

Understanding and Assessing Climate Change: Preparing for Nebraska's Future

2024 Climate Change Impact Assessment Report Chapter 5 - Water Systems



Chapter 5

Water Systems

Aaron Young,¹ Crystal Powers,² Camilla Correll, Alexander Furneaux, Kanak Kanti Kar, and Tirthanker Roy

¹Groundwater content lead and corresponding author: ayoung3@unl.edu

²Surface water content lead and corresponding author: cpowers2@unl.edu

Key messages

1. Changes in precipitation impacting water availability intersect multiple issues, including energy, health, agriculture, and more.
2. Nebraska's residents and agriculture sector rely heavily on the state's groundwater resources for irrigation and drinking water.
3. If appropriately managed, groundwater will continue to be Nebraska's best resource for resiliency against future climate change.
4. Climate change will have complex impacts on Nebraska's water, likely affecting both groundwater and surface water quantity and quality. These impacts will ripple throughout Nebraska's economy, communities, and environment.
5. With climate change, irrigation water demand will likely increase as the growing season becomes longer and the rate of evapotranspiration increases.
6. At the state level, the trends in groundwater-level changes tend to follow the trends in precipitation.
7. Drought impacts on Nebraska's groundwater and surface water may be more severe as the climate warms.

Introduction

Nebraska's water system is delicately balanced between too much and too little. Throughout the state's history, flooding and drought have been recurring events that have prompted human intervention to manage access to water. As more extreme wet and dry periods are expected due to climate change, it is essential to implement efforts that mitigate impacts and adapt to these changes to ensure the sustainability of Nebraska's communities.

Management of water resources affects the state's rivers, streams, lakes, reservoirs, wetlands, and groundwater resources, which collectively support environmental, social, and economic functions. Across Nebraska, communities use water resources for various purposes, providing a wide range of benefits throughout the ecosystem. These ecosystem services include access to drinking water, irrigation of agricultural lands, recreation, and energy production. Water is essential for life and has both direct and indirect impacts that connect with the key topics discussed in this report.

As climate change alters the water balance for Nebraska and the states with which it shares water, we will need to look to adaptation strategies to increase the absorptive capacity and retain water on the landscape to improve water use efficiency in a state. These efforts can help support the resilience of over 9 million acres of irrigated land, accounting for 91% of the consumptive water use of the state and contributing \$1.5 billion in annual crop value (UNL Water, 2024). Adaptation strategies to a change in water availability will also protect Nebraska's wealth of recreational opportunities, including boating, hunting, fishing, swimming, outdoor education, and more. These recreational amenities are valued at \$4 billion annually, employing more than 24,000 people (NGP, 2022). Individual events such as the annual sandhill crane migration yield over \$17.2 million alone, while resources such as Lake McConaughy attract over 2 million visitors annually (UNL Water, 2024). Adaptation strategies must also focus on the increasing number of major flood events and the associated economic and recovery costs (NeDNR, 2022).

This chapter briefly overviews surface water and

groundwater resources projected to be impacted by climate change and outlines their current and future impacts. It identifies areas for further research and action to make these resources more resilient and adaptable to climate change's impacts.

Nebraska's water management framework

Managing water in the state has evolved over the past 200 years, shifting away from independent management toward collaborative water planning and implementation practices that recognize water as a shared asset. Today surface and groundwater management responsibilities are shared by the Nebraska Department of Natural Resources (NeDNR), 23 local Natural Resource Districts (NRD), Nebraska Department of Agriculture (NeDA), Nebraska Game and Parks Commission (NGPC), Nebraska Department of Environment and Energy (NDEE), and Nebraska's water users (Figure 5.1). While the NeDNR, NRDs, and NDEE play the most prominent roles in this management arrangement, NeDA and NGPC also occupy important niches. Coordination and collaboration between these agencies and land managers are vital to managing the state's water resources.

Surface water quantity rights are based on "first-in-time" rule, where the oldest water rights receive water first, administered by NeDNR (UNL, n.d.). The public owns groundwater in Nebraska, and landowners are granted correlative rights, meaning access to beneficial use and "share and share alike" in groundwater-level changes, managed by the public through NRDs. However, surface water and groundwater are also physically and legally connected, so NeDNR also identifies when existing water uses may have insufficient water supplies now or in the future. These basins are called fully or over-appropriated, and surface and groundwater use limitations have been implemented through an integrated planning process involving NeDNR, NRDs, and the public (NeDNR, n.d.).

Furthermore, NeDNR plays a key role as the agency responsible for administering interstate agreements on water use. Nebraska is a member of six interstate water compacts, agreements, or court decrees with its upstream and downstream neighbors: Wyoming, Colorado, and Kansas. These compacts allocate water among states to determine appropriations for water taking and are already becoming legal battlegrounds, straining relationships between neighboring states.

Water quality management is also collaborative across local, state, and federal scales. The U.S. EPA sets maximum contaminant levels for drinking water administered through NDEE for public water supplies. Private wells are not regulated; therefore, monitoring and treatment are the well owner's responsibility. Potential point sources of pollution, such as industrial and livestock facilities, are regulated by NDEE. Each NRD establishes policies based on local conditions to address non-point sources impacting water quality, such as field agrichemical applications or erosion.

Surface water

Rivers and streams

Nebraska's rivers drain west to east toward the Missouri River. They provide an essential source of water (Figure 5.2) in areas where groundwater resources are limited or difficult to obtain. The state has 13 major river basins delineated (Figure 5.3) from north to south.

- » **White River and Hat Creek:** Located in northwest Nebraska before flowing to South Dakota.
- » **Niobrara River:** Located in northwest/northern Nebraska, the Niobrara River includes two U.S. Bureau of Reclamation (USBR) dam and reservoir projects irrigating 45,500 acres. The river has 76 miles of national scenic river designation.
- » **Missouri River tributaries:** Located on Nebraska's northeastern edge, these tributaries drain directly into the Missouri River.

