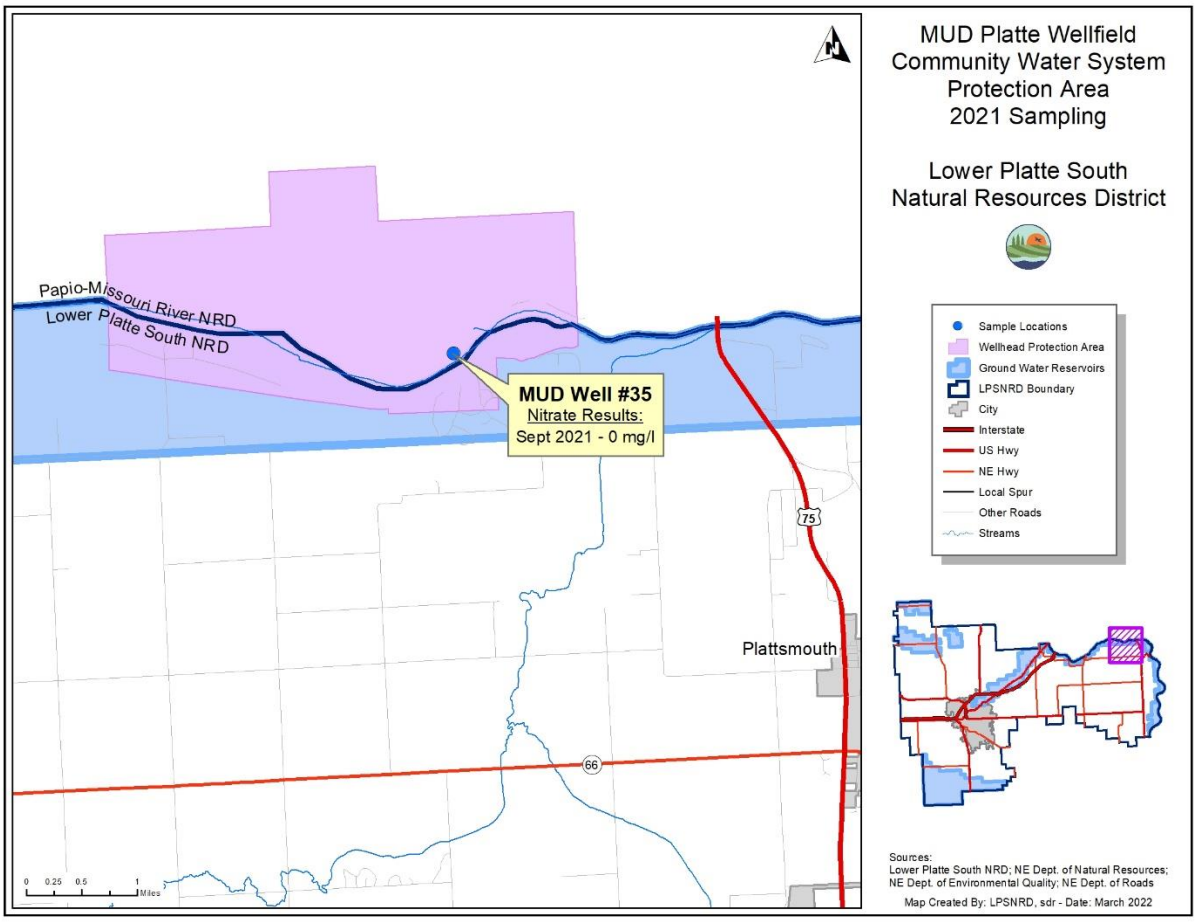
Figure 32 – Malcolm



4.1.2.20 Metropolitan Utilities District (MUD)

The Metropolitan Utilities District (MUD) serves the greater Omaha area. It gets its water supply from the Missouri River and several wellfields, one of which is the Platte wellfield just northwest of Plattsmouth along the lower reaches of the Platte River. The CWSPA for the MUD Platte wellfield occupies about 12 square miles along the Platte River, most of it on the north side of the river in the Papio-Missouri River NRD. LPSNRD staff sample one well in the wellfield, and the 2021 result of District sampling is shown in Figure 33.

Figure 33 – Metropolitan Utilities District (MUD)



4.1.2.21 Otoe County RWD #3/Weeping Water

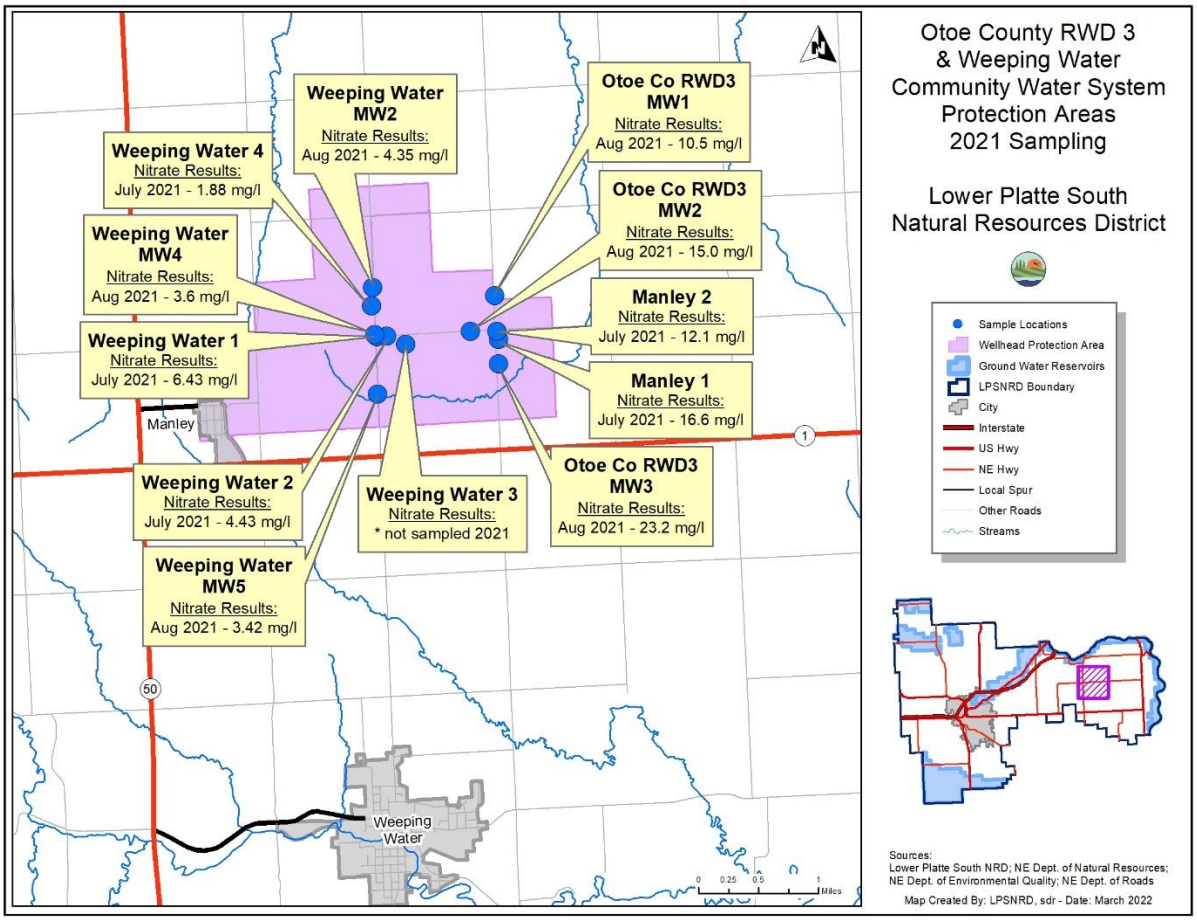
Applicable Regulations: Section K(1))

The CWSPAs for Otoe County Rural Water District #3 (OCRWD#3) and the City of Weeping Water are located within about one mile of each other just northeast of the village of Manley in central Cass County, and the CWSPAs overlap. The total area of the two CWSPAs is slightly over four square miles, and the overlap area is about one square mile. Water from the OCRWD#3 wells is combined with water from other supply wells throughout the system to supply customers in other parts of Cass and Otoe Counties, including the Village of Manley. Water from the Weeping Water wellfield is used to supply customers in the City of Weeping Water, which is about five miles south of the wellfield.

In 2006, District sampling results indicated that the triggers for a Phase II groundwater management area had been exceeded in these two CWSPAs. As a result, a Phase II Verification Study was initiated and was completed in 2009. This study resulted in the installation of six dedicated monitoring wells in the CWSPA, as well as collection of a great deal of geologic, soil, and other data (EA Engineering, Science, and Technology, 2009b). Unfortunately, two of the monitoring wells for the Weeping Water investigation (MW-1 and MW-2) were inadvertently installed too close to the county road right-of-way, and had to be decommissioned in mid-2009. As a result of additional investigation, two new wells were installed in 2011-2012 to replace these wells. The nitrate sampling results for the PWS and monitoring wells in 2021 are displayed in Figure 34.

The results of the District nitrate sampling from 2006-2009 indicated that the trigger for Phase II and possibly Phase III had been exceeded. However, conversations with NDEE late in 2009 indicated that the boundaries of the two CWSPAs might need modified based on the additional information gained in the verification study. The District supplied the information to NDEE, and new boundaries for the two CWSPAs were proposed and adopted. LPSNRD then delineated the entire combined area of the two CWSPAs as a joint Phase II GWMA in January 2010. In 2011 the District held a public hearing on, adopted, and began implementation of rules and regulations for the Phase II area, including requirements for nitrogen certification, and increased levels of cost-share for best management practices. In early 2012, the District worked with UNL Extension to hold nitrogen certification classes for those required operators in the CWSPA, and began implementation of enhanced cost-share for BMPs installed in the CWSPA. Re-certification for operators was held in 2017. Also, in 2016, the City of Weeping Water installed a new well to replace an older well that had been showing high nitrate levels, and nitrate in the City's system has decreased considerably since that time. All this information will continue to be incorporated into LPSNRD's management efforts for the CWSPA.

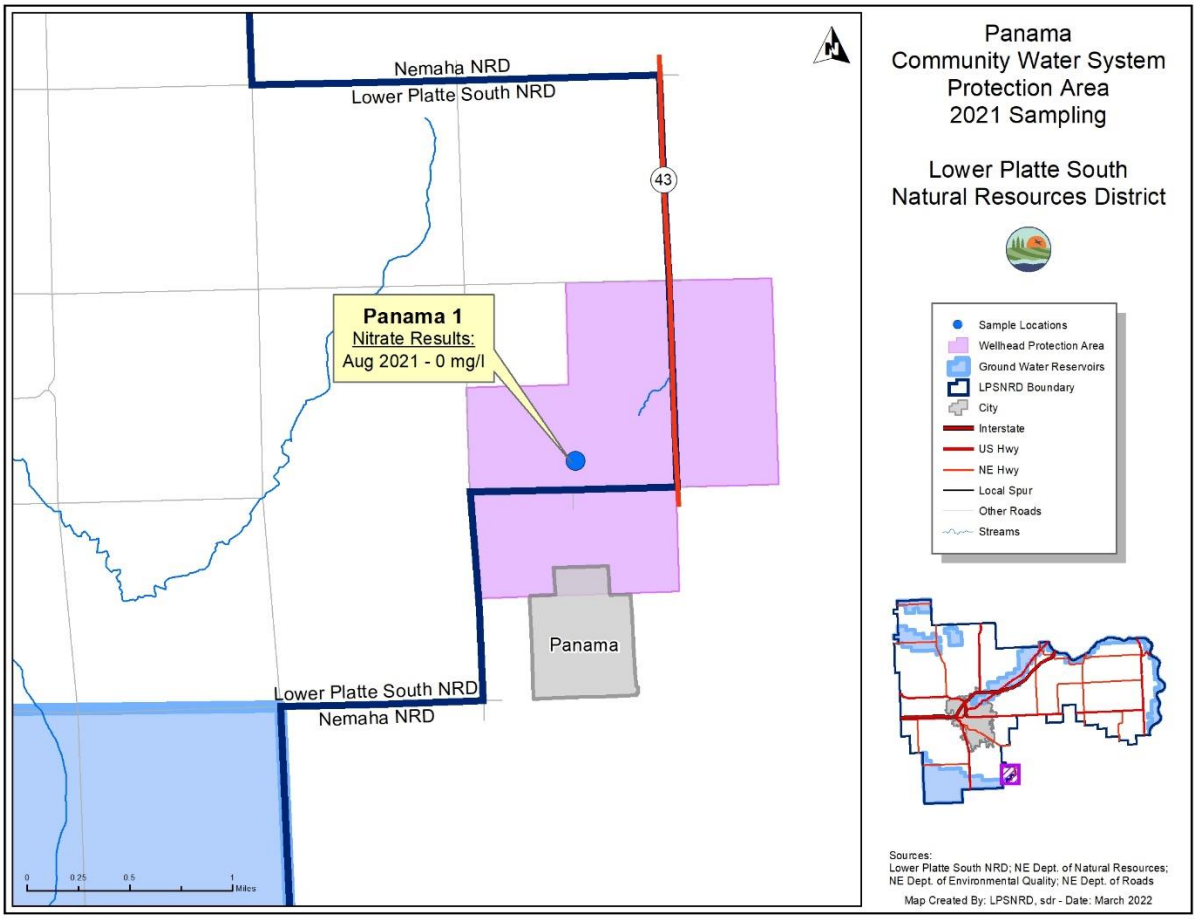
Figure 34 – Otoe County RWD #3/Weeping Water



4.1.2.22 Panama

The Village of Panama's CWSPA occupies about one square mile north and east of the village in southeastern Lancaster County; the CWSPA overlaps the boundary between LPSNRD and the Nemaha NRD, and the Village itself is within NNRD. However, the one PWS well for the Village is located within LPSNRD, and the 2021 nitrate results are shown in Figure 35.

