LOWER PLATTE NORTH
NATURAL RESOURCES DISTRICT

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Lower Platte North Natural Resources District

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Hydrogeologic Evaluation and Subarea Delineation Study

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1.0 Introduction

The Lower Platte North Natural Resources District (LPNNRD) is based in Wahoo, Nebraska and covers just over one million acres in east-central Nebraska stretching northwest of Newman Grove to the southeast near Memphis, Nebraska (See Figure 1). The LPNNRD along with the other 22 NRDs in Nebraska are charged with developing and protecting the state's natural resources. As with all the NRDs, the LPN works in partnership with landowners, private industry, and with other government agencies to fulfill its mission.

In 1995, the LPNNRD adopted a Groundwater Management Plan that addresses both water quality and water quantity concerns in the District (HWS, 1995). When the plan was implemented, it placed the entire District in a Phase I (educational) Groundwater Management Area (GWMA) for water quality. Since that time, the LPNNRD has designated two Phase 2 water quality management areas due to elevated levels of nitrate-nitrogen in the aquifers. In January 2003, the LPNNRD began a Phase 2 GWMA near Bellwood, Nebraska that covers approximately 30 square miles. The second Phase 2 area was started in January 2004 and is generally located from Richland to Schuyler, Nebraska and covers approximately 55 square miles.

With regard to water quantity, in the LPNNRD Groundwater Management Plan, GWMAs can be designated when 50 percent of the monitoring wells within a subarea are at or below the designated trigger level for three consecutive spring readings. For example, if there are five wells in a subarea that are completed within a confined aquifer and three of the five wells are at or below the designated trigger level (7percent of the potentiometric and aquifer thickness) readings for three consecutive spring measurements, then the area can be designated a GWMA Level 1 for water quantity.

For the past 15 years, the LPNNRD has been monitoring the groundwater resources of its district through a network of groundwater monitoring wells. The groundwater levels in the wells have been monitored to evaluate fluctuations in the water table within unconfined aquifers and the potentiometric surface within confined aquifers across the district. Additionally, the wells have been sampled for various constituents ranging from general inorganic chemicals, such as nitrate-nitrogen, to radioactive isotopes, nitrogen isotopes and pesticides. Characterization of water quality and quantity changes across the district has become much easier to quantify with the wealth of information collected from these wells. It is with this information that the two GWMAs for quality were designated in 2003 and 2004. Based on recent well measurements the LPNNRD has reached the trigger level to declare a GWMA for water quantity in the uplands of Butler County in January 2007. The District needed to prepare for potential water quantity management areas within the Todd Valley and the Platte Valley of Saunders County. Extensive irrigation and the development of the Metropolitan Utilities District's municipal well field on the Lower Platte River are driving these concerns.

This Hydrogeologic Evaluation and Subarea Delineation Report was prepared to delineate aquifer subareas within the LPNNRD. The details of how the aquifer subareas were delineated are described in the following sections of this report. The subareas are either isolated aquifers, sometimes referred to as 'pocket aquifers' or are in hydrologic connection with other aquifers as well as surface water. The report provides the locally elected LPNNRD directors and the LPNNRD staff detailed hydrogeologic information on the aquifers within their district so that they can better manage their groundwater resources for both quality and quantity.

