GROUNDWATER MANAGEMENT PLAN

VOLUME I

Prepared for:
Central Platte Natural Resources District

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January 2023

Olsson Project No. 019-28790

ACRONYMS AND ABBREVIATIONS

CDL....Cropland Data Layer
COHYST....Cooperative Hydrology Study
CPNRD....Central Platte Natural Resources District
EPA....Environmental Protection Agency
ET....evapotranspiration
GMP....Groundwater Management Plan
GWMA....Groundwater Management Area
HPRCC....High Plains Regional Climate Center
HU....Hydrologic Unit
IMP....Integrated Management Plan
MAD....Maximum Acceptable Decline
MRLC....Multi-Resolution Land Characteristics Consortium
NARD....Nebraska Association of Resources Districts
NeDNR....Nebraska Department of Natural Resources
NDOT....Nebraska Department of Transportation
NIR....net irrigation requirement
NLCD....National Land Cover Dataset
NRD....Natural Resources District
ppm....parts per million
PRRIP....Platte River Recovery and Implementation Program
USDA....United States Department of Agriculture
USGS....United States Geological Survey

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EXECUTIVE SUMMARY

The Central Platte Natural Resources District contains abundant groundwater resources. The aquifer that underlies the CPNRD has been heavily developed for irrigating the extensive cropland across the CPNRD. As this development was occurring, the Nebraska Legislature tasked the CPNRD with managing this resource beginning in 1982. The CPNRD wrote a groundwater management plan (GMP) which was adopted in 1985. This original GMP and the science completed as part of plan development envisioned a potential for the ongoing expansion of irrigated acres to have a dramatic impact on the aquifer through 2020. Even though irrigation development continued for several more decades, far surpassing the stable level of irrigated acres envisioned in the original GMP, these aquifer impacts have not occurred.

Under the original GMP, acceptable levels of groundwater level declines, called maximum acceptable declines (MADs), were developed for 24 groundwater management areas (GWMAs) across the CPNRD. The MADs generally ranged from 10-30 feet, or approximately 10% or less of the total saturated thickness of the aquifer in each GWMA. Most, if not all, of these MADs were expected to be reached in the absence of management activities. At the time the original GMP was developed, State Statutes did not provide the CPNRD with the authority to explicitly cap the total number of allowable irrigated acres through some type of moratorium that would be enacted when the expected stable level of irrigated acres was reached. Therefore, the GMP was designed to limit continued development as the MAD in each GWMA was approached by expanding the well spacing requirements through a series of phase designations. As these phases were reached, the original GMP also imposed a required reduction in the percentage of acres developed for irrigation that could be irrigated each year. The first trigger, which would move a GWMA from Phase I to Phase II management, would occur when the groundwater level fell by 50% of the MAD in any GWMA. Despite expectations to the contrary when the GMP was first developed, no GWMA has ever reached the Phase II level of groundwater management.

Today, the science available for groundwater management has developed considerably since the 1980's. Furthermore, the management regime in the Upper Platte River Basin has expanded beyond groundwater management only to a system of integrated management that manages the groundwater and surface water resource in each NRD as the single, interconnected system that they are. To address the impacts of groundwater development on surface water supplies, a moratorium on new groundwater acres (a tool added to the Nebraska Statutes since the original GMP was developed) was enacted in 2004. The CPNRD is currently engaged in offsetting the impact of groundwater development that occurred after 1997 through a series of management activities that have occurred over the previous 15 years that have included targeted retirements of groundwater irrigated acres and increased groundwater recharge utilizing Platte River high flows.

Given the age of the GMP, the enhanced science available for groundwater management and planning, and the changed management regime that exists today, the CPNRD has developed this revised GMP to improve the ways that groundwater quantity and quality management will occur going forward. The primary changes to this GMP include minor changes to the management phase triggers and a change in how groundwater will be managed if water level declines approach the MAD in each GWMA. Two GWMAs were subdivided due to differences in irrigation development that have occurred across those GWMAs. Finally, instead of imposing limits on the number of irrigated acres that can be irrigated in any individual year, a system of required measurement of groundwater pumping and a limit on the amount of groundwater that can be pumped per irrigated acre will be used to keep water level declines at or less than the MAD as needed in the future. The GMP also applies to the management of groundwater quality, a trigger change was made to Phase II and III to align with current Maximum Contaminant Levels (MCLs).

The best available data was used to make projections as to the likelihood that each GWMA would experience water level declines sufficient to hit the phase triggers relative to the MAD. A baseline scenario was used that projects recently experienced climatic conditions and resulting groundwater pumping for currently irrigated acres fifty years into the future. While the future demand on the groundwater resource is inherently unknowable, an additional set of scenarios was also developed to evaluate how these likelihoods might change if groundwater pumping in the future is higher than recently experienced. For each phase level and irrigation scenario, an assessment was made as to whether the phase trigger was unlikely, somewhat likely, likely, or very likely to be met. Under the baseline scenario, few GWMAs appear likely to hit most of the phase triggers. As expected, likelihoods increased under the higher irrigation scenarios. While these are merely projections based on the best available science and may not fully represent what occurs given actual future pumping demands, these projections provide a valuable tool for the CPNRD in making decisions on where to focus monitoring and educational resources going forward. In addition, the extensively updated data and information contained in this GMP brings the plan forward four decades, providing the CPNRD with a valuable set of management tools for a future of sustainable groundwater use.

1. INTRODUCTION

Nearly 138,000 people live in the Central Platte Natural Resources District (CPNRD), and they rely on clean groundwater for their drinking water supply, they rely on groundwater to supply their irrigation wells during critical times in the growing season, and companies across the District rely on groundwater for various industrial uses. One of the primary missions of Nebraska's Natural Resource Districts (NRD) is to locally manage the groundwater resources that sustain each of Nebraska's 23 Districts. Therefore, each NRD is required by law to maintain a Groundwater Management Plan (GMP). CPNRD's GMP is to be based on the best available information on the quantity and quality of groundwater within the District to ensure that the plan is protective of the water resources.

The CPNRD's GMP was written in 1985 and was last updated in 1993 (CPNRD 1985, 1993). Since 1985, the NRD has acquired and developed significant data and information about the groundwater resources in the District. Furthermore, over the last 35 years, the groundwater management rules and regulations implemented by CPNRD have changed significantly as the water management goals have evolved. For these reasons, the GMP for the CPNRD has been updated into a GMP that will proactively protect this invaluable natural resource.

This GMP was prepared under contract to the CPNRD in Grand Island, Nebraska. CPNRD is the project sponsor, and the plan was prepared on behalf of the landowners, land managers, land stewards, flora, fauna, and District visitors (**Photo 1**).

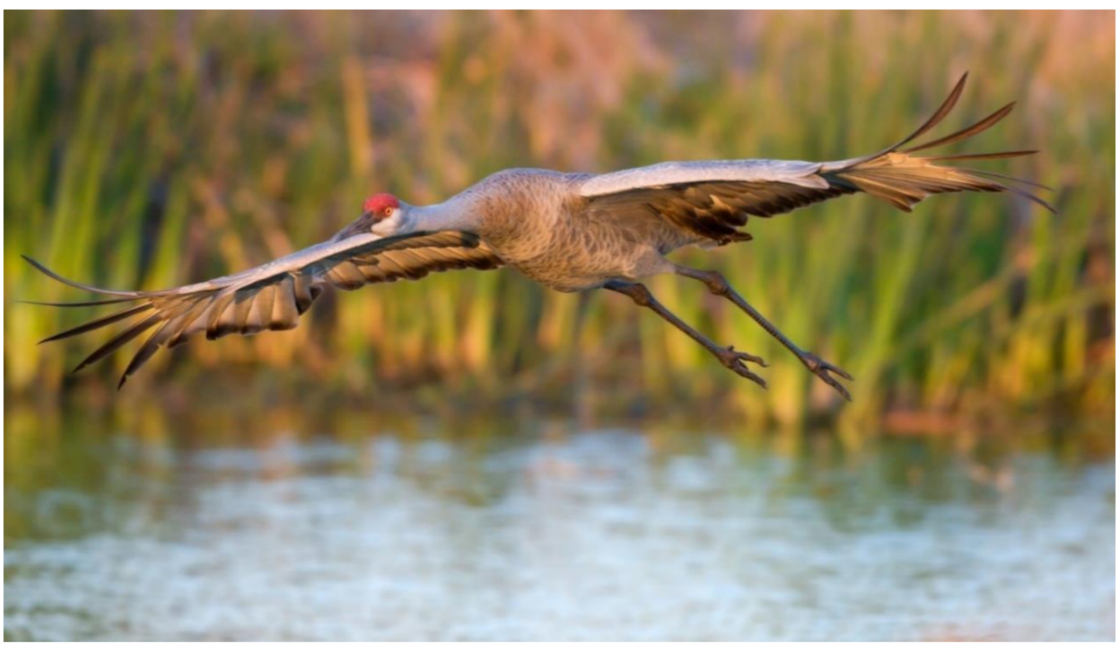

Photo 1 A migratory sandhill crane.

1.1 Groundwater Management Plan Objectives and Organization

The objectives of this plan are numerous and unique to the CPNRD. Although based on the statutory requirements of all GMPs, the objectives of this GMP go well beyond the strict legal requirements because the plan is written to meet the specific needs of the groundwater resources and users in the CPNRD. Each NRD's GMP is unique in that way. Each NRD's GMP is written by the NRD after actively soliciting public comments and opinions on the issues and concerns related to their groundwater supply. Additionally, the NRD draws upon existing research, data, studies, agencies, and other subdivisions of the state to develop the plan. Ultimately, each GMP reflects the unique hydrogeology, the limits of the water supply, and the unique demands placed on the resource. Consequently, the plan's primary objectives are to describe the resources available, describe the current demands and contamination levels of the resources, and define the methods that the NRD will use to oversee the sustainable use of the groundwater resources.

This GMP is organized as follows. Section 2.0 provides a description of the setting of the CPNRD. This includes aspects of climate, topography, and hydrogeology of the District and how each affect groundwater supplies. Section 3.0 provides a description of population, land use, and adjudicated groundwater rights to document the current groundwater demand. Section 4.0 is a summary of the groundwater monitoring and modeling completed to date documenting water levels, water quality, and groundwater modeling along the central portion of the Platte River and its tributaries. Section 5.0 is a summary of the issues identified by water users through public CPNRD Board of Directors water committee meetings. Section 6.0 describes the way groundwater rules and regulations will be applied by the CPNRD to meet these objectives. Section 6.0 also defines the groundwater triggers and primary controls that the CPNRD will use to manage groundwater supplies into the future. Note that all maps referenced throughout this document are included in Volume II.