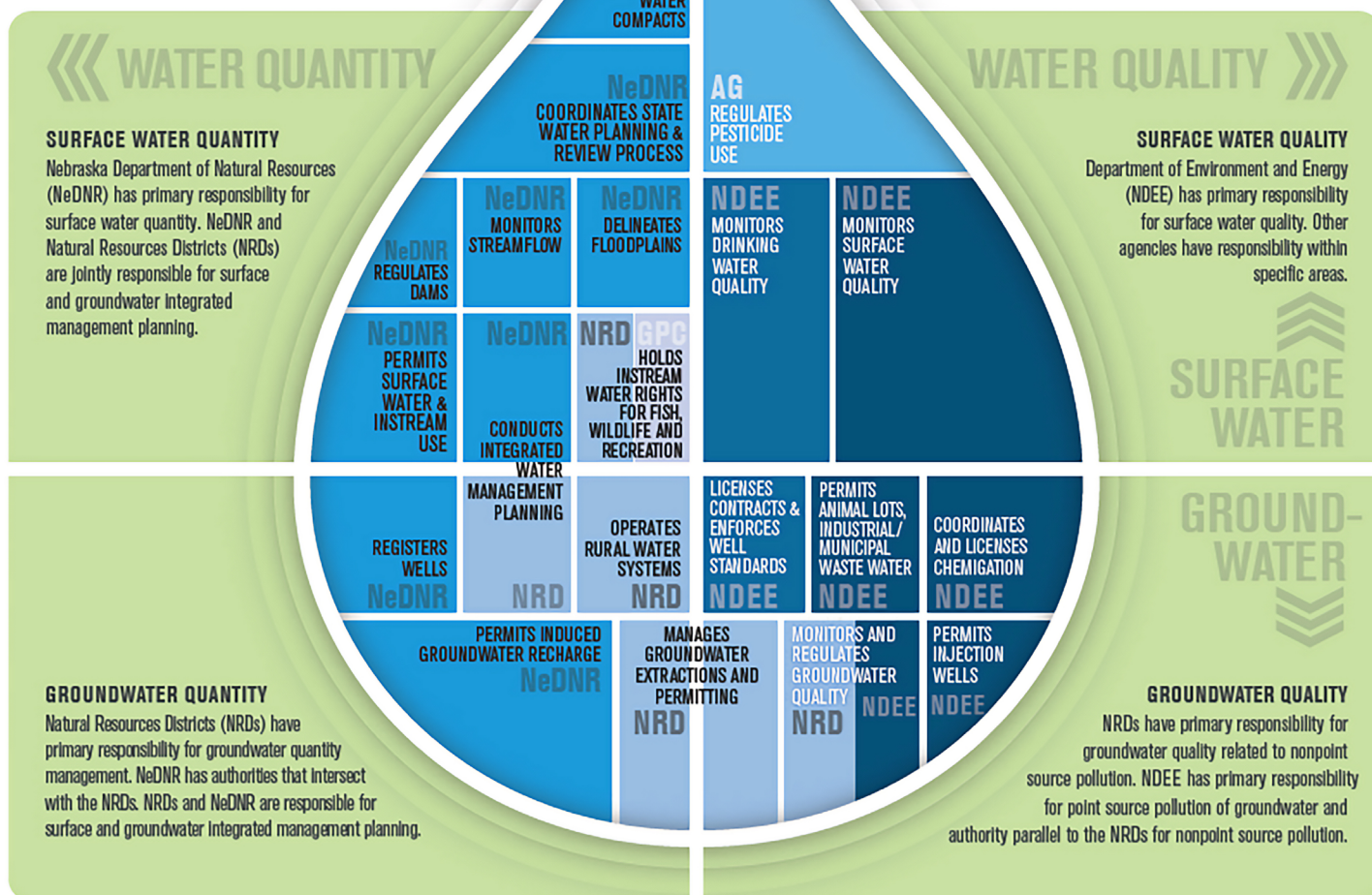


Figure 5.1. Nebraska's water management framework. (Source: NeDNR, n.d.)

» **Elkhorn River:** Located in northeast Nebraska, the Elkhorn River flows into the Platte River.

» **Loup River:** Located in central Nebraska, the Loup River is an important site for many recreational activities. The river also includes several reservoirs constructed by the USBR for flood management and irrigation purposes.

» **Platte River (North, South, Middle, and Lower):** The Platte River begins in the mountains of Colorado and Wyoming and is the largest drainage system crossing the entire state. The river valley is an important passageway across the state, historically the path of multiple transcontinental trails such as the Oregon Trail, Mormon Trail, and Pony Express. It is also the corridor of major bird migration in the spring and fall through the North American Central Flyway.

» **Blue River (Big and Little) and Nemaha River:** Located in southeast Nebraska.

» **Republican River:** Located from southwest to south central Nebraska, the Republican River is extensively managed through dams and reservoirs for flood management and irrigation (HDR, 2006).

Nebraska's rivers and streams have a long history of use for navigation by First Nations, including the Lakota, Ponca, Pawnee, and Plains Comanche, who regularly returned to rivers such as the Niobrara for seasonal hunting and settlements (NPS, 2023). The Lewis and Clark expedition traveled the state's rivers, and immigrants journeyed westward. Nebraska's rivers and streams provided power and water for early agriculture and commercial growth. Today, usage has expanded to include barging and recreational canoeing, kayaking, and tubing opportunities. The Missouri River is the primary navigable river route in the state, though other rivers provide localized navigation needs. Along the Missouri River, multiple projects by the U.S. Army Corps of Engineers (USACE) have altered its course to stabilize its banks, create a clear navigable channel, and manage its flow. These

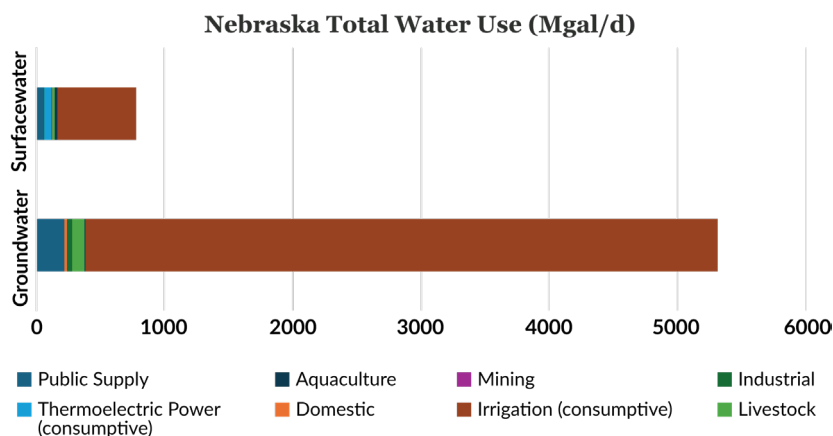


Figure 5.2. Nebraska's total consumptive water use in 2015. (Source: USGS, 2015)

projects have dramatically altered the river's landscape, removing river edge habitat and disturbing natural channel processes such as channel migration and sediment uptake, transport, and deposition (USACE, 2018). Recent efforts to re-naturalize river edges throughout the state's river system aim to reintroduce habitat and provide localized flood mitigation. However, much work remains to restore these riverine ecosystems to benefit from these services.