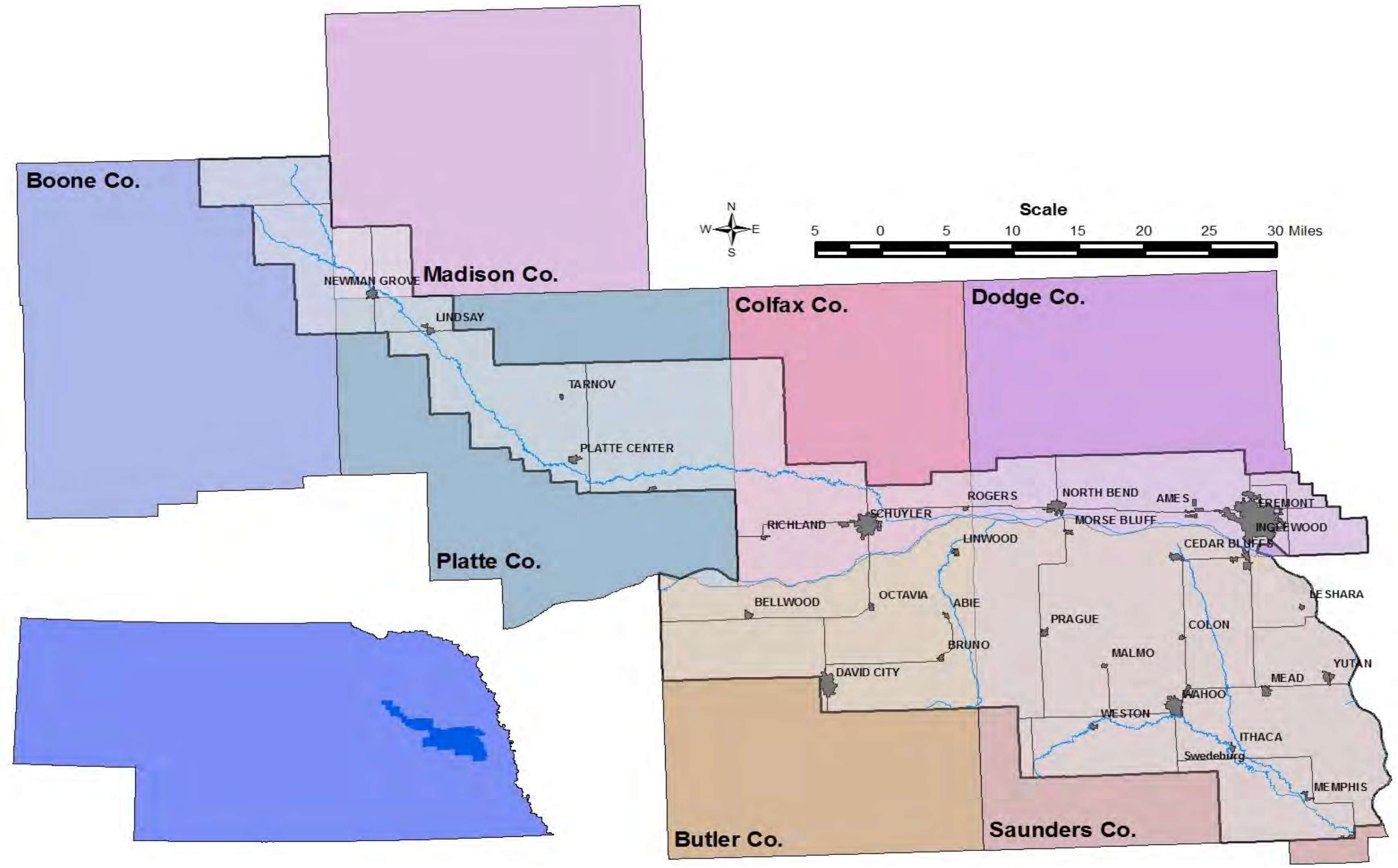


Illustration 1 Lower Platte North Natural Resources District Boundary with County Lines and Cities for Reference.

Before the aquifer delineations are described, it is important to understand the fundamentals of how groundwater and surface water interact as one resource. The following section on how groundwater and surface water are connected is summarized from a report prepared by the United States Geologic Survey called "Ground Water and Surface Water: A Single Resource" (Winter and others 1998).

Streams interact with groundwater in three basic ways: Streams gain water from inflow of groundwater through the stream bed (Illustration 2); they lose water to groundwater by outflow through the streambed (losing stream, Illustration 3); and some streams do both by gaining in some reaches and losing in other reaches.

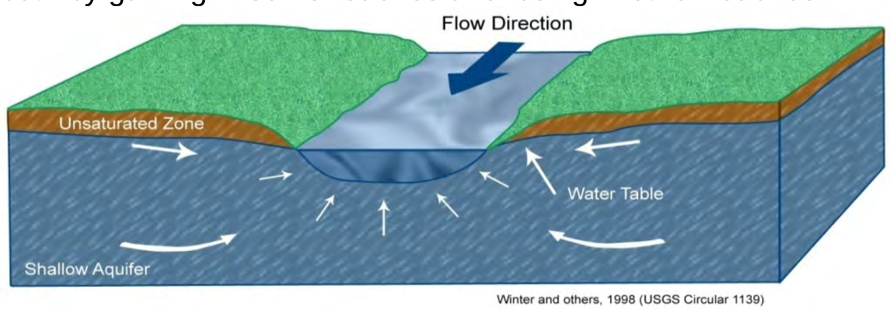


Illustration 2 Gaining streams receive water from the groundwater system.

Within the LPNNRD, the Platte River is described as a gaining stream. This can be determined by carefully evaluating the water table contour maps drawn across the river. Maps illustrating this point are presented later in this report. On the maps where the water table contour lines cross the Platte River, and the lines point in the upstream direction, the river is defined as a gaining stream. The opposite is true in a losing stream, as shown by the Platte River east of North Platte in western Nebraska. In western Nebraska, the Platte River is primarily a losing segment ,as illustrated by the water table contour lines that point downstream.