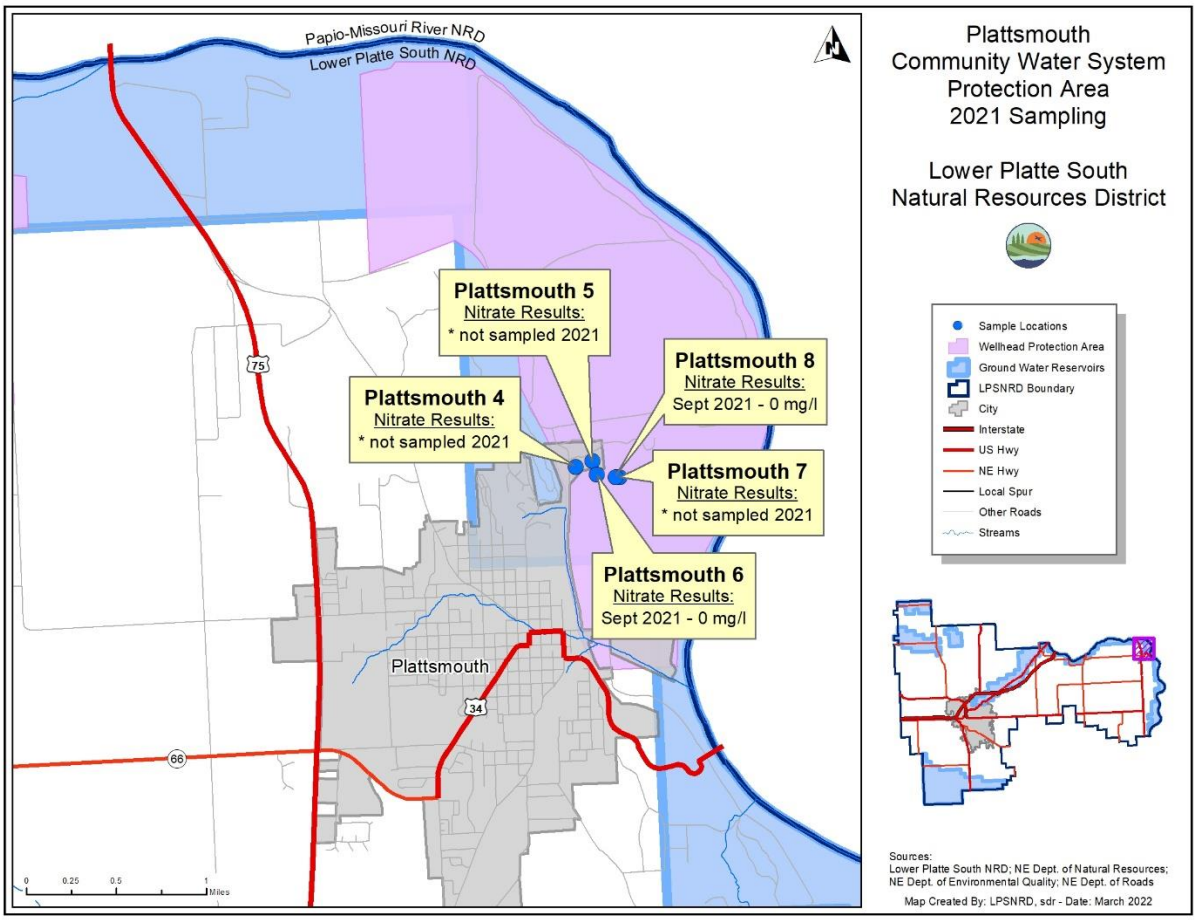
Figure 35 – Panama



4.1.2.23 Plattsmouth

The City of Plattsmouth's CWSPA occupies about 3 ¼ square miles to the northeast of the city along the Platte and Missouri Rivers in northeastern Cass County. District staff historically sampled six PWS wells for the city, but in 2011 widespread flooding along the Missouri River caused extensive damage to Plattsmouth's wellfield. In 2012, the City completed repairs to the system which included installation of one new high-capacity production well and decommissioning of three wells that were damaged. Plattsmouth has indicated recently that in the future it intends to purchase water for some or all of its supply from the Metropolitan Utilities District (MUD), and so future LPSNRD sampling may be affected by these arrangements. 2021 sampling results for the two currently accessible wells are shown in Figure 36.

Figure 36 – Plattsmouth



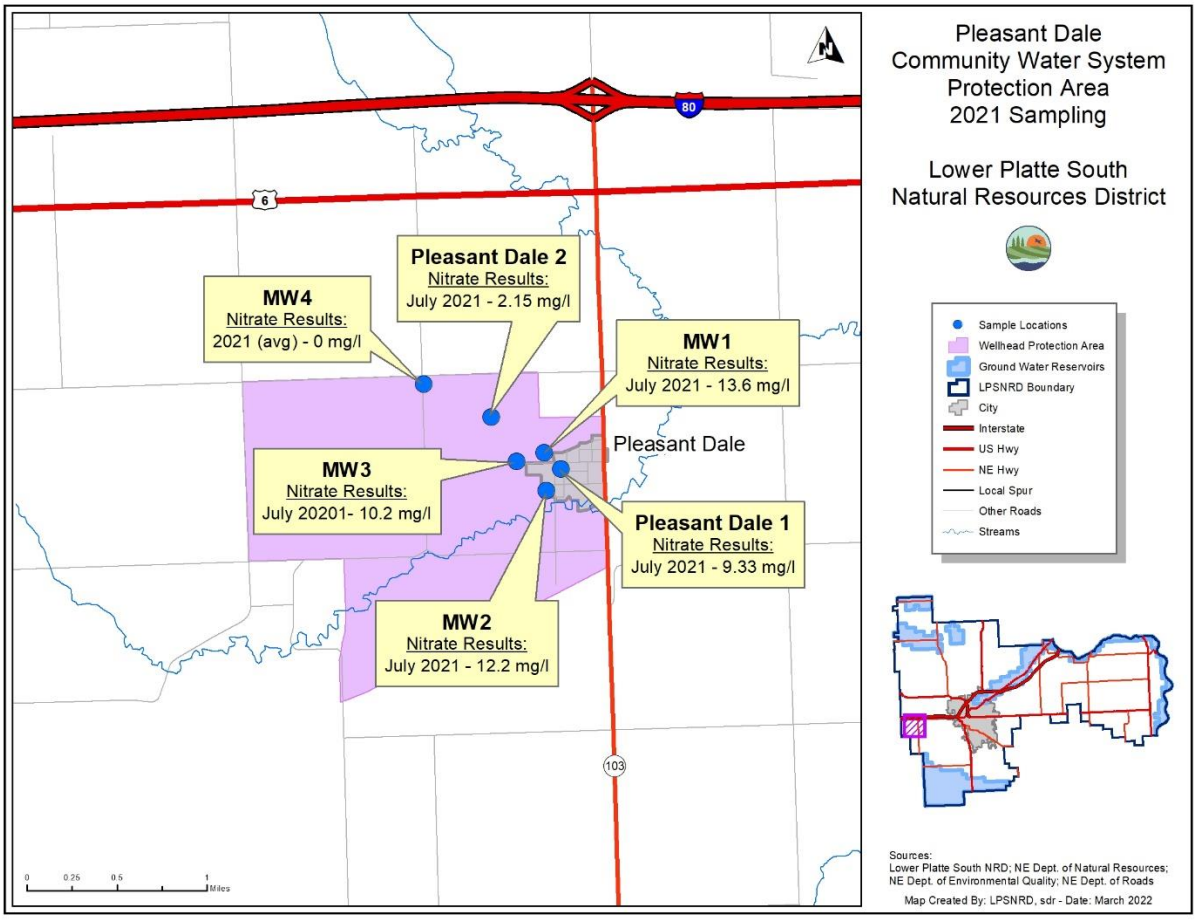
4.1.2.24 Pleasant Dale

Applicable Regulations: Section K(1)

The CWSPA for the Village of Pleasant Dale occupies about 2 ½ square miles west and north of the village in eastern Seward County. In 2006, District sampling results indicated that the triggers for a Phase II groundwater management area had been exceeded in the CWSPA. As a result, a Phase II Verification Study was initiated and was completed in 2009. This study resulted in the installation of three dedicated monitoring wells in the CWSPA, as well as collection of a great deal of geologic, soil, and other data (EA Engineering, Science, and Technology, 2009c). As a result of the verification study and subsequent sampling, the LPSNRD designated the Pleasant Dale CWSPA as a Phase II GWMA in December 2009. The District's Phase II regulations for the CWSPA became effective in 2013.

The nitrate sampling results for the two PWS and three monitoring wells in 2021 are displayed in Figure 37. In 2011-2013, District monitoring indicated that nitrate levels in the Pleasant Dale CWSPA had exceeded the Phase III trigger. However, in 2015, the nitrate level in these wells had dropped back below the Phase III trigger. In 2018, the NRD l began a 2-year verification study to determine whether or not the CWSPA merits designation as a Phase III GWMA. In 2019, additional shallow and deep soil sampling was completed, and installation of one additional monitoring well was completed in 2020. The report for this investigation has been completed and shared with Pleasant Dale officials. With sampling results from the new monitoring well, it appears that the Phase III trigger has not been exceeded, so LPSNRD will continue Phase II activities and consult with Pleasant Dale on future activities.

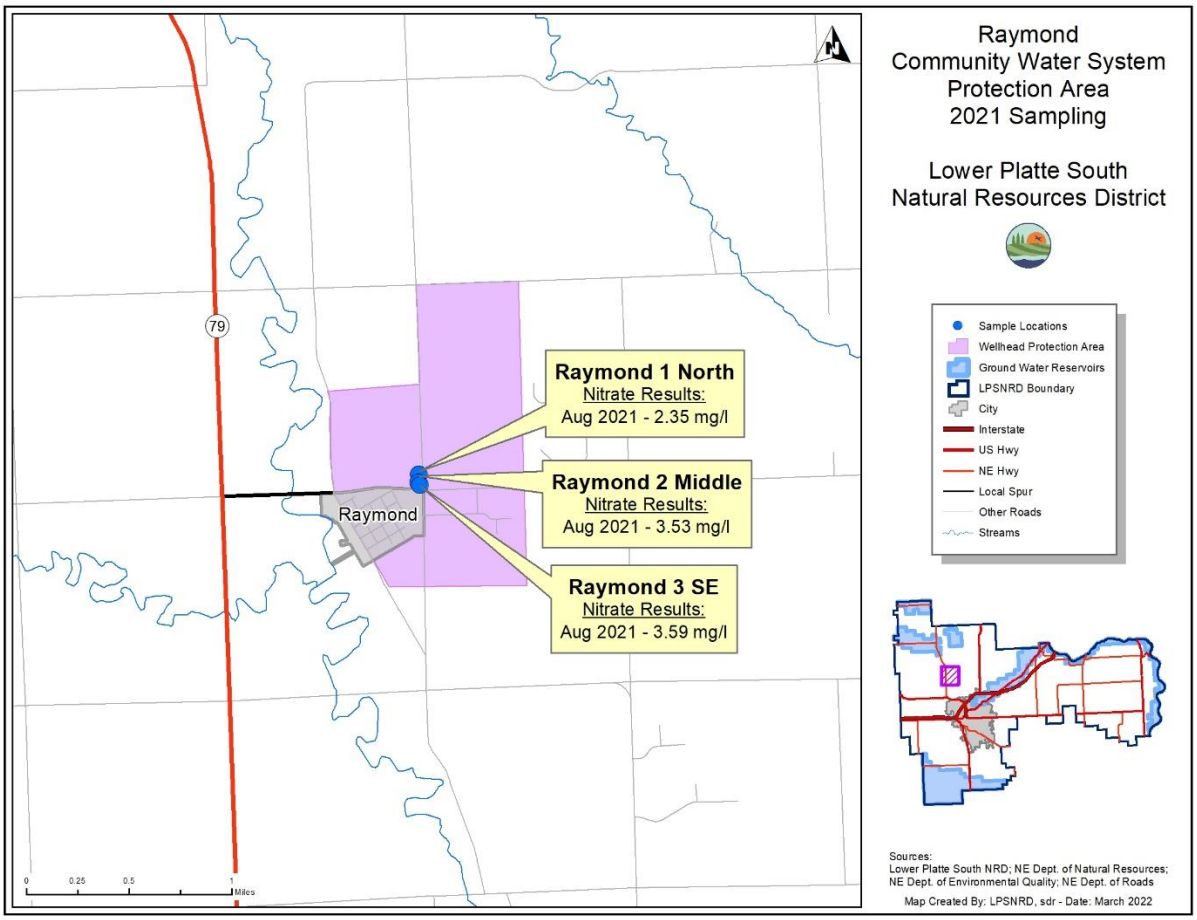
Figure 37 – Pleasant Dale



4.1.2.25 Raymond

The Village of Raymond's CWSPA covers a little more than one square mile north and east of the village in northwestern Lancaster County. District staff sample three PWS wells for the Village, and the 2021 sample results from these wells are shown in Figure 38. Sampling results from 2018 indicated that nitrate levels in the Raymond CWSPA exceeded the Phase II trigger, and in 2019 the District retained a private consultant to begin Phase II verification studies for the CWSPA. These studies began in 2020 with shallow and deep soil sampling, which is now complete. Three dedicated monitoring wells were installed in 2021, and it is anticipated that the study will also be completed in early 2022. All of these activities will result in a recommendation as to whether the Raymond CWSPA should be designated as a Phase II management area.

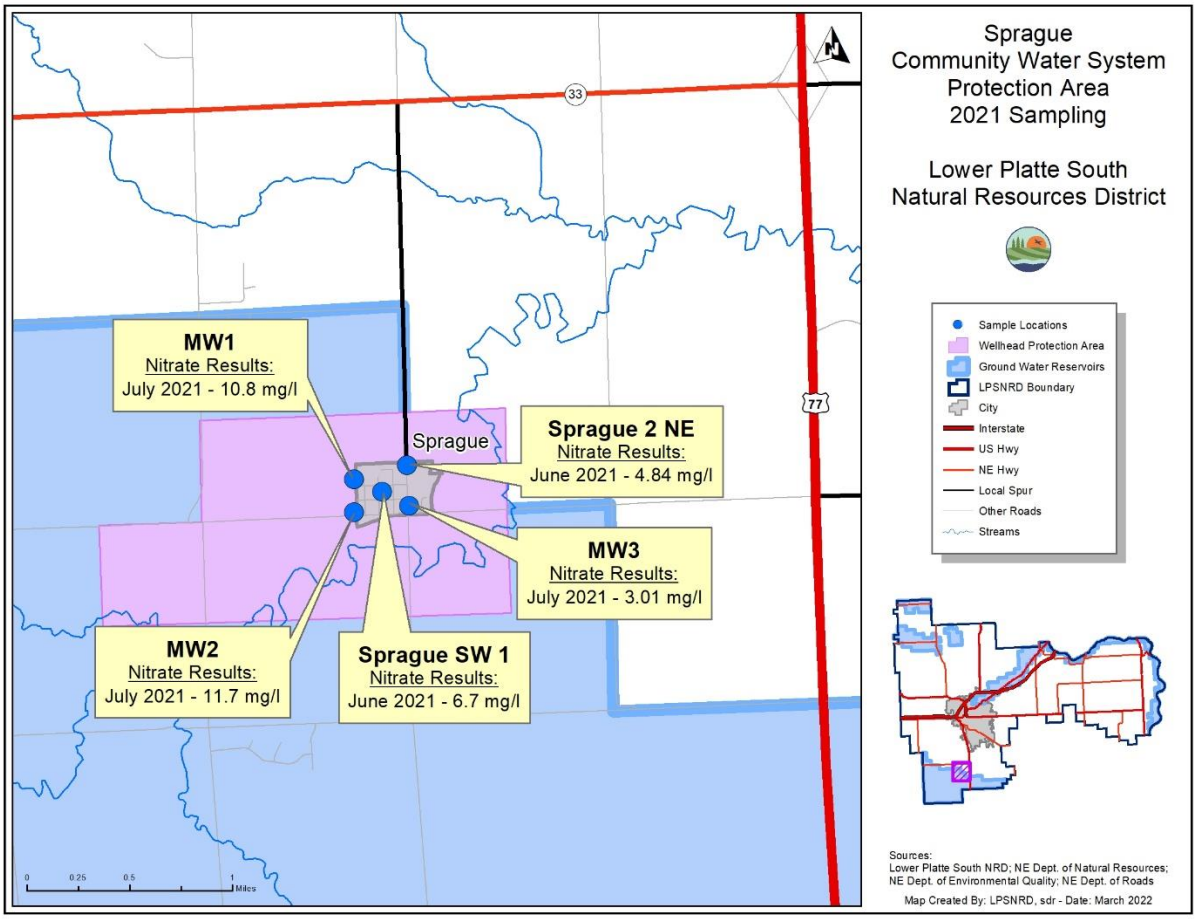
Figure 38 – Raymond



4.1.2.26 Sprague

The Village of Sprague's CWSPA occupies about 1 ¾ square miles around the village in southwestern Lancaster County. In 2006, District sampling results indicated that the triggers for a Phase II groundwater management area had been exceeded in the CWSPA. As a result, a Phase II Verification Study was initiated and was completed in 2009. This study resulted in the installation of three dedicated monitoring wells in the CWSPA, as well as collection of a great deal of geologic, soil, and other data (EA Engineering, Science, and Technology, 2009d). The nitrate sampling results for the two PWS and three monitoring wells in 2021 are displayed in Figure 39. As has been the case for the past few years, these sampling results show that nitrate levels in the Sprague CWSPA are very close to the Phase II trigger (for 2021 they exceeded that trigger). In December 2009, the LPSNRD Board directed the staff to continue to monitor the PWS and monitoring wells in the CWSPA to determine if those levels are in fact being exceeded. Given that the nitrate levels in samples from the Sprague monitoring network have exceeded Phase II triggers for several years but continue to occasionally decline below the trigger, in 2022 LPSNRD will consider whether to begin the process of designating the Sprague CWSPA as a Phase II GWMA.