1.2 Groundwater Management Plan Area

As illustrated in **Figure 1** and on **Map 1**, the CPNRD lies in the south-central part of Nebraska, straddling the Platte River. There are 2,136,304 acres or 3,338 square miles in the District. The GMP area coincides with CPNRD's area. CPNRD extends for about 175 miles from the Lincoln-Dawson county line on the west near Gothenburg, to Highway 81 on the east near Columbus. It includes all or part of 11 counties along a 205-mile stretch of the Platte River. The counties include all of Dawson County and parts of Frontier, Custer, Buffalo, Howard, Hall, Nance, Merrick, Hamilton, Platte, Polk. There are three first class cities in the District with populations greater than 5,000 but less than 100,000: Grand Island, Kearney and Lexington. There are nine second class cities with populations more than 800 but less than 5,000: Central City, Cozad, Doniphan, Elm Creek, Gibbon, Gothenburg, Wood River, Shelton, Elm Creek. And there are 16 villages with populations under 800: Alda, Amherst, Cairo, Chapman, Clarks, Duncan, Eddyville, Eustis, Farnam, Hordville, Miller, Oconto, Overton, Riverdale, Silver Creek, and Sumner.

1.3 Authority and Statutory Requirements

Nebraska Revised Statutes (Neb. Rev. Stat.) § 46-701 through § 46-756 are called Nebraska's Groundwater Management and Protection Act. In the declaration of intent and purpose, the Nebraska Legislature granted legal authority to the NRDs to regulate certain activities that contribute to groundwater depletion.

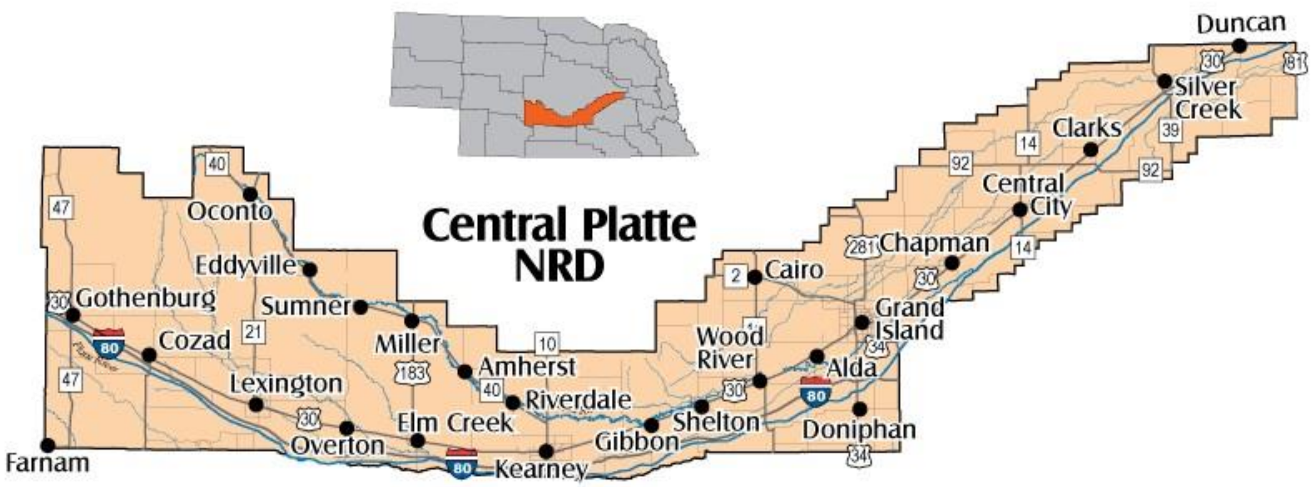

Figure 1 Map of the entire CPNRD, the GMP Planning Area.

"The Legislature finds that ownership of water is held by the state for the benefit of its citizens, that ground water is one of the most valuable natural resources in the state, and that an adequate supply of ground water is essential to the general welfare of the citizens of this state and to the present and future development of agriculture in the state. The Legislature recognizes its duty to define broad policy goals concerning the utilization and management of ground water and to ensure local implementation of those goals. The Legislature also finds that natural resources districts have the legal authority to regulate certain activities and, except as otherwise specifically provided by statute, as local entities are the preferred regulators of activities which may contribute to ground water depletion.

Every landowner shall be entitled to a reasonable and beneficial use of the ground water underlying his or her land subject to the provisions of Chapter 46, article 6, and the Nebraska Ground Water Management and Protection Act and the correlative rights of other landowners when the ground water supply is insufficient to meet the reasonable needs of all users. The Legislature determines that the goal shall be to extend ground water reservoir life to the greatest extent practicable consistent with reasonable and beneficial use of the ground water and best management practices." Neb. Rev. Stat. § 46-702.

The act further describes the items that must be included in GMPs that are written by NRDs and reviewed and approved by the Nebraska Department of Natural Resources (NeDNR). **Table 1** lists the specific requirements of the plan and provides a cross-reference to the location of the content.

Table 1 Statutory requirements of a GMP and content location index.

Nebraska Revised Statute	Description of Required Content	Location in this GMP
46-709 (1)	Groundwater supplies within the District including transmissivity, saturated thickness maps, and other groundwater reservoir information including depth to water	Section 2.2 and Map
46-709 (2)	Local recharge characteristics and rates from any sources, if available	Section 2.3 and Map
46-709 (3)	Average annual precipitation and the variations within the District	Section 2.1 and Figure 3
46-709 (4)	Crop water needs within the District	Section 3.3 and Map
46-709 (5)	Current groundwater data collection programs	Section 4.0 and Map
46-709 (6)	Past, present, and potential groundwater use within the District	Section 3.0
46-709 (7)	Groundwater quality concerns within the District	Section 4.2 and Appendix A (Volume IV of GMP 1993)
46-709 (8)	Proposed water conservation and supply augmentation programs for the District	Section 1.5
46-709 (9)	The availability of supplemental water supplies, including the opportunity for groundwater recharge	Section 1.5
46-709 (10)	The opportunity to integrate and coordinate the use of water from different sources of supply	Section 1.5
46-709 (11)	Groundwater management objectives, including a proposed groundwater reservoir life goal for the District.	Sections 5.1 and 5.3

Nebraska Revised Statute	Description of Required Content	Location in this GMP
46-709 (12)	Existing subirrigation uses within the District	Section 3.3 and Map
46-709 (13)	The relative economic value of different uses of groundwater proposed or existing within the District	Section 3.7
46-709 (14)	The geographic and stratigraphic boundaries of any proposed management area	Section 5.3 and Map
46-709	Each District's groundwater management plan shall also identify, to the extent possible, the levels and sources of groundwater contamination within the District	Appendix A (Volume IV of GMP 1993)
46-709	Groundwater quality goals	Section 4.2 and Appendix A (Volume IV of GMP 1993)
46-709	Long-term solutions necessary to prevent the levels of groundwater contaminants from becoming too high and methods to reduce high levels sufficiently to eliminate health hazards, and practices recommended to stabilize, reduce, and prevent the occurrence, increase, or spread of groundwater contamination	Section 4.2 and Appendix A (Volume IV of GMP 1993)
46-710	During preparation or modification of a groundwater management plan, the District shall actively solicit public comments and opinions and shall utilize and draw upon existing research, data, studies, or any other information which has been compiled by or is in the possession of state or federal agencies, natural resources Districts, or any other subdivision of the state.	Sections 3.0 and 5.0

1.4 Implementation of Rules and Regulations

To implement the actions described in this GMP, the CPNRD will implement the District's current Rules and Regulations for the Enforcement of the Nebraska Groundwater Management and Protection Act (CPNRD 2021). The rules and regulations are a separate document from the GMP. Keeping the two documents separate provides enough flexibility to update the rules and regulations based on additional monitoring data and changing groundwater conditions without having to update the entire GMP. As required under the Groundwater Protection Act, changes to the groundwater rules and regulations will be made available for public comment prior to implementation by the CPNRD Board of Directors.

1.5 Water Management in the Central Platte NRD

Before the details of this GMP are presented, it is important to understand how CPNRD's GMP relates to some of the primary water planning documents developed for the upper Platte Basin. Two of the primary water planning documents developed for central Nebraska during this time period are summarized here to provide context for this GMP: CPNRD's Integrated Management Plan (IMP) and the Upper Platte River Basin-Wide Plan. And finally, the Platte River Recovery

Implementation Program (PRRIP) is described with reference to how it relates to groundwater management in the CPNRD.

The CPNRD keeps a continuous account of water use activities in an annual report published to the CPNRD website. The CPNRD consistently seeks projects that help meet water management goals using different sources of supply.

1.5.1 Integrated Management Plan

Water management in Nebraska is accomplished through the combined efforts of the NeDNR and the NRDs. NRDs manage groundwater, whereas surface water is managed by the NeDNR. In areas where groundwater and surface water are connected, NRDs have the authority through Neb. Rev. Stat. § 46-715(1)(b) to jointly develop an IMP with NeDNR. A full copy of the current IMP for the CPNRD is available on the NeDNR website (www.dnr.ne.gov) and in **Appendix B**.

With the Platte River running through the center of the CPNRD, the importance of the interconnection between surface and groundwater is readily apparent and therefore, the CPNRD and NeDNR began working on the IMP for the CPNRD in 2005 (CPNRD 2019). The NRD began meeting with stakeholders in December 2005 to begin education on the requirements set by NeDNR and the issues that would need to be considered in developing the plan. The members included both surface and groundwater interests such as irrigators, city utilities, power districts, economic development, and banking representatives. In June 2006, the draft plan was finished, and it included one goal and eleven objectives. Originally the IMP was to be in place within three years, however, an extension to complete the plan set the deadline for 2009.

The IMP was approved in May of 2009 and the NRD also revised the Rules and Regulations to correlate with the requirements in the IMP. In 2010, the DNR held an open comment period for the annual review of the basin IMPs. On March 22, 2012 a revised IMP was adopted and became effective on May 21, 2012. In 2018-2019 the IMP was further revised and adopted in the fall of 2019. With an effective date of September 11, 2019 the plan includes descriptions of the authority; management area boundaries; the plan vision; potential sources of funding; scientific methods used for the analyses; a description of the accomplishments to date; the primary goals and objectives of the plan; and action items, which include the water management controls and triggers, along with monitoring and evaluation.

The three goals of the current IMP are:

1. To incrementally achieve and sustain a fully appropriated condition while maintaining economic viability, social and environmental health, safety, and welfare of the basin.

2. To ensure that no act or omission of the CPNRD or the NeDNR would cause noncompliance by Nebraska with any interstate decree, compact, or other formal state contract or agreement.
3. Keep the IMP current, maintain consistency with the Basin-Wide Plan, and keep water users informed.

To achieve these goals, objectives and action items are defined in the plan. Additionally, as stated in the current IMP, the CPNRD will continue with the existing groundwater controls which are: 1) groundwater moratorium, 2) certification of groundwater uses, 3) groundwater variances, 4) groundwater transfers, and 5) municipal and industrial accounting. Furthermore, the NeDNR will continue the existing surface water controls which are: 1) maintaining the moratorium on new surface water appropriations and on expanded surface water uses; 2) transfers of appropriations are subject to statutory criteria and Department rules; 3) continuation of surface water administration and monitoring of use of surface water; 4) no additional requirements of surface water appropriators to use additional conservation measures, and 5) no other reasonable restrictions on surface water use.

