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Nebraska Statewide Groundwater-Level Monitoring Report 2022

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Conservation and Survey Division
School of Natural Resources

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Institute of Agriculture and Natural Resources
University of Nebraska–Lincoln

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University of Nebraska-Lincoln

University of Nebraska–Lincoln

The Conservation and Survey Division of the University of Nebraska–Lincoln is the agency designated by statute to investigate and interpret the geologically related natural resources of the State, to make available to the public the results of these investigations, and to assist in the development and conservation of these resources. It consists of program areas in geology, water, soils, and remote sensing-geographic information systems.

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Nebraska Water Issues of Interest in 2022

R.M. Joeckel, Nebraska State Geologist and Director of the Conservation and Survey Division; Senior Associate Director, School of Natural Resources

Surface water

The 2022 drought made the year the second driest of the 21st century and the 15th-lowest on record for annual rainfall. (Olberding, 2023). More than 99% of the state was experiencing moderate to exceptional drought by the beginning of 2023 (Drought.gov, undated). farmers were estimated to have lost more than $2 billion (Hammel, 2022a), and 55% percent of respondents to a Nebraska Rural Poll expressed concerns about extreme temperatures and worsening drought (Vogt, 2022). Resource managers expressed concerns about the abilities of both surface-water and groundwater irrigation to offset the drought and the need to protect groundwater resources in southwestern Nebraska; furthermore, there were incidents of illegal water removal from the Cambridge and Red Willow canals (Ourada, 2022). Abnormally low rainfall in the drainage basin contributed to the severe reduction and cessation of flows in the Platte River between Grand Island and Columbus (Barton, 2022; Mach, 2022). Local rainfall and releases of water from Lake C. W. McConaughy upstream temporarily renewed flow in August (Ozaki, 2022). Flow persisted through the year on the Platte downstream of the Loup River confluence, however, and overall conditions were said to be better than during the historic drought year of 2012 (Blum, 2022; Gaarder, 2022).

Nebraska's first recorded fatality from primary amebic meningoencephalitis occurred after an individual went swimming in the Elkhorn River in August (Nebraska Department of Health and Human Services, 2022; Riess et al., 2022).

Groundwater, water-supply and environmental issues

The City of Lincoln began its Alternatives Analysis Study in July 2022 as part of the Water 2.0: Securing Lincoln's Second Source initiative. The goal of the study is the selection of a final plan for a long-term second source of municipal water (i.e., groundwater) in January 2023, which is projected to be necessary by 2048 (City of Lincoln, Nebraska, undated).

Concerns were raised in April 2022 regarding new data showing high concentrations of pesticides in groundwater at the closed AltEn ethanol plant near Mead, and the leaching of contaminants from leaking wastewater lagoons was implicated (Hammel, 2022b). The Nebraska Department of Environment and Energy approved emergency repairs of wastewater lagoons onsite and it issued a permit to AltEn for a remedial action plan to reduce stormwater pollutants in runoff to a nearby stream; it also approved a wet cake (an ethanol production byproduct) grading plan onsite (Nebraska Department of Energy and Environment, 2023). An investigation team consisting of researchers from the University of Nebraska, University of Nebraska Medical Center, Creighton University, and local and public health personnel has been assembled to address health risks associated with pesticides from the AltGen plant. The University of Nebraska Medical Center College of Public Health held two town halls about potential human health impacts from the AltEn plant and developed an online survey of perceived health risks (University of Nebraska Medical Center College of Public Health, undated).

Responding to record low static water levels in some groundwater-monitoring wells in its jurisdiction, the Lower Big Blue Natural Resources District announced an immediate 180-day moratorium, on the construction of new wells in the NRD on December 16 (Nebraska's Natural Resources Districts, 2022a). The Central Platte Natural Resources District contracted with Olsson, Inc. (Lincoln) for a revision of its Groundwater Management Plan (Nebraska's Natural Resources Districts, 2022b)

Legislation

LB1015 (Adopt the Perkins County Canal Project Act) was passed by the Nebraska legislature and approved by Governor Ricketts in April, then provisions/portions of the bill were amended into LB1011 by AM1999 (Nebraska Legislature, 2022a). These measures address the potential construction, management, and operation of the Perkins County

Canal from the South Platte River in northeastern Colorado into southwestern Nebraska, as specified in Article VI of the South Platte River Compact of 1923 with the State of Colorado (Nebraska Legislature, 1923). The total cost of the canal project is estimated at approximately $600 million, and AM1999 specifies an appropriation of $53.5 million for FY2022-23. LB1023, a bill pertaining to the proposed construction of a large recreational lake in the Platte River Valley near Ashland, was also passed by the Legislature and approved by Governor Ricketts in April; provisions/portions of this bill were also amended into LB1011 by AM1999 (Nebraska Legislature, 2022b). The cost of the proposed lake is estimated to be as much as $1 billion, but most of the funding is expected to be private (Hammel, 2022c). Concerns about groundwater, surface water, and water supply in the enclosing area have been expressed. Consequently, the Legislature appropriated $1 million in state funds under AM1999 to "study the consequences of any lake in the Lower Platte River Basin to the public water supply of impacted communities" during FY2022-23 (Nebraska Legislature, 2022a).

Federal legislation included the Water Resources Development Act of 2022 (WRDA), passed in December, which addresses scores of U.S. Army Corps of Engineers activities, including Missouri River mitigation in Nebraska (U.S. Senate Committee on Environment and Public Works, 2022). At the end of December, the Environmental Protection Agency announced the final revised definition of "Waters of the United States" (U.S. Environmental Protection Agency, 2022). The Future of Water Act of 2022 was introduced in Congress in March with the goal of prohibiting futures trading of water or water rights (117th Congress, 2022). It was referred to the Subcommittee on Commodity Exchanges, Energy, and Credit. (Nebraska Legislature, undated, 2021b). Governor Ricketts submitted a letter to the EPA in September maintaining the state's authority to manage water despite the Biden administration's redefinition of "Waters of the United States" within the Clean Water Act (Anonymous, 2021).

SELECT RECENT PUBLICATIONS INVOLVING CSD PERSONNEL

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INTRODUCTION

Groundwater-level information is valuable to citizens and stakeholders.
It quantifies the availability of groundwater and informs management decisions.

This report is a synthesis of groundwater-level monitoring programs in Nebraska. It is a continuation of the series of annual reports and maps produced by the Conservation and Survey Division (CSD) of the University of Nebraska in cooperation with the U.S. Geological Survey (USGS) since the 1950s. Groundwater-level monitoring began in Nebraska in 1930 in an effort to survey the state's groundwater resources and to observe changes in its availability on a continuing basis. The CSD and USGS cooperatively developed, maintained, and operated an observation-well network throughout the state. These two agencies were responsible for collecting and archiving this information, and for making it available to the citizens.

Although CSD and USGS still occupy the central role in the statewide groundwater-level monitoring program, other agencies have assumed the responsibilities of building and maintaining observation networks and measuring groundwater-levels. The CSD and USGS continue to operate some of the original observation wells, but today the majority of measurements are made by agencies such as Natural Resources Districts (NRDs) (Fig.1), U.S. Bureau of Reclamation, U.S. Fish and Wildlife Service, and Public Power and Irrigation Districts. Because these agencies are located throughout the state, they are able to implement groundwater-level monitoring programs using local field staff, landowner contacts, taxing and regulatory authority, and first-hand knowledge of local conditions. Collectively, these agencies have developed an extensive network of observation wells throughout the state.

The CSD provides vital technical expertise to these agencies as they develop and implement groundwater-level monitoring plans. The CSD evaluates the adequacy and accuracy of the groundwater-level data and provides the statewide assessment of groundwater-level changes across many of the state's aquifers (Figs. 2–3).

The CSD has long provided technical services to stakeholders by integrating groundwater-level change data with multiple data sets in order to:

1) Determine the amount of groundwater in storage and its availability for use.
2) Assess the water-supply outlook by identifying changes in the volume of groundwater in storage.
3) Identify areas in which changes in groundwater levels may have an economic impact.
4) Assist state and local agencies in the formulation and administration of resource-management programs.
5) Determine or estimate the rate and direction of groundwater movement, specific yield of aquifers, base flow of streams, sources and amounts of groundwater recharge, and locations and amounts of groundwater discharge.
6) Assess the validity of hydrogeologic interpretations and the assumptions used in developing models of groundwater systems.