Figure 39 – Sprague



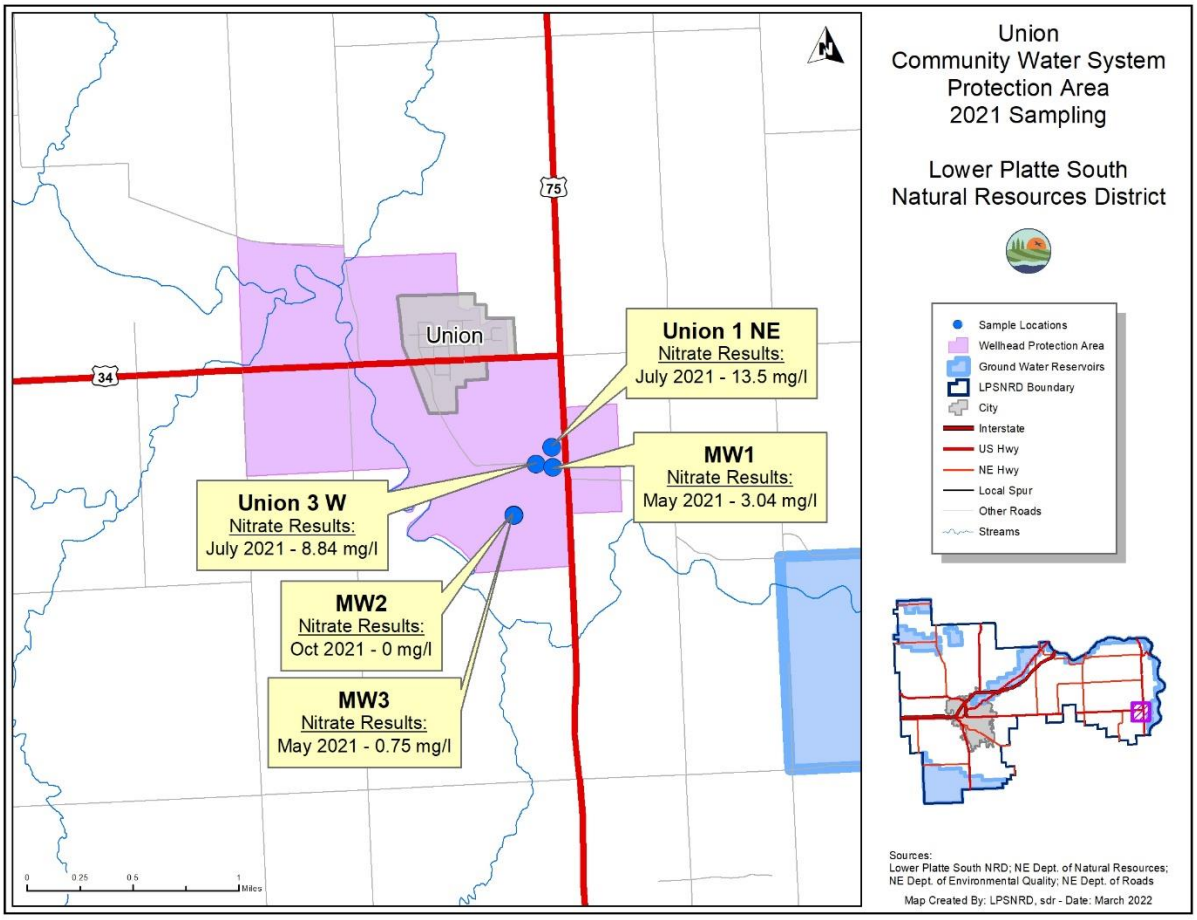
4.1.2.27 Union

Applicable Regulations: Section K(1)

The CWSPA for the Village of Union occupies about one square mile south of the village in southeastern Cass County. In 2006, District sampling results indicated that the triggers for a Phase II groundwater management area had been exceeded in the CWSPA. As a result, a Phase II Verification Study was initiated and was completed in 2008. This study resulted in the installation of three dedicated monitoring wells in the CWSPA, as well as collection of a great deal of geologic, soil, and other data (EA Engineering, Science, and Technology, 2008c). For several years, LPSNRD had not sampled Union's individual public supply wells, but in 2012 the NRD coordinated with the Village to begin sampling those wells. The nitrate sampling results for the three monitoring wells and two public supply wells in 2020 are displayed in Figure 40.

As a result of the verification study and subsequent sampling, the LPSNRD designated the Union CWSPA as a Phase II GWMA in December 2009. The District developed and adopted Phase II regulations for the Union CWSPA which became effective on November 1, 2013, and as already mentioned these regulations include nitrogen certification requirements and additional BMP promotion. Over the past several years, nitrate levels in Union's wells have been either slightly above or slightly below the Phase II trigger. As shown in Figure 40, those levels were slightly below the trigger in 2021. LPSNRD will continue to monitor these wells and work with the Village to gain more complete information for evaluation of Union's Phase status.

Figure 40 – Union

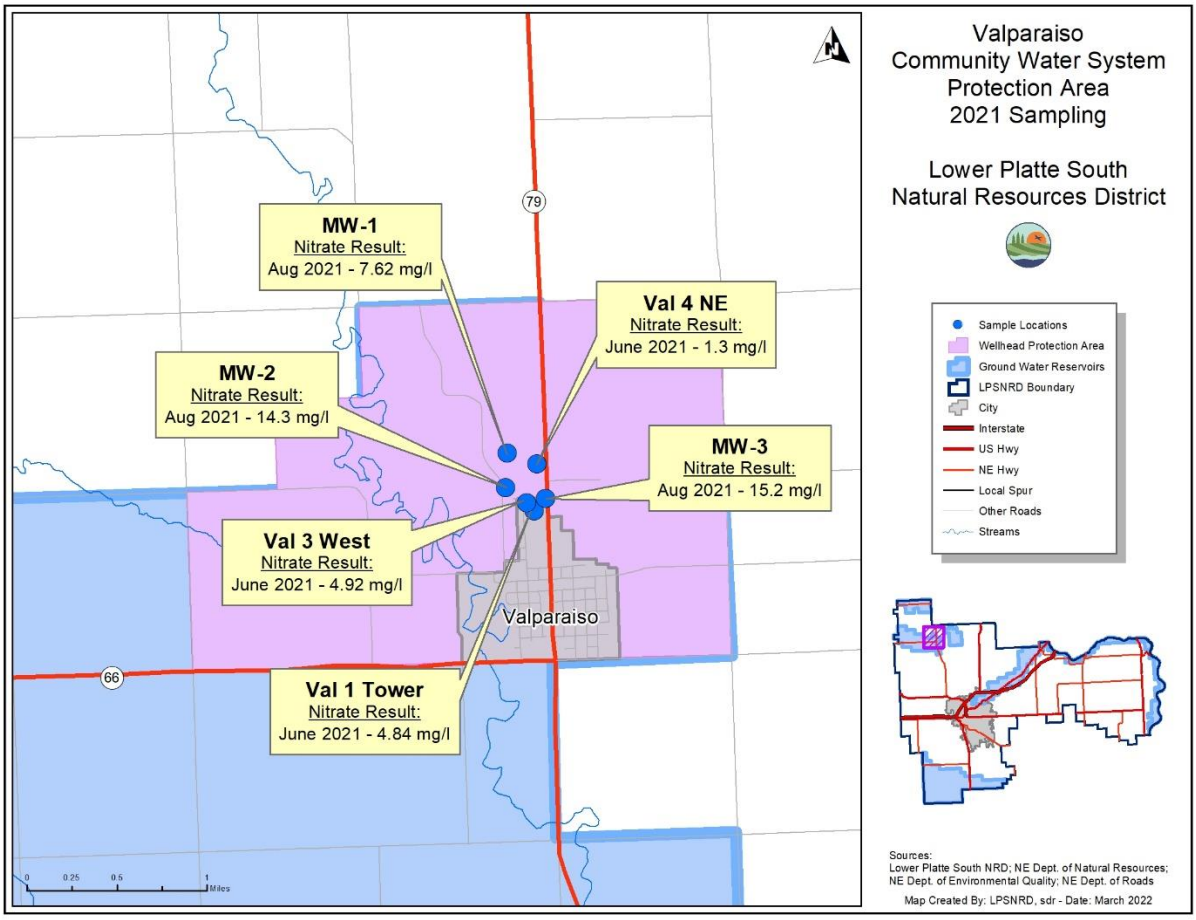


4.1.2.28 Valparaiso

Applicable Regulations: Section K(1)

The CWSPA for the Village of Valparaiso covers about 5 ¼ square miles surrounding the village in southwestern Saunders County. In 2001, District sampling results indicated that the triggers for a Phase II groundwater management area had been exceeded, and subsequent investigations resulted in the installation of three dedicated monitoring wells in the CWSPA, as well as collection of a great deal of geologic, soil, and other data (EA Engineering, Science, and Technology, 2003). As a result of this study, the Valparaiso CWSPA was designated as a Phase II GWMA in 2004, and implementation of the Phase II area began, and continues to the present. The nitrate sampling results for the two PWS and three monitoring wells in 2021 are displayed in Figure 41. These results are at the 50% level of MCL exceedance for Phase II designation as per the LPSNRD's GWMP. As already noted, in recent revisions of the District's Groundwater Rules and Regulations (Effective Date: January 15, 2020), a procedure was included for suspending Phase II and moving back to Phase I if nitrate levels dropped below appropriate triggers for a period of not less than three years. Given that the nitrate levels in samples from Valparaiso have been alternately slightly above or below that trigger, in 2022 LPSNRD will continue consideration of the process of suspending Phase II requirements for the Valparaiso CWSPA.

Figure 41 – Valparaiso

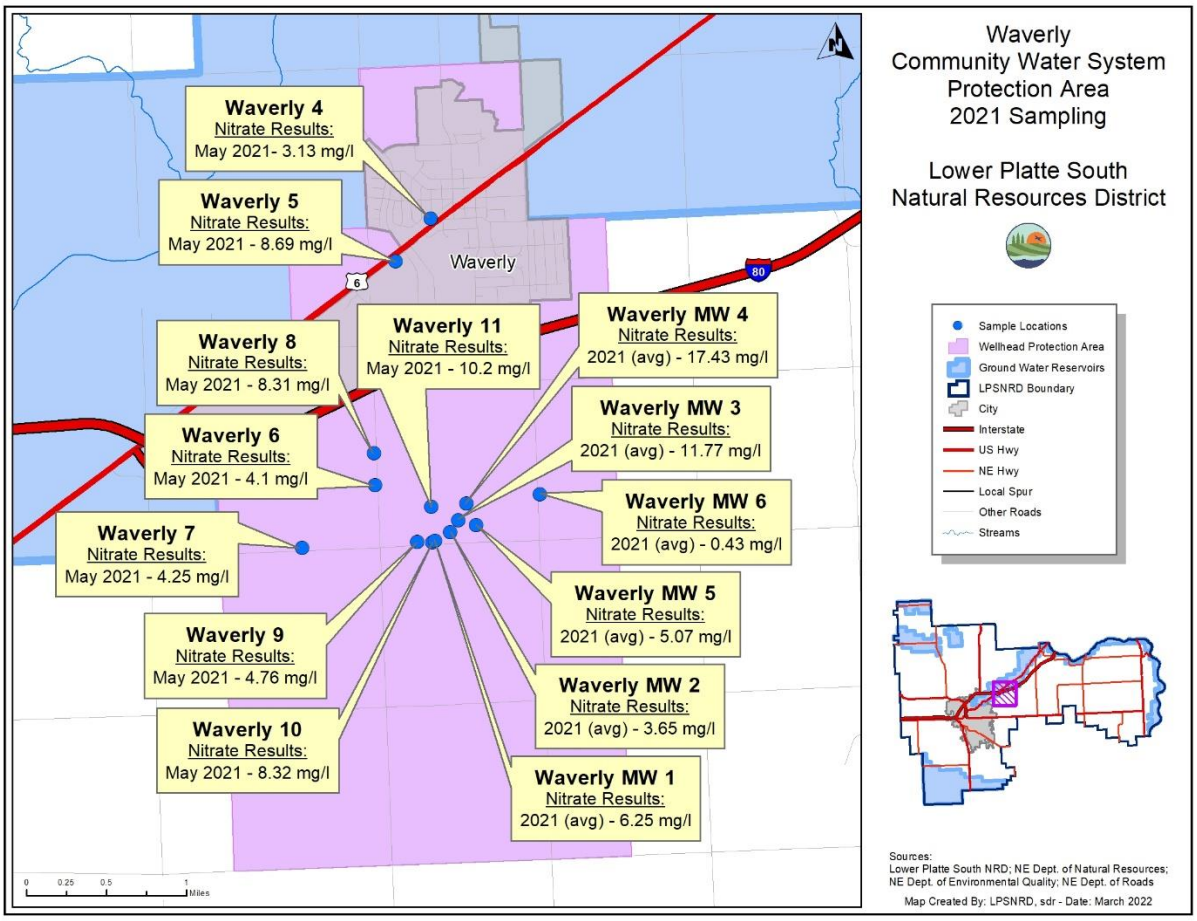


4.1.2.29 Waverly

The City of Waverly's CWSPA occupies more than eight square miles around and south of the city in northeastern Lancaster County. District staff sample eight PWS wells for the village, and the 2021 nitrate results are shown in Figure 42. The results from 2017 through 2020 indicate that the Waverly CWSPA has exceeded the Phase II trigger.

In 2017, LPSNRD signed a cooperative agreement with the City of Waverly to support development of a comprehensive Drinking Water Protection Plan for the City's water supply. The project is also supported by the Nebraska Department of Environment and Energy and the University of Nebraska Water Sciences Laboratory. This study will involve land use surveys, water sampling, vadose zone sampling, installation of dedicated monitoring wells, and other activities contained in a typical two-year verification study. In signing the agreement, LPSNRD specified that the results of this project will allow the District to determine whether or not the Waverly CWSPA should be designated as a Phase II GWMA. As shown in Figure 42, the northern portion of the Waverly CWSPA is contained within the current Lower Salt Creek GWR Phase II area, but as already mentioned the LPSNRD is taking steps to consider the suspension of that Phase II area due to stable or declining groundwater nitrate levels. Therefore, the Waverly project will be important to determine whether or not this area should be designated as a Phase II GWMA. An important part of the Waverly project is utilization of new airborne electromagnetic (AEM) in all study aspects, but particularly as it relates to delineation of a new CWSPA boundary. AEM data as well as all existing information has been utilized in running a more sophisticated groundwater model to evaluate CWSPA boundaries, and these boundaries were modeled on a 50-year time of travel rather than the traditional 20-year timeframe as per current NDEE guidelines. In 2019, the modeling was completed and the boundaries of the CWSPA were slightly modified. In addition, in 2018 a mass groundwater quality sampling of private domestic and irrigation wells was completed in the CWSPA, and soil samples were collected to document nitrate levels already present in the soil and vadose zone. Once all these activities are concluded and the results reported, LPSNRD will determine whether the Waverly CWSPA should be designated as a Phase II area, and it is anticipated that this determination will be reached in 2022. In addition, in 2019 and 2020, LPSNRD cooperated with UNL, the City of Waverly, and the farmer tenant of Waverly's property surrounding the south wellfield in the establishment of a Best Management Practice Demonstration Farm to implement and evaluate the effects of various BMPs on soil and water quality. It is intended that these demonstration activities will provide real-world demonstrations to the current tenant as well as farmers in the surrounding area of the soil and water quality benefits as well as economic advantages of implementing various best management practices. Finally, LPSNRD has cooperated with the City of Waverly, UNL, and NDEE to begin the process of establishing a dedicated Drinking Water Protection Specialist position to work with Waverly as a pilot project, but then branch out into the remaining 30 CWSPAs in LPSNRD. NDEE has indicated that the agency can contribute up to $500,000 for a five-year project to implement this important position, and LPSNRD and UNL are cooperating in this effort. As of this writing, details for all of the entities involved are being worked out.