Climate change threatens Nebraska's rivers and streams, most notably due to changing flow conditions and water quantity. Like the rest of the U.S., Nebraska

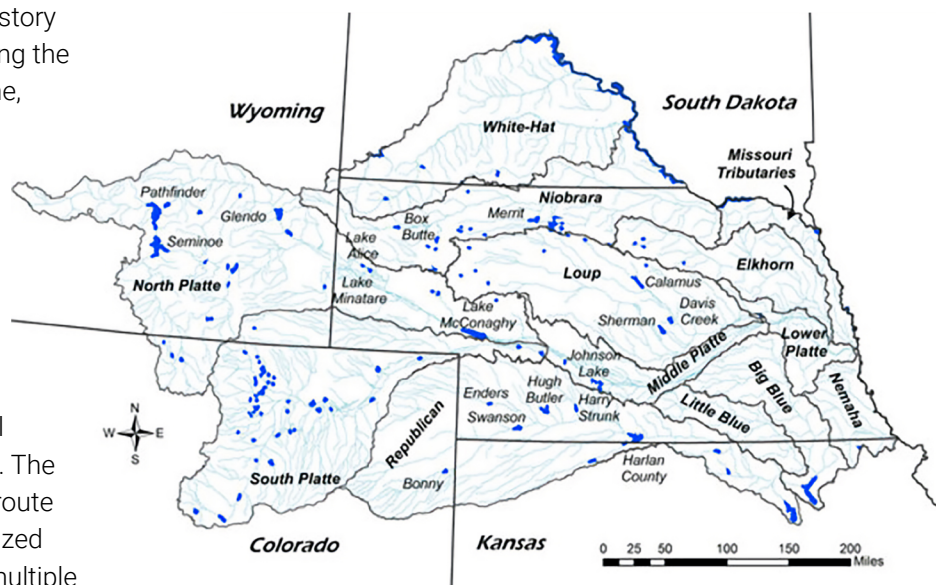


Figure 5.3. Distribution of Nebraska's watersheds and location of principle irrigation reservoirs. (<https://cropwatch.unl.edu/nebraska-reservoir-response-recent-rains>)

is expected to experience a greater number of very heavy precipitation events and longer dry spells, contributing to large fluctuations in river and stream flow (see Chapter 4). Research indicates that certain river basins, such as the Platte River, present a risk of more frequent floods in the near future (USACE, n.d.). Drought and flood conditions threaten Nebraska's navigable waterways by making river travel unsafe or unsuitable based on flow conditions. Particularly in drought conditions, natural flows on the Missouri are supplemented by water released from the mainstream reservoir system (USACE, 2018). The changing flow will have far-reaching and disruptive impacts on access to water, water quality, and recreation activities—all carrying economic implications.

Due to declining water quality, Nebraska's rivers and streams face well-documented threats. Stream and river flow changes directly impact water quality due to the concentration of nutrients in water during droughts and increased erosion during floods. Over the past decade, water quality monitoring has provided an evolving picture of nutrient concentrations in the state's rivers and streams. Figure 5.4a shows that nitrogen trends are increasing in most river basins. Phosphorus trends are stable or improving in most river basins, as seen in Figure 5.4b. Nutrient loading in rivers and streams, combined with increasing temperatures, also threatens the biological integrity of these resources, diminishing the number of plant and animal species that these streams can sustain. In addition to field nutrient runoff, an increase in major precipitation events will contribute to agricultural leaching into surface and groundwater resources.

These rivers and streams also expose infrastructure and agriculture to potential damage from flooding (Figure 5.5). Wetter winters and springs, combined with warmer winters and more extreme precipitation

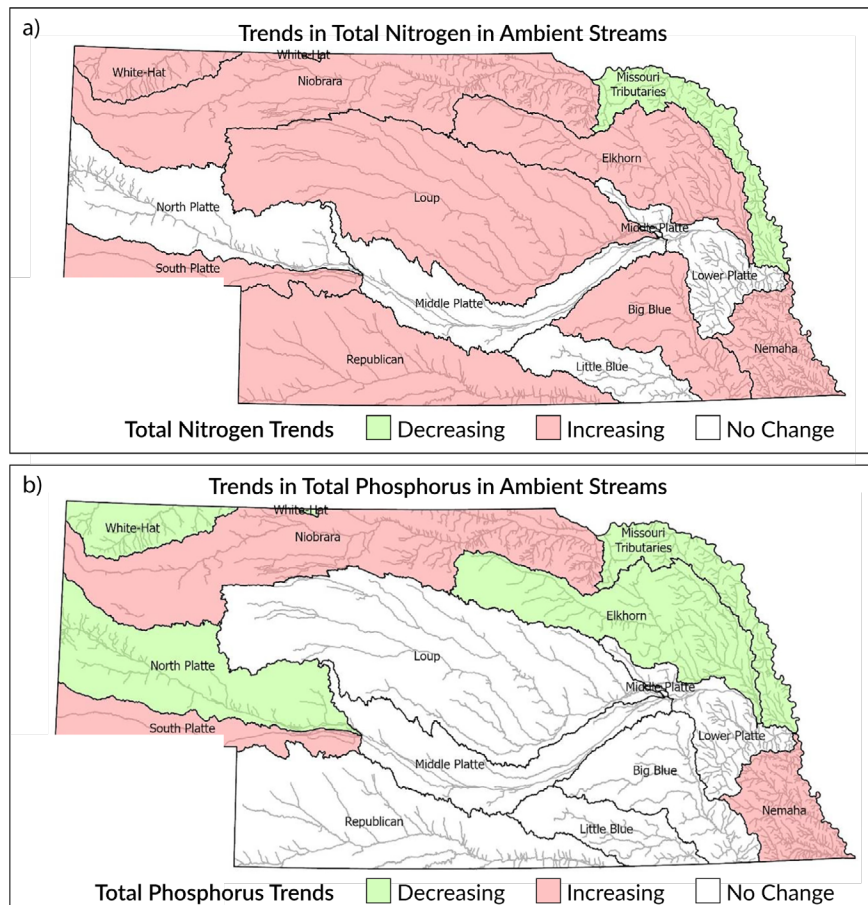


Figure 5.4. Ambient streams' (a) total nitrogen trends and (b) total phosphorus by river basin, 2002–2021. (Source: NDEE, 2023a)

events due to climate change, lay the groundwork for more damaging floods. For example, the spring 2019 floods caused over \$3 billion in property and infrastructure damage (Nguyen-Wheatley, 2020). Over the past four decades, Nebraska has experienced an increase in the number of billion-dollar flood events and the associated costs of recovery (NeDNR, 2022). Additional risks compound given the age and hazard potential of many of the state's dams and levees. Of the over 2,900 dams, 85% are estimated to have been constructed before 1960, with 12% considered high or significant hazard potential (NeDNR, 2022).