The need for this essential information only escalates as water-use pressures steadily increase. The CSD strives to meet this challenge by focusing on fundamental data, building collaborative relationships with the agencies that depend on the information, and providing scientifically accurate information in a timely manner.

Purpose and Methods

The vast majority of groundwater used in Nebraska is pumped from the High Plains aquifer (HPA), although there are multiple aquifers in the state (Fig. 2, 3). The HPA underlies parts of eight states, including South Dakota, Wyoming, Nebraska, Colorado, Kansas, Oklahoma, Texas, and New Mexico. In total, Nebraska overlies approximately 64,600 mi^2 of the HPA, or 36%

Figure 1. Nebraska Natural Resources Districts

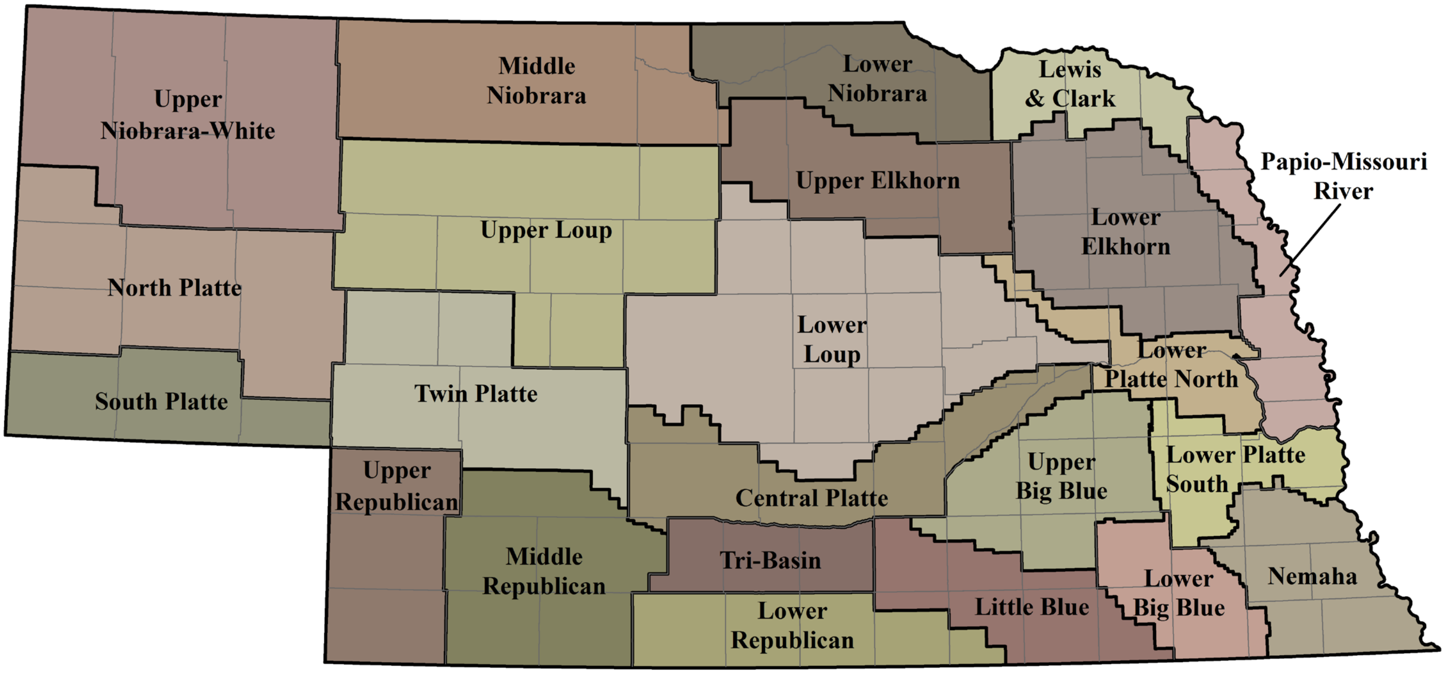
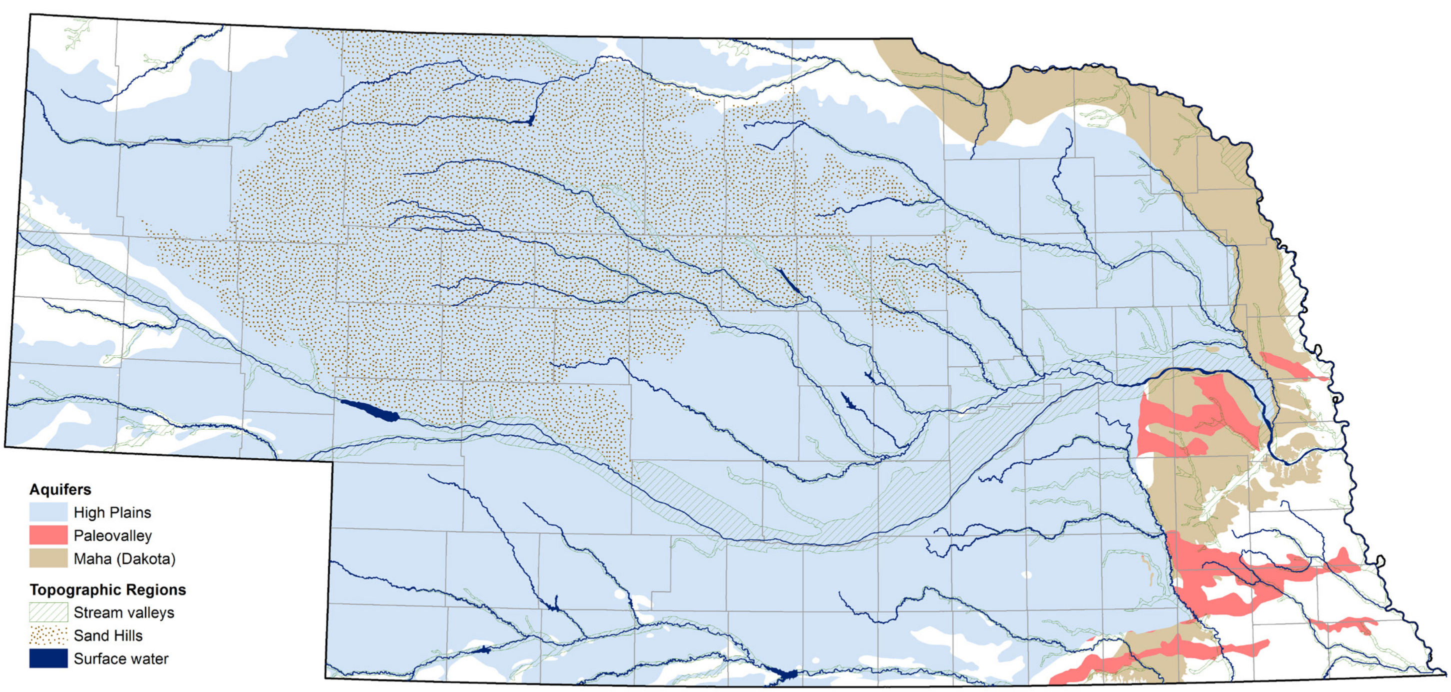


Figure 2. Important Aquifers and Topographic Regions of Nebraska



Note: The aquifer units shown here may contain little or no saturated thickness in some areas.