Figure 42 – Waverly



4.1.2.30 Weeping Water

See Otoe County Rural Water District #3.

4.2 Groundwater Quantity

Designated areas of management for groundwater quantity follow the same boundaries as those for groundwater quality—that is, Groundwater Reservoirs, the Remaining Area, and Community Water System Protection Areas. Spring 2020 to pring 2021 water level changes are shown for the entire District in Figure 10, and representative long-term trends are shown in Figures 11 and 12. Typically, water levels are measured from irrigation wells and dedicated monitoring wells. Public water supply wells are not usually measured. In 2021, no GWRs or areas in the RA exceeded the trigger levels for advancement to Phase II, and the majority of the wells measured showed a small decrease in water levels (Table 3).

As has been documented in earlier versions of this report, in late 2013 and early 2014, the District drafted new rules and regulations for the proposed Dwight-Valparaiso-Brainard Special Management Area (DVB SMA—see Figure 42) to respond to seasonal declines in groundwater levels in the northwestern portion of the District. The District adopted new rules and regulations for the DVB SMA which went into effect on March 1, 2014. These regulations included the following:

- A prohibition on new irrigated acres;
- An allocation for all certified irrigated acres as follows:
    - Pivot/sprinkler: 21 acre-inches per three years with a maximum of nine inches applied in any one year
    - Gravity/flood: 30 acre-inches per three years with a maximum of 12 acre-inches applied in any one year
- Required completion of an irrigation management certification class for all irrigators;
- Establishment of cost-share programs;
- Requirement that new wells be completed to a depth such that they are less likely to be affected by seasonal water declines; and
- Requirement that all new well permits for this area be approved by the Board of Directors.

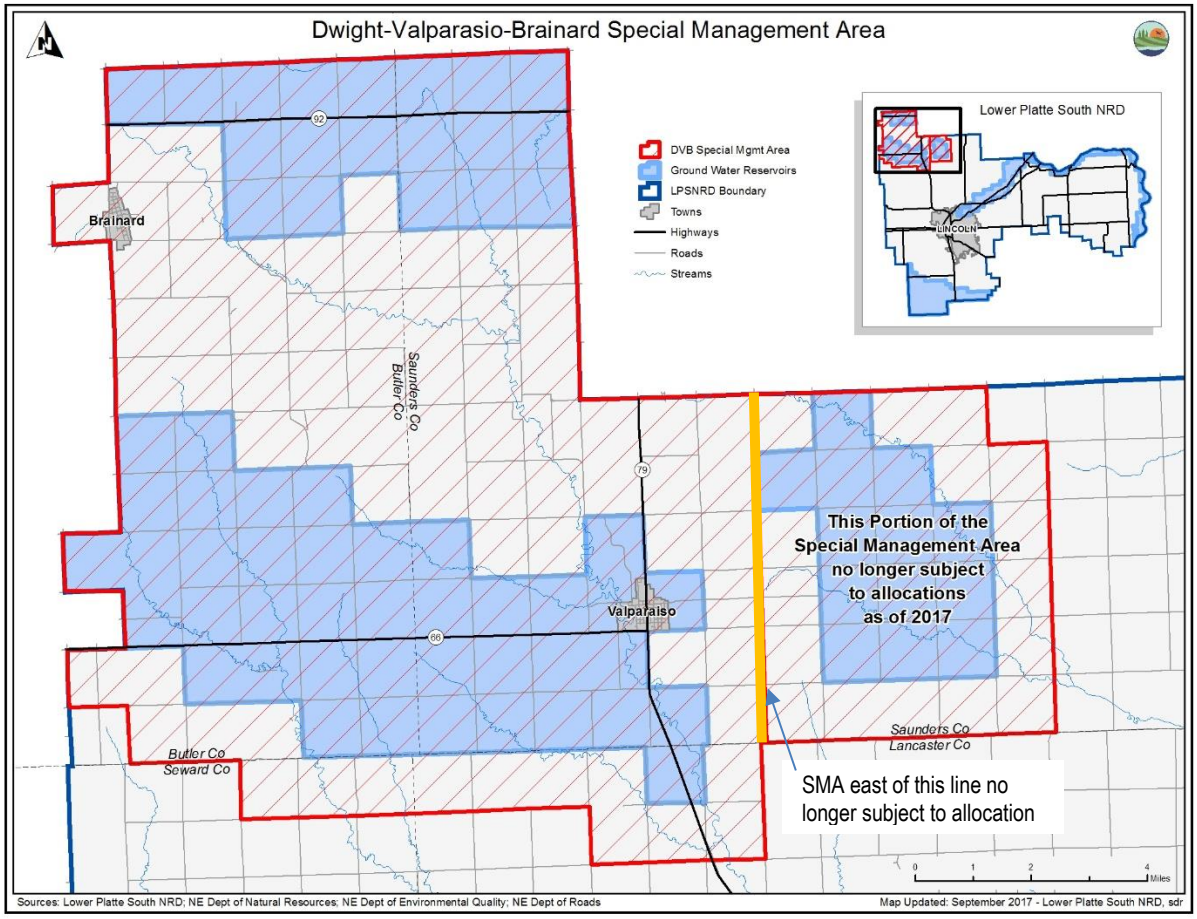
At the completion of the 2016 growing season, the three-year allocation period described above had been completed. As a result, the District revised its Groundwater Rules and Regulations to account for the expiration of this allocation period. Based upon water use records submitted to the District by water users in the DVB SMA, it appeared that the allocation amounts originally adopted were adequate to maintain irrigation in the area, and so the allocation amounts were adopted for a second three-year allocation period. However, additional hydrogeologic data collected by the NRD, especially via the airborne electromagnetic (AEM) surveys conducted over the past several years, indicated that the geology of the eastern portion of the SMA is considerably different than that of the western portion. This is mainly due to the more unconfined nature of the aquifers in the eastern portion, which results in much less seasonal decline in groundwater levels. As a result, the District removed the allocation amount for the eastern portion of the SMA

(all of the SMA located in T13N, R6E of Saunders County—see Figure 43), but kept the prohibition on new irrigated acres for the entire SMA.

In addition, in 2014 the District formed an advisory group to help evaluate its progress and guide implementation of the SMA in the future. This group, consisting of local irrigators, dryland farmers, well owners, business owners, and representatives of the three villages, met for the first time in December 2014, and subsequently in January 2016, March 2018, and March 2019.The advisory committee recommended that the SMA move to a three-year "rolling" allocation with the same annual amounts, and that there be no separate allocation for flood irrigation. As a result, in 2019 the District revised its Groundwater Rules and Regulations to reflect these recommendations, and those regulations took effect early in 2020. Finally, one of the recommendations of the advisory group was the establishment of a weather station within or near the SMA so farmers in the area could have more local information as far as weather conditions, crop requirements, etc. In 2021, LPSNRD staff contacted UNL to begin the process of establishing this weather station, and it is anticipated that the station will be installed in 2022.

As mentioned above, current regulations require that irrigators in the SMA attend an irrigation management certification class. The NRD held its first such class in February 2015, and all 63 irrigators obtained certification by attending this class. Re-certification of these irrigators took place in March 2019, and will continue going forward.

Figure 43 – Dwight-Valparaiso-Brainard Special Management Area



4.2.1 Irrigated Acre Certification

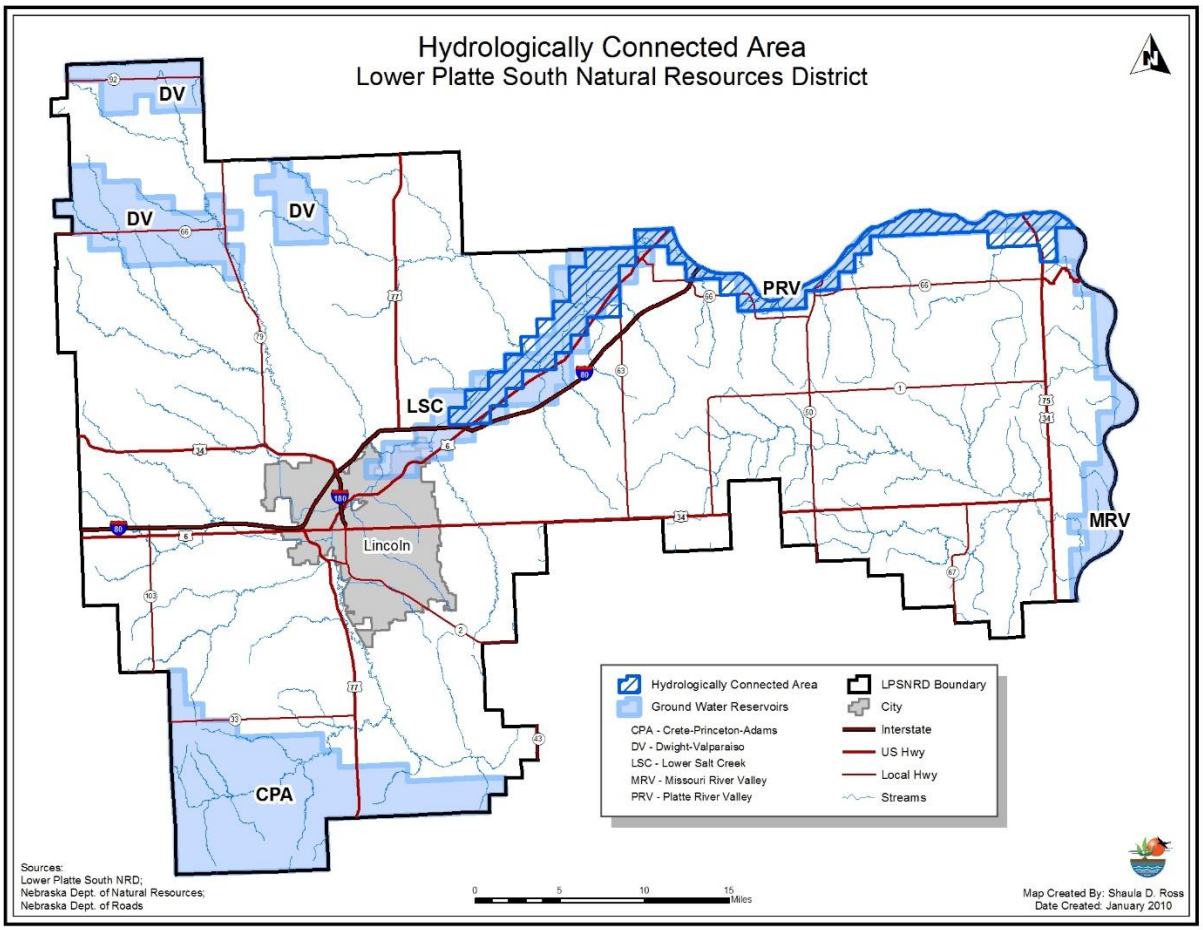
One of the tools used by LPSNRD as well as many other Districts in Nebraska to effectively manage groundwater quantity concerns is the certification of irrigated acres. In an agricultural state like Nebraska, irrigation is a primary use of groundwater. Therefore, accurate data as to the location and number of irrigated acres as well as the water applied to those acres is critical in making management decisions. In the Lower Platte South NRD, certification of irrigated acres is taking place in two phases, one involving what's known as the Hydrologically Connected Area (HCA), and the other involving the remainder of the District.

4.2.1.1 Hydrologically Connected Area

Applicable Regulations: Section Q

The Nebraska Department of Natural Resources (NDNR) has designated areas within Nebraska known as Hydrologically Connected Areas (HCAs). These are defined as areas where ground and surface water resources are directly connected and have relatively immediate and substantial impacts on one another. In LPSNRD, the HCA occupies all or parts of about 70 sections along both sides of Salt Creek between roughly Waverly and Ashland, and then along the south side of the Platte River from Ashland to Plattsmouth. Figure 44 shows the location of the HCA in LPSNRD. NDNR has been working on a groundwater model for the Lower Platte River basin for the past several years, incorporating a variety of additional information to further evaluate the nature of the HCA in LPSNRD and other NRDs in eastern Nebraska. It is anticipated that NDNR will publish these model results and an associated map revision of the HCA in approximately the next five years, so the HCA in LPSNRD may be modified in the future.

Figure 44 – Hydrologically Connected Area (HCA)



Legislation passed in 2009 (LB483) required the Lower Platte South NRD and other Districts in the Lower Platte River Basin to develop regulations limiting the expansion of irrigated acres within the designated HCAs. An important consideration in this process was identification of "historically groundwater irrigated acres," those acres which were under irrigation from a groundwater source before the requirements of this law took effect. As a result of this requirement, the District developed and passed rules and regulations for the certification of historically groundwater irrigated acres and allowing for limited expansion of these acres on an annual basis for a five-year period through 2012. Those regulations were incorporated into the NRD's Groundwater Rules and Regulations in early 2013, and the requirements were extended indefinitely.

As a natural extension of the above activities, the District developed its voluntary Integrated Management Plan (IMP) in conjunction with NDNR. Following approval by both LPSNRD and NDNR, the IMP became effective on May 15, 2014. For more detail regarding the development of the IMP, see LPSNRD-NDNR, 2014.

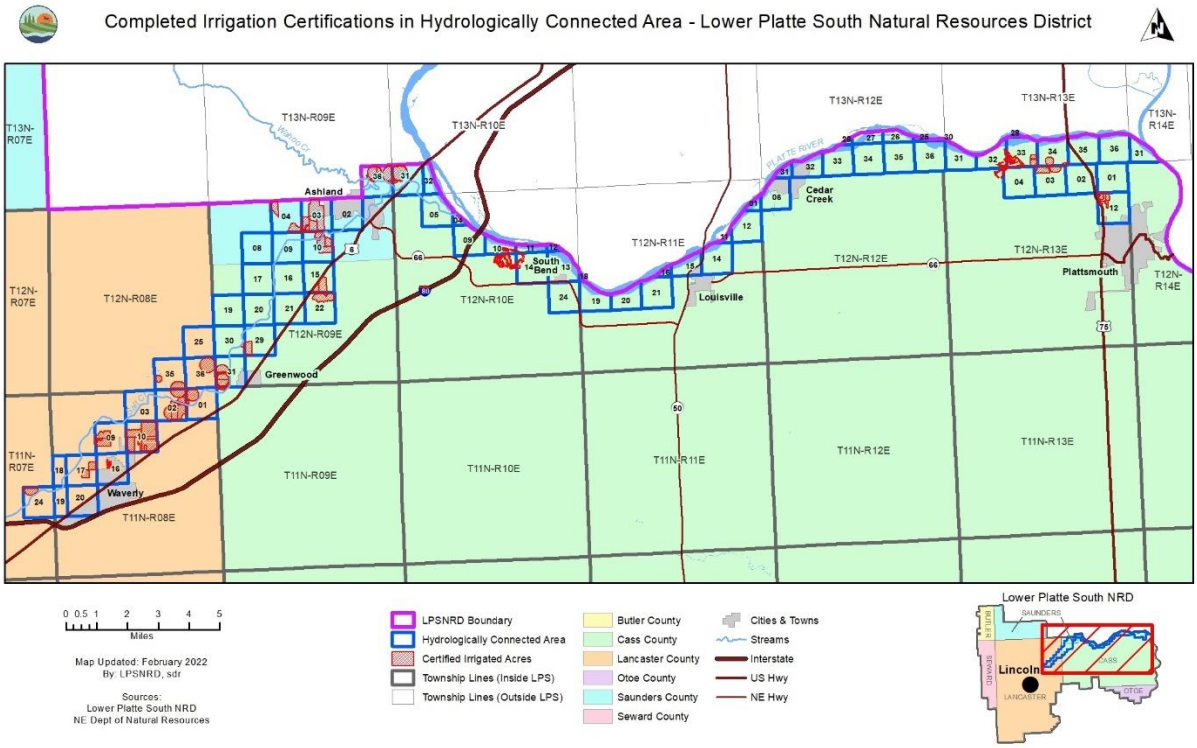
As part of the effort toward a more comprehensive management strategy, LPSNRD joined six other NRDs and NDNR to form the Lower Platte River Basin Coalition (LPRBC) to jointly develop a water management plan for the entire Lower Platte River basin. As of early 2018, all seven participating NRD Boards and NDNR had approved the Interlocal Agreement that continues the Coalition and adopts the first five-year plan. For more information on the LPRBC, refer to its website at https://lprbc.nebraska.gov/. In 2020, LPSNRD Board members, management, and staff attended several meetings of the Coalition and the technical committee. At the end of 2021, the first five-year increment for the Coalition expired, and beginning in 2022 LPSNRD will work with the other members and NDNR to determine a way forward for the second five-year increment.