In December of 2017, the Nebraska Association of Resource Districts (NARD) compiled a timeline of water management from each NRD. A forty-year timeline for CPNRD is included for reference in **Appendix C**. Included in the timeline is reference to CPNRD's Water Bank and the Canal Rehabilitation Project. The Water Bank is a program the CPNRD operates with the goal of retiring irrigated acres and therefore "return" water to the river. The CPNRD initiated the Water Bank in 2007 and was the first NRD program of its kind in the state.

The Canal Rehabilitation Project is comprised of partnerships with Thirty Mile Irrigation District, Cozad Ditch Company, Southside Irrigation District, and Six Mile Canal Company. The project began in 2012 with the intent of increasing irrigation efficiency, protecting water supplies, and increasing flows to the Platte River. Improvements included clearing vegetation, grading, new check structures, farm crossings, flow measurement devices, erosion control, and construction of bridges, drop structures, pipe laterals, and a SCADA automated monitoring system. Additional information on the activities performed as part of the Canal Rehabilitation Project is included in the Long Range Implementation Plan (**Appendix D**). The CPNRD also uses the Cozad Canal, Thirty Mile Canal, and Orchard Alfalfa Canal for the diversion and recharge of excess streamflow beyond the Platte River target flows.

The 30-Year Acreage Reserve Program was created in 2021 to provide a long-term solution in protecting surface water rights. Surface water users have the option to opt-in or opt-out of the program annually. The purpose of the Acreage Reserve Program is to "ensure that Platte River Basin water supplies are optimized and managed efficiently with maximum benefits and to meet water management obligations" (CPNRD 2022c). The Acreage Reserve Program allows irrigators to retain their surface water right, but they do not exercise it during the designated period, therefore decreasing direct diversions from the river.

1.5.2 Upper Platte Basin-Wide Plan

The Upper Platte River Basin-Wide Plan was a collaborative planning effort of NeDNR and the five NRDs of the upper Platte River Basin: Central Platte, South Platte, North Platte, Twin Platte and Tri-Basin NRDs (NeDNR 2019) (**Figure 2**). Like the individual IMPs, this Basin-Wide Plan contains goals and objectives; however, unlike IMPs, the Basin-Wide Plan does not require groundwater or surface water controls (**Appendix E**). Instead, this Basin-Wide Plan provides clear goals and objectives for the entire basin, to which the NRDs can then align the controls and actions of their IMPs and GMPs to achieve. As such, the goals of the Basin-Wide Plan are like the IMP:

1. Incrementally achieve and sustain a fully appropriated condition while maintaining economic viability, social and environmental health, safety, and welfare of the Basin.
2. Prevent or mitigate human-induced reductions in the flow of a river or stream that would cause non-compliance with an interstate compact or decree or other formal state contract or agreement.
3. Partner with municipalities and industries to maximize conservation and water use efficiency.
4. Work cooperatively to identify and investigate disputes between groundwater users and surface water appropriators and, if determined appropriate, implement management solutions to address such issues.
5. Keep the Upper Platte River Basin-Wide Plan current and keep stakeholders informed.

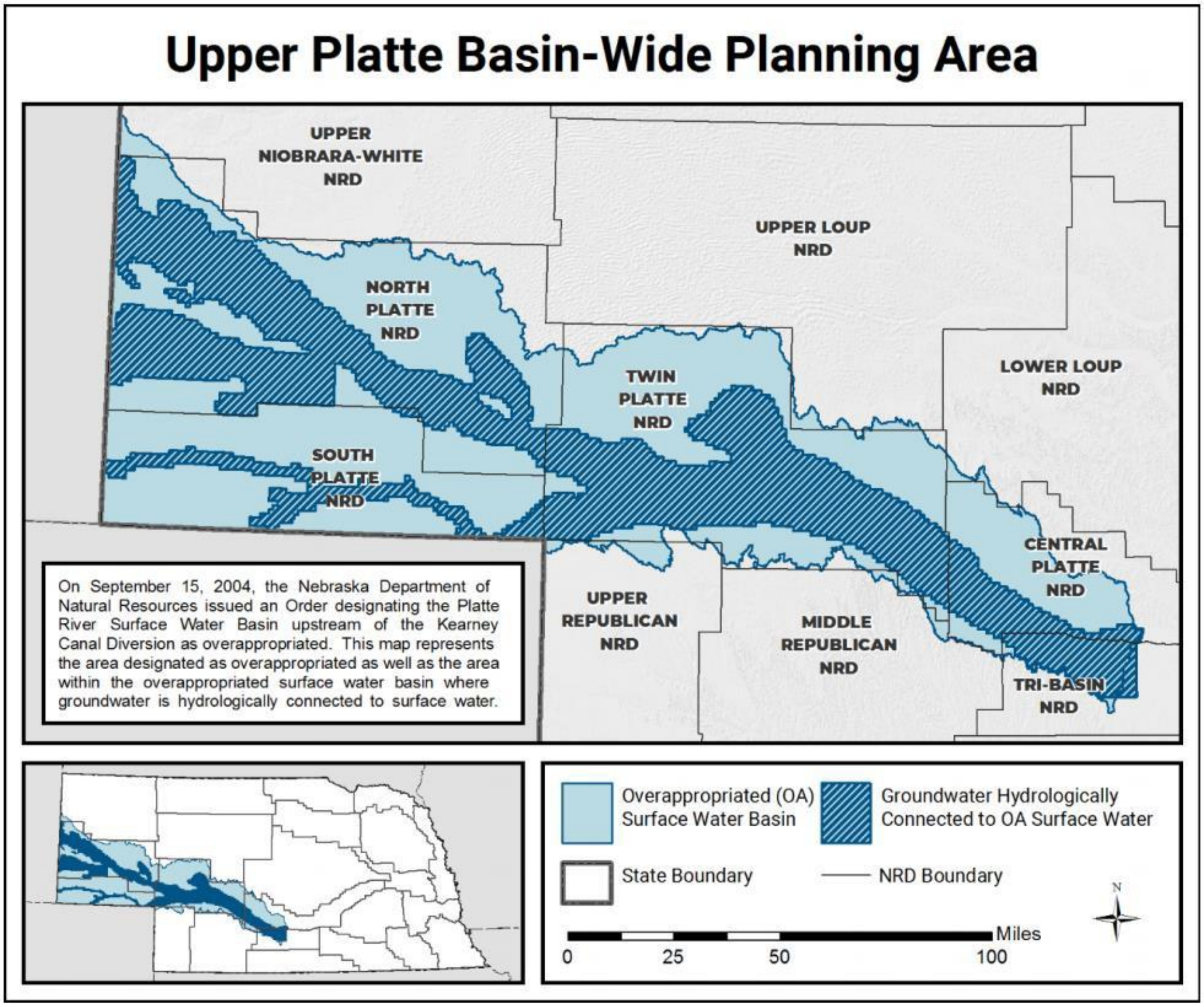

Figure 2 Upper Platte Basin-Wide Planning Area (from NeDNR 2019).

1.5.3 Platte River Recovery Implementation Program

CPNRD participates in the Platte River Recovery Implementation Program (PRRIP) with the states of Nebraska, Colorado, Wyoming and the United States Department of the Interior to find a solution for the four threatened and endangered species in the Central Platte Basin and the water rights for the landowners/operators in the District (**Photo 2**). The species are the pallid sturgeon, the piping plover, the least tern and the whooping crane. The PRRIP was developed by the federal government along with the basin states of Nebraska, Colorado, and Wyoming and signed in 2006. Local, state, and federal government agencies are working with groups throughout the basin to build a framework for a long-term program that will satisfy the requirements of the Endangered Species Act for water users in the basin.

The three components of the program include the Water Plan, Land Plan and Adaptive Management Plan. The details of the three plans are available at www.platteriverprogram.org. The PRRIP's water plan objective is to use incentive-based water projects to provide sufficient water to and through the central Platte River habitat area to assist in improving and maintaining habitat for the target species. The PRRIP identified potential water conservation and water supply projects (such as storage reservoirs, groundwater recharge, water leasing, and improved water management) and estimated the amount of water that could be re-regulated/conserved and credited toward the Program objectives.

The CPNRD is an active participant in the PRRIP, and the interconnected surface and groundwater resources of the District are managed in a way that is consistent with the objectives of the PRRIP. The PRRIP Water Plan includes water service agreements CPNRD has approved with Nebraska Public Power District and Central Nebraska Public Power and Irrigation District. While the purpose of this GMP is not explicitly for the protection of threatened and endangered species, the goal of ensuring longevity of the water resources in the CPNRD is in alignment with the PRRIP. The IMP includes many more references to the importance of the PRRIP (see Section 8.1 of CPNRD IMP, **Appendix B**).

Photo 2 The four threatened and endangered species of the Upper Platte River Basin. Clockwise, from top left: pallid sturgeon, least tern, whooping crane, piping plover.

2. GROUNDWATER SUPPLY

2.1 Setting and Climate

Nebraska's topographic and geologic setting varies across the state from lush soils to rugged, rock escarpments (Korus et al 2013). The setting of the CPNRD is dominated by the Platte River Valley that dissects the District from west to east. Thus, as shown in **Map 2**, the dominant topographic region of the CPNRD is the Valley topographic region that is described as having low relief with surficial soils that are dominated by fine to coarse sand with moderate soil fertility (Korus et al 2013). Topographic relief across the District is about 1,644 feet with the highest land surface elevation reaching 3,081 feet near Gothenburg (**Map 3**). The lowest elevation of 1,437 feet occurs near Duncan.