Figure 3. Generalized Geologic and Hydrostratigraphic Framework of Nebraska

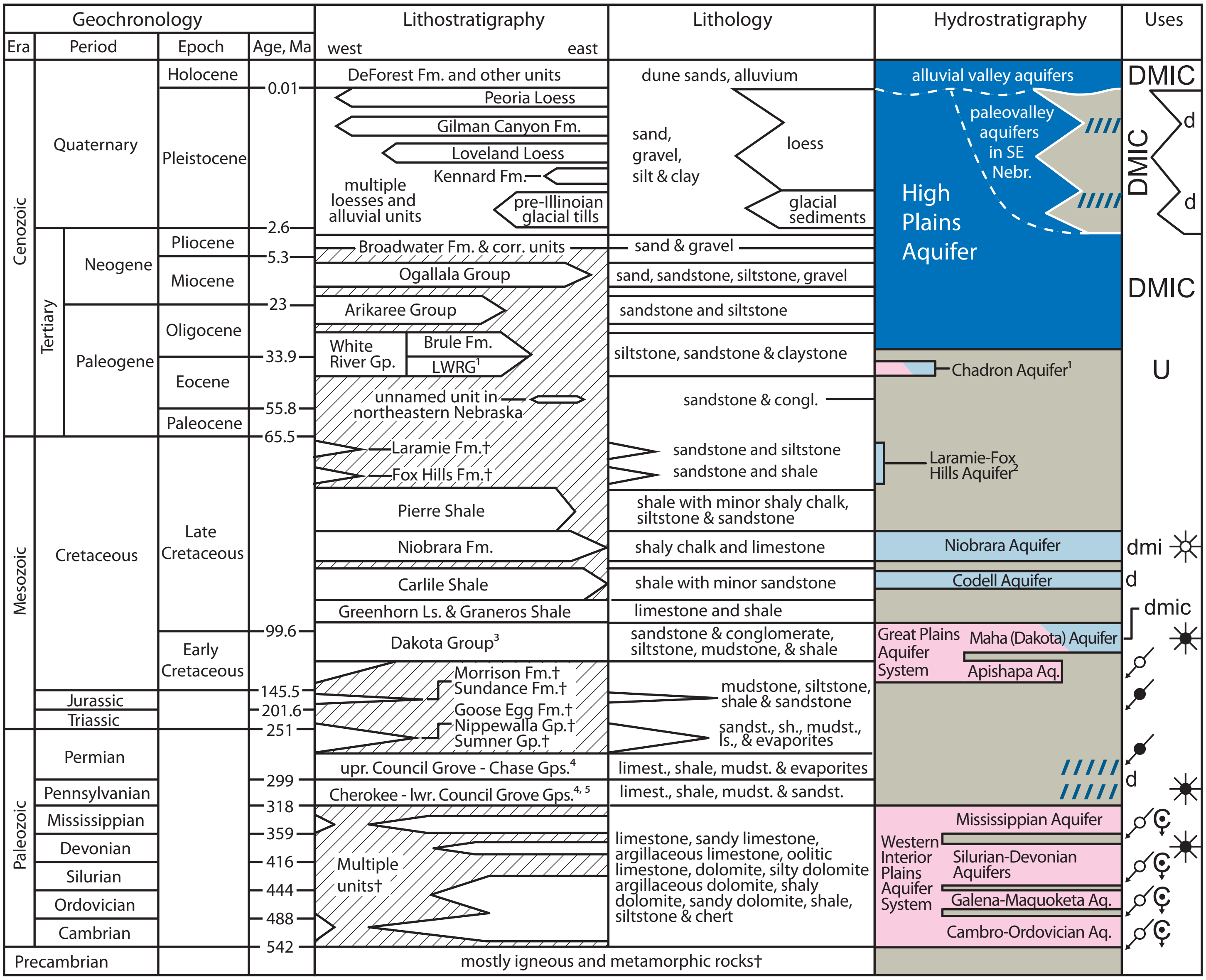


Diagram is not to scale relative to geologic time and stratigraphic thicknesses.

Hydrostratigraphic characteristics and water quality

- primary aquifers with good quality water
- secondary aquifers with good quality water
- secondary aquifers with generally poor quality water
- //// aquitards with local low-yield aquifers
- aquitards

[1] lower White River Group - includes Chamberlain Pass and Chadron Formations according to some authors; "Chadron Aquifer" historically refers to aquifer in lower White River Group

[2] important aquifer in Colorado, but present in Nebraska only in extreme southwestern Panhandle

[3] Dakota Formation in adjacent states

[4] includes correlative units with different names in northwest Nebraska

[5] Cherokee, Marmaton & Pleasanton Groups are not exposed in Nebraska

†present only in subsurface

Groundwater uses and related aspects

- D major domestic use
- d minor domestic use
- I major irrigation use
- i minor irrigation use
- M major municipal use
- m minor municipal use
- C major commercial/industrial use
- c minor commercial/industrial use
- units used for wastewater injection
- units with potential use for wastewater injection
- U unit mined for uranium by in-situ leaching (Dawes Co.)
- unit with potential use for carbon sequestration
- unit producing petroleum or natural gas
- unit with natural gas potential

From Korus and Joeckel, 2011

of the total aquifer by area. By volume as of 2009, Nebraska has approximately 2.040 billion acre-feet of saturated sediments, or 69% of the total volume of the HPA (McGuire et. al., 2012). The greatest area of saturated thickness in the HPA, nearly 1,000 feet, is located under the western portion of the Nebraska Sand Hills (c.f. Korus et. al. 2013, pp. 44).

Although Nebraska is fortunate to have such vast supplies of groundwater, any groundwater supply is vulnerable to depletion through overpumping. According to the 2017 U.S. Census of Agriculture, Nebraska leads the nation in irrigated acres with more than 8.6 million acres. Without proper oversight, irrigation pumping on this scale can rapidly deplete aquifers and lead to large-scale economic hardship. The present report illustrates the changes in groundwater levels in Nebraska at different time scales, resulting from both natural and anthropogenic influenced changes. This information is important to both state and local lawmakers in assessing the current state of Nebraska's groundwater resources, and to local producers in making land management decisions.

This report summarizes changes in Nebraska's groundwater levels over periods of one and ten years prior to 2022, as well as from predevelopment times (generally pre-1960) to 2022. These changes are depicted in maps that delineate regional trends on a statewide basis. **We stress that the maps presented in this report provide overviews of the general locations, magnitudes, and extents of rises and declines. Local conditions, which may vary considerably, are not depicted in the maps in this report and, indeed, they cannot be represented with accuracy at the scale of the maps.** The reader is referred to Figures 1 through 4 for the boundaries of NRDs and the locations of rivers, aquifers, and counties mentioned in the text.

The one- and ten-year changes are presented in the spring 2021 to spring 2022 and spring 2012 to spring 2022 maps, respectively. Groundwater levels measured from thousands of wells throughout the state during the spring of 2022 (Fig. 5) were compared to levels measured in the same wells in the spring of the preceding target year. For the one- and ten-year change maps, contours were generated using computer interpolation. These contours were incorporated into the final maps in areas where the principal aquifer is geographically continuous and in relatively good hydraulic connection, and where data density is comparatively high. In areas not meeting these criteria, the computer-generated contours were manually edited at various scales in order to conform to hydrogeologic boundaries that prevent the flow of groundwater. Such boundaries include: (1) areas where relatively impermeable bedrock units outcrop or exist in the shallow subsurface, such as southeastern Nebraska and in areas of Scotts Bluff County, (2) valley boundaries in eastern Nebraska where alluvial aquifers are a major source of groundwater but upland areas between them lack a primary aquifer, and (3) areas where the HPA is dissected by deeply entrenched parts of the Niobrara, Republican, and Platte River valleys.