The NRD's regulations for the Hydrologically Connected Area state that all acres historically irrigated with groundwater would be certified no later than March 31, 2010. By the deadline, LPSNRD had received and verified 34 separate certifications from 27 landowners in the HCA for a total of 2,964.48 acres. Current statute also allows the NRD to approve a limited amount of new or expanded irrigated acres each year. Based on the above certification total, LPSNRD can allow a maximum of 592.9 new acres of irrigated land each year. Recent revisions to the District's Groundwater Rules and Regulations removed the requirement that applications for those new acres must be received by October 1 of each year; in other words, applications for expanded acres in the HCA can be received on an ongoing basis. In 2021, the NRD did not receive any new requests to expand irrigated acres in the HCA, as was the case in 2020 and 2019. As of this writing, the total certified irrigated acres in the HCA stands at 3,268.2. Figure 44 shows the locations of those acres.

A map of the certified historically groundwater irrigated acres in the HCA is shown as Figure 45. The certification is summarized as follows:

Total # of Acres Certified in HCA:	3,268.2
Cass County:	931.29 acres (17 certifications from 12 separate entities)
Lancaster County:	1,351.59 acres (13 certifications from 11 separate entities)
Saunders County:	985.32 acres (10 certifications from 6 separate entities)

Figure 45 – Locations of Certified Irrigated Acres in the Hydrologically Connected Area



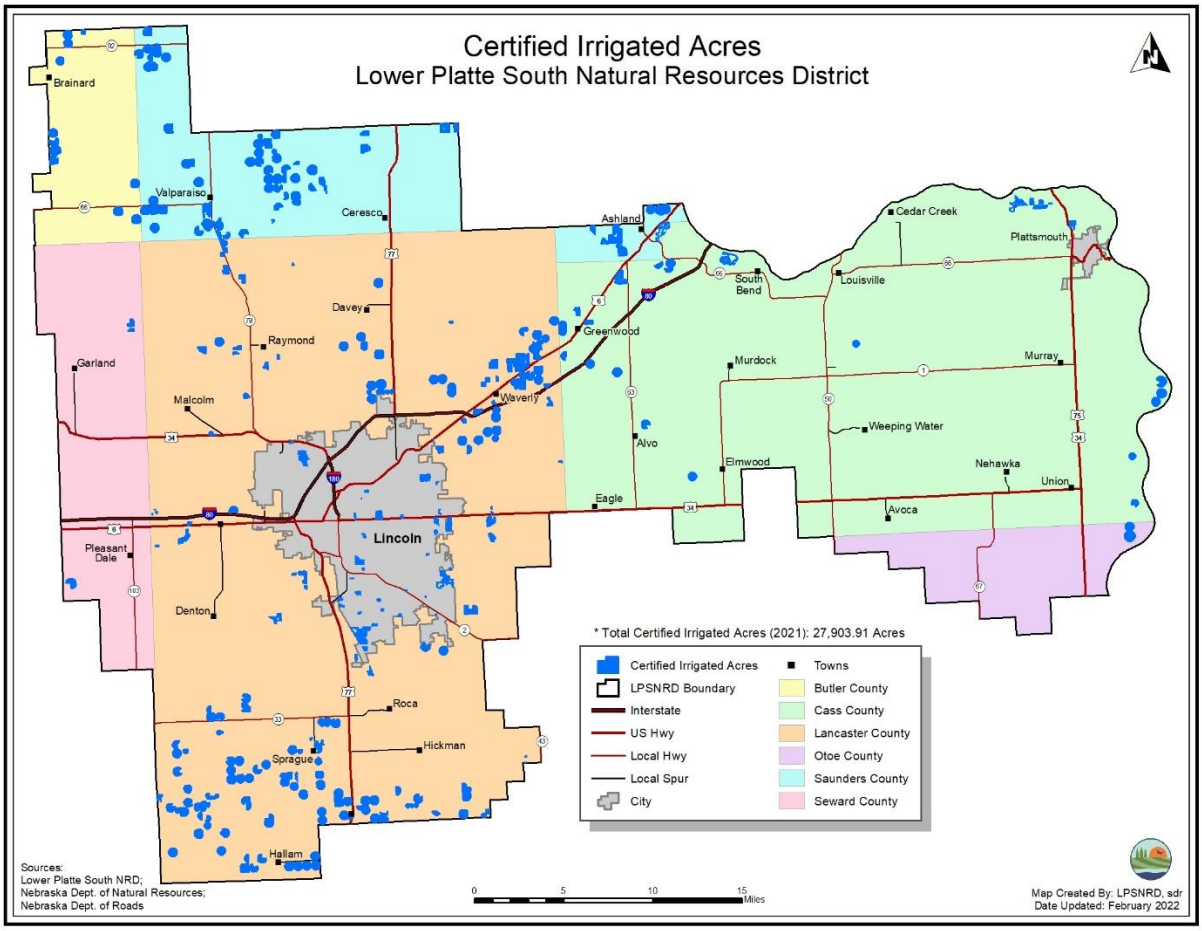
4.2.1.2 Remainder of District

Applicable Regulations: Section I, Rule 2

As part of its ongoing efforts at groundwater quantity management, the District is also continuing certification of irrigated acres in the remainder of the District outside the HCA. In late 2009, the District revised its rules and regulations to move the deadline for certification of irrigated acres in the remainder of the District from January 1, 2010 to January 30, 2011. On October 31, 2011, the District revised its rules and regulations again to now state that any lands irrigated with groundwater shall first be certified by the District prior to those lands being irrigated with groundwater. In 2020, the District received and approved applications to certify an additional 61.32 acres, and so as of December 31, 2021, LPSNRD had certified a total of 24,636.71 acres. Adding the

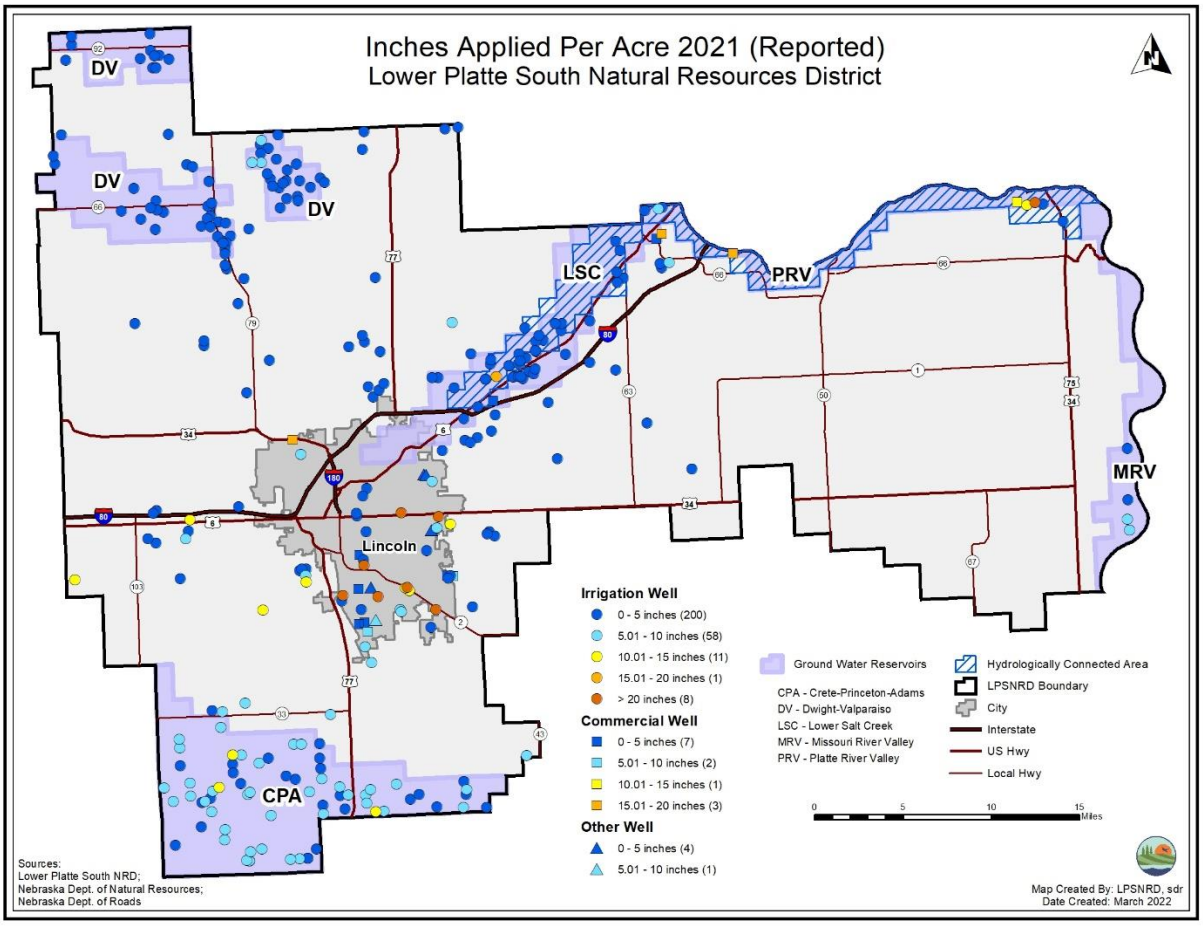
3,268.2 certified acres in the HCA to the 24,636.71 certified acres in the non-HCA brings the grand total to 27,904.91 groundwater irrigated acres in LPSNRD as a whole. The location of those acres is shown in Figure 46.

Figure 46 – Location of Certified Irrigated Acres in the Lower Platte South NRD



In addition to gathering information about the irrigated acreage in LPSNRD, the Groundwater program also administers the water well meter program (see Section 8). Out of the readings received in 2020 and 2021, District staff was able to calculate overall usage and the number of inches applied to a certain area. Figure 46 shows the number of inches applied per acre in 2021 for 296 wells across the District. The wells are separated by use and the calculated usage amount, which varies from zero to greater than twenty inches. Note that the majority of wells were utilized to apply five acre-inches or less.

Figure 47 – Irrigation Application Amounts



5. WATER WELL PERMITS

Applicable Regulations: Section B

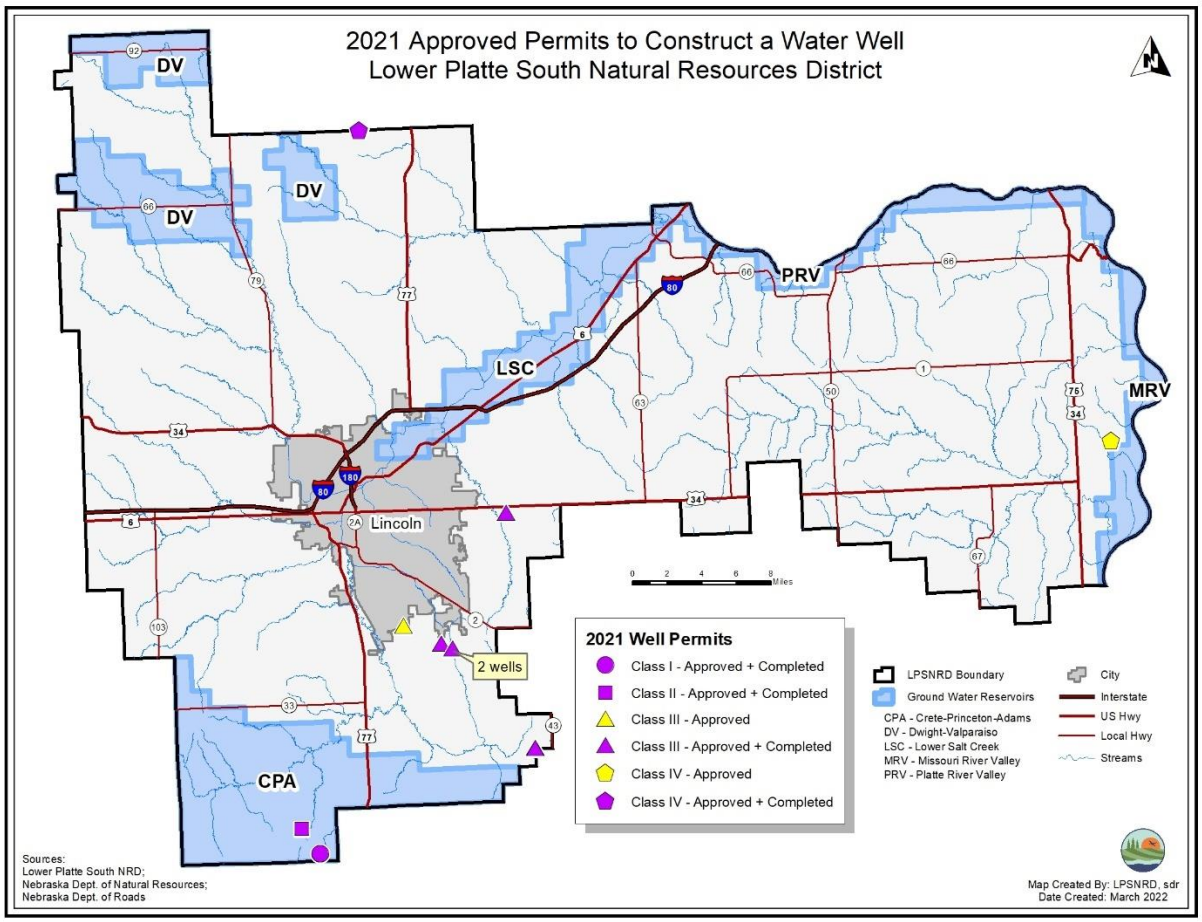
An important responsibility given to NRDs is that of permitting new and replacement water wells within their jurisdiction. In the LPSNRD's 2008 revisions to the Groundwater Rules and Regulations, the District adopted additional requirements for the permitting of all wells which pump more than 50 gpm. These requirements vary based on the actual pumping rate and total amount of water pumped, as well as whether the proposed well is located within a Groundwater Reservoir or the Remaining Area (the District requires additional activities for non-domestic wells pumping more than 20 gpm in the RA). The regulations establish four classes of well permits (see LPSNRD Groundwater Rules and Regulations, Section C for more details): Class I is for wells in a GWR proposed to pump more than 50 but less than 1000 gpm; Class II is for wells in a GWR proposed to pump more than 1000 gpm; Class III involves wells in the RA designed to pump more than 20 but less than 250 gpm; and Class 4 IV is for wells in the RA designed to pump more than 250 gpm (again, domestic wells pumping less than 50 gpm are exempt from NRD permit requirements). Since GWRs generally have greater

supplies than the RA, the thresholds for various permit actions are higher in GWRs than in the RA. Essentially, the new regulations are aimed at demonstrating that there is groundwater of adequate quality and quantity in a given area before a specific well is permitted.