There is one more type of river/aquifer interaction to identify for the LPNNRD area, disconnected streams (Illustration 4). Disconnected streams have a zone of unsaturated material beneath the stream segment. The important thing to note with these stream segments is that if the rate of recharge from the stream bed is greater than the lateral groundwater flow, then a mound in the water table occurs beneath the stream bed. Another important feature of disconnected stream beds is that pumping by nearby groundwater wells will not affect the stream flow in this type of system. Alternatively, in both the losing and gaining stream scenarios, pumping from nearby wells, can affect instream flows in the river.

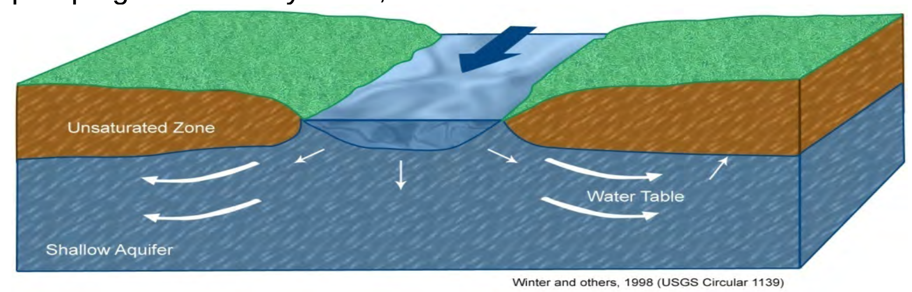


Illustration 3 Losing streams lose water to the groundwater system.

1.1 Regional Hydrogeology

The LPNNRD Groundwater Management Plan subdivides the district into four regions with distinct hydrogeology:

- Platte River
- Shell Creek
- Todd Valley
- Uplands Region

Illustration 5 has the four regions identified and the following provides general information on the hydrogeology of each region.

1.1.1 Platte River

The Platte River Region is characterized by fluvial sand and gravel of varying thickness overlain by alluvial silt and clay and Peoria, Gilman Canyon, Loveland and other loess deposits. Gravel appears to be thicker in areas where the sand and gravel deposits overlie paleovalley deposits that in some cases continue on to the Uplands. West of North Bend the paleovalley sand and gravel aquifers are often separated from the upper Platte River sand and gravel aquifers by a clay aquitard.

1.1.2 Shell Creek

Shell Creek drains the extreme northwest of the district. The region extends from the Sandhills to the Platte River and dissects glacial terrain similar to that of the Uplands. In the upper reaches of the Shell Creek Region, the principal source of groundwater is from the Ogallala Formation.

1.1.3 Todd Valley

The Todd Valley is an ancient valley carved by the ancestral Platte River. It is characterized by fluvial sand and gravel overlying the Dakota Group and overlain by the Peoria Loess. The sand and gravel deposits include fine sand overlying medium to coarse sand with gravel near bedrock. Gravel is not ubiquitous and follows buried channels trending northwest to southeast. The Todd Valley aquifer is connected to the Platte River alluvial sand and gravel deposits but the water table at the north end of the Todd Valley appears to have a west-to-east gradient and it is unclear how much water flows from the Platte Valley aquifer into the Todd Valley. Some lateral recharge may come from the Platte River aquifer through sand and gravel near Morse Bluff. At the end of the region, the Todd Valley aquifer discharges water to the Platte River aquifer near Ashland.