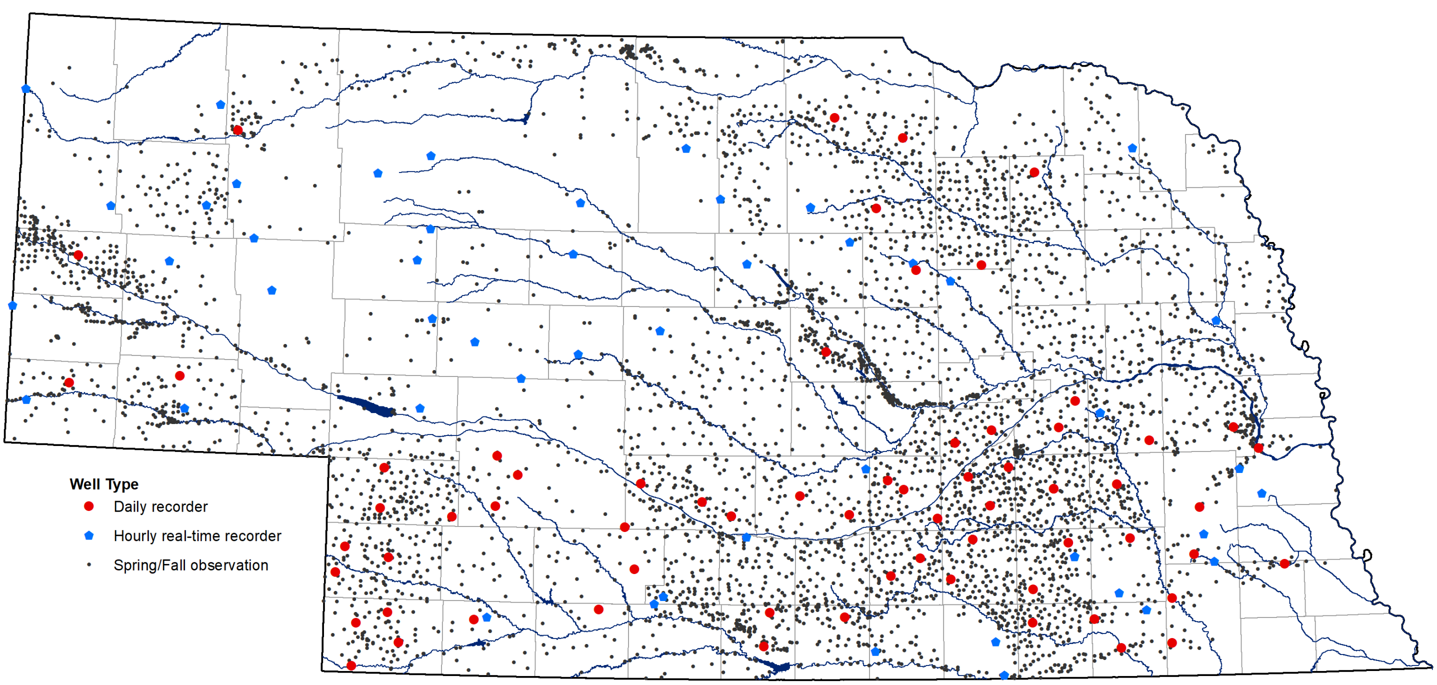
For the predevelopment to spring 2022 map, groundwater levels from wells measured in 2022 were compared to estimated predevelopment groundwater levels in the same wells. An estimated predevelopment groundwater level is the approximate average groundwater level at a well site prior to any development that significantly affects groundwater levels. Predevelopment groundwater levels are generally presumed to be those that predated intensive groundwater irrigation. Such intensive use of groundwater began during the approximate period 1930 to 1960, although not synchronously across the state. Predevelopment map contours were drawn manually with the aid of previously existing maps for similar time periods and with knowledge of major hydrogeologic boundaries.

Areas of sparse data are shown with a hatched pattern on all maps (e.g., Fig. 7). A point-density interpolation was used to determine the number of observation points within a 6-mile (approximately 10-kilometer) search radius. Areas of sparse data were defined as areas with zero observation points within the search radius.

Precipitation maps were prepared by comparing total precipitation over the time period of interest to the 30-year normal provided by the National Climate Data Center (www.ncdc.noaa.gov). The 30-year normal currently in use is calculated on the basis of average annual precipitation during 1981-2010. A precipitation surface is generated using the inverse distance weighted interpolation method in ArcGIS with a 1,640 ft (500 m) cell size. The resulting surface is classified with a defined interval of ten percent and contoured. The resulting contours are smoothed and then converted to polygons.

Figure 4. Counties, Major Cities, and Streams of Nebraska

Figure 5. Location of Observation Wells by Type



Sources: U.S. Geological Survey, Nebraska Water Science Center; U.S. Bureau of Reclamation, Kansas-Nebraska Area Office; Nebraska Natural Resources Districts; Central Nebraska Public Power and Irrigation District; Conservation and Survey Division, School of Natural Resources, University of Nebraska-Lincoln

Factors Causing Groundwater-Level Changes

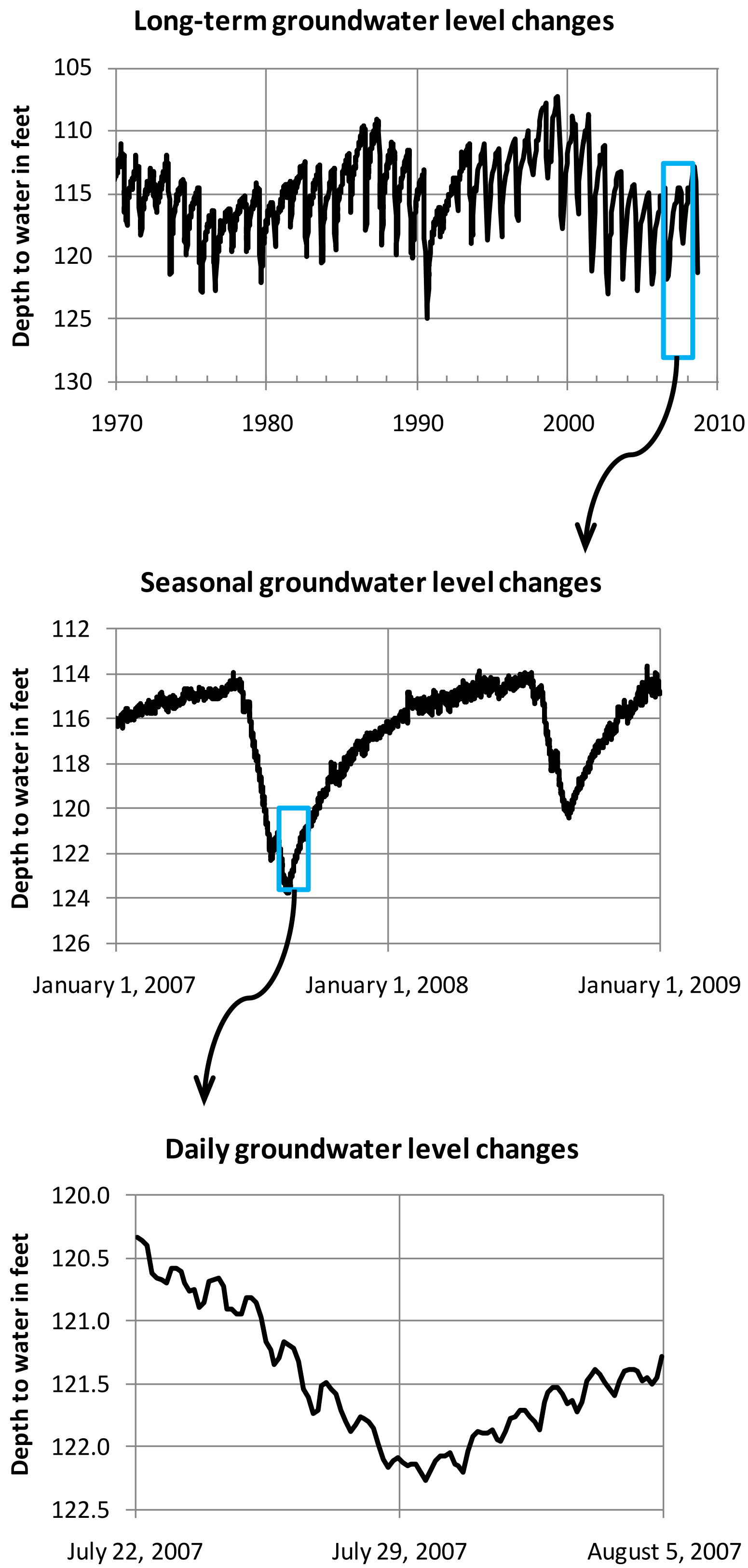
Long-term groundwater-level changes result from the changing balance between recharge to, discharge from, and storage in an aquifer. If recharge and discharge are in balance, such as they were before widespread irrigation development, groundwater levels are generally steady because the amount of water stored in the aquifer does not change. Minor changes in groundwater levels may occur due to natural variations in precipitation and streamflow, but generally the system is in equilibrium. If, however, the rate of recharge exceeds the rate of discharge over a long period, the amount of water stored in the aquifer increases and groundwater levels rise. Conversely, if the rate of discharge exceeds the rate of recharge for a long period, the amount of water in storage is depleted and groundwater levels decline. The magnitudes, locations, and rates of groundwater-level changes are controlled by many factors, including: the aquifer's storage properties, permeability, and saturated thickness; the locations, rates, and pumping schedules of wells; the locations and rates of artificial recharge areas; and the degree of hydraulic connection between the aquifer and surface water bodies.