The District issued ten water well permits during 2021 (Figure 48). Of these, six were for irrigation, three were for commercial use, and one was for public water supply. Of the ten permits issued in 2021, eight have been completed. By well permit class, the District received one Class I permit and one Class II permit; these permits are for wells located within a Groundwater Reservoir. In addition, the NRD received six Class III permits, and two Class IV permits; these permits are for wells located within the Remaining Area. All filing fees and required information were submitted for these applications.

Finally, in 2020, the District received a well permit application for a large commercial water use in the southwest part of the NRD near Hallam. Monolith Nebraska, a facility engaged in production of carbon black and, in the future, anhydrous ammonia, applied for a Class II permit for one well estimated to produce approximately 320-400 million gallons per year; the plan was to drill two additional wells so the estimated volume could be produced by rotating pumping, and to provide some system redundancy. For such a volume, current LPSNRD regulations require the completion of an aquifer test and hydrogeologic analysis to evaluate the impact of that amount of withdrawal on nearby preexisting wells and the aquifer itself. Monolith completed the aquifer test in September 2020 and submitted a draft hydrogeologic analysis report at the end of 2020. LPSNRD retained an outside expert consulting firm to review the report and make recommendations. This review was completed in mid-2021, and included a plan for working with adjoining landowners to address concerns as well as a plan for long-term monitoring of groundwater levels and quality. This plan included the installation of three dedicated monitoring wells and periodic updating of the groundwater modeling. As per the original proposal, Monolith applied for two additional permits in April 2021, but as noted above the total amount of water to be pumped did not change. Based on the modeling results and conditions applied to the permits, LPSNRD granted all three permits in July 2021, and the two additional wells were drilled in late 2021. It is anticipated that installation of the monitoring network will begin in 2022 and will provide baseline information prior to the plant expansion coming online sometime in 2024. In addition, in the future LPSNRD will be reviewing its Groundwater Rules and Regulations to consider modifications to address the permitting process for high yield/high volume industrial wells.

Figure 48 – Approved Permits to Construct a Water Well

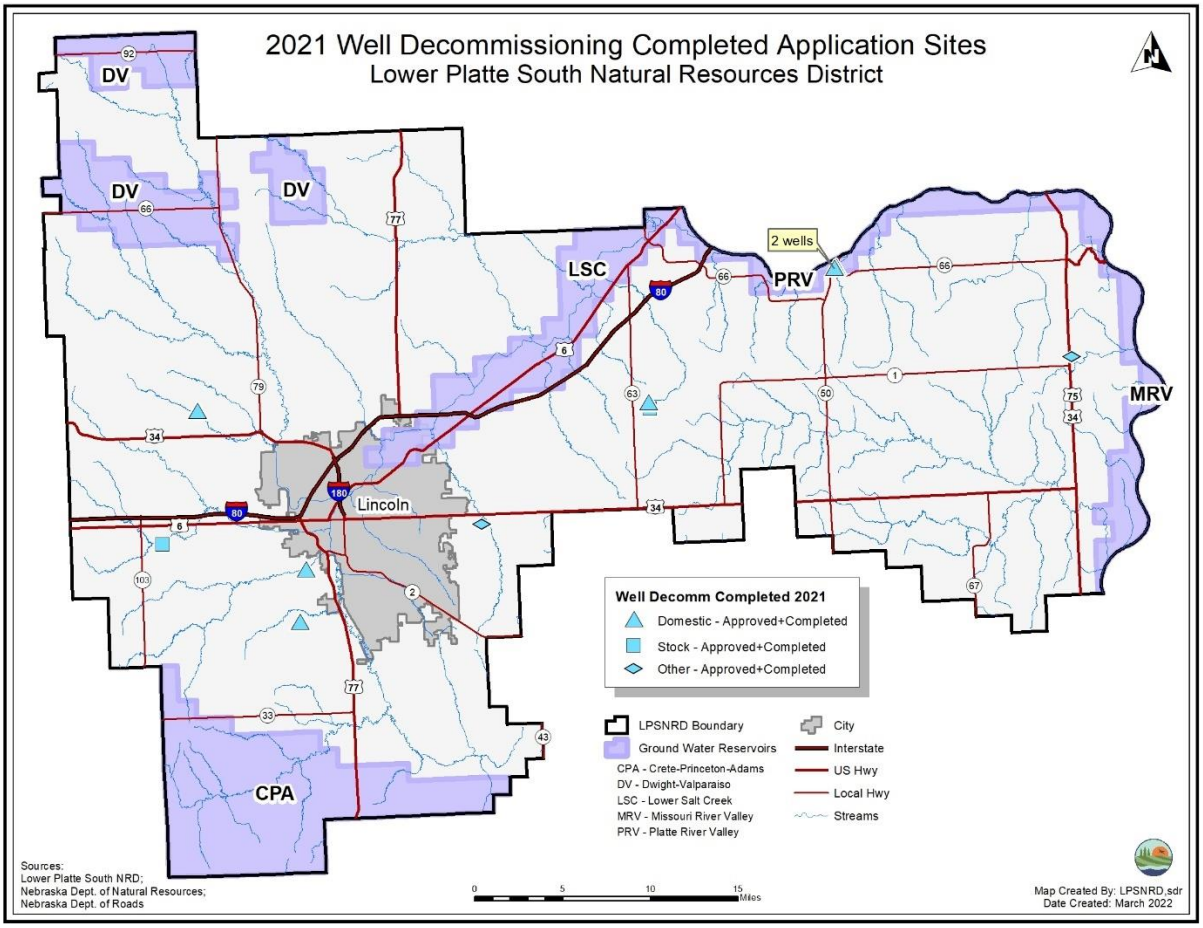


6. WATER WELL DECOMMISSIONING

If not properly sealed at the surface, water wells can be a physical safety hazard to people and animals, as well as conduits for surface runoff and pollution to make its way directly into groundwater. Therefore, since the mid-1980s, Nebraska has had requirements not only for proper water well construction, but also the proper decommissioning or abandonment of unused wells to protect human health and groundwater quality. The state's NRDs are charged with promotion of proper well decommissioning through cost-share programs, inspections, and information and education programs.

The LPSNRD Water Well Decommissioning Cost-Share Program decommissioned 10 wells in 2021 (Figure 49). Six of the wells that were decommissioned in 2021 were domestic, two were for livestock, and two were for other uses. Since the LPSNRD's program inception in October 1990, as of December 31, 2020, **a total of 1,040 wells within the District have been decommissioned**.

Figure 49 – Well Decommissioning Application Sites

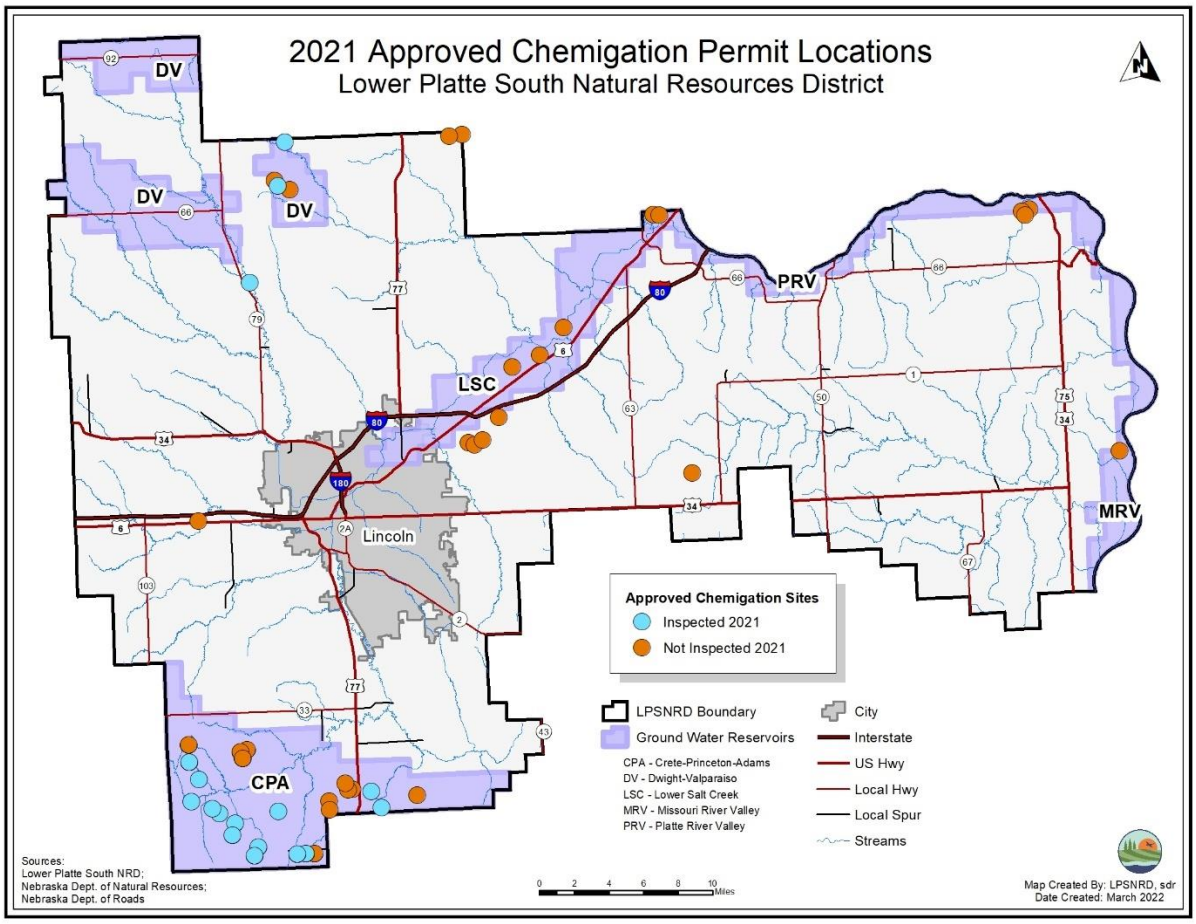


7. CHEMIGATION

Chemigation is generally defined as the application of chemicals such as liquid fertilizers, pesticides, fungicides, etc. through an irrigation distribution system. Properly done, chemigation is a safe, cost-effective, and efficient means of applying such materials. However, in order for this to be true, the irrigation system has to be fitted with appropriate safety equipment. Such equipment has been required by Nebraska law since the late 1980s, and NRDs, together with NDEE, are charged with overseeing chemigation activities in the state. The Districts issue chemigation permits and inspect systems for proper installation and operation of the required safety equipment.

In 2021, LPSNRD continued its inspection and permitting duties pursuant to the Nebraska Chemigation Act. The District inspects systems on a three-year rotation or when modifications are made to an already permitted system. In 2021, the Lower Platte South NRD inspected 17 systems, and issued 30 renewal permits for a total of 47 permits (Figure 50). Chemigation permits were issued for a total of 5,068 acres in 2021. A breakdown of permits and number of acres covered by groundwater reservoir or area is presented in Table 5.

Figure 50 – Approved Chemigation Permit Locations



Groundwater Reservoir	# of Chemigation Permits	# of Acres
Crete-Princeton-Adams	25	2,999
Dwight-Valparaiso	4	461
Lower Salt Creek	3	231
Missouri River Valley	1	95
Platte River Valley	4	264
Remaining Area	10	1,018

Table 5 – Chemigation Permits and Acreage by Groundwater Reservoir or Area

District staff also performed permit compliance monitoring on systems by noting the locations of chemigation sites while in the field. The chemigation locations were recorded while performing such duties as groundwater sampling and water level monitoring. The permit status for each location was verified upon returning to the office. No violations were found in 2021.

8. WATER METERS

Applicable Regulations: Section C

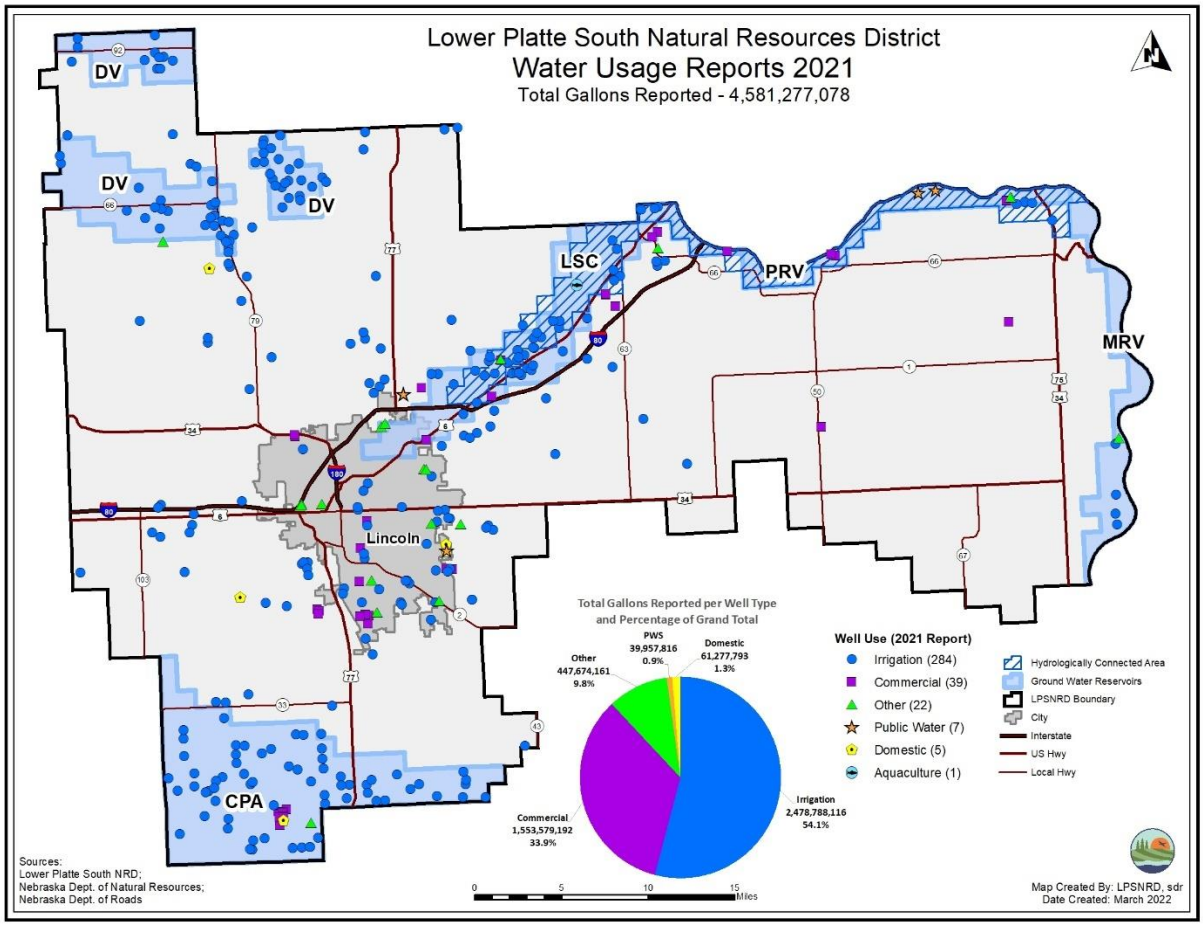
Water meters for accurately measuring the flow from a well are among the most important tools used to document and manage the use of groundwater. In Nebraska, NRDs are given the authority to require the installation of water meters, and several Districts throughout Nebraska have implemented that requirement.