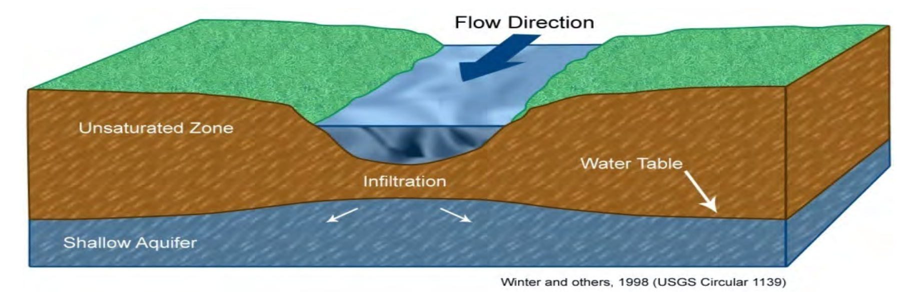
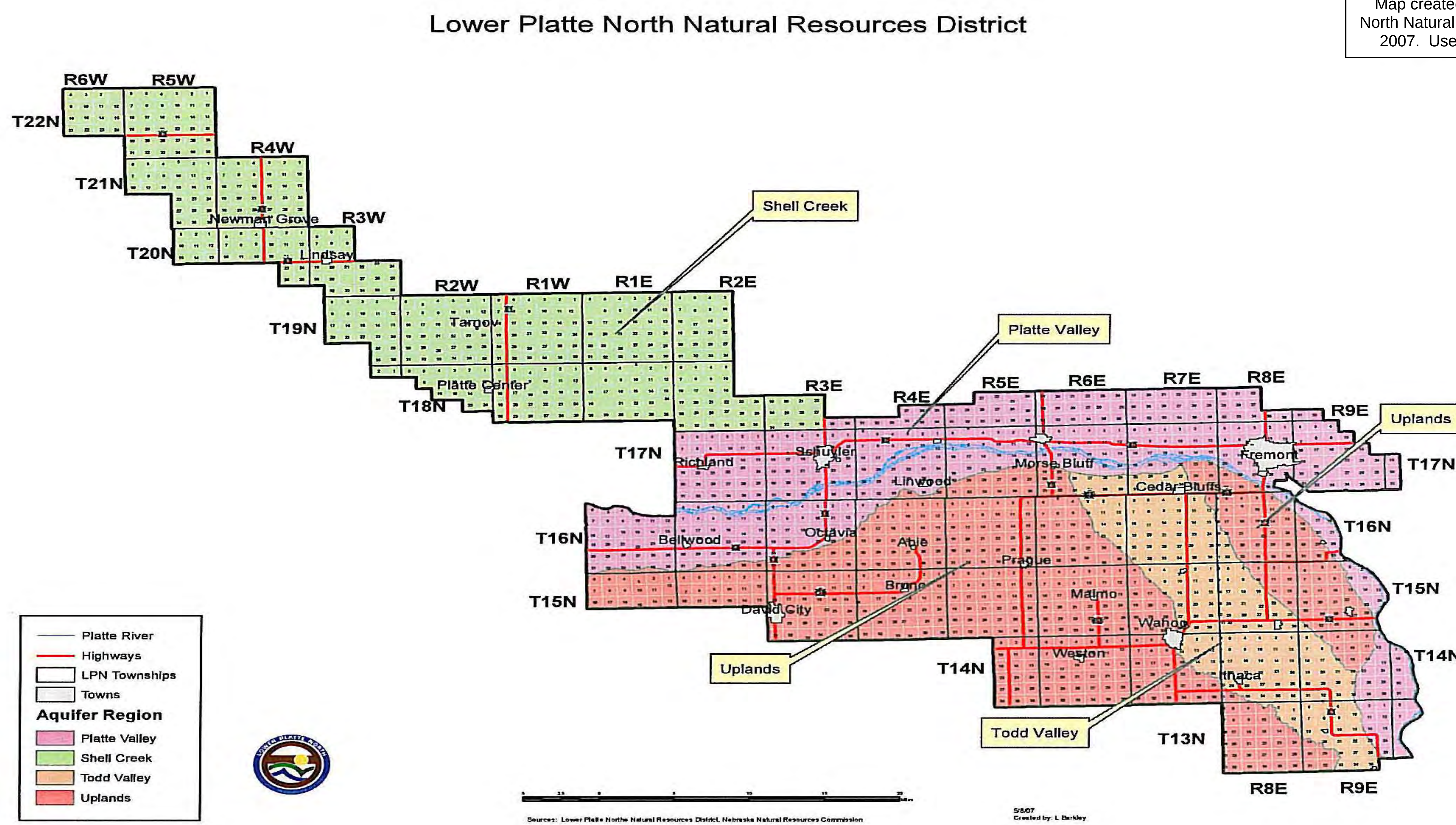


Illustration 4 Disconnected streams are separated from the groundwater system by an unsaturated zone.

1.1.4 Uplands

The Uplands Region is characterized by glacial till and loess deposits interspersed with sand and gravel, overlying sand and gravel in paleovalleys in some areas and bedrock in others. The underlying bedrock is typically the Dakota Group. The sandstone units of the Dakota Formation contain brackish to saline water. Loess deposits include the Peoria Loess (present at the surface) which are typically 30- to 40-feet thick. Glacial till is present over much of the Uplands Region, with interbedded loess and alluvial sand, gravel and clay. Sand and gravel deposits between units of loess or till comprise discontinuous aquifers sometimes referred to as 'pocket aquifers' with limited aerial extent and localized sources of recharge. Paleovalley deposits such as the one beneath David City are characterized by west-to-east drainages cut into bedrock with sand and gravel of variable thickness. The sand and gravel deposits are overlain by till and loess.