Lakes and reservoirs

Nebraska has over 2,000 natural lakes and over 1,000 reservoirs and sandpit lakes, which provide important water sources for irrigation, flood mitigation, recreation, and power generation (NeDNR, 2022). Notably, the

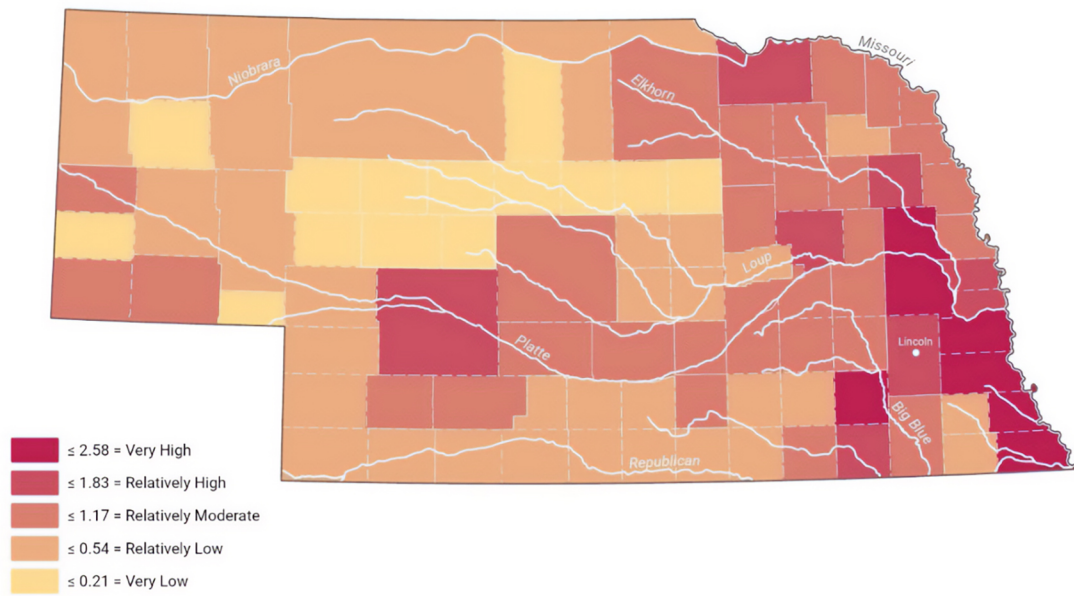


Figure 5.5. Annualized frequency of riverine flooding by county. (Source: NeDNR, 2022)

USBR manages 21 dams throughout the state in the Niobrara River basin, the Loup River basin, the Platte River basin, and the Republican River basin, creating reservoirs used primarily for irrigation and recreation.

Like rivers and streams, nutrient loading and warming temperatures due to climate change expose these resources to water quality risks. For example, eutrophication is the excessive richness of nutrients in a lake or other body of water, frequently due to runoff from the land. This causes a dense growth of algae and plant life and the death of animal life from lack of oxygen. Public lakes surveyed displayed elevated levels of eutrophication, with 43 of 45 lakes assessed meeting the Trophic State Index threshold for either hypereutrophic or eutrophic conditions (NDEE, 2023a). Between 2010 and 2019, 187 No Swim warnings were issued in 22 lakes and reservoirs due to harmful algae blooms (HABs) (Powers et al., 2020). Other contaminants, such as mercury entering water resources through runoff, have prompted fish consumption advisories in 130 lakes and seven stream segments as of 2021 (NDEE, 2023a). Eutrophic conditions, HABs, and pollutant loading all impact the recreational function of these resources by lowering habitat quality that supports wildlife and fish for hunting, fishing, and observation and swimming and boating opportunities. Fewer opportunities to access

these recreational opportunities hurt the state's recreation economic sector, extending beyond outfitters, campgrounds, and guides to indirect recreation supports provided by communities close to recreation areas such as hotels, restaurants, and other attractions.

Wetlands

Wetlands are important water resources that provide many ecosystem services impacting the environment, social and recreational opportunities, and the economic viability of the state's agricultural resources. Their impact on water movement plays a key role in groundwater recharge, filtration of pollutants, and flood storage. The unique hydrology of wetlands and their supported ecosystems provide habitat for many migratory and non-migratory species. In Nebraska, the state's more than 5,000 wetlands (NeDNR, 2022) account for 990 plant species, 13 amphibian species, 18 reptile species, 176 bird species, and 29 mammal species that use these water resources at some point in their life cycle (LaGrange, 2022).

Among its neighboring states, Nebraska has the largest acreage of wetlands despite a 35% loss in wetland acreage in the past 200 years (LaGrange, 2022). The state contains multiple wetland complexes grouped into four categories: playa, riverine, saline/

alkaline, and sandhills. However, wetlands in Nebraska continue to face substantial threats contributing to their degradation or disappearance. Human activity, including urban and rural development expansion, threatens wetlands—though the impacts are more acute to smaller and riverine wetlands (LaGrange, 2022). Eastern saline wetlands are particularly imperiled by these development patterns, prompting the need for conservation and restoration efforts to protect these unique ecosystems in eastern Nebraska. More broadly, throughout the state, invasive species such as reed canary grass (*Phalaris arundinacea*) and European common reed (*Phragmites australis*) threaten to outcompete native vegetation, lowering the capacity of wetlands to provide native habitat and filtration functions.

Climate change is expected to impact wetlands due to changes in temperature and the timing and amount of precipitation. These changes will likely alter wetland conditions and processes (i.e., functions and values), including the types of habitats they provide and their ability to manage water quality and flooding. Wetlands also play a key role in greenhouse gas cycling. While they can be a source of some greenhouse gases when disturbed, they are also an important sink for greenhouse gases by storing carbon and preventing it from entering the atmosphere. The effects of climate change on wetlands include the loss of carbon stored in the soil, changes in soil structure, and more frequent drying or flooding, which can result in a change in wetland types and changes in plant or animal communities. For example, playa wetlands are renewed annually through precipitation and dry up as the season progresses. As the supply of water trends toward extreme oversupply and undersupply, this can stress this hydrologically sensitive resource. Drought periods necessitate the pumping of water into wetlands for wildlife, recreation, and groundwater recharge by local, state, and federal agencies and their partners (NGP, 2024).