The climate in the CPNRD is typical of continental, temperate conditions with large seasonal variations in temperature and precipitation. The High Plains Regional Climate Center (HPRCC) collects and reports climate data across the District. The following information was summarized from their records (HPRCC 2019). The record low temperature for western CPNRD in Gothenburg was measured as -33 degrees Fahrenheit (°F) in 1899, with a record high of 116°F in 1954. In the east, the temperature extremes are similar with a record low temperature measured in Central City at -28°F in 1963, and a record high at 116°F in 1936. The average daily temperature ranges from west to east for the two cities are fairly similar and range from approximately 8°F to 83°F in Gothenburg and 7 to 86°F in Central City. Precipitation varies more dramatically across the CPNRD from west to east with an average of 25 inches per year near Farnam and 31 inches per year near Duncan (see **Figure 3**). Dark blue areas indicate higher

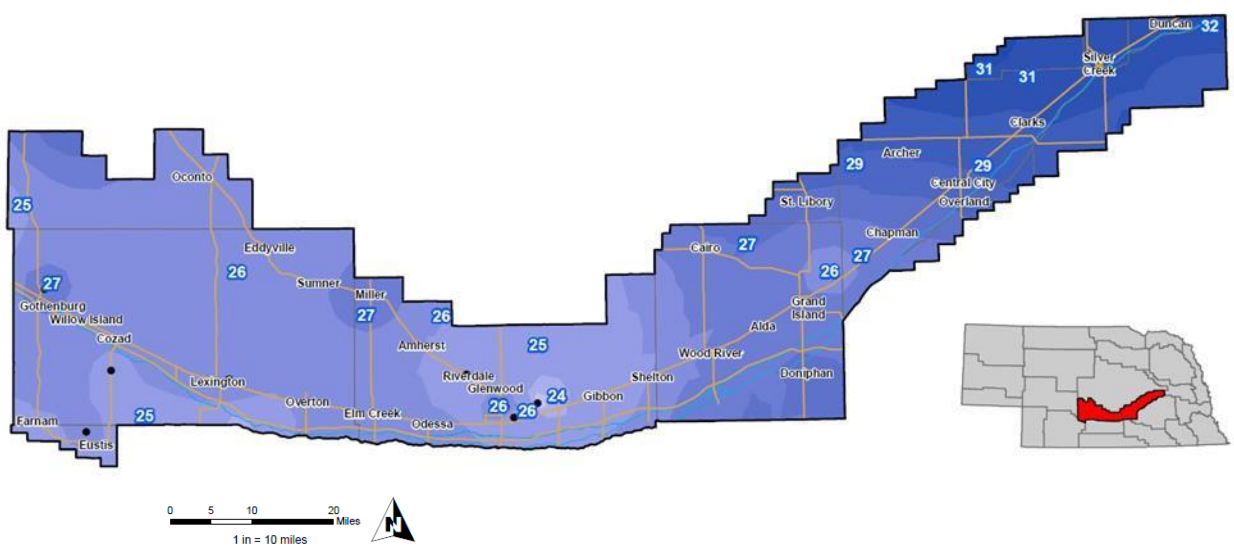

Figure 3 Average precipitation across the CPRND (HPRCC 2019).

precipitation averages (generally the eastern CPNRD), and light blue areas indicate lower precipitation averages (generally the western CPNRD).

For comparison, the average annual precipitation amounts range from less than 16 inches per year in western Nebraska near the Wyoming border to over 34 inches per year in the southeastern part of the state along the Missouri River. In The CPNRD, over two-thirds of the precipitation occurs as rainfall during the growing season from April through September (HPRCC 2019).

Interannual precipitation averages for Grand Island show the periodic wet and dry periods that have been experienced since 1990 (**Figure 4**). Although this chart does not represent the CPNRD as a whole, the trends translate beyond just the area surrounding Grand Island. For example, the drought of 2012 was experienced across the state.

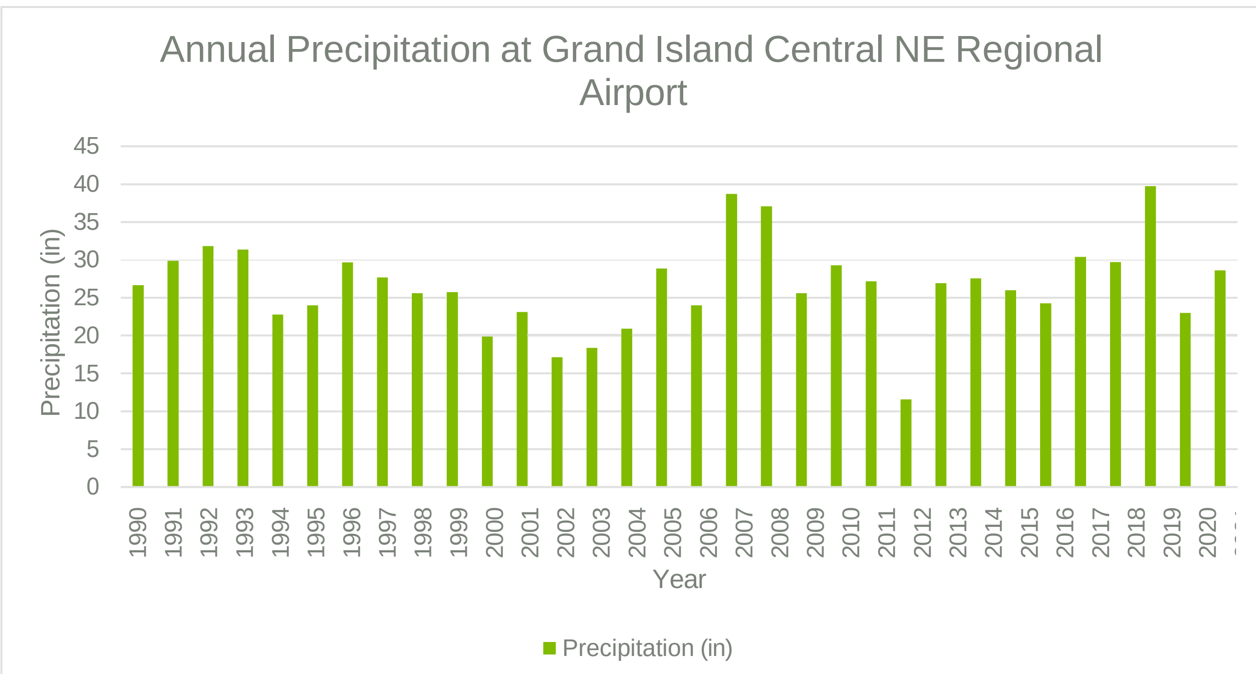

Figure 4 Annual precipitation at the Grand Island Central Nebraska Regional Airport from 1990 to 2021 (HPRCC 2022).

Climate data averages don't always tell the whole story. In March 2019, the year this plan began development, Nebraska experienced all-time, record-breaking, devastating floods. Flooding along the Platte River caused levee failures, severe damage to roads, bridges, farmland, and urban areas. In 2019, areas in the CPNRD recorded over 40 inches of rain which is 15 inches above average.

Based on the data collected by climate scientists around the world (**Figure 5**) and research by scientists at the University of Nebraska, high intensity storm events like the March 2019 flood were predicted by climate scientists at the University of Nebraska in their 2014 Climate Report (Wilhite et al 2014).

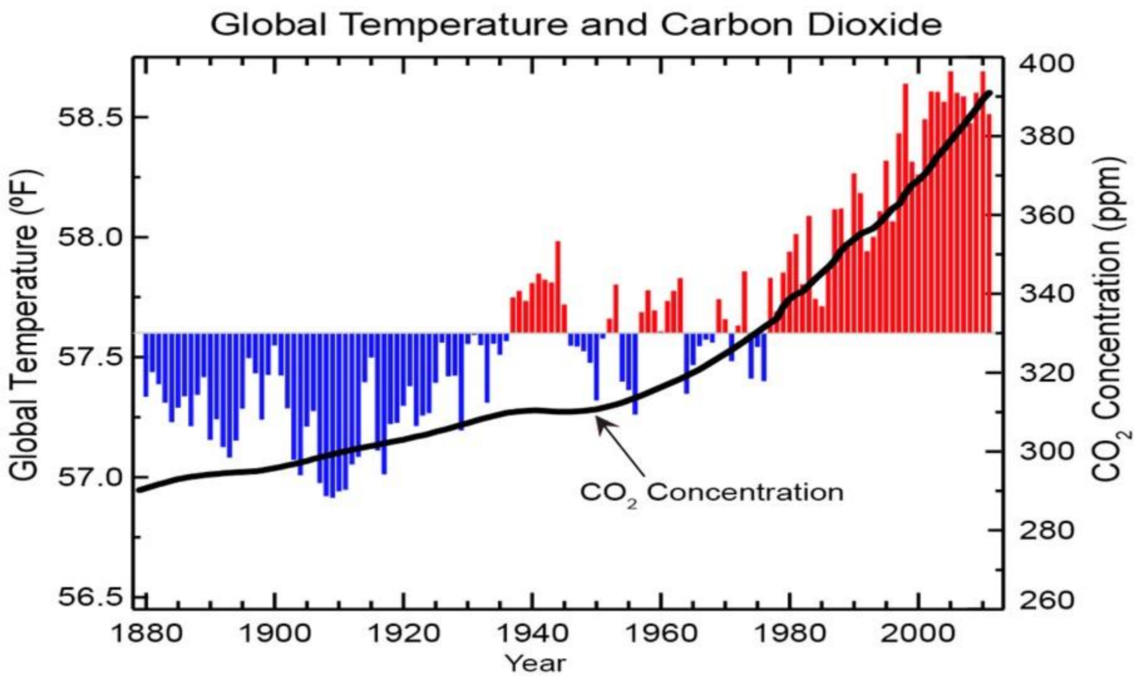

Figure 5 Global temperature and carbon dioxide (Wilhite et al 2014).

To summarize some of the major conclusions of the report, in Nebraska since 1895:

- Temperatures have risen about 1ºF
- Frost-free season has increased 5-25 days
- Very heavy precipitation events have increased by 16% in the Great Plains Region

Additionally, for Nebraska, the predictions are:

- A projected temperature increase of 4-5ºF for the low emissions scenario or 8-9ºF for the high emissions scenario by 2100
- Projected summer of 2100 will have 13-25 days over 100ºF
- Number of nights over 70ºF will increase by 20-40 days by 2100
- Soil moisture is projected to decrease 5-10% by 2100
- Reduced snowpack in Rocky Mountains means reduced streamflow in our rivers
- Increasing heavy precipitation events
- Increasing flood magnitude
- Increasing drought frequency and severity

As stated in the University of Nebraska's Climate Roundtable Report (UNL-SNR 2015), "The threats to water resources is real. Nebraska … will continue to see pressure on water resources grow with increases in frequency and intensity of droughts and more temperature extremes." The long-term impacts of climate change have the potential to increase demand and stress the CPNRD's water supply. As such, as part of this update to CPNRD's GMP, the predicted changes to climate will be discussed in more detail in the discussion on triggers established to ensure that CPNRD's groundwater reservoir is not over tapped.

2.2 Geology and Hydrogeology

The geology and hydrogeology of the CPNRD has been the subject of numerous scientific investigations along with extensive water level and water quality monitoring by the District since the last GMP update (CPNRD 1993). Before the results of the monitoring and modeling are presented, it is important to understand the hydrogeology of the CPNRD. The following discussion is summarized from the Cooperative Hydrology Study (COHYST) Hydrostratigraphic Units and Aquifer Characterization Report (Cannia et al 2006). For reasons of consistency, this summary is used as the basis to describe the geologic framework of the District.

As described in the COHYST hydrostratigraphic report, the High Plains aquifer underlies the entire study area (Cannia et al 2006). The High Plains aquifer is the most widely used and best-known aquifer in Nebraska, and it consists of multiple layers of sand, gravel and sandstone with lesser amounts of silt, siltstone and clay (Korus et al 2013). From oldest to youngest, the geologic units of the High Plains aquifer are the Brule Formation, the Arikaree Group, the Ogallala Group, the Broadwater Formation and younger unconsolidated sand and gravel units deposited during the Pleistocene epoch (2.6 million to 10,000 years ago). Across the entire CPNRD and beneath the unconsolidated sand and gravel deposits, the first bedrock unit encountered are the strata of the Ogallala Group.