Map created by Lower Platte North Natural Resources District, 2007. Used by permission.



2.0 Subarea Delineation

Since the LPNNRD Groundwater Management Plan was developed, management of the water resources has been implemented using the four region subdivisions. Due to the increased water usage and potential for additional aquifer development in the area, further refinement of the four regions as necessary to better manage the District's water resources. With that in mind, the LPNNRD began the process of subarea delineation whereby subareas within the four hydrogeologic regions could be managed based on the localized hydrogeology.

The first step to subarea delineation was to gather and evaluate the existing hydrogeologic data on the four regions. Information was gathered from the Nebraska Conservation and Survey Division (CSD), the Department of Natural Resources, (DNR), the University of Nebraska-School of Natural Resources, and the Center for Advanced Land Management Information Technologies (CALMIT). Geographic information system (GIS) data sets were developed, integrated and interpreted to produce geographic data sets to illustrate the hydrogeologic characteristics. For example, well logs provided by the DNR and CSD, and the bedrock surface from the CSD were reviewed and used to estimate the thickness of gravel and the presence of paleovalleys. This was integral in delineating subareas for most of the LPNNRD.

For areas in which the principal source of groundwater was alluvial deposits, well logs were reviewed and the likelihood of a productive aquifer being present at each location was determined by the presence of basal sand and gravel overlying bedrock. Significant aquifers were identified as areas with 30 feet or more of basal sand and gravel deposits, similar to methods to delineate aquifers in the Lower Platte South NRD (Druliner and Mason, 2001).

Additionally, paleovalley, upland and Ogallala Aquifer thickness subareas were delineated as follows. There are several paleovalleys in the LPNNRD with thick deposits of sand and gravel. Paleovalley subareas were delineated using the bedrock surface and the presence of an aquifer was determined again by the thickness of gravel. Upland subareas with discontinuous aquifers, such as the one near Swedeburg were delineated primarily by the transition into another subarea. For example, an upland area may have been defined by the adjacent boundaries of a paleovalley subarea. Finally, the thickness of the Ogallala aquifer was used to define subareas in the northeastern most portion of the District.

As with any scientific evaluation, the interpretations and conclusions are only as good as the data set used to develop them. To complete the evaluations, only well logs that reached bedrock and had useful lithologic description were included in the study. Sand and gravel thickness was not the only parameter evaluated. After the gravel thickness was spatially interpolated, it was compared to other sources of spatial data such as the bedrock surface, transmissivity and specific yield.

For additional detailed information on the three aquifer types present in the unconsolidated sediments of the LPNNRD (paleovalley aquifers, aquifers in alluvium of modern and abandoned stream valleys and smaller-scale aquifers of multiple origins), refer to the Introduction to a Hydrogeologic Study completed as one of the first publications of the Eastern Nebraska Water Resources Assessment (ENWRA) (Devine, et al, 2009). The publication provides detailed descriptions of recent test hole drilling and geophysical studies that are currently being completed in eastern Nebraska including the LPNNRD.

The following sections describe in more detail how the subareas were delineated in each of the four regions. The subareas were delineated based on the data sets and maps available at the time of the study. Reinterpretations of the subarea delineations may be warranted should new information become available for a specific area.

2.1 Platte River Region Subareas

Several subareas were delineated within the Platte Valley Region based on paleovalley deposits and the geographic nature of the NRD boundary. In the Platte River Valley north of Inglewood subareas are based on gravel, and to the south, the region becomes very narrow in places, essentially separating the Leshara area from the Wann area. These two areas are designated as the Leshara Platte Valley and Wann Subareas.

A distinctive north-south trending paleovalley lies just west of the town of Fremont, forming the Fremont Subarea. To the west, gravel is thicker in a paleovalley forming the Schuyler Subarea, and further west, the continuation of a paleovalley that runs through David City forms the Bellwood Subarea. Areas of the Platte River Region with thinner but still viable basal sand and gravel are the Octavia, Northbend and Fremont East Subareas. A small area north-northeast of Ames is similar hydrogeologically to the Uplands Region. It is designated the Platte River Upland Subarea. The Platte River Upland Subarea has little yield and current supports one registered center pivot.

2.1.1 Platte River Region Connectivity

For much of the Platte River Region, groundwater and surface water appear to be connected due to relatively high riverbed connectivity along the active channel of the Platte River. Areas where this is not the case include surface water bodies located in overbank clay deposits or loess that have minimal hydraulic connectivity due to the stratigraphic isolation.