It is a common misconception that the rate of recharge from precipitation can be used as a "safe yield" or "sustainable limit" on the rate of groundwater extraction from an aquifer (Bredehoeft, 1997). This concept is a gross oversimplification of hydrogeologic processes. The aquifer properties and all sources of recharge and discharge must be taken into consideration. Recharge is provided primarily by precipitation, but also by irrigation return flow and seepage from canals, reservoirs, and streams. Discharge occurs as baseflow to streams and lakes, evapotranspiration, and groundwater pumping. Groundwater levels, therefore, respond to a variety of natural and anthropogenic factors affecting recharge and discharge and are controlled largely by the physical properties of the aquifer. Limiting groundwater extraction to a rate equal to or less than the rate of recharge from precipitation will not prevent depletion of the aquifer. In fact, groundwater "mining" is prone to occur to one degree or another in any heavily pumped aquifer. A holistic, adaptive approach to groundwater management based on hydrologic mass balance is more appropriate. These strategies are discussed by several authors (e.g., Sophocleous, 1997, 1998, 2000; Alley and Leake, 2004; Maimone, 2004; Korus and Burbach, 2009a).

Groundwater-level changes can be observed at many different temporal scales (Fig. 6). Changes may occur over several minutes or hours in response to pumping, floods, or earthquakes. Long-term changes may occur due to the cumulative effects of pumping over many irrigation seasons, prolonged droughts or periods of high rainfall, or seepage from man-made water bodies. Similarly, groundwater levels can be observed at multiple spatial scales. For example, groundwater levels decline around the immediate vicinity of an individual well during pumping, but also from the cumulative effects of many irrigation wells pumped over many irrigation seasons at the scale of an entire regional aquifer. Groundwater levels rise along the banks of a stream during a flood, but they may also rise significantly over an entire drainage basin during a prolonged wet period. The temporal and spatial scales of observation must be taken into account when using the maps presented in this report.

The maps presented in this report were generally created at a scale of 1:557,000 or 1:500,000. **They are intended solely to identify regional conditions and trends at varying time scales throughout the entire state of Nebraska, and not at the local scale**. As such, these changes chiefly reflect the interplay between precipitation, groundwater pumping, and artificial recharge from reservoirs and canals.

Figure 6. Example of Groundwater-Level Changes at Different Temporal Scales



Data from Plymouth Recorder well, Jefferson County

CHANGES IN GROUNDWATER LEVELS, SPRING 2021 TO SPRING 2022

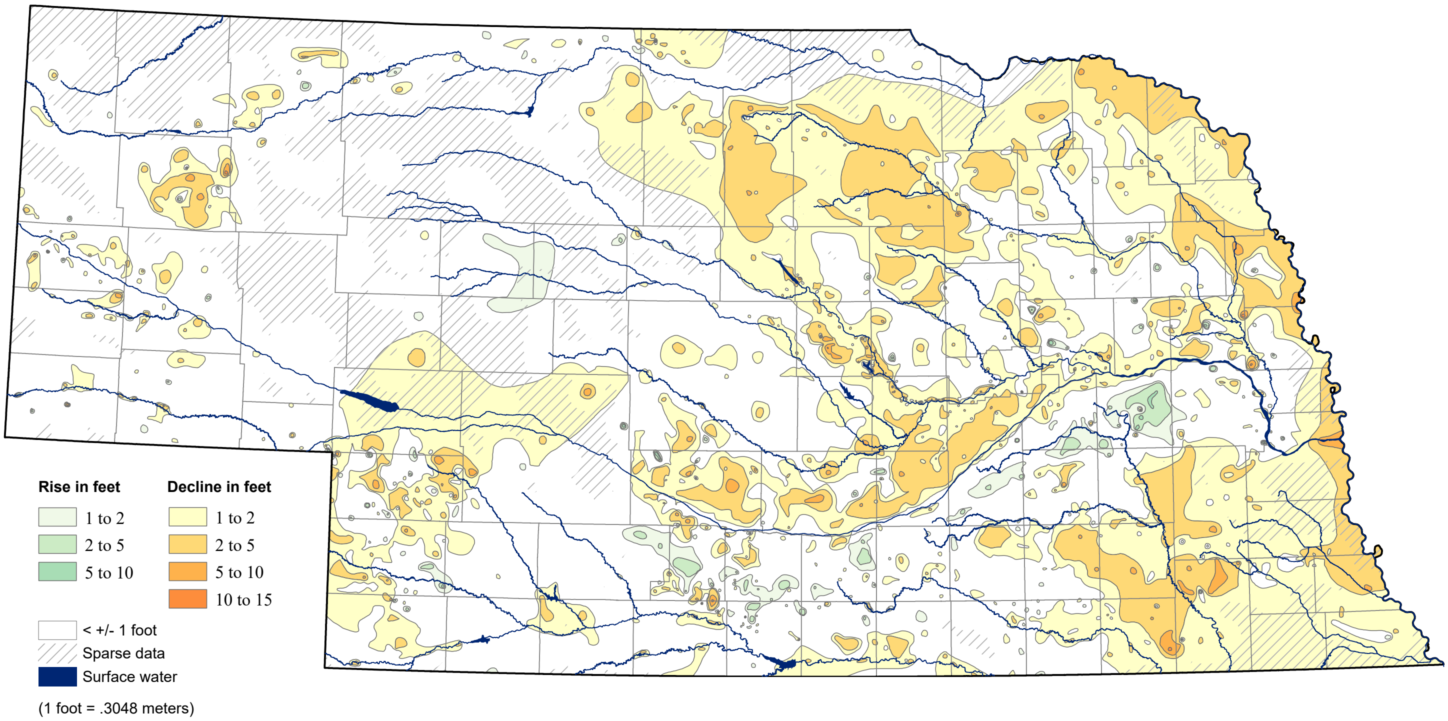
From the spring of 2021 to the spring of 2022, groundwater levels in Nebraska recorded an average decline of 1.05 feet following a drier than average year.

Groundwater levels in Nebraska generally declined from the spring of 2021 to the spring of 2022. In total, 4,787 wells were measured consecutively in the spring of 2021 and spring 2022. Groundwater-level declines were recorded in 78% of measured wells, and 45% of all measured wells experienced a decline of greater than one foot (Fig. 7). Groundwater-level rises were recorded in 21% of measured wells, and only 7% of all measured wells recorded a rise greater than one foot. The average groundwater-level change for all measured wells in Nebraska in the spring of 2022 was a decline of 1.05 feet. From January 2021 to January 2022, precipitation values for Nebraska were below the 30-year normal at 122 of 179 reporting stations in Nebraska (Fig. 8). Precipitation values ranged from 49% of the 30-year normal in Banner County to 137% in Keith County. Precipitation amounts were spatially variable, though the driest areas were in the Panhandle, and the areas with the highest precipitation totals were in the southcentral part of the State.

After consecutive years of generally below average precipitation, from the spring of 2021 to the spring of 2022 groundwater levels have declined throughout most of Nebraska. The greatest declines were measured in the eastern half of the State, with declines in most areas ranging from 1-5 feet, and declines locally from 5-15 feet. Similar declines were measured in central Box Butte County in the panhandle. In the western half of Nebraska, declines tend to be more local in scale.