Figure 6 illustrates the stratigraphic description of the geologic and hydrostratigraphic units used in the COHYST hydrostratigraphic report and adopted for this plan. **Table 2** provides a lithostratigraphic description of the geologic and hydrostratigraphic units used in this study along with their water supply capability. In **Table 2**, the word communication is used to mean a direct hydraulic connection to an adjacent hydrologic unit or stream. Note that since this project is focused on evaluating the groundwater resources of the CPNRD, a focus was placed on defining the vertical and lateral extent of the units within the High Plains Aquifer that are known to be present in the CPRND. The Arikaree and the Chadron Formation of the White River Group of the High Plains Aquifer are not known to occur in this area and therefore are not discussed further.

Hydrostratigraphic Units (HU) 1-3 are Quaternary, Paleogene, or Neogene in age. Unit 1 in the study area is primarily loess. Unit 2 includes the alluvial deposits that are in direct communication with the Platte River and are a very important source of groundwater in the study area. Unit 3 is composed of Pleistocene loess and silt. Unit 4 is composed of the fine-grained silts and siltstones of the Ogallala Group. Unit 5 is the sand and sandstone component of the Ogallala Group. Unit 6 is a fine-grained lower unit within the Ogallala that is found at the base of the principal aquifer.

Using previously published maps, the configuration of the principal aquifer beneath the CPNRD reveals a significant aquifer. **Map 4** illustrates the depth to the base of the principal aquifer (the bottom of Unit 5) as mapped by the United States Geological Survey (USGS) in 2015. **Map 5** illustrates the estimated depth to groundwater based on the water table elevation in spring of 2018. Although the configuration of the water table changes throughout the year, **Map 6** illustrates the average saturated thickness of the principal aquifer as reported by the USGS which ranges from 36 to 539 feet across the CPNRD.

Other parameters used to illustrate an aquifer's productivity are transmissivity and hydraulic conductivity. Hydraulic conductivity is a measure of a material's capacity to transmit water. Transmissivity is the hydraulic conductivity multiplied by the thickness of the aquifer. **Maps 7 and 8** illustrate the estimated hydraulic conductivity and transmissivity of the principal aquifer (COHYST 2022). The hydraulic conductivity can vary depending on the aquifer material and porosity. Hydraulic conductivities and transmissivities in the CPNRD are estimated to be from 3 to 325 ft/day and 335 to 63,800 ft^2/day, respectively.

The hydrogeologic properties illustrated in **Maps 4-8** illustrate the enormous capacity of the aquifer that lies beneath the CPNRD. Using the aquifer properties in the maps, a calculation of the volume of water held within the aquifer, or storage, beneath the CPNRD can be made.

2.3 Groundwater Recharge and Soil Types

Groundwater recharge to the aquifers varies across the CPNRD based on several factors including soil type, topography, and vegetation to name a few. The silty, clayey to silty, and sandy soils of the CPNRD were mapped by the UNL CSD and are presented in **Map 9**. According to the map, there are 29 distinct groups of soils based on whether the soil developed on the wind-blown silt deposits (called loess) or in the alluvium and bottomlands. These distinct soil groupings influence the groundwater recharge infiltration rates illustrated in **Map 10**. This data was retrieved from a USGS study of average annual recharge (2000-2009) for the High Plains Aquifer (USGS 2011). The water-infiltration rates are estimates that can vary significantly based on the amount of vegetative cover, soil moisture conditions prior to the precipitation event, and the intensity and duration of the storm. Soil class, topography, and vegetation are important for estimating groundwater recharge and the CPNRD's groundwater supply.

Direct measurements of recharge at the local level are not widely available. Statewide regional recharge estimates for planning and water management purposes have been developed in much of Nebraska through a study using remotely sensed data. For example, estimated regional mean annual recharge rates for the Platte River valley within the CPNRD range from about 1.5 to 4 inches per year. In the uplands beyond the stream valleys, regional estimated annual recharge rates generally range from 1.9 to 3 inches per year (Szilagyi et al. 2005).

In 2007 CPNRD initiated a field investigation in collaboration with the USGS on recharge rates in Central Nebraska (USGS 2008). The results of the study are valuable for this plan since the investigation included a variety of methods. Some of the primary results are summarized as follows:

- Recharge beneath the studied groundwater irrigated site occurred at a rate 11-14 times greater than beneath the dryland or rangeland sites
- Recharge estimates at the irrigated cropland site ranged from 2.7-6.3 inches per year
- Recharge estimates at the dryland site ranged from 0.5-2.5 inches per year
- Recharge estimates at the rangeland site ranged from 0.4-2.1 inches per year

Table 2 Stratigraphic description of geologic and hydrostratigraphic units used in groundwater modeling efforts (Cannia et al 2006).

System	Series	Geologic Unit	Hydrostratigraphic Unit	Description	Water Supply
Quaternary	Holocene	Valley-fill deposits	Unit 2	Gravel, sand, silt, and clay with coarser materials more common. Generally, stream deposits. Upper fine material, if present, is assigned to Hydrostratigraphic Unit 1. Lower fine material, if present, is assigned to Unit 3.	Source of major supply of water in the alluvial valleys. Usually in direct communication with active streams.
	Pleistocene and Holocene	Dune Sand	Unit 1	Generally fine sand but may contain some medium and even coarse sand. May also contain some finer material. Windblown deposits.	Source of water to livestock and domestic wells. Usually shallow water table related to evapotranspiration areas in the models. Often in communication with shallow lakes within the sand hills.
		Loess deposits	Unit 1 when above Unit 2, otherwise Unit 3	Generally, silt, but may contain some very fine sand and clay. Deposited as windblown dust.	Unit generally low transmissivity with occasional fractures. Rarely used as water source for low yielding wells.
	Pleistocene	Alluvial deposits	Unit 2	Gravel, sand, silt, and clay with coarser materials more common. Generally, stream deposits. Upper fine material, if present, is assigned to Hydrostratigraphic Unit 1. Lower fine material, if present, is assigned to Unit 3.	Major source of water for all uses throughout COHYST area. Limited to alluvial valleys and channel deposits in the west and extensive deposits in the east. Often in hydrologic connection with active streams. Generally, of good quality for all uses.
Neogene/Paleogene	Pliocene	Broadwater Formation	Unit 2	Coarse fluvial gravel and sand dominate with some silt and clay. Assigned to Hydrostratigraphic Unit 2. Generally, found in channel deposits north of the North Platte and Platte River.	Major source of water where saturated thickness is sufficient for large capacity wells. Occasionally in communication with Pleistocene sediments.
	Upper and middle Miocene	Ogallala Group	Unit 4-6	Heterogeneous mixture of gravel, sand, silt, and clay. Generally, stream deposits but also contains windblown deposits. Upper fine material, if present, is assigned to Hydrostratigraphic Unit 4. Center coarse material, if present, is assigned to Unit 5. Lower fine material, if present, is assigned to Unit 6. Often sandstone and conglomerate layers exist through our area.	Major source of water throughout much of the study area. Does not exist in eastern part of eastern model area or the northwest corner of the western model area. Generally, yields sufficient water for all uses. Occasionally in communication with Pliocene and Pleistocene sediments.
	Lower Miocene and Upper Oligocene	Arikaree Group	Unit 7	Predominately very fine to fine-grained sandstone but may also contain siltstone. Locally, may contain conglomerate, gravel, and sand.	Major source of water in the northwestern part of the western model unit where sufficient saturated thickness exists to supply large capacity wells. Used for livestock and domestic wells. Generally, in communication with upper and middle Miocene sediments
	Lower Oligocene	Brule Formation of White River Group	Unit 8 of the High Plains Aquifer or Unit 9 if below	Predominately siltstone but may contain sandstone and channel deposits. Sometimes highly fractured with areas of fracturing difficult to predict. Upper part of Brule Formation is included in High Plains aquifer and Hydrostratigraphic Unit 8 only if fractured or contains sandstone or channel deposits, otherwise it is Unit 9	Generally, an aquiclude except where fractured or alluvial channel deposits exist. Fractures and channel deposits generally are only identified in the western model unit along drainage basins. High capacity wells are common where these conditions exist and where they are in communication with overlying saturated

System	Series	Geologic Unit	Hydrostratigraphic Unit	Description	Water Supply
				and is excluded from the High Plains aquifer. Wind-blown volcanic deposits with some fluvial deposits.	sediments that have sufficient transmissivity to supply water at the rate of withdrawal. Often used as stock and domestic wells.
	Upper Eocene	Chadron Formation of White River Group	Unit 9; below the High Plains aquifer	Silt, siltstone, clay, and claystone. Generally, forms impermeable base of High Plains aquifer. Fluvial deposits and wind-blown volcanic deposits.	Generally, an aquiclude except for basal fluvial sediments. These sediments exist as channel deposits in the western and central model areas. They are generally deep and used for domestic or livestock where no other supply exists. Rare high capacity wells exist in the western model unit.
Cretaceous	Undifferentiated	Undifferentiated	Unit 10; below the High Plains aquifer	Shale, chalks, limestone, siltstone, and sandstone. Except for a few minor areas of Fox Hills Sandstone in the extreme western part of the COHYST area and the Dakota Group in the extreme eastern part of the area, generally forms an impermeable base of High Plains aquifer. Deep marine deposits to beach deposits.	Generally, an aquiclude except for sand deposits. Often used as domestic or livestock wells where no other supply exists.

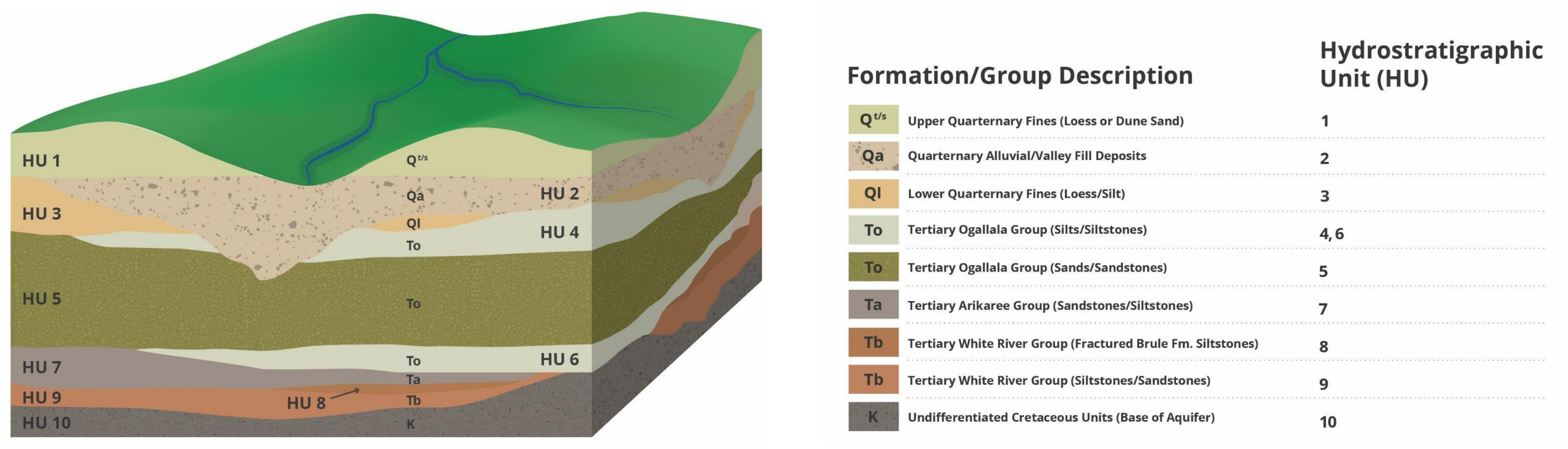

Figure 6 Stratigraphic display of the hydrostratigraphic units identified in the COHYST hydrostratigraphic report (adapted from Cannia et al 2006).