Groundwater

Nebraska's groundwater resources are vast compared to other states overlying the High Plains Aquifer (HPA), sometimes known locally as the Ogallala Aquifer. The HPA underlies parts of eight states, including South Dakota, Nebraska, Kansas, Oklahoma, Texas, Wyoming, Colorado, and New Mexico. Nebraska's portion of the HPA, which covers all but the easternmost part of the state, encompasses approximately 64,600 mi² or about 36% of the total area of the HPA. However, by volume, Nebraska contains approximately 2.040 billion acre-feet of saturated sediments, or around 69% of the total HPA volume (McGuire et al., 2012). In parts of Grant, Cherry, and Hooker Counties, the thickness of the HPA exceeds 1,000 feet, the greatest saturated thickness in all the HPA (Korus et al., 2013).

Nebraska's groundwater resources are crucial to our way of life, providing residents with access to private drinking water supplies, municipal water systems, and water for industrial and agricultural uses. Approximately 88% of Nebraskans rely on groundwater as a source of domestic water (Woita, 2023). Even though more than 1.7 million people rely on groundwater as a source of drinking water in our state, groundwater withdrawals for domestic and municipal water system use are only a fraction of our total water withdrawals. As of 2015, it is estimated by the U.S. Geological Survey that irrigation accounts for nearly 91% of water use in Nebraska (Figure 5.2).

Since the state's inception in the 1850s, agriculture has been the main driving force of the economy. However, precipitation rates vary widely across the state, ranging from as little as 11 inches in the Panhandle to more than 32 inches in eastern Nebraska (Chapter 3). While most precipitation falls during the summer, total annual precipitation can vary significantly from year to year. By providing supplemental crop irrigation, farmers can provide consistent moisture to fields in parts of the state where natural precipitation may not provide optimal yields. Early irrigation projects beginning in the first decade of the 20th century provided irrigation to farms near surface water sources through early canal systems. With rapid advancements in drilling technology following World War II, groundwater-fed irrigation systems began to expand rapidly (Figure 5.6).

Active Irrigation Wells in Nebraska

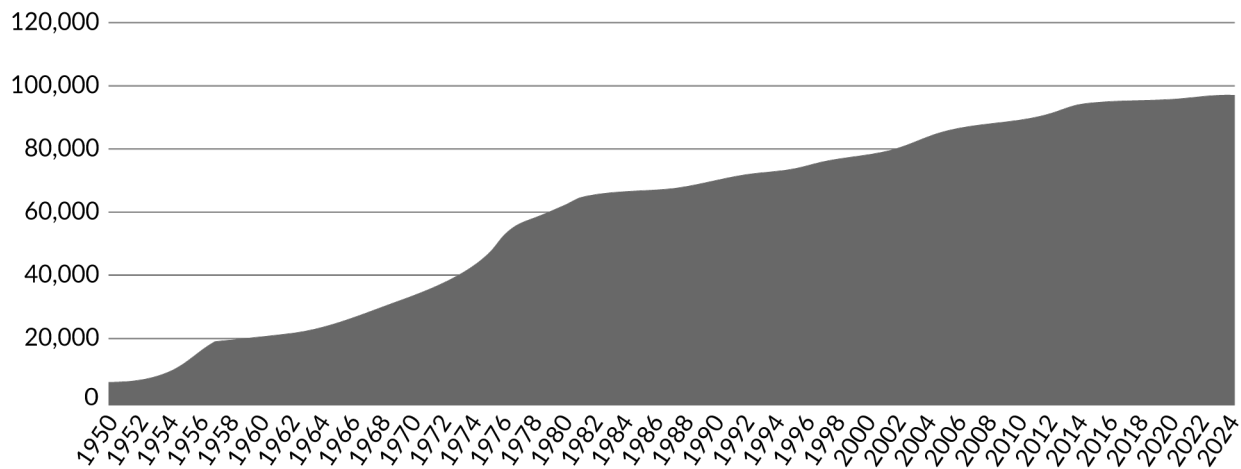


Figure 5.6. The number of active irrigation wells registered in Nebraska by year, beginning in 1950. (Source: NeDNR, 2024)

By the early 1950s, about 7,500 irrigation wells were in use statewide. In the following decades, the number of irrigation wells registered in Nebraska rapidly expanded to nearly 90,000 by 2010, reaching about 97,000 by early 2024. Over the last decade, the installation of high-capacity wells in Nebraska has greatly slowed down due to local regulations and restrictions on the installation of new high-capacity wells in highly pumped regions. Nebraska had 9.4 million acres of irrigated cropland in 2022 (NDRPRA, 2022). Of the 9.4 million irrigated acres, more than 9.1 million acres are irrigated using groundwater (NARD, 2023). As of 2022, Nebraska has the most acres of irrigated cropland in the U.S., surpassing California's 8.2 million irrigated acres reported by the 2022 Census of Agriculture (USDA, 2022). These statistics represent all acres of farmland in Nebraska that are equipped to be irrigated during a given year. However, due to crop rotations, use allocations, and local precipitation patterns, not all land capable of being irrigated each year is irrigated.

Although Nebraska's groundwater resources are vast, withdrawing water from our aquifers at rapid rates does not occur without consequence. Fluctuations in the distance from land surface to groundwater, also known as the depth to groundwater, result from the changing balance between recharge and discharge from water stored in our aquifers. Rapid and extensive groundwater withdrawals do not leave enough time for replenishment through recharge. Before widespread irrigation development, recharge to and discharge from Nebraska's aquifers were generally in equilibrium.

Water levels changed minimally, primarily reflecting long-term changes in precipitation trends. However, as groundwater withdrawals increase, this balance becomes much more complicated. Although many variables contribute to changes in depth to groundwater levels at a local level, at a statewide scale, trends in changing groundwater levels tend to follow patterns of statewide precipitation changes (Figure 5.7).