2.1.2 Platte River Region Aquifer Type

Most of the Platte River Region can be considered unconfined and connected with surface water. This is due to relatively high riverbed conductivity. There are in places deeper sand and gravel units separated from upper aquifers by clay layers. Wells in these areas will respond as confined or semi-confined.

2.2 Shell Creek Region Subareas

Several subareas are delineated in the Shell Creek Region based on gravel thickness southeast of the Ogallala Formation. In the upper reaches of the Shell Creek Region, the principal source of groundwater is from the Ogallala Formation, so the saturated thickness as defined by the CSD was used to identify different subareas.

The southern Shell Creek Region from about four miles south of the town of Lindsay to the boundary with the Platte River Region is characterized by east-west trending paleovalleys and a small area similar to the Uplands Region. One paleovalley trends west to east through the town of Tarnov and is delineated as the Middle Shell Creek Subarea, and the other is south of Platte Center, designated as the Lower Shell Creek Subarea. The area north of Platte Center is delineated as the Platte Center Subarea. The area at the east end of the Platte Center Subarea has discontinuous gravels and glacial till similar to portions of the Uplands Region and is delineated as the Shell Creek Uplands Subarea. The north extremity of the Shell Creek Region is designated the Upper Newman Grove

Subarea, and a small area of very thin saturated thickness delineated the Upper Shell Creek Subarea. The Upper Newman Grove Subarea has more than 150 feet of saturated thickness and the Newman Grove Subarea has 50- to100-feet of saturated thickness. The Newman Grove and Lower Newman Grove Subareas are also subdivided based on saturated thickness.

2.2.1 Shell Creek Region Connectivity

Over most of the Shell Creek Region groundwater is too deep below ground surface to be directly connected to surface water. Only in the lower reaches of Shell Creek and parts of Loseke Creek is groundwater shallow and water table contours indicate a gaining stream characteristic.

2.2.2 Shell Creek Region Aquifer Type

Most of the Shell Creek Region is covered by thick loess and clay deposits, approximately two-thirds of the region was identified as confined to mostly confined by the CSD. The southern portion of the region was identified as mostly unconfined because the piezometric surface is below the confining units, or it can be drawn down below confining units during pumping.

2.3 Todd Valley Region Subareas

Two areas within the Todd Valley Region appear to have thicker gravel due to continuation of paleovalleys. One trends east-southeast from the Uplands Morse Bluff to the Leshara Uplands Subareas. Another paleovalley apparently crosses the southern Todd Valley from the David City-Wahoo Subarea to the Yutan South Subarea. For this evaluation, neither of these paleovalleys warrants subarea designation.

2.3.1 Todd Valley Region Connectivity

Loess cover and water table more than 30 feet below ground surface over most of the Todd Valley Region suggest that groundwater-surface water connection is not present. In the southeast portion of the region, along Wahoo Creek and east, however, groundwater is shallow and therefore surface and groundwater connectivity is characteristic in this area.

2.3.2 Todd Valley Region Aquifer Type

The Todd Valley aquifer can be considered unconfined (CSD, 2008). Though there is a low-permeability loess deposit covering most of the valley, the water table is either below this unit or quickly drops below the layer under pumping conditions. Exceptions to this occur in stream valleys where the loess is missing. One example is along Wahoo Creek where groundwater is shallow and the aquifer often exhibits confined behavior due to the overbank clay deposits.

2.4 Uplands Region Subareas

In the Uplands region, two paleovalleys are delineated based on the distribution of basal gravel units. Across the northern part of the Uplands thick gravels are found near Morse Bluff and appear to continue across the north end of Todd Valley to the town of Leshara. Based on the gravel distribution, this paleovalley continues to the northwest across the Platte River Valley to the lower reaches of Shell Creek. Subareas in the Uplands Region defined from this feature are the Morse Bluff and Leshara Uplands Subareas.

Another paleovalley in the Uplands Region begins in the Platte River Valley northwest of the town of Bellwood and continues to the east through David City toward Wahoo. This valley bends to the south and becomes the Valparaiso Aquifer in the Lower Platte South NRD as defined by Druliner and Mason (2001). Another paleovalley begins just south with remnants on the east side of the Todd Valley and south of the town of Yutan. The David City, Weston, and Yutan South Subareas are delineated along this paleovalley. The central and southern parts of the Uplands Region west of the Todd Valley Region and the central part of the Uplands Region east of the Todd Valley are characterized by discontinuous pockets of sand and gravel that can reach 20- to 30-feet thick, though no continuous deposit has been delineated from data available for this investigation. These parts of the Uplands Region are delineated as the Prague, Swedeburg and Yutan Subareas.