3. GROUNDWATER DEMAND

Preparing an estimate of the groundwater demand in an area involves gathering groundwater use information from a variety of sources. No one entity tracks all water uses across the District, and estimates must be based on information such as population, land use, and groundwater well distribution as part of the analysis. To summarize groundwater demand in the CPNRD, in this section, information is provided on factors that influence water use. There is also a discussion how these factors, groundwater use reporting, and groundwater demand have changed since 1985, when the last GMP was prepared.

3.1 United States Geological Survey Water Use Estimates

The USGS compiles national water use estimates periodically by county. Currently, the most recent USGS compilation was for the year 2015 (USGS 2018). Groundwater use for the eleven CPNRD counties is categorized into five major uses: public supply, domestic, industrial, irrigation, and livestock. **Table 3** provides the USGS estimated groundwater use for each category in acre-feet per year. This is one way to look at water use in the CPNRD but it does not tell the whole story. For one, the data provided is for each entire county. Only Dawson County has 100 percent of the land area within the CPNRD. For this reason, **Table 3** is an overestimate of the water use in the CPNRD, but it does provide an estimate and a starting point for discussion. To better understand the number of irrigated acres within the CPNRD by county, **Table 4** is provided as a comparison.

Table 3 Estimated water use (acre feet per year) in 2015 by county (USGS 2018).

County	Percent of County in CPNRD	Public Supply	Domestic	Industrial	Irrigation	Livestock	Total
Buffalo	64%	7,230	5,134	2,365	265,560	1,894	282,183
Custer	11%	1,323	1,188	0	281,870	5,537	289,918
Dawson	100%	6,692	2,634	740	279,210	4,282	293,558
Frontier	4%	303	291	0	71,640	986	73,220
Hall	99%	13,383	6,120	2,634	223,610	1,177	246,924
Hamilton	9%	1,390	1,188	2,343	276,410	740	282,071
Howard	9%	628	684	0	140,300	1,390	143,002
Merrick	94%	897	863	0	191,330	897	193,987
Nance	12%	415	404	0	81,810	773	83,402
Platte	4%	5,560	1,894	8,810	224,180	3,564	244,008
Polk	42%	437	583	0	182,900	1,480	185,400
Total		**38,258**	**20,983**	**16,892**	**2,218,820**	**22,720**	**2,317,673**
Percent of Total		1.7%	<1%	<1%	96%	1%	100%

Table 4 Area of CPNRD irrigated acres by county (provided by CPNRD).

County	County Area (acres)	CPNRD Irrigated Acres
Buffalo	619,590	180,682
Custer	1,648,333	28,280
Dawson	648,378	293,870
Frontier	623,738	6,358
Hall	349,626	223,705
Hamilton	347,443	13,229
Howard	364,378	20,207
Merrick	310,323	184,429
Nance	282,643	12,209
Platte	431,398	7,211
Polk	280,538	58,570
Total	**5,906,387**	**1,028,750**

3.2 Population

In some parts of the state, changes in population may have a measurable effect on groundwater demand. For example, in the Papio-Missouri River NRD, with the state's two largest cities, over 65 percent of groundwater used in the District is for public water supply and domestic water use. Compare that with the CPNRD counties where less than 3 percent of the total groundwater used is for drinking water, so population change in the CPNRD may result in less of an effect on groundwater demand.

Table 5 presents the 2000 and 2020 populations within the CPNRD by county. This presents only the population within the CPNRD, rather than the entire county.

Based on the data provided by the CPNRD, there has been an overall decline in population by 5 percent. That does not describe the whole picture of population trends in the CPNRD, because in Buffalo, Platte, and Hall Counties where the three cities of Kearney, Columbus, and Grand Island are located, there have been population increases ranging from 3% to 20%. Even with these gains, the groundwater demand by public water systems and domestic wells has not made a significant impact on the water use in CPNRD. As noted in the 1985 GMP, the important parameter to watch is irrigation water use which relates to land use, the next topic to consider.

Table 5 County populations in the CPNRD in 2000 and 2020 (provided by CPNRD).

County	2000 Population	2020 Population	Percent Change (%)
Buffalo	39,038	46,786	20%
Custer	543	444	-18%
Dawson	24,365	24,111	-1%
Frontier	607	525	-14%
Hall	53,527	62,895	18%
Hamilton	633	670	6%
Howard	797	745	-7%
Merrick	7,568	7,092	-6%
Nance	243	143	-41%
Platte	508	521	3%
Polk	1,194	1,045	-12%
Average Percent Change over all Eleven Counties			**-5%**

3.3 Land Use

In addition to the information presented in Section 3.1, another way to estimate the amount of water used for irrigation is through land use mapping. **Map 11** illustrates land use across the District based on 2019 land use information mapped by the Multi-Resolution Land Characteristics Consortium (MRLC 2019). A summary of the number of acres of each land use type is provided in **Table 6**. The dominant land use type in the District is Cultivated Crops. **Map 12** shows the certified irrigated acres and acres that are considered sub-irrigated in the CPNRD. The certified irrigated acres represent a snapshot of the maximum number of acres that could be irrigated.

Table 6 Land uses in the CPNRD. (MRLC 2019)

Land Use Class Name	Acres
Barren Land	1,934
Cultivated Crops	1,157,684
Deciduous Forest	7,229
Developed, High Intensity	6,570
Developed, Low Intensity	37,705
Developed, Medium Intensity	20,948
Developed, Open Space	56,376
Emergent Herbaceous Wetlands	38,811
Evergreen Forest	263
Hay/Pasture	17,928
Herbaceous	702,773
Mixed Forest	832
Open Water	24,410
Shrub/Scrub	1,924
Woody Wetlands	64,406
Total	2,139,792

Data collected by the United States Department of Agriculture (USDA) provides a further breakdown of crop type (**Table 7**). The principal crops grown in the area consist of corn, soybeans, and alfalfa. Corn and soybeans account for the majority of the groundwater-irrigated crops. Slight discrepancies between the total number of cropped acres between Tables 4 and 5 can be attributed to differing years and data collection methods.

Table 7 Crop types grown in the CPNRD. (USDA 2021)

Crop Type	Acres
Alfalfa	66,479
Barley	88
Barren	1,368
Corn	783,727
Dry Beans	83
Fallow/Idle Cropland	1,650
Millet	287
Oats	2,135
Other Crops	2
Other Hay/Non Alfalfa	4,596
Peas	77
Popcorn or Ornamental Corn	3,707
Rye	941
Sorghum	9,304
Soybeans	292,273
Spring Wheat	62
Sweet Corn	81
Triticale	47
Winter Wheat	5,281
Other	236
Total	1,172,422

The groundwater demand for the irrigated crops in the CPNRD was estimated using information on the crop information requirements and information from the NeDNR. Specifically, crop irrigation requirements were calculated using net irrigation requirements (NIR) for various crop types derived from land use data. The requirements are calculated by a software program called CropSim, which was developed at the University of Nebraska. CropSim calculates water consumption for various types of crops and vegetation growing in a variety of soil types. CropSim uses crop coefficients, reference crop evapotranspiration values and climatic conditions to predict NIR. NIR is the net amount of water needed to supplement precipitation water stored within the soil to achieve optimal crop yield.

The results of this analysis provided an estimate of groundwater irrigation for the past 25 years. **Figure 7** represents the groundwater demand in acre-feet for the major crop types in the

CPNRD. This data was also used to develop the COHYST groundwater model. Variability in precipitation greatly affects a crop's reliance on supplemental irrigation, and groundwater demand is noticeably low for certain years, namely the wet years of 1993 and 2010. Conversely, dry years like 2012 saw a large increase in groundwater demand to supplement below average natural precipitation totals.

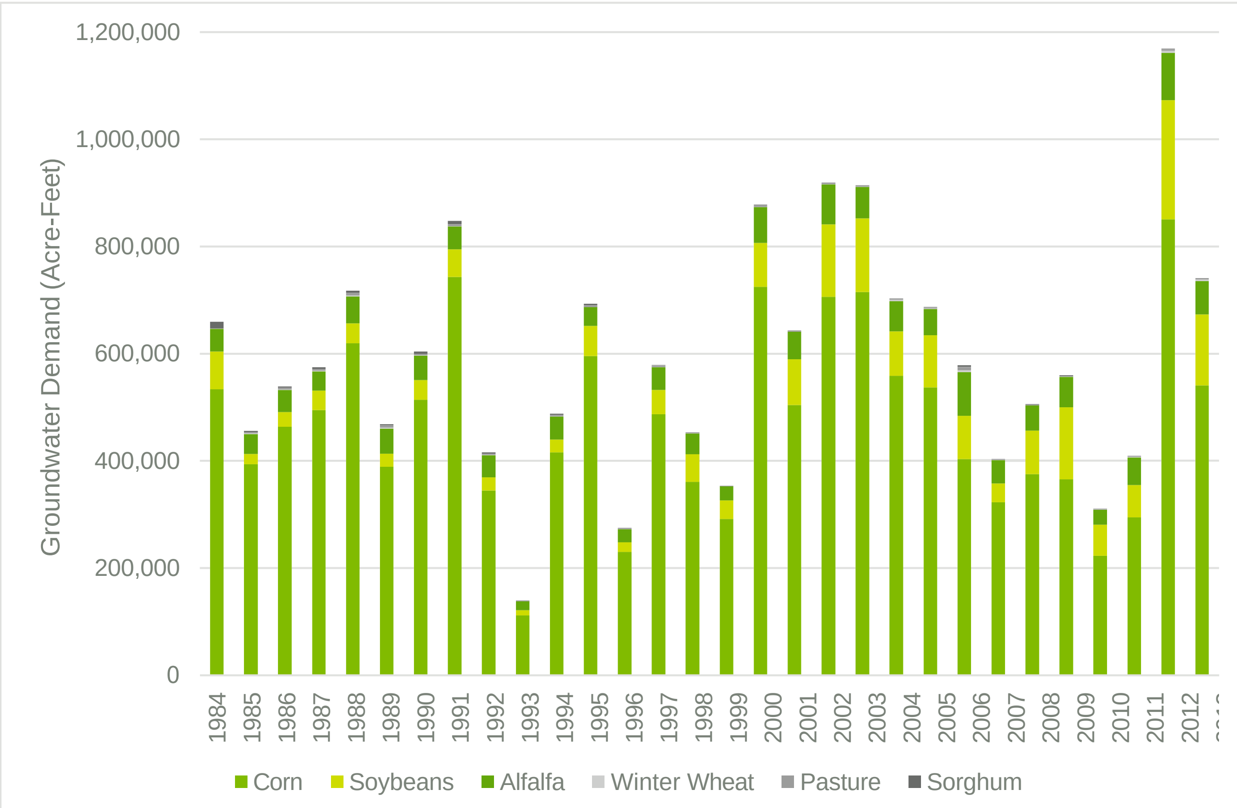

Figure 7 Groundwater demand of groundwater irrigated crops in the CPNRD from 1984 to 2013.