In exceptionally wet years, more water is available for aquifer recharge, and less supplemental irrigation water is pumped, resulting in a modest groundwater-level rise. Conversely, less water is available for recharge in extremely dry years, and more water is pumped, resulting in a net decline in water levels. During years of drought, groundwater-level declines tend to be more substantial than recoveries in extremely wet years. For example, although it is difficult to compare the magnitudes of extreme drought events to extreme flooding events from a climate perspective, following the extreme flooding of 2019, statewide average depth to water in wells experienced an average rise of 1.60 feet (Figure 5.7). Following the extreme drought of 2012, the average depth to water in wells declined by 2.54 feet. Both climate events were extremes for Nebraska, but the decline from the extreme drought was nearly one foot greater than the increase from the 2019 extreme flooding. Groundwater-level changes resulting from drought events tend to have roughly double the impact on groundwater levels compared to years of much-above-average precipitation. This ratio appears to increase as more water is pumped from our aquifers.

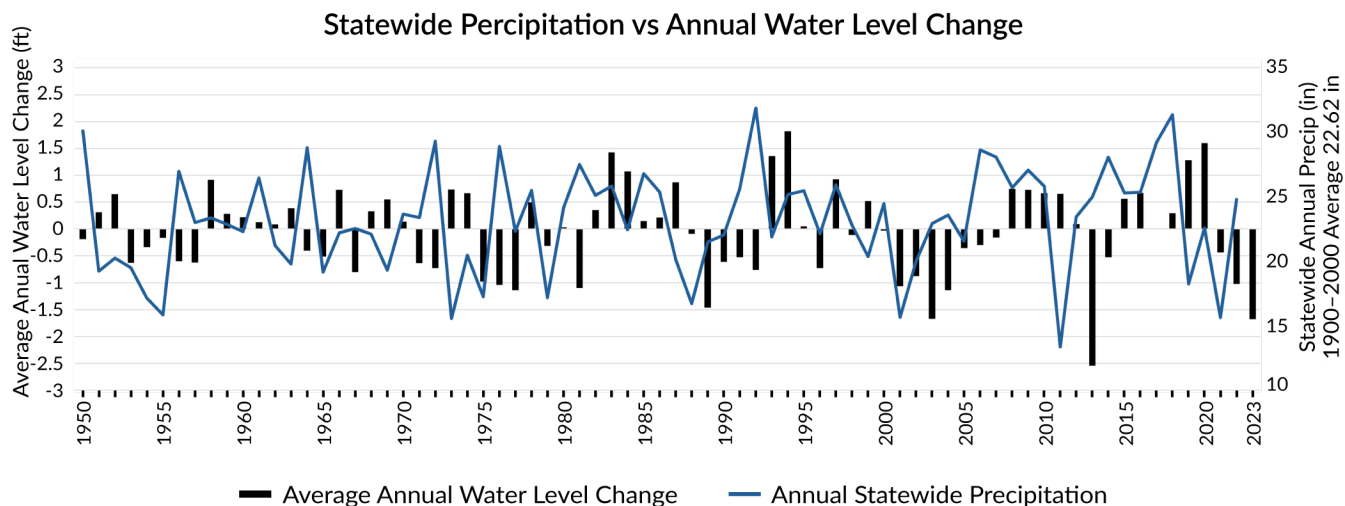


Figure 5.7. Black bars represent the average annual change in depth to groundwater measured in wells in Nebraska in feet. The blue line represents the departure from the statewide average annual precipitation, with the long-term statewide average precipitation of 22.62 inches on the X-axis.

Annually, groundwater levels are measured in the spring from thousands of wells statewide. The results of these measurements are illustrated in the annual *Nebraska Statewide Groundwater-Level Monitoring Report* available from the Conservation and Survey Division at the University of Nebraska–Lincoln. Statewide trends in Nebraska’s aquifers are evaluated by comparing the departure of annual spring groundwater-level measurements to estimated predevelopment groundwater levels or the depth to groundwater before the widespread installation of high-capacity wells. Figure 5.8 illustrates the average variation of annual spring water levels from predevelopment estimated values. Figure 5.9 illustrates the long-term trend in groundwater levels in individual wells for each location over the past 30 years. Generally, water levels in wells in the state’s western portion have steadily declined for several decades. In parts of Box Butte County, groundwater-level declines have reached nearly 130 feet from predevelopment (Figure 5.8). These western regions receive relatively little precipitation and pump groundwater from deep aquifers, which receive little recharge. In the southeastern region of Nebraska, depth to groundwater in wells fluctuates by a few

feet yearly due to variability in annual precipitation trends and varying irrigation withdrawals. However, since the early 1980s, groundwater in this region has slowly increased or remained steady. This is likely due in part to increasing irrigation efficiencies, regulation of groundwater pumping, and stabilization of groundwater levels as aquifers equilibrate to decades of pumping (Korus & Burbach, 2009).

Significant rises in groundwater levels have also occurred. Long-term data suggests that water levels in the Sandhills region have steadily risen since at least the 1970s, and in some parts of the Sandhills, slowly rising since as early as the 1940s. This region has little impact from pumping and other human use. Studies are ongoing to determine why water levels in the Sandhills region continue to increase. Water infiltration from unlined irrigation canals installed in central Nebraska in the early 1900s has caused significant local groundwater-level rises. Since predevelopment, water levels have risen more than 120 feet in parts of Gosper and Phelps Counties. Similarly, reservoirs such as Lake McConaughy, Calamus, and Merritt have locally raised water levels by as much as 80 feet.