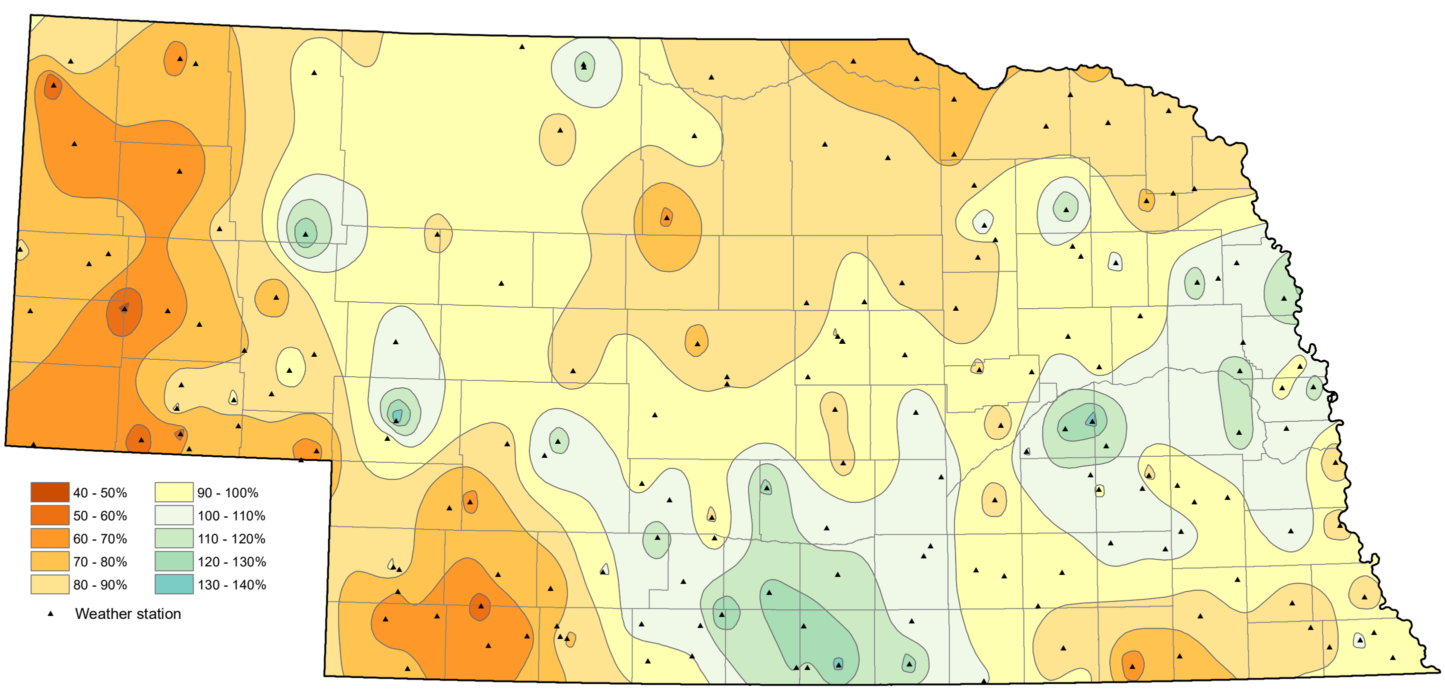
From the spring of 2021 to the spring of 2022 few areas in Nebraska recorded groundwater-level rises. Most notably, rises of up to 10 feet were recorded in Butler County where precipitation totals were likely above the 30-year average. More localized increases were recorded on the south side of the Platte River, and in the central Sandhills. Other field-scale rises of 1-2 feet were recorded throughout the state, and generally correspond to crop rotations, changing irrigation patterns or localized precipitation events.

Figure 7. Groundwater-Level Changes in Nebraska - Spring 2021 to Spring 2022



Sources: U.S. Geological Survey, Nebraska Water Science Center; U.S. Bureau of Reclamation, Kansas-Nebraska Area Office; Nebraska Natural Resources Districts; Central Nebraska Public Power and Irrigation District; Conservation and Survey Division, School of Natural Resources, University of Nebraska–Lincoln

Figure 8. Percent of Normal Precipitation - January 2021 to January 2022



Sources: National Climate Data Center, Asheville, North Carolina; High Plains Regional Climate Center, University of Nebraska-Lincoln

CHANGES IN GROUNDWATER LEVELS, SPRING 2012 TO SPRING 2022

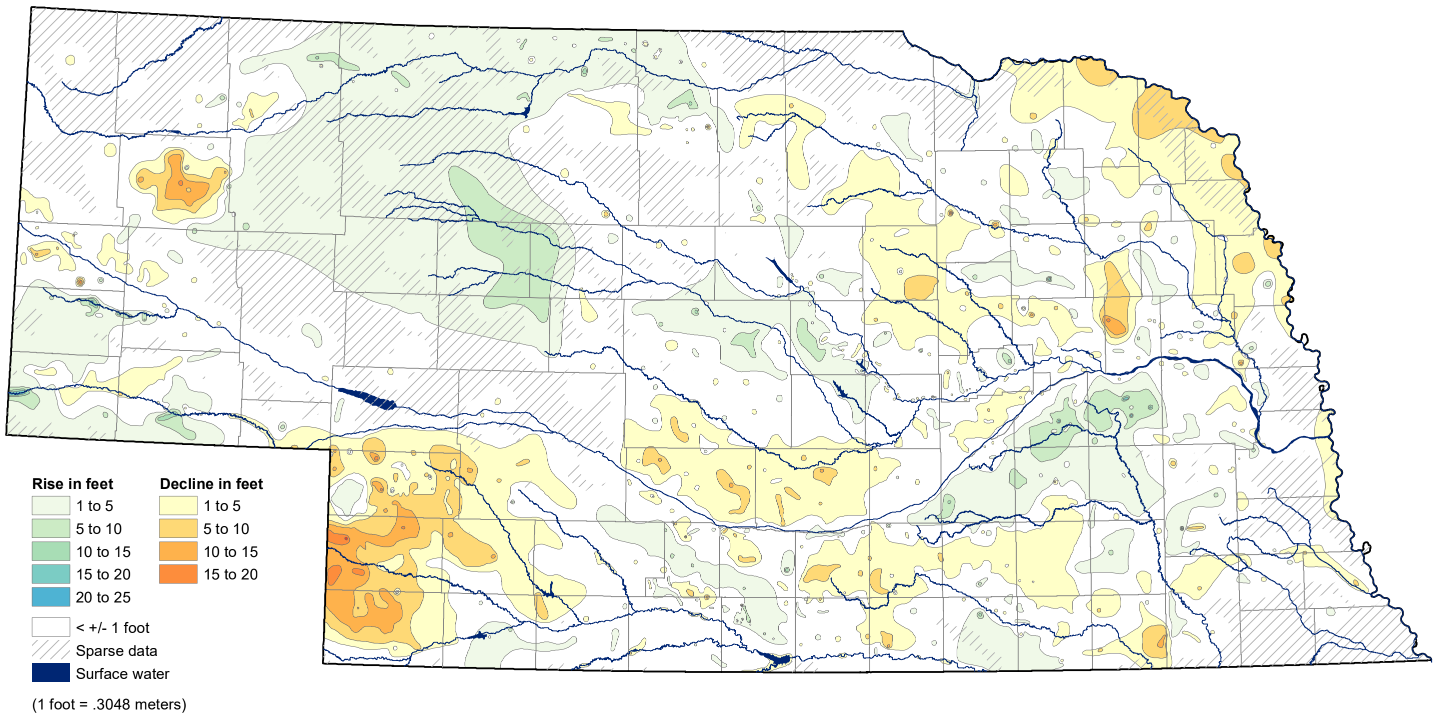
Following major shifts in weather conditions and record setting drought, modest groundwater-level declines were recorded throughout Nebraska over the last 10 years.

Of 3,988 wells measured in both the spring of 2012 and the spring of 2022, 42% of wells recorded groundwater-level rises, with 27% of wells rising more than one foot (Fig. 19). Groundwater-level declines were recorded in 58% of wells measured in Nebraska from the spring of 2012 to spring 2022, and 38% of measured wells experienced declines of greater than one foot. Groundwater levels in wells have declined by an average of 0.55 foot statewide over the last 10 years.

Weather conditions from the spring of 2012 to the spring of 2022 ranged from record-setting drought to periods of much above-average precipitation. From the spring of 2012 through the spring of 2013, Nebraska experienced the driest single year on record, resulting in groundwater-level declines that eliminated many of the groundwater-level rises associated with the high-rainfall years between 2007 and early 2012. Precipitation values over most of Nebraska were near the long-term average in late 2013 and 2014. Between 2014 and 2019, precipitation levels generally remained near or slightly above the 30-year average. Precipitation values in early 2019 were well above the 30-year average for much of central and northern Nebraska, with some stations recording nearly double average annual precipitation amounts. Recently, beginning in early 2020, weather stations in Nebraska have generally recorded below average precipitation. Despite the major year-to-year fluctuations in precipitation extremes, precipitation values have generally remained near the 30-year average for Nebraska over the last 10 years (Fig. 10).