3.4 Well Registration

Another way to look at how groundwater demand has changed since the 1985 GMP is to evaluate types and number of registered groundwater wells. As of May 2021, there were 25,594 active registered wells in the CPNRD (NeDNR 2022). **Table 8** compares the number and type of registered wells in 1985 and the number of wells in May 2022. By looking only at the total number of registered wells, the initial impression is that the number of registered wells has multiplied nearly two and a half times. A straight comparison of the number of registered wells is not valid, though, because up until 1993, registrations were only required for municipal, irrigation, and industrial wells; and excluded domestic or other types of non-supply type wells (such as monitoring or groundwater heat exchange wells).

Table 8 Wells registered in the CPNRD in 1985 and 2022.

Registered Well Type	Active Registered Wells in 1985*	Active Registered Wells in 2022
Irrigation	10,710	17,112
Industrial/Commercial	26	143
Other	53*	8,339
Total Wells	***10,789***	***25,594***

*In 1985, well registrations were only required for municipal, irrigation, and industrial wells.

A full tally of the number of active registered wells in the CPNRD is listed in **Table 9**, and **Map 13** illustrates the spatial distribution of current groundwater wells, categorized by type, across the CPNRD. Municipal and public water supply wells are not included in this inventory; however, a description of the calculation of municipal water use within the CPNRD is included in the IMP (see Section 10.6.1.5 of CPNRD IMP, **Appendix B**). The locations of municipal supply wells are considered confidential information and not included in this plan. **Map 14** includes the wellhead protection areas that designate the source water boundaries for municipal water supply systems across the CPNRD (personal communication, NDEE). Each wellhead protection area is regulated by NDEE and the local water provider to protect the drinking water resource of residents in the vicinity. City ordinances or county zoning regulations may be enforced to restrict fertilizer application, livestock counts, fuel storage, etc. in the interest of preserving water quality.

Table 9 All active registered wells in the CPNRD, 2022.

Registered Well Type	Active Registered Wells, May 2022
Domestic	4,358
Ground Heat Exchange	267
Industrial / Commercial	143
Injection	149
Irrigation	17,112
Livestock	1,040
Monitoring	1,689
Observation	372
Recovery	40
Other	424
Total Wells	***25,594***

3.5 Well Distribution

Another way to illustrate where the demand for groundwater is concentrated is to calculate the density of well development across the District. **Map 15** was generated by calculating the density of active high-capacity wells registered per mile across the District. The areas with the highest density of active irrigation wells are within the stream valley aquifers of the Platte River. Conversely, the areas with the lowest density of irrigation wells are in the upland areas where groundwater aquifers are isolated and highly variable in their production capacity. Thus, the distribution of high-capacity wells is correlated to the distribution of groundwater aquifers in the District because the density of high-capacity wells can only be accommodated in the more productive stream valley aquifers.

3.6 Climate Change and Water Resources

Nebraska's climate is changing. This has been documented by rigorous scientific measurements completed by climate scientist and citizens across the state. According to the United States Environmental Protection Agency (EPA), in the past century, most of the state has warmed by at least one degree Fahrenheit (F) (US EPA 2016). Currently, there is a public debate about the cause of climate change but according to the world's leading scientists, the warming of our planet is unequivocal and the data in **Figure 8** illustrates this fact.

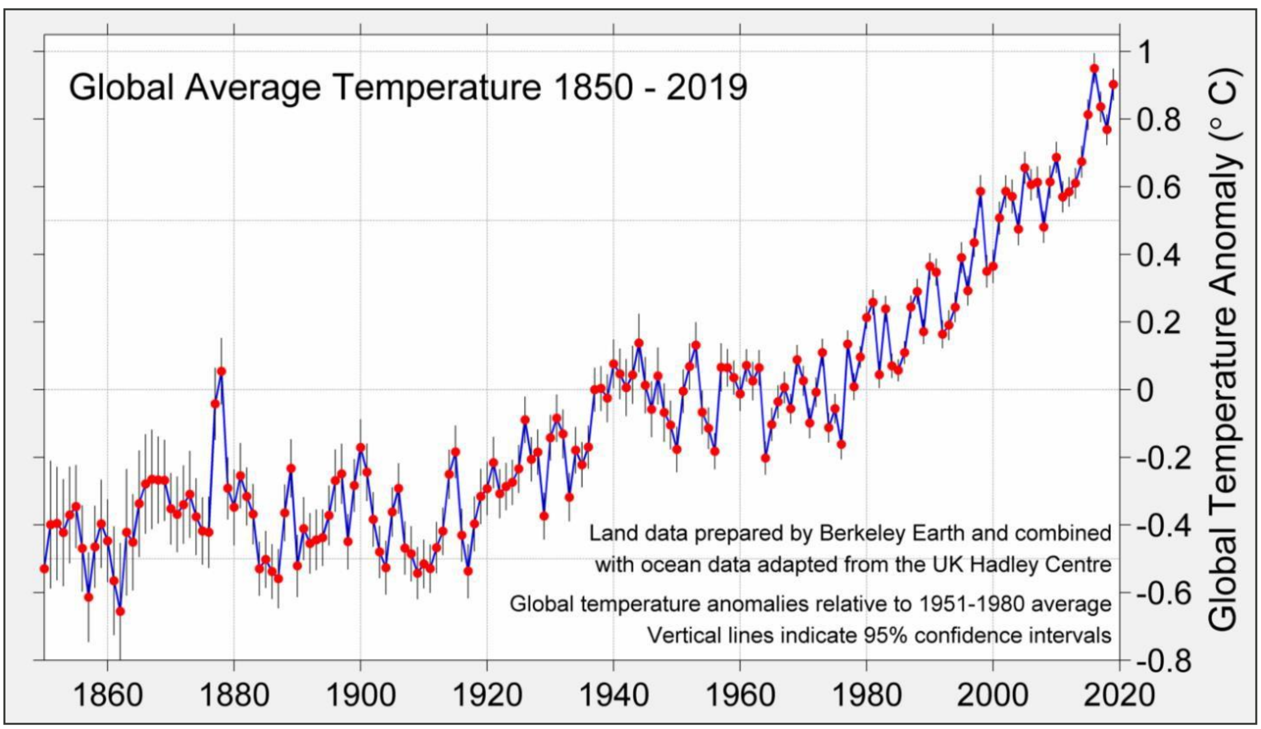

Figure 8 Global average temperature 1850-2019 (Berkeley Earth 2021).

The question for the CPNRD and for this GMP update is: how will this change affect the District's water resources? Numerous publications have been written to answer these questions and the following excerpts are provided in response:

How will precipitation patterns change in Nebraska?

> *Although summer droughts are likely to become more severe, floods may also intensify. During the last 50 years, the amount of rain falling during the wettest four days of the year has increased about 15 percent in the Great Plains. River levels during floods have become higher in eastern Nebraska. Over the next several decades, heavy downpours will account for an increasing fraction of all precipitation, and average precipitation during winter and spring is likely to increase. Both of these factors would further increase flooding. (US EPA 2016).*

These predictions were also documented in the publication, *Understanding and Assessing Climate Change, Implications for Nebraska* (Wilhite et al 2014). The data presented indicate that since 1895 in Nebraska:

- Temperatures have risen about 1º F
- Frost-free season has increased 5-25 days
- Very heavy precipitation events have increased 16 percent

The UNL report provided the following predictions for the state:

- A temperature increase of 4-5ºF or 8-9ºF by 2100
- Summer of 2100 will have 13-25 days over 100ºF
- Increasing heavy precipitation events
- Increasing flood magnitude
- Increasing drought frequency and severity

Furthermore, there are some predictions that the changes may have both negative and positive effects.

How will increased temperature affect agriculture in Nebraska?

> *Hot weather causes cows to eat less and grow more slowly, and it can threaten their health. Increased winter and spring precipitation could leave some fields too wet to plant, and warmer winters may promote the growth of weeds and pests. Hotter summers and drier soils would cause droughts to become more intense. Increased drought, along with a greater number of extremely hot days, could cause crop failures. Even where ample water is available, higher temperatures would reduce yields of corn.*

> *Increased concentrations of carbon dioxide, however, may increase yields of wheat and soybean enough to offset the impact of higher temperatures. Warmer and shorter winters may allow for a longer growing season, which could allow two crops per year instead of one in some instances. Increased precipitation at the beginning of the growing season could also be beneficial to some crops. (US EPA 2016)*

With this uncertainty, the need to update the CPNRD's GMP to ensure that the District has considered the predicted changes is even more apparent. In Section 6 of this plan, the predicted changes in temperature and precipitation in Central Nebraska have been evaluated through a series of groundwater modeling scenarios simulating increased irrigation. These modeling simulations provide insight into how the groundwater management actions taken now can help mitigate some of the negative effects that climate change will have on CPNRD's groundwater resources now and in the future.

3.7 The Value of Water

As required under Neb. Rev. Stat. § 46-709 (13), a groundwater management plan is to describe the relative economic value of different uses of groundwater proposed or existing within the District. As described in Section 3.1, the primary groundwater uses within the CPNRD are domestic, agricultural, and industrial. The price of water within CPNRD generally follows the priority for water use designated by the state, with domestic often being more expensive than agriculture water because of the cost of delivery, infrastructure, and treatment requirements in urban environments and for domestic use.

According to a statewide survey conducted by the Nebraska League of Municipalities, Grand Island, one of the largest communities in the CPNRD, has very competitive water rates that it charges to its residents and businesses. As reported in the survey, a typical Grand Island family using 10,000 gallons of water a month pays about $7 less per month than most families using the same amount of water in Nebraska cities of 5,000 to 100,000 in population. The average across Nebraska was $17.54 a month, while Grand Island's rate was $10.26. Likewise, commercial customers using about 200,000 gallons of water a month, such as an apartment high-rise or a school, pay about half the amount in Grand Island that they would pay in other Nebraska cities — $114 in Grand Island versus $226 in the survey average (The Independent 2002).

The cost of water for agriculture can be evaluated by reviewing the cost paid by producers to irrigate using surface water. According to a recent press release, the Central Nebraska Public Power and Irrigation District reported that 2019 irrigation service rates would be $34.61 per acre for a base allotment of 9 inches. That said, in 2019, the cost to irrigate 80 acres with 9 inches per acre would be $2,768.80 (The Kearney Hub 2019).

Since life and virtually all economic enterprises within CPNRD would not be viable without water, the true value of water is not reflected by simply the cost it takes to attain and use the resource. For example, consider how groundwater declines have impacted the economy of Kansas. Between 1996 and 2005, groundwater withdrawal reduced Kansas' wealth approximately $110 million per year or nearly $1 billion in 9 years (Fenichel et al 2016).