The LPSNRD Groundwater Rules and Regulations require that all new wells constructed to pump over 50 gallons per minute (gpm) be fitted with a water meter that can accurately measure the flow, and that the volume of water pumped from those wells be reported by the well owner/operator to the District annually. In addition, those regulations require that all wells capable of pumping more than 50 gpm be fitted with a water flow meter prior to use. There is no specific requirement of a given type of meter; LPSNRD only requires that the meter installed be accurate, and have the capability of showing the total volume of water pumped. In addition, owners of any wells that are retrofitted with water meters must also begin reporting total annual pumpage to LPSNRD.

2021 was the eleventh year of the requirement that any well owner/operator who has a well equipped with a water flow meter provide annual water usage information to the District on the volume of water pumped. Out of the readings received this year and at the end of 2021, District staff was able to calculate overall gallons used in 2021 from the metered wells across the District (Figure 51). These wells pumped a total of 4,581,277,077 gallons in 2021 (Figure 51). Of those wells, 298 are irrigation wells and are responsible for 54% of that total, or 2,478,788,115 gallons (approximately 91,271 acre-inches or 7,606 acre-feet; see Figure 47 for acre-inches pumped by individual irrigation wells.

The District has also implemented a cost-share program for installation of new water meters. The program provides 50% cost-share for the purchase of a water meter, to a maximum of $650. The District completed one application for the water meter cost-share program in 2021.

Figure 51 – Water Usage Reports



9. SOIL SAMPLING

Sampling soil content and analyzing for nutrients assists in determining the application rate of additional nutrients needed for a field while reducing the potential for water and soil pollution. LPSNRD cost-shares on the sampling of soil as a way to more accurately determine the amount of additional nitrogen needed for crops.

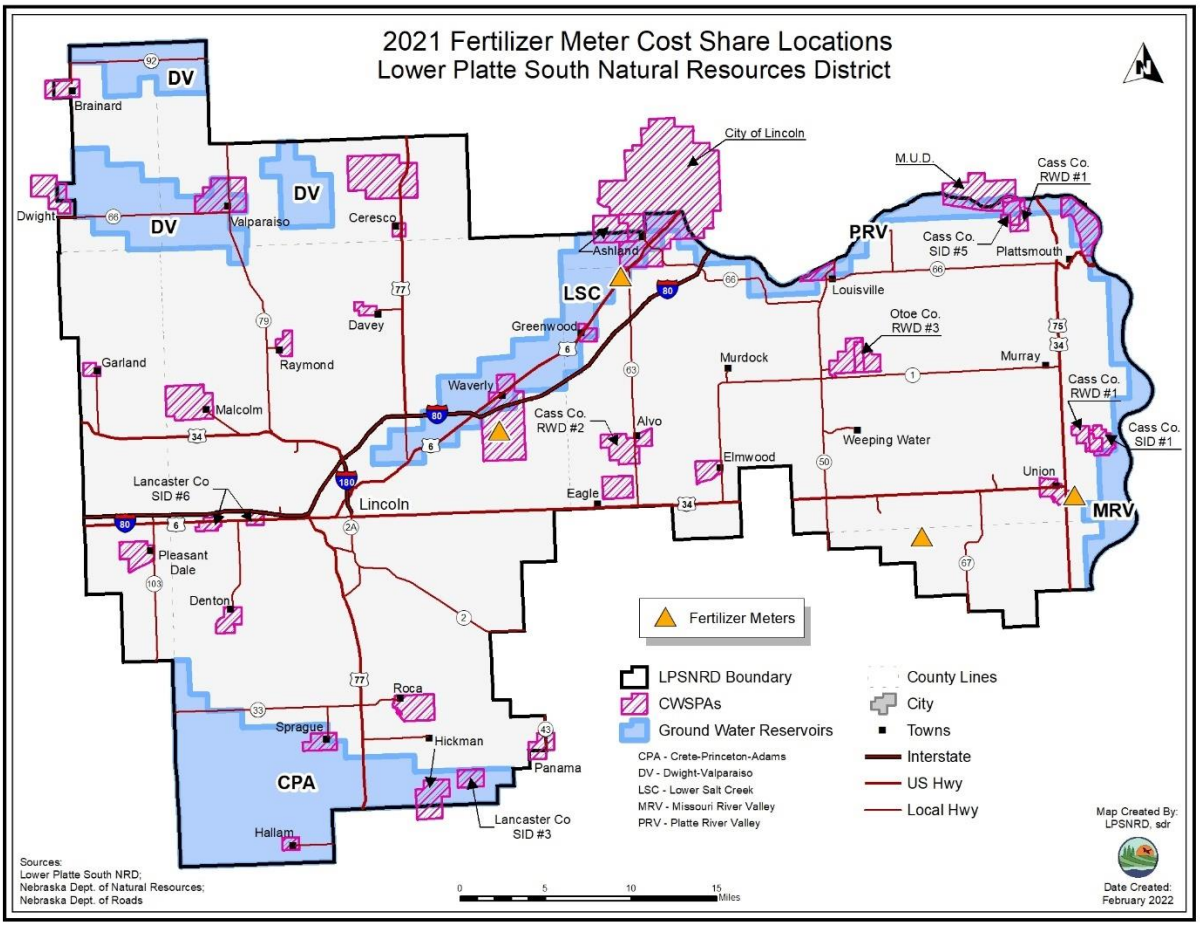
In 2021, the District did not receive any applications for the Soil Sampling Program.

10. FERTILIZER METERS

Accurate application of nitrogen fertilizer to crop ground is an important part of protecting groundwater from leaching of nitrates. If producers can accurately control the amount of fertilizer applied, it is less likely that excess nitrates will leach below the crop root zone and infiltrate to groundwater. LPSNRD cost-shares on the purchase of these meters as a way of promoting proper nitrogen management.

In 2020 the District received and approved four applications for the Fertilizer Flow Meter Cost-Share Program (Figure 52).

Figure 52 – Fertilizer Meter Cost–Share Locations

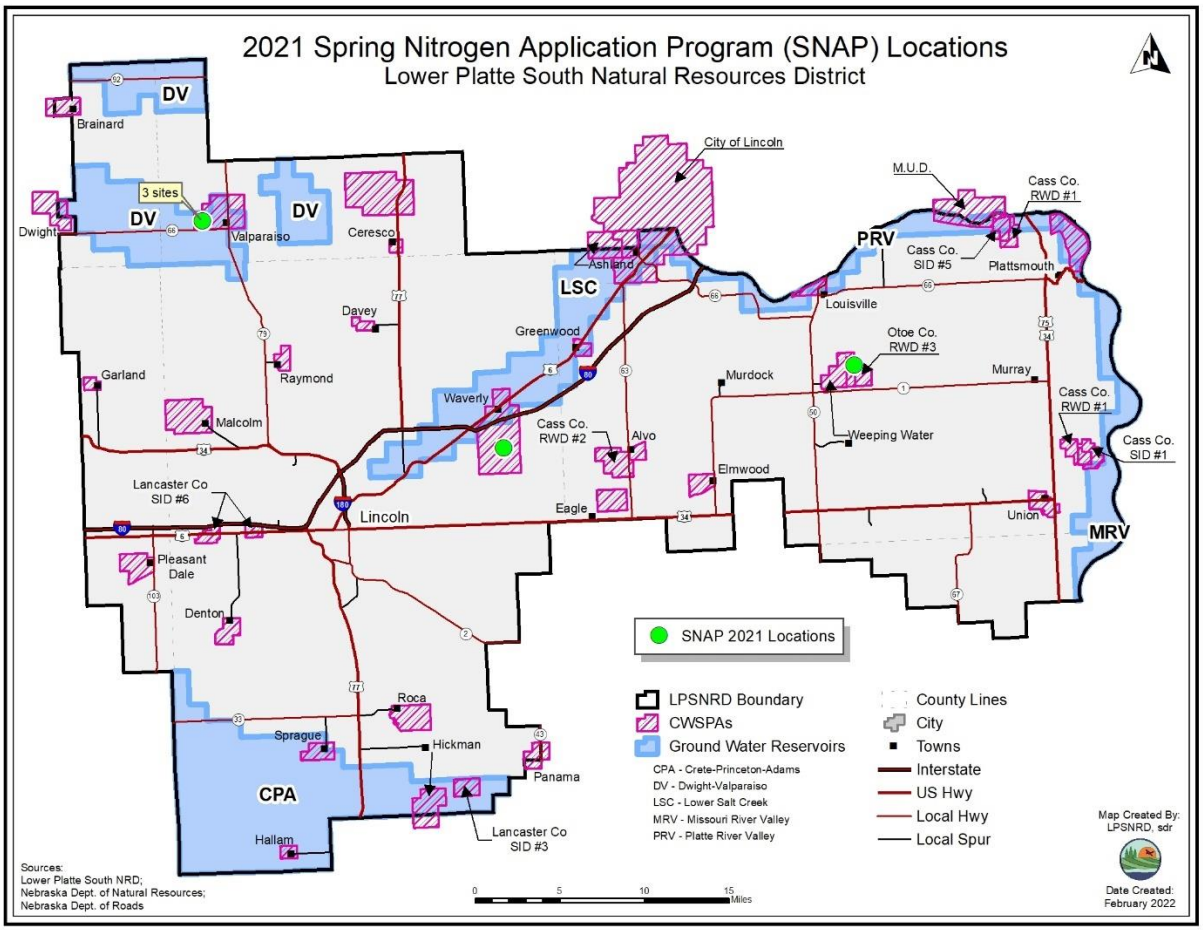


11. SPRING NITROGEN APPLICATION PROGRAM (SNAP)

Application of nitrogen fertilizer in the spring instead of the fall can reduce pollution of groundwater through the accurate and uniform application of the fertilizer, as well as allowing less time for the fertilizer to leach into the groundwater. The precise and uniform application of nutrients in the spring is a known best management practice. LPSNRD cost-shares on the application of spring (after March 1) versus fall fertilizer in all of the CWSPA areas throughout the District.

In 2021, the District received and approved five applications for the Spring Nitrogen Application Program (SNAP; Figure 53).

Figure 53 – Spring Nitrogen Application Program (SNAP) Locations



12. IRRIGATION MANAGEMENT

Proper irrigation management goes hand-in-hand with fertilizer management to prevent the leaching of nitrate to groundwater. If only the amount of water used by the crop is applied, less deep infiltration is available to carry excess nitrate to groundwater. The

District cost-shares on a variety of best management practices associated with irrigation water management. In 2021, LPSNRD did not approve any cost-share applications for these practices.

13. SALT WATER INTRUSION

Applicable Regulations: Section H

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 Formation or older Paleozoic bedrock is fairly close to the surface, as some units within the Dakota and older units contain saline water. 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 salt water 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 total dissolved solids (TDS). In 2021, the District had no inquiries or reports of salt water intrusion. However, 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 in 2021 continued applying salt water to various portions of the wetlands complex to further this restoration effort.

14. IMPROPER IRRIGATION RUNOFF

Applicable Regulations: Section M

Nebraska's NRDs are granted authority to deal with the improper runoff of groundwater applied as irrigation water. Such runoff is a waste of groundwater, can contribute to both ground and surface water quality problems, and can cause a variety of erosion problems. As noted below, in 2021 the District continued to work with parties involved in one 2009 complaint; there were no new complaints.

15. TRANSFER OF GROUNDWATER

Applicable Regulations: Section N

The District has the responsibility of reviewing and approving or denying applications to transfer groundwater from one area to another. In 2021, no requests were received for such a transfer.

16. VARIANCES

Applicable Regulations: Section P

LPSNRD also has provisions in its regulations for granting variances from those regulations upon petition if a landowner, well owner, or other individual can demonstrate such a need. In 2021, the District received one request for variance in association with

the Monolith wells described above. This request asked the District to set aside the requirements for aquifer testing, hydrogeologic analysis, and measurement of water quality parameters and static water levels in the two new wells to be drilled in 2021. In April and May, the Board of Directors granted the variance request for aquifer testing and hydrogeologic analysis based on the information already submitted and the likelihood that additional aquifer testing would yield essentially similar results. However, the Board did not grant the request for measurement of water quality parameters and static water levels as these pieces of information would provide additional baseline data for the facility when it begins full production.

17. COMPLAINTS/ENFORCEMENT/INVESTIGATIONS

Applicable Regulations: Sections D, J, K, L, M, N, O

As described above, 2021 was the eleventh year that the District required any well owner and/or operator who has a well equipped with a water flow meter to annually provide water usage information on the volume of water pumped to the District. LPSNRD staff requested usage information from all metered wells and will continue to work with owners of irrigation, commercial, and other wells so that they are in compliance with the water well flow meter rules and regulations.

Also, in 2021, District staff inspected 142 wells for required water flow meters. The inspection included taking photos of the meter, GPS locations, verifying the serial number on the meters, checking for proper installation, and verifying the water meter readings and units. The inspector would attempt these activities while the well was running, so it could be verified that the meter was working properly. All wells checked during these inspections had a meter installed properly and no violations were found at the time of the inspection. Wells that were listed as inactive irrigation wells were also checked to make sure they were not being used. Staff will continue inspecting at least 25% of the metered wells each year, so that all wells will be inspected at least every four years.

Beginning in 2014, the District revised the Groundwater Rules and Regulations to add the Dwight-Valparaiso-Brainard (DVB) Special Management Area. With this addition, one of the new rules for this area was that there shall be no new groundwater irrigated acres from any water well location in the special management area beyond those acres certified by the District on March 1, 2014. The District also established an initial three-year allocation of 21 acre-inches per irrigated acre not to exceed nine acre-inch annual maximum for sprinkler irrigation and 30 acre-inches per irrigated acre not to exceed a twelve acre-inch maximum for gravity irrigation, beginning in calendar year 2014. . 2016 was the final year of the three year allocation. As of January 1, 2017, the District removed the allocation for the portion of the Special Management Area located in Township 13 N, Range 6 E, Saunders County due to reduced concern over in-season water level declines. However, the Board of Directors voted to apply the same initial allocation in the rest of the Special Management Area for the next three years (2017-2019). 2020 was the first year of this allocation, and, as noted in Section 4.2, LPSNRD

revised its regulations to implement a three-year "rolling" allocation for the SMA. The District did not have any new violations of the 9 inch annual maximum in 2021.

From time to time, the District receives a variety of complaints or inquiries regarding various water resources concerns. These issues are investigated on a case-by-case basis, and the District will then determine if any violations of its rules and regulations have occurred. An ongoing issue has involved an irrigation complaint filed in September of 2009 due to groundwater irrigation runoff from a property located in Saunders County. The party involved worked with NRCS to prepare a plan to control irrigation runoff, which was approved in early 2010 and the party implemented the plan. Since that time, the downstream neighbor has reported that irrigation runoff has occurred again in years following the initial investigation and has showed staff and the Board of Directors video evidence of irrigation runoff. Each year, the operator submitted their irrigation management plan, and it was determined that they were following their irrigation management plan. In early 2015, the operator informed the LPSNRD that they are working with NRCS to design a water control structure to control any runoff from leaving their property. A hearing was held in April 2015 to enter into an Order to Cease and Desist for Irrigation Runoff Complaint #002 with regard to violator. In early 2016, a water/sediment control basin was constructed to control irrigation runoff. On July 25, 2018, the LPSNRD received a call that groundwater runoff was occurring below the water/sediment control basin. The compliance specialist conducted an inspection and took photos above and below the basin. On July 31, 2018, the compliance specialist received another call stating that irrigation runoff was occurring. Also, on September 6, 2020, the LPSNRD received a call that groundwater runoff was occurring below the water/sediment control basin. In all the above cases, the compliance specialist conducted an inspection and took photos above and below the basin. Staff reviewed all available information and presented it to the Water Resources Subcommittee along with the inspection reports. In both 2018 and 2019, the Water Resources Subcommittee recommended the Board of Directors determine there was no irrigation runoff and no violation of the NRD's April 22, 2015 Cease and Desist Order against Benes Service Company, Inc. The Board of Directors approved the motion and both parties were notified of the action in each case. There was no additional action on this complaint in 2021.