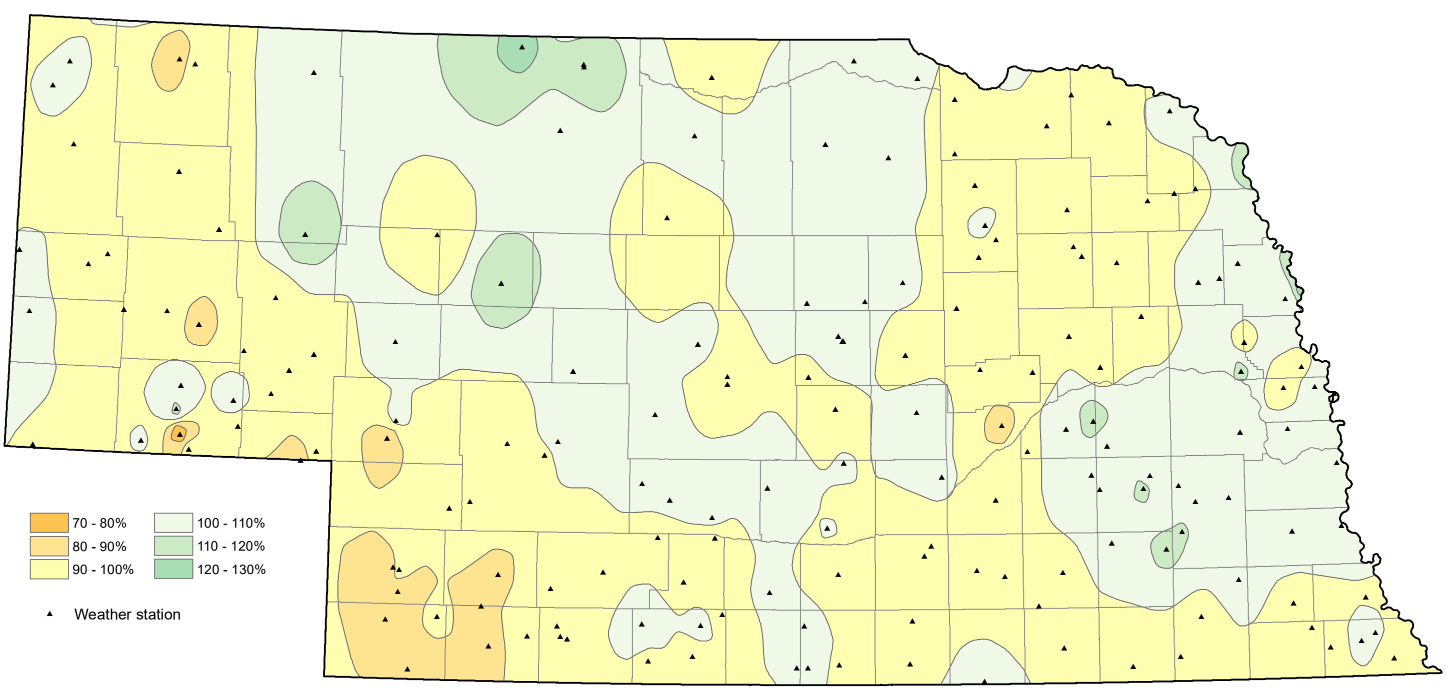
From the spring of 2012 to the spring of 2022, groundwater levels have fluctuated regionally, despite near-average precipitation statewide. The regional patterns of groundwater-level changes may have resulted from: (1) extreme regional variability in year-to-year precipitation and associated irrigation pumping rates, (2) delayed reaction time of aquifers to climate trends, (3) and increased runoff during brief, high-intensity rainfall events. Although some long-term trends can be observed at this scale, such as steadily increasing levels in the central Sand Hills, steadily rising levels in Butler, Polk and York counties, and steadily decreasing levels in known problem areas, groundwater levels have fluctuated from year to year due to extreme variations in yearly rainfall, recharge, and evapotranspiration over the past 10 years. Groundwater-level changes mapped in Figure 12, therefore, may exhibit the effects of short-term extremes rather than long-term trends.

Figure 9. Groundwater-Level Changes in Nebraska - Spring 2012 to Spring 2022



Sources: U.S. Geological Survey, Nebraska Water Science Center; U.S. Bureau of Reclamation, Kansas-Nebraska Area Office; Nebraska Natural Resources Districts; Central Nebraska Public Power and Irrigation District; Conservation and Survey Division, School of Natural Resources, University of Nebraska–Lincoln

Figure 10. Percent of Normal Precipitation - January 2012 to January 2022



Sources: National Climate Data Center, Asheville, North Carolina; High Plains Regional Climate Center, University of Nebraska-Lincoln

CHANGES IN GROUNDWATER LEVELS, PREDEVELOPMENT TO SPRING 2022

Long-term groundwater-level changes in Nebraska primarily reflect aquifer depletion in areas of dense irrigation development and increases in storage due to seepage from canals and reservoirs.

Spring 2022 groundwater levels indicate both long-term declines and long-term rises from predevelopment in certain areas of Nebraska (Fig. 11). Almost all the areas of significant groundwater-level declines correspond to high irrigation-well densities in aquifers that are deep and have little direct connection to surface water (Fig. 12). The greatest decline from predevelopment to 2022 is approximately 128 feet, in Box Butte County just north of the city of Alliance. Notable groundwater-level declines from predevelopment to spring 2022 have occurred in Box Butte County, the southwestern part of the state near Chase, Perkins, and Dundy counties, and in the Panhandle. A large area of smaller declines in southeast to south-central Nebraska reflects slight depletion of the High Plains aquifer. The largest groundwater-level rises occurred in Gosper, Phelps, and Kearney counties, where there are extensive canals and surface-water-irrigation systems.

The predevelopment groundwater levels used in Chase, Perkins, and Dundy counties are representative of the approximate average groundwater levels prior to 1953. A general trend of declining groundwater levels that began around 1966 correlates temporally with the intensive use of groundwater for irrigation. The approximate average groundwater levels prior to 1938 were utilized as predevelopment values for the groundwater-level change map in Box Butte County. Intensive groundwater development for irrigation since 1950 has caused groundwater levels to decline by 5 feet to more than 125 feet from predevelopment levels (Fig. 11). Records from wells in both the southwestern counties and in Box Butte County indicate that rates of decline have been essentially steady, despite subsequent changes in groundwater management practices, water use allocations, and fluctuations in the amount of annual precipitation (Korus and Burbach, 2009b).