2.4.1 Uplands Region Connectivity

Over nearly all of the Uplands Region groundwater is deep and separated from aquifers by glacial till and loess, creating an effective separation between the surface water and aquifer. Only in the lower reaches of Wahoo Creek between the towns of Weston and Wahoo is there a good potential for interaction between surface and groundwater.

2.4.2 Uplands Region Aquifer type

Most of the Uplands Region can be considered confined, particularly in the discontinuous areas where aquifers are localized sand deposits. The thick till and loess deposits act as confining beds, and in parts of paleovalley areas such as the western portion of the David City Subarea have piezometric surface above the confining bed. This is variable, however, and local conditions can vary between confined and unconfined depending on pumping rates and temporal changes in the water table. The Weston Subarea between Weston and Wahoo is most likely an unconfined aquifer.

3.0 Map Descriptions and Details

3.1 District Regions and Subareas

Figures 1.1 through 1.5 depict the four regions and the subareas within each region as defined by this project in cooperation with the LPNNRD. Subarea delineation methods were discussed in the previous section and data used to develop the subareas are displayed on the subsequent maps. The information presented on the maps includes data published by the CSD on towns, streams, NRD boundary, townships and ranges as referenced at the bottom of the map. As with all subsequent maps, the sources of data and data derivation are provided in this following discussion and on the maps, as appropriate.

3.2 Gravel Thickness

Figures 2.1 through 2.5 illustrate the thickness of gravel across the district. Subareas were delineated in part by the thickness of sand and gravel overlying bedrock. Gravel thickness was determined from well logs provided by the DNR and test hole boring logs provided by the CSD. Logs were reviewed and if penetration depth was adequate, any sand and gravel logged near the bedrock depth was recorded. Gravel thickness was useful in determining the presence of paleovalleys that provide good aquifers. The gravel thickness at each well was then interpolated across the LPNNRD and patterns compared to the surface of the bottom of the principal aquifer provided by the CSD (Figures 5.1-5.5) to break out subareas based on aquifer potential. In the Shell Creek Region north of the Lindsay area the Ogallala Formation was the principal aquifer, so the saturated thickness as defined in the 1995 Groundwater Management Plan (GWMP) was used to define subareas.

3.3 STATSGO Soils Types

Figures 3.1 through 3.5 of soils in the LPNNRD regions were compiled from State Soil Geographic (STATSGO) data sets provided by the Natural Resource Conservation Service. Maps that cover large areas include generalized soil associations from the STATSGO database, and maps that provide a large enough scale display detailed Soil Survey Geographic (SSURGO) soil map units. STATSGO soil associations were created by the U.S. Department of Agriculture, Soil Conservation Service. SSURGO coverages are provided in the project geographic database, but the level of detail is too great to include on this map series.

3.4 Bedrock Geology

Figures 4.1 through 4.5 illustrate the bedrock geology map as generated from CSD's digital coverage of the bedrock formations underlying alluvial deposits in the LPNNRD. Some contacts were slightly modified based on the 1995 GWMP (HWS, 1995).

3.5 Depth to Bedrock

Figure 5.1 through 5.5 illustrate the depth to the base of the principal aquifer. The base of the aquifer, herein referred to as the bedrock surface, is a compilation of the surface contours provided in the 1995 GWMP, and the surface used in the groundwater model of the southern Todd Valley prepared for the U.S. Army Corps of Engineers (URS, 2007). Minor adjustments were made to the map in areas where recent well logs provided bedrock elevations.

3.6 Geologic Cross-Sections

Figure 6.1 through 6.5 illustrate geologic cross-sections constructed from CSD test hole boring logs. Lines were chosen along principal aquifers and across the subareas. The locations of lines are plotted on the maps and displayed on cross-section schematic diagrams. Because of the large distances that the cross-sections cover, the lithostratigraphic units are generalized with hydrostratigraphy emphasized. Sand and gravel are combined, as well as silt and clay. Surface silt and clay are generalized as loess, and till is broken out. The detailed materials that are generalized in the cross-section panels are shown with symbols in each boring.

3.7 Registered Wells

Figures 7.1 through 7.5 depict the distribution of registered wells with discharge rates greater than or equal to 300 gpm. Well locations and registration information provided by DNR for wells registered through 2008. The density of high capacity wells is based on calculating the number of wells with discharge rates greater than or equal to 300 gpm per square mile.

3.8 Pre-Development Water Table (1979)

Figure 8.1 through 8.5 illustrate the pre-development water table was defined by the CSD as the 1979 water table surface. Contours of this surface are provided by the CSD and presented in this series for each region.