18. INFORMATION/EDUCATION

One of the most important activities that the LPSNRD undertakes is education of its citizens about groundwater quality and quantity issues. The District is involved in a wide variety of such activities. Highlights of the District's 2021 activities are described below, but of course it's important to note that many normal activities in schools were adjusted again in 2021 due to the ongoing COVID-19 pandemic.

18.1 Programs for Students and Teachers

- With the ongoing COVID pandemic, a mix of in-person and virtual groundwater related classroom presentations were given at area schools to 720 elementary, junior, and senior high school students. The students utilized hands-on models, kits, and

activities such as the District's groundwater flow model, Hach nitrate test kit, Incredible Water Journey, and Wetland in a Bag.

- In the Fall, the District led field trips for over 1500 students – elementary and senior high school biology students focusing on different water quality parameters and the influence of land practices on surface and ground water.
- The district participated in the Nebraska Association of Resources District's ACE Camp in Halsey where LPSNRD staff led a session on water quality.
- The Earth Wellness Festival was held virtually in March, and LPSNRD sponsored and helped facilitate it. Teachers could watch videos from Major presenters on different natural resources topics, and also career oriented videos from community presenters. The NRD created a career video for this event.
- The NRD's virtual classroom webpage, on the NRD website, continues to be utilized by educators and families in the District. It has shorter Explorin' Videos, longer Field Trip videos, a presentation video with our groundwater flow model, and activity sheets. The page contains a wide variety of natural resources topics, including groundwater and wetlands and staff is always available via zoom for follow-up question and answers.
- The NRD hosted one Test Your Well Night in partnership with the Science Club at Elmwood-Murdock High School. These nights invite landowners with private wells to bring in water samples to be tested for nitrates. Information regarding the NRDs groundwater programs is available at the event. In addition, LPSNRD also provided a specific Test Your Well Night Handout that contains NRD quality and quantity sampling information for the area. The Science Club students ran the nitrate tests using Hach equipment. If there were any samples at 6 ppm (parts per million) or greater, the NRD kept the sample and sent it to Midwest Labs for an additional nitrate test. At the event, 35 samples were tested for nitrate (20 were sent on to Midwest Labs). For samples that were sent onto Midwest Labs, NRD staff followed up with a mailing to the landowners sharing those additional results.

18.2 Public Information

- LPSNRD utilized social media to report through Facebook the following updates on groundwater programs: groundwater spring and fall levels, number of wells sampled annually, groundwater meters, Test Your Well Night information, and all Monolith meetings/public hearings/Special Board meeting.
- The groundwater staff continued to provide input for website improvements at LPSNRD.org. The website allows access to a lot of groundwater information and is compatible with a variety of devices. The website gives landowners new tools for electronically submitting well flow meter reports and it allows interactivity with constituents on information concerning certified acres, chemigation, water quality and water levels. In December 2021, LPSNRD.org became capable of being translated into nine languages on-demand. These languages are common in the Lincoln area when English is not a first language.
- Several months of consideration by the LPSNRD Board of Directors, leading up to approval, in June 2021, for Monolith Materials to construct three wells to support an expansion of its manufacturing plant near Hallam was tracked step-by-step at

LPSNRD.org. Information and Zoom links about Board meetings, special Board meetings, hearings and an open house were provided online as appropriate during a public process. Audio recordings of several hearings, presentations and other testimony were provided. In addition, audio recordings of all LPSNRD Board of Directors meetings are provided at LPSNRD.org.

- LPSNRD continued implementation of its voluntary Integrated Management Plan (IMP) in 2021. The 2020 annual report summarizing IMP progress was posted on the websites of both the NRD and NDNR.
- A webpage dedicated exclusively to the IMP, with links offered to the entire plan, the Water Balance and Stakeholder Perspectives studies that preceded the plan, and the Annual Report, was maintained throughout 2021. The IMP webpage is accessible through the website's Programs menu and the IMP and IMP Annual Report are also accessible through the Publications menu.
- Links were maintained on LPSNRD.org in 2021to data from seven aerial electromagnetic (AEM) surveys completed since 2007 over parts of the district. Links take visitors to the Eastern Nebraska Water Resources Assessment website, ENWRA.org, to view the data.
- The District's voluntary Water Quality Management Plan (WQMP) was completed in March 2019 and was approved by the USEPA in May 2019. The plan, which is posted a LPSNRD.org, serves as a guide in the development and implementation of water quality, hydrology, and aquatic resources projects in the District and can aid in securing financial support for these types of projects.
- LPSNRD advertises its groundwater quality and conservation programs and activities in many printed publications across the District.
- Groundwater quality and quantity radio spots are aired year-round on Lincoln radio stations owned by NRG Media and Alpha Media.
- The District's "Look Out Below" logo remained on a Cass County Rural Water District #2 water tower near Eagle.
- LPSNRD groundwater programs and activities are also regularly promoted in the LPSNRD newsletter and at LPSNRD.org.
- Groundwater programs and water quality best management practices (BMPs) are featured in brochures being produced and printed in-house on an as-needed basis.

19. EASTERN NEBRASKA WATER RESOURCES ASSESSMENT (ENWRA)

The Eastern Nebraska Water Resources Assessment (ENWRA) was formed in 2006 by a joint agreement between the six NRDs which cover the easternmost portion of Nebraska. The Lewis and Clark, Lower Elkhorn, Lower Platte North, Lower Platte South, Nemaha, and Papio-Missouri River NRDs formed a coalition aimed at developing a three-dimensional geologic framework and water budget for all of eastern Nebraska (Divine *et al.*, 2009). In the years since its inception, ENWRA has hired a project coordinator, and has completed a variety of projects and investigations aimed at gaining a better understanding of the complex water system in the glaciated portion of eastern Nebraska. An excellent description of these activities is presented in Divine *et al*., 2009. Additional updated information can be found on the website, www.enwra.org.

The ENWRA Coordinator has 60% duties as the coordinator and 40% duties as a UNL-CSD survey hydrogeologist to help NRDs and other entities with groundwater quantity and quality related issues in eastern Nebraska. Between 2007 and 2020, ENWRA NRDs conducted almost 21,000 miles of airborne electromagnetic (AEM) flights across the ENWRA area resulting in significant regional and local scale assessment coverage. Much of the AEM was co-funded with the Nebraska Department of Natural Resources (NDNR) and/or reimbursed with state Water Sustainability Fund (WSF) Dollars. Over 4,300 miles of the ENWRA AEM flight total has been conducted for the LPSNRD to date and new updated links to the different AEM data deliverables on the ENWRA website have been generated and added to the LPSNRD website.

The *Nebraska GeoCloud and AEM Data Integration Project* (GeoCloud), a WSF funded ENWRA project scheduled to go online June 30, 2020, houses all the AEM data collected in Nebraska statewide in a cloud-based platform. The GeoCloud project's multi-NRD Interlocal agreement (which includes ENWRA NRDs) is scheduled for a five-year renewal including $23,000 annually from ENWRA for additional enhancements and to maintain and continue the Platform. Recent developments to the Nebraska GeoCloud include summarizing NDNR well logs for each Nebraska NRD in a uniform geologic database and the creation of new online profile and 3D data viewing tools (https://youtu.be/Fs4OsWJQhe8). More information on the AEM related projects can be found in Section 20 below.

ENWRA received another WSF award in December 2021 for ENWRA Recharge and Focus Area Mapping (WSF #5312), a three-year project with the UNL-CSD and U.S. Geological Survey. The new ENWRA project will focus on groundwater recharge in eastern Nebraska with $144,000 from WSF, $96,000 in matching funds from ENWRA, and $74,000 in USGS Cooperative dollars. The three-phase project will develop a regional recharge map designed for upload to the Nebraska GeoCloud in Phase 1, detailed focus area work in Phase 2, and updated refinements to the online recharge map products with recommendations for the focus areas in Phase 3. The project also includes the creation of an updated CSD water table contour map for the region. One of the five focus areas planned for in depth recharge mapping and sustainability evaluation across NRD boundaries includes LPSNRD's Crete-Princeton-Adams Groundwater Reservoir, part of the Dorchester Sterling paleochannel system.

Additional 2021 ENWRA activities included:

- Several ENWRA virtual meetings in spring and summer 2021, including updates to the Lower Elkhorn and Nemaha NRD Boards of Directors;
- Updates to the ENWRA website including posting the US Geological Survey groundwater age-dating project report link (WSF #4125) and the ENWRA archive database, an archive created by Dana Divine linking to historical CSD geologic survey records in scanned PDF format for eastern Nebraska (2.9 GB on Dropbox);
- Coordinating public/consultant/agency inquiries for AEM flight data:
- Geologic test-hole planning with various NRDs;
- Administering agreements, financials, and grants;

- Updates of three-dimensional projects for each ENWRA NRD in GeoScene 3D;
- Collecting, analyzing, compiling, and graphing annual water levels and water quality results; and
- Maintaining pilot site well cluster installations and instrumentation.

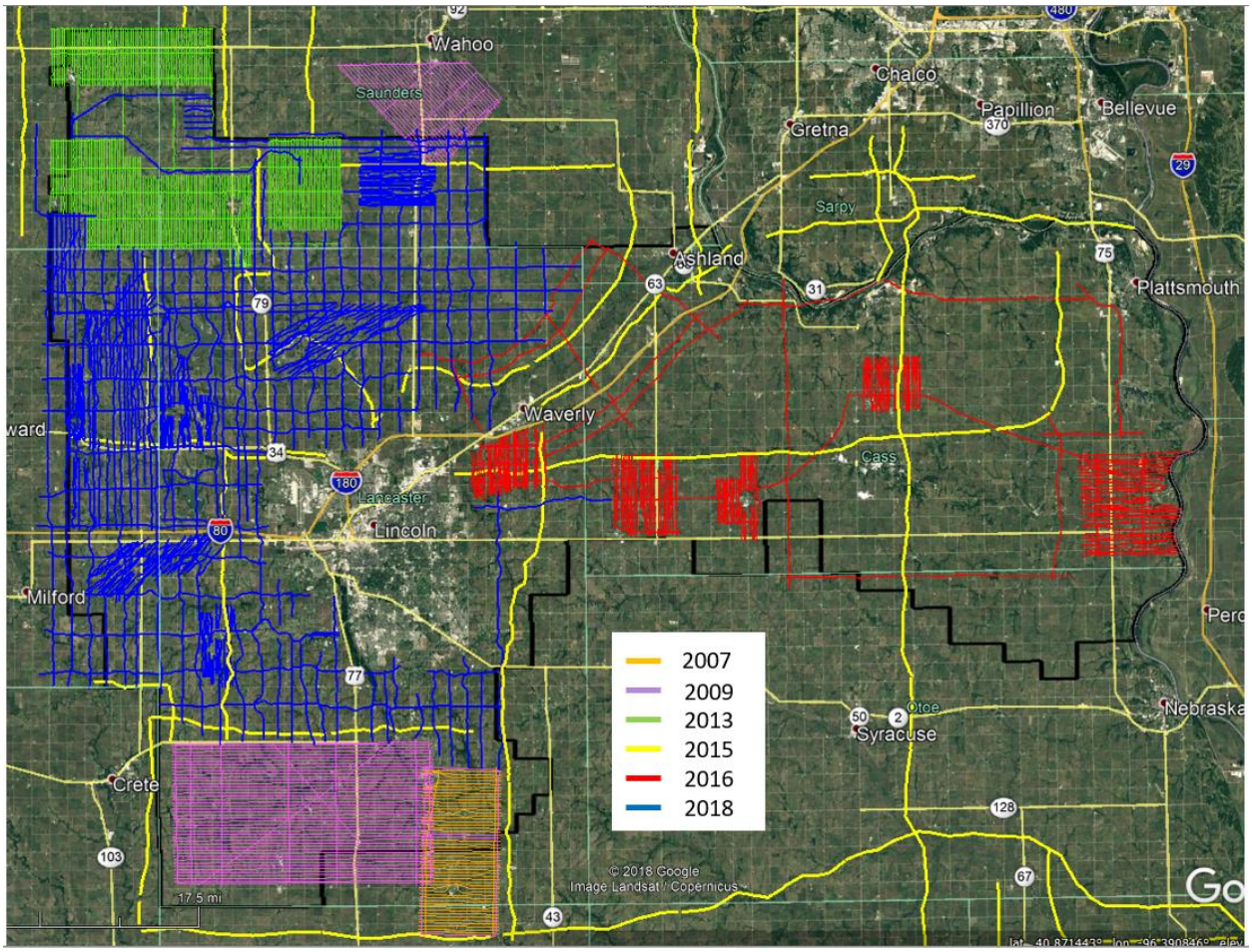
20. RESEARCH

In addition to the research activities undertaken by the ENWRA project, the District engages in a variety of other research related actions. As already mentioned in Section 4.1.2, LPSNRD has begun a program to collect data on the occurrence of nitrate in the vadose zone at several CWSPA locations throughout the District. Over the next several years, LPSNRD expects to include locations which represent a wide variety of land use, soil, and hydrogeologic settings to help determine loading amounts and general rates of movement, which will help to guide future nitrogen management activities. In 2016, District staff began discussion of a project with UNL-WSL to develop SOPs for vadose zone sample collection which will be able to be utilized by all 23 NRDs in Nebraska. As already described, this project will include everything from basic sample collection and analysis to high-grade, research techniques. The cooperative agreement for this project was signed in early 2017, and vadose zone sampling at several sites was initiated in the fall of 2017. These are sites for which LPSNRD has historical data, and this ongoing sampling will allow for at least qualitative analysis of infiltration rates and movement of contaminants through the vadose zone. In addition, UNL-WSL is evaluating a variety of analytical techniques involving additional parameters (e.g. ammonia, arsenic, etc.) as well as advanced isotopic and age-dating techniques which will provide additional information on contaminant movement rates. LPSNRD signed an additional cooperative agreement with UNL-WSL to further this effort As noted above, in 2021 UNL-WSL performed vadose zone resampling of six sites across LPSNRD representing cropland within and outside CWSPAs as well as native prairie in one of the NRD's WMAs, and the report is anticipated in 2022. Again, it is the District's intent to continue working with UNL-WSL on additional vadose zone sampling activities in the future.

Regarding AEM developments in 2021, the GeoCloud project went live online in the summer of 2020 and houses all AEM for Nebraska including over 4,300 miles of flight data for LPSNRD since 2007 (see Figure 54 depicting large-scale collection of AEM data within LPSNRD). It is possible that additional airborne or other geophysical data collection will be undertaken in the future, but it is anticipated this would be on a more local and focused scale than what has been accomplished to date. The next step is anticipated to be initiation of pilot projects focusing on products (e.g., geological models, groundwater models, etc.) that can be created with the AEM data. A first step toward that district goal was achieved in December 2021 with a $247,500 award in grant funds from the Nebraska WSF, administered by the Nebraska Natural Resources Commission (WSF #5311). The grant will be matched with another $165,000 in LPSNRD funds to develop a three-dimensional (3D) AEM-based hydrogeologic framework (or "Framework" for brevity) using existing AEM data, geologic logs, and other relevant available geologic and hydrogeologic reports and data. The Framework will be developed using state-of-the-art 3D visualization computer software to develop 3D geological

models from large datasets (like AEM), and will also include hardcopy map products. In addition, this grant will be used to prepare all of LPSNRD's AEM data for incorporation into numerical groundwater models, both on a regional and local scale. Finally, the project will also develop a set of detailed recommendations for additional work with the AEM data and hydrogeologic framework, as well as evaluate the necessity for groundwater modeling.

Figure 54 –AEM Flight Lines in LPSNRD Completed Since 2007



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