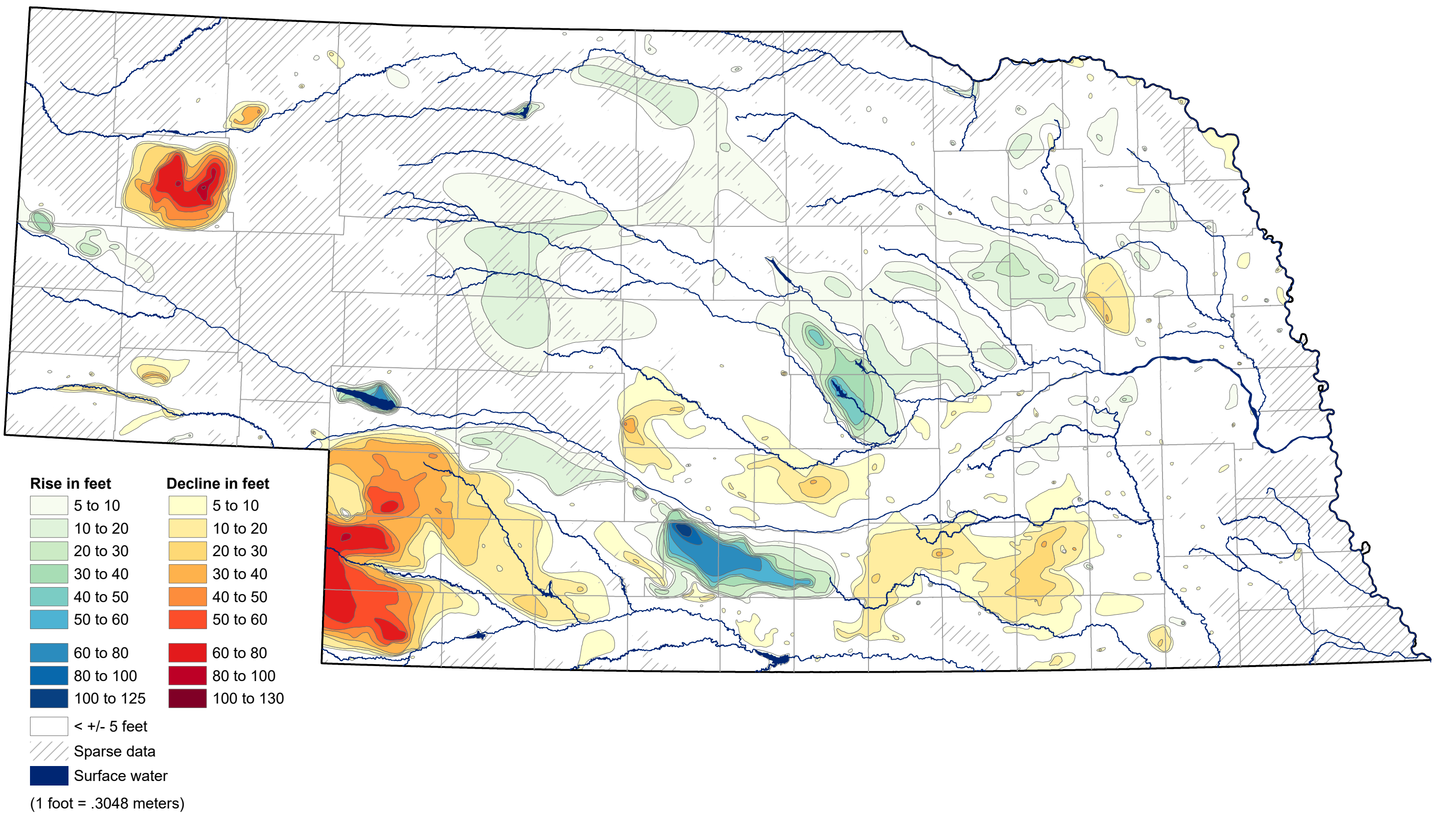
Much of southeastern to south-central Nebraska has experienced long-term groundwater-level declines since predevelopment times (Fig. 11). Predevelopment water levels in this area are generally representative of the approximate average water levels prior to 1950. Groundwater levels in large parts of this region have declined more than 10 feet, and in some areas by more than 30 feet, since predevelopment.

Groundwater-level declines also occurred in large areas between the Platte and Loup or South Loup rivers and in the Republican River Valley and the Panhandle. Irrigation-well densities are high in some, but not all, of the aforementioned areas. Aquifer characteristics, rates of recharge, and irrigation scheduling may have contributed to these declines as well.

Groundwater-level rises from predevelopment generally occurred in areas of surface-water irrigation systems. Storage of water in Lake C. W. McConaughy began in 1941, and seepage losses caused groundwater-level rises of as much as 60 feet in nearby observation wells (Ellis and Dreeszen, 1987). Groundwater levels around the lake generally stabilized by about 1950 and since then have fluctuated in response to changes in reservoir levels and precipitation (Johnson and Pederson, 1984). Water released from storage in Lake C. W. McConaughy is subsequently diverted from the Platte River near Sutherland west of North Platte, and then flows through the Tri-County Canal and a series of reservoirs toward Dawson, Gosper, Phelps, and Kearney counties, where it has been used for irrigation since 1941. The deep percolation of water from these irrigation-distribution systems and from excess water applied to crops has gradually increased groundwater levels by more than 100 feet (Fig. 11). Groundwater levels have also risen in response to seepage from Sutherland Reservoir, Lake Maloney, and their associated canals in eastern Keith and central Lincoln counties. Similarly, there are groundwater-level rises of as much as 60 feet associated with irrigation canals in southern Sioux, Scotts Bluff, and western Morrill counties.

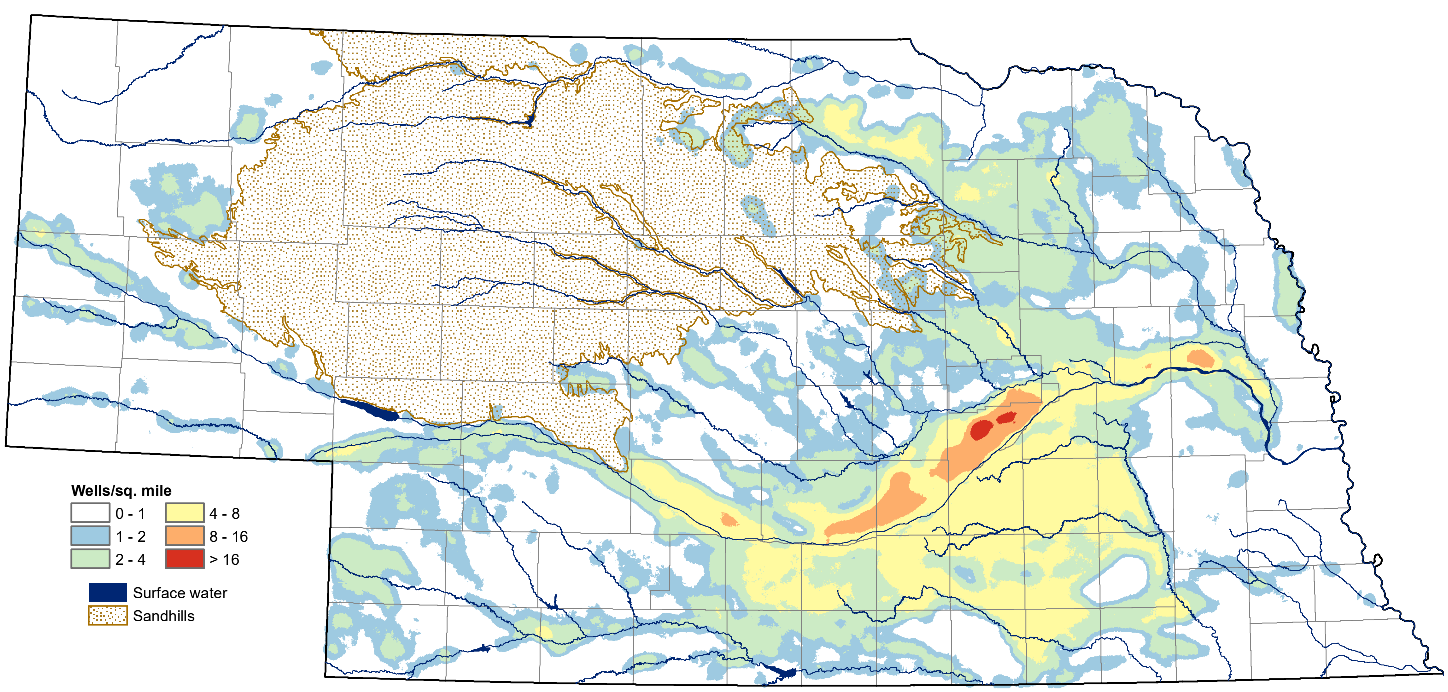
Groundwater-level rises of 10 to more than 50 feet occurred in portions of central Nebraska (Fig. 11). The highest groundwater-level rises occurred in Valley, Sherman, and Howard counties in response to sustained seepage from irrigation canals, Sherman and Davis Creek reservoirs, and the deep percolation of irrigation water applied to crops.

Figure 11. Groundwater-Level Changes in Nebraska - Predevelopment to Spring 2022



Sources: U.S. Geological Survey, Nebraska Water Science Center; U.S. Bureau of Reclamation, Kansas-Nebraska Area Office; Nebraska Natural Resources Districts; Central Nebraska Public Power and Irrigation District

Figure 12. Density of Active Registered Irrigation Wells - December 2022



Source: Nebraska Department of Natural Resources

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