3.9 Groundwater Level Change (1987-2006)

Figures 9.1 through 9.5 illustrate the changes in the water table between 1987 and 2006. The change in water table was calculated by subtracting water levels provided by the LPNNRD and interpolating change across the area. In areas without measurements supplemental information was provided by CSD water level change contour maps.

3.10 Groundwater Level Change (2000-2006)

Figures 10.1 through 10.5 depict the changes in the water table between 2000 and 2006. The change in water table was calculated by subtracting water levels provided by the LPNNRD and interpolating change across the area. In areas without measurements supplemental information was provided by CSD water level change contour maps.

3.11 Estimated Depth to Water

Figures 11.1 through 11.5 depict the depth to initial groundwater from the ground surface as calculated using well registration data provided by the DNR. Wells that have a recorded static water level, representing the depth to the static water table at the time of well installation, were used in this calculation. Thus, it is assumed that the water level reflects the uppermost or principal aquifer at each location. The head in lower confined aquifers may differ considerably. Scattered depths were interpolated across the LPNNRD. Since the well registrations span many years and the precision and accuracy of the measurements are not standardized, the depth to water is very approximate. It does, however provide a guide to the depth to water and provide a starting point for detailed site investigations.

3.12 Saturated Thickness

Figures 12.1 through 12.5 illustrate the saturated thickness of the principal aquifer as provided by the CSD and the 1995 GWMP. Contours were a compilation of these two sources.

3.13 Estimated Specific Yield

Figure 13.1 through 13.5 depicts the estimated specific yield provided by the CSD. As with all maps in this report, the map shading is generated from the contour lines. For the specific yield maps, no new data was incorporated into the CSD data set.

3.14 Transmissivity of the Principal Aquifer

Figures 14.1 through 14.5 illustrate the aquifer transmissivity as provided by the CSD. For the transmissivity maps, no new data was incorporated into the CSD data set.

3.15 Estimated Groundwater Elevation, Spring 2006

Figures 15.1 through 15.5 illustrate the water level measurements for the spring of 2006. The water level measurements were provided by the LPNNRD and were contoured to show the approximate water table elevation. Supplemental contours (dashed contour lines) provide more information in areas where more water levels were available. Water table maps produced by the CSD were consulted to aid in configuring the contours at surface water bodies and areas with sparse measurements.

3.16 Surface Water Bodies and Potential Recharge Potential

Figures 16.1 through 16.5 depict the potential recharge areas. STATSGO soil associations and depth to water were used to delineate areas that may provide significant vertical recharge to aquifers. Similarly subsurface materials such as till or thick loess deposit silt and clay were used to identify areas of low recharge.

3.17 Aquifer Types

Figures 17.1 through 17.5 illustrate the CSD aquifer type designations. The CSD provided a data set delineating aquifers as confined, mostly confined, mostly unconfined and unconfined. This is a generalized map set and local conditions vary depending on the depth of a well, pumping rate, transmissivity, specific yield and the elevation of the piezometric surface relative to a confining bed. In many places a confined aquifer may exist at depth where shallow aquifers are unconfined. To see the contrast between regions and subareas, such as the Uplands, David City and Platte River areas, refer to the cross-sections delineated in Figures 6.1 through 6.5.

3.18 Aquifer and Surface Water-Groundwater Connectivity

Figures 18.1 through 18.5 depict the surface water-groundwater connectivity mapped as areas that are likely to be connected, have a potential to be connected under pumping conditions, and areas that are unlikely to have surface-groundwater interactions. These areas were preliminarily delineated in this study using the depth to groundwater, the configuration of water table contours at stream crossings and the local hydrogeology.

3.19 DNR Surface Water Appropriations

Figures 19.1 through 19.5 illustrate the surface water appropriations as provided by the DNR. The surface water irrigation rights point coverage illustrates the appropriation diversion point and the acres that each appropriation is defined to irrigate. Surface water storage use rights are depicted by the quantity of storage rights in acre-feet. Additionally, induced groundwater recharge points and instream flow rights are indicated on the maps.

3.20 Groundwater Geochemistry

Figures 20.1 through 20.5 illustrate bicarbonate, chloride, sulfate, conductivity, and sodium concentrations in groundwater as recorded by the LPNNRD as part of their groundwater monitoring program. Constituents were displayed for the period from 2001 to 2007.

3.21 2005 Land Use

Figures 21.1 through 21.5 illustrate the land-use for 2005 as provided by CALMIT at UNL. Areas depicted on the maps include irrigated and non-irrigated land, natural, urban and pasture land. Additionally, biofuels facilities are identified on the map based on information from the Nebraska Department of Environmental Quality from permitting information reported in 2007.

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