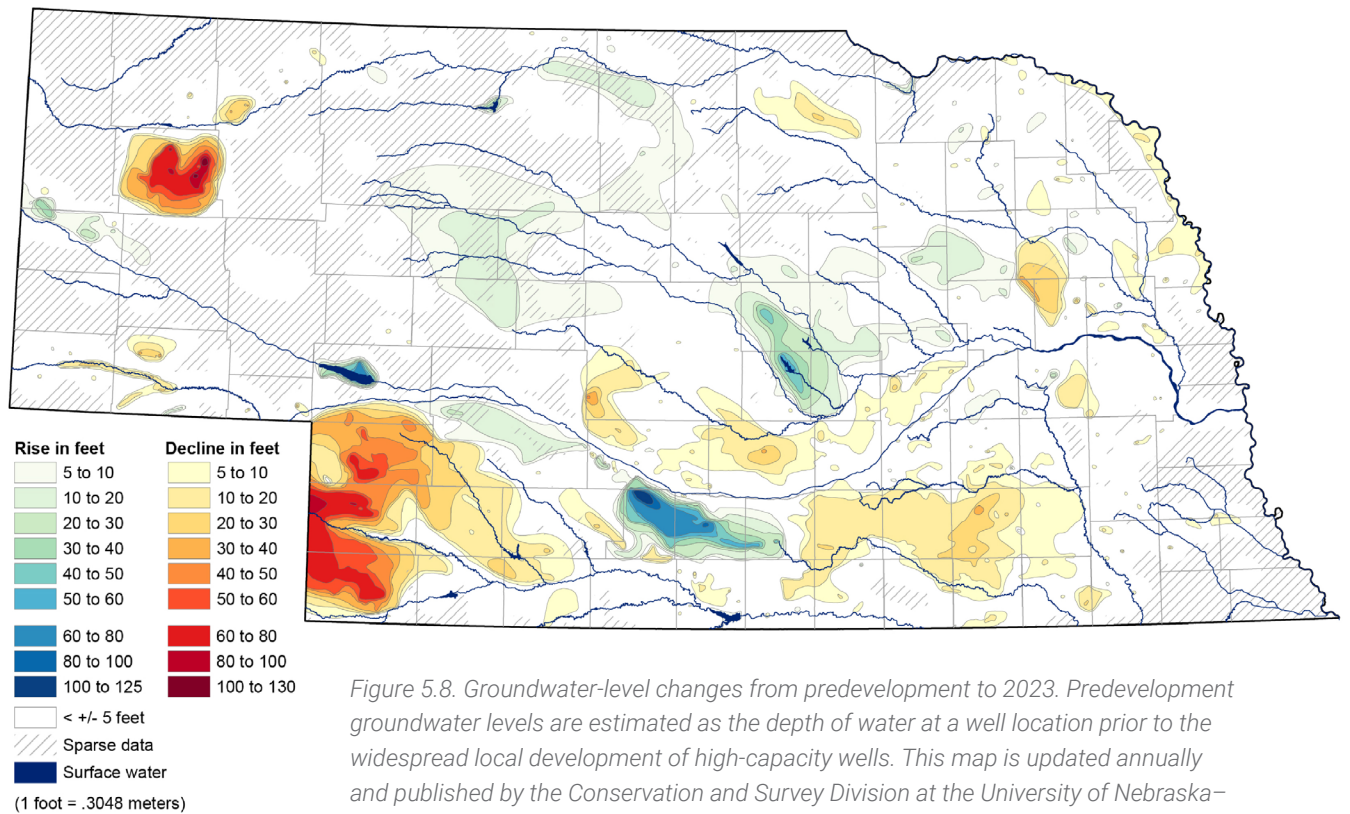


Figure 5.8. Groundwater-level changes from predevelopment to 2023. Predevelopment groundwater levels are estimated as the depth of water at a well location prior to the widespread local development of high-capacity wells. This map is updated annually and published by the Conservation and Survey Division at the University of Nebraska–Lincoln in the annual Groundwater Level Monitoring Report. More information can be found at <https://go.unl.edu/groundwater>. (Source: UNL CSD, 2024)

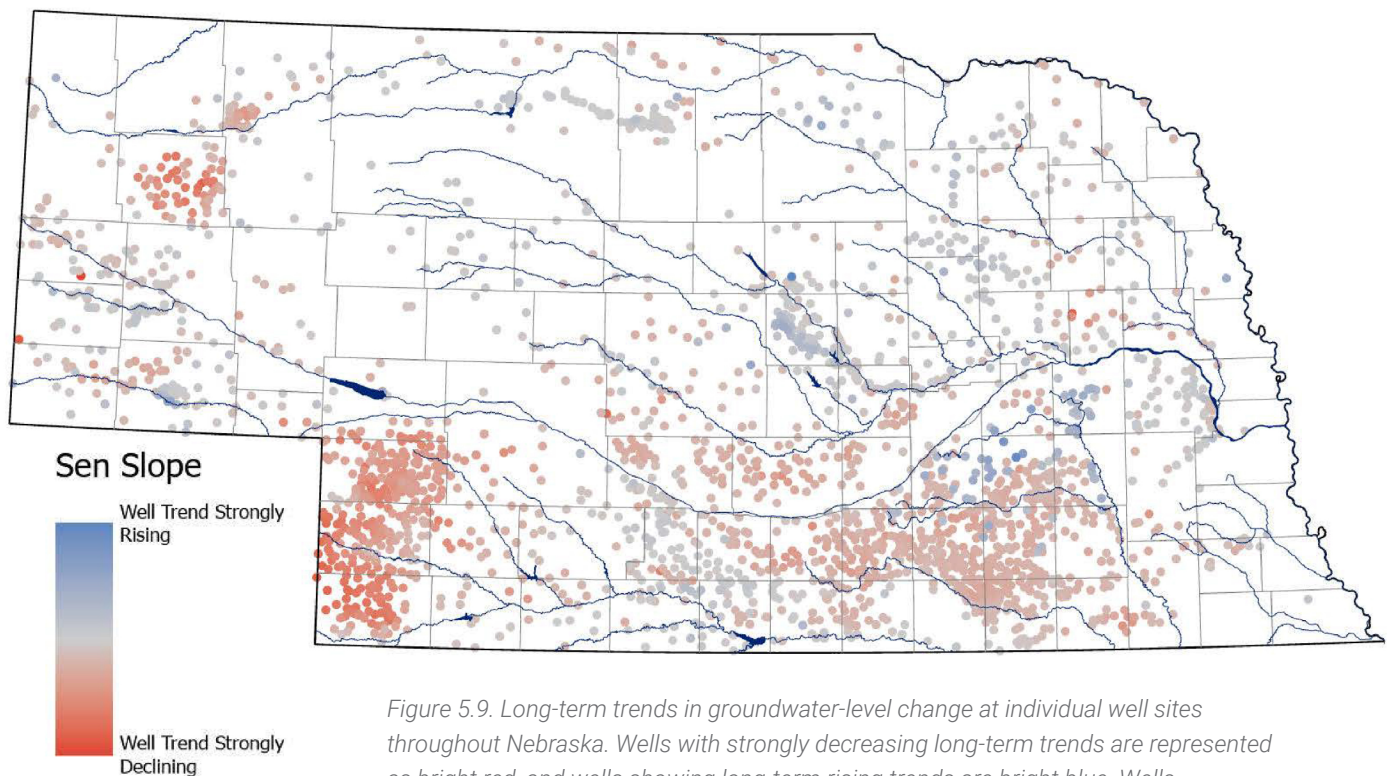


Figure 5.9. Long-term trends in groundwater-level change at individual well sites throughout Nebraska. Wells with strongly decreasing long-term trends are represented as bright red, and wells showing long-term rising trends are bright blue. Wells trending neither up nor down are gray. Trends are calculated using Sen Slope.

Several factors buffer statewide average groundwater-level departures from predevelopment.