In the CPNRD, changes to the timing, duration, and/or intensity of precipitation and recharge would have a significant impact to the economy of the District. Organizations such as the U.S. Water Alliance have an ongoing campaign called "the Value of Water" to educate and inspire the nation about how water is essential, invaluable, and in need of investment.

4. CURRENT MONITORING AND MODELING

In order to develop an effective approach to groundwater quantity and quality management within the CPNRD, an understanding of the current groundwater quantity and quality issues and opportunities is vital. Consequently, the water supply within the CPNRD is monitored for both water quantity and water quality. The groundwater monitoring data is used to illustrate water level trends and it is also used as input into groundwater modeling programs to evaluate the long-term viability of the water supply. In this section, the current CPNRD, state, and federal groundwater monitoring programs are described with a discussion of recent monitoring results. Following the discussion on monitoring, the current state-of-the-art groundwater modeling programs used to evaluate CPNRD's groundwater resources are presented. The modeling discussion includes a synopsis of the groundwater modeling completed as part of this GMP update to evaluate the groundwater controls that are best suited to ensure that the water supply will be sufficient for beneficial use now and in the future.

4.1 Groundwater Quantity Monitoring

Currently, over 400 groundwater levels are collected from irrigation and observation wells in both the spring and the fall each year. The network of monitoring wells is distributed across the entire District with one well located approximately every three miles (**Map 5**). Water level measurements are compared to the baseline water level measurements of 1982 and the previous year's water levels to establish water level changes and trends over time.

The saturated thickness of the aquifer varies across the District and therefore a water level drop of one foot has a more significant impact on some parts of the District than on others. Along with the aquifer conditions (saturated thickness, hydraulic conductivity, depth to water), the soil type, irrigation intensity, and topographic characteristics vary across the District. For these reasons, twenty-four Groundwater Management Areas (GWMAs) were established to document water level changes across the various regions of the District (**Photo 3**). As part of the groundwater quantity monitoring program, groundwater depths and aquifer saturated thicknesses are used to help evaluate the water level changes over time. Based on the characteristics of each GWMA, the maximum acceptable decline (MAD) was calculated for each of the management areas and presented in the 1985 GMP (**Table 10**).

Photo 3 A water level measurement being collected from an observation well.

Table 10 Maximum acceptable decline for each groundwater management area.

Groundwater Management Area	"Maximum Acceptable" Water Level Decline in feet bgs	Groundwater Management Area	"Maximum Acceptable" Water Level Decline in feet bgs
GMWA 1	30	GMWA 13	15
GMWA 2	20	GMWA 14	15
GMWA 3	20	GMWA 15	15
GMWA 4	20	GMWA 16	15
GMWA 5	30	GMWA 17	10
GMWA 6	30	GMWA 18	10
GMWA 7	30	GMWA 19	10
GMWA 8	20	GMWA 20	10
GMWA 9	25	GMWA 21	20
GMWA 10	20	GMWA 22	10
GMWA 11	15	GMWA 23	10
GMWA 12	25	GMWA 24	20

Note: bgs = below ground surface

The water level monitoring data is evaluated each year and water level trends calculated by the CPNRD staff are presented to the Board of Directors and the public. For example, the spring 2020 water level measurements were reported as follows:

> “The average spring groundwater levels across the District had an accumulated gain of 3.29 feet from spring 1982 to spring 2020…A majority of the NRD’s 24 Ground Water Management Areas (GWMAs) saw increases because of above-average precipitation during 2019 that continued through this spring. Last year’s groundwater levels were also up 2.08 feet compared to 1982 because of the above-normal precipitation. Six of the 24 GWMAs are currently below the 1982 groundwater levels and subject to the 25% decline regulation that does not allow transfers of irrigated acres into the areas or supplemental wells.”

The 25 percent decline regulation referred to in the quote, is one of the groundwater management actions implemented under the Groundwater Rules and Regulations (CPNRD 2022a). As written in the 1985 GMP and the Groundwater Rules and Regulations, the maximum acceptable decline sets forth a series of actions to manage groundwater quantity across the District. The rules incorporate the following water quantity phase levels, triggers, and controls listed in **Table 11**.

Table 11 Summary of triggering criteria and subsequent restrictions (CPNRD 1985).

Phase Level	Percent of “Maximum Acceptable” Water Level Decline	Irrigation Well Spacing	Percent Reduction in Annual Irrigation Acreage
Phase I	Decline is < 50 percent	---	---
Phase II	50 percent	900 feet	25 percent
Phase III	70 percent	1,200 feet	50 percent
Phase IV	90 percent	1,500 feet	75 percent
Phase V	100 percent	1,800 feet	Not specified[1]

[1] The percent reduction in annual irrigated acres will be set by the CPNRD Board of Directors when the percent maximum acceptable water level decline is 100 percent.

The phased approach illustrated in **Table 11** was the heart of the water quantity management plan in the 1985 GMP. The plan involved implementing, or potentially removing, a succession of more stringent controls based on annual water level monitoring in the 24 GWMAs. For example, if a GWMA had water level declines that, on average, were greater than 50 percent of the maximum acceptable decline, any new irrigation wells within the GWMA would need to be placed a minimum of 900 feet apart from another registered irrigation well and the District would implement a “rotation” as an additional management device. As described in the 1985 GMP:

> *“It is the District’s philosophy that each acre that an irrigator wishes to irrigate should receive sufficient water to grow a crop using the best available technology for water use*

efficiency. In other words, the planning committee and Board did not wish to suggest that irrigators attempt to grow crops with less than a reasonable water requirement to produce desired yields. This is generally the philosophy of a restrictive allocation system (all acres receiving less water than needed for full production), whereas rotation as used in this plan means that fewer acres receive an adequate amount of water."

There have been some questions among the CPNRD staff and Board of Directors about how this paragraph is interpreted and how the planned "rotations" are to be carried out. Furthermore, based on the monitoring results over the past 35 years, there are several GWMAs that consistently have had sustained water level declines even with implementation of the phased water quantity controls. For this reason, one goal of this GMP update is to evaluate the groundwater quantity triggers and controls and update them, as needed, based on the current understanding of the aquifer response to irrigation, management triggers, and controls. More about how the 1985 GMP triggers and controls were evaluated for this GMP update is presented in Section 4.5 and recommended changes to the triggers and controls are presented in Section 6.0.

4.2 Groundwater Quality Monitoring

The CPNRD maintains a groundwater quality monitoring program that collects water samples across the District annually to evaluate nitrate levels, which is the primary contaminant of concern. The monitoring program was established in the 1985 GMP and has since been updated in the Groundwater Rules and Regulations. The objectives and phases of the water quality program are based upon the experience, studies, and research that have been conducted over the past several decades.

The objectives of the program are to:

- Extract the nitrates in the groundwater by utilizing them for the nitrogen needs of the crop;
- Fully utilize the residual nitrates in the soil profile for the nitrogen needs of the crop;
- Reduce fertilizer applications to account for nitrogen available in the soil and irrigation water;
- Reduce the "opportunity time" for fertilizer to leach below the root zone;
- Encourage farm practices, techniques and the installation of equipment that have proven to be helpful in reducing groundwater nitrate levels and nitrate leaching;
- Research new equipment and techniques that have potential for reducing groundwater nitrates.

The CPNRD's program establishes management areas in those parts of the District where groundwater quality is a problem, with each problem area being placed in a category or "Phase" depending upon the level of nitrates or other contaminates within that area. Phase I quality management areas are established when the average nitrate level within an area reaches 0 to 7.5 parts per million (ppm). In a Phase I quality management area, the CPNRD coordinates with the University of Nebraska and the Natural Resources Conservation Service and emphasizes irrigation and fertilizer management through information, education, and demonstration programs, and selects, from a number of the alternatives, those management and assistance programs they feel will be most appropriate for that given area. Farming practices, techniques and equipment that have proven to be helpful in reducing nitrate levels will be supported and demonstrated by the CPNRD with the widespread installation of those techniques and equipment on a voluntary basis with the landowners. Irrigators within a Phase I quality management area are prohibited from making fall applications of fertilizer on sandy soils in order to reduce the “opportunity time" for leaching. The controls that are implemented when an area reaches Phase I are as follows;

- Restrictions on timing and location of commercial nitrogen fertilizer application

Areas that have average nitrate levels of 7.6 ppm to 10.0 ppm, are determined to be in a Phase II quality management area (or a control area). In a Phase II quality management area, the CPNRD uses the activities and techniques utilized in a Phase I area and will, in addition, implement mandatory regulations. Those additional regulations include a requirement that all irrigators be certified by attending a class and training session on fertilizer management and irrigation water management, similar to the current program on pesticides. To reduce the amount of commercial fertilizer applied irrigators are required to test their irrigation water to determine how much nitrogen would be applied through the water during irrigation and test for residual nitrates in the root zone to determine how much carry-over nitrogen is available for next year's crop. Controls for areas in Phase II quality management are:

- All controls for the Phase I area will apply to Phase II Areas
- Producer certification through educational programs describing best management practices
- Groundwater quality sampling and analysis
- Deep soil sampling and analysis
- Calculating nitrogen requirements using methods approved by the CPNRD Board
- Monitoring water use with meters or another approved method by the CPNRD Board
- Annual reporting to CPNRD

Phase III quality management areas are established on those areas where the average nitrate concentration in the groundwater is, or later becomes, 10.1 ppm or greater. In a Phase III quality management area, the CPNRD will carry out the same type of demonstration, education, and regulation program as in Phase I and Phase II areas and will impose additional regulations.

Such regulations include a requirement that part of the commercial fertilizer be applied by side dressing, to further reduce the "opportunity time" for leaching; and such other reasonable regulations as the Board feels are necessary to resolve the problem.

Water quality controls for areas in Phase III are:

- All controls for the Phase II area will apply to Phase III areas.
- Restrictions on application rate of commercial nitrogen fertilizer and use of inhibitor

A summary of controls for groundwater quality are summarized below:

- Voluntary adoption of farming practices, techniques, and equipment that are proven to reduce nitrate levels through cooperation of the CPNRD and landowners
- Restrictions on timing and location of commercial nitrogen fertilizer application
- Groundwater quality sampling and analysis
- Deep soils sampling and analysis
- Calculating nitrogen requirements using methods approved by the CPNRD Board
- Educational programs describing best management practices
- Monitoring water use through metering or another approved method by the CPNRD Board
- Annual reporting to CPNRD (could include water use, fertilizer application, soil sampling, water sampling, etc.)
- Restrictions on application rate of commercial nitrogen fertilizer and use of inhibitor

A map of the current active Phases is included as **Figure 9**. As part of the water quality monitoring program, the CPNRD reviews this map annually based on water samples collected each year. As of the writing of this plan, there are approximately 576,577 irrigated acres in Phase I, 228,439 irrigated acres in Phase II, and 224,201 acres in Phase III (CPNRD 2022b). The majority of the Phase II and III acres lie along the Platte River in Buffalo, Hall, and Merrick Counties.