- » In the early 1970s, 23 NRDs were developed to conserve the state's groundwater resources. The NRDs were given statutory authority to manage Nebraska's groundwater quantity and quality through a board of locally elected officials. Each establishes locally tailored planning and policy. These policies often begin with incentive programs for adopting technology and management to improve water and other input efficiencies. If groundwater quantity or quality continues to degrade, a phased set of regulations is implemented, including water allocations and moratoriums on new high-capacity wells.
- » Nebraska's farmers and ranchers, through education and more than a century of inherited knowledge and experience, have become stewards of the land that is their livelihood. During the 1970s, for example, some producers attempted to grow irrigated corn in the nutrient-poor soils of the Sandhills. Most of these ventures were unsuccessful and left lasting scars and reduced soil fertility in the region, some of which are still visible today. Even with today's financial incentives to grow corn on marginal lands, it is extremely rare to find row-crop agriculture in the Sandhills despite abundant water supplies.
- » Technological advancements have allowed Nebraska farmers to apply irrigation water much more efficiently. Moving away from flood irrigation and toward center pivot irrigation improves efficiency and reduces the impact on groundwater quality.

At a local level, many variables contribute to changes in depth to groundwater. This includes natural variables such as changes in climate or microclimate (especially precipitation), local geology, groundwater transit time, flow direction, and aquifer confinement, as well as anthropogenic variables including groundwater withdrawal, altered stream flows, artificial recharge projects, and local and statewide pumping regulations. Furthermore, due to regional variations in travel times for water in the subsurface, the complete effects of major climate events may not be apparent for months to several years following the event. These factors,

particularly the direct regulation of groundwater withdrawal, make forecasting long-term supply changes difficult. Multiple modeling studies are ongoing to better understand the future of our water resources in a changing climate. Although these studies are not yet complete, preliminary findings include the following.

- » Statewide trends in groundwater-level changes will continue to follow trends in statewide precipitation. Extreme weather events are expected to increase in the coming decades (see Chapter 3). Due to the contrasting impacts of drought and extreme precipitation events, and assuming current water-use regulations remain near current limits, water levels will likely continue to decline very slowly over the long term as in recent decades (Figure 5.10).
- » As more high-capacity wells are installed in Nebraska, the impacts of drought on groundwater will likely become more severe compared to the recharging effects of extremely wet years.
- » The future impacts of climate change on groundwater will likely result from limits set on pumping by regulations developed by Nebraska's NRDs. Historically, compared to other states in the HPA, these regulations set forth by our NRDs have managed to keep groundwater-level declines to a minimum. The regulations developed by the locally elected boards in response to the changing climate will likely be the key to conserving groundwater resources.
- » With proper management, groundwater will continue to be one of many resources available to provide resiliency against future climate change.
- » Longer growing seasons and higher rates of evapotranspiration (ET) may increase the demand for irrigation water.

Groundwater quality is critical for the 88% of Nebraskans who rely on it for drinking water, as well as Nebraska's industries, farmers, and ranchers. Nebraska's NRDs, state and federal agencies, and the University of Nebraska conduct extensive groundwater quality testing and report in the Quality-Assessed Agrichemical Contaminant Database (NDEE, 2024b). Nebraska's groundwater already faces challenges with both agrichemicals and naturally occurring chemicals in the water. However, more research

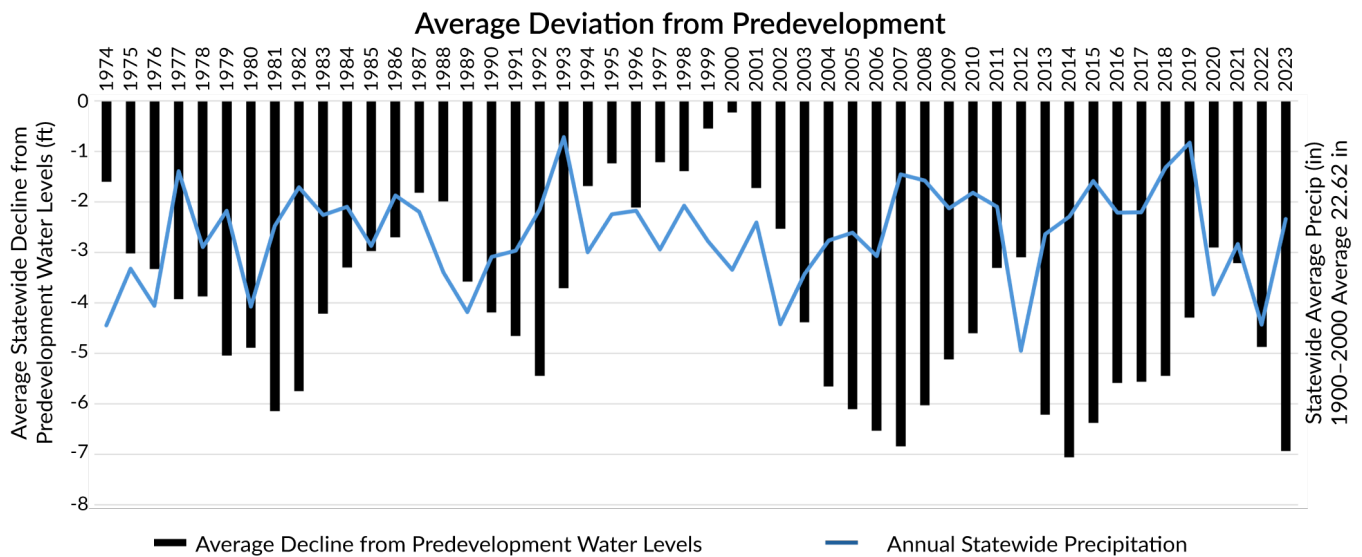


Figure 5.10. Black bars represent the average annual departure of wells measured from predevelopment groundwater-level estimates. Predevelopment groundwater levels are estimated as the depth of water at a well location prior to the widespread local development of high-capacity wells. The blue line represents the statewide average annual precipitation.

will be needed to determine the impacts of climate change on groundwater water quality. Soluble agrichemical loss to groundwater is sensitive to the type of land use, amount and timing of precipitation and irrigation, soil type, and depth of groundwater (Nebraska Water Center, 2024), several of which may be impacted by future climate change.

Gaps and needs

- » Continued research on the interaction between surface water and groundwater, and the potential future impact of climate change on Nebraska's water resources.
- » Research and modeling of the impact of global climatic teleconnections on Nebraska's groundwater quantity and quality.
- » Analyses and case studies of the impact of conservation practices on groundwater and surface water quantity and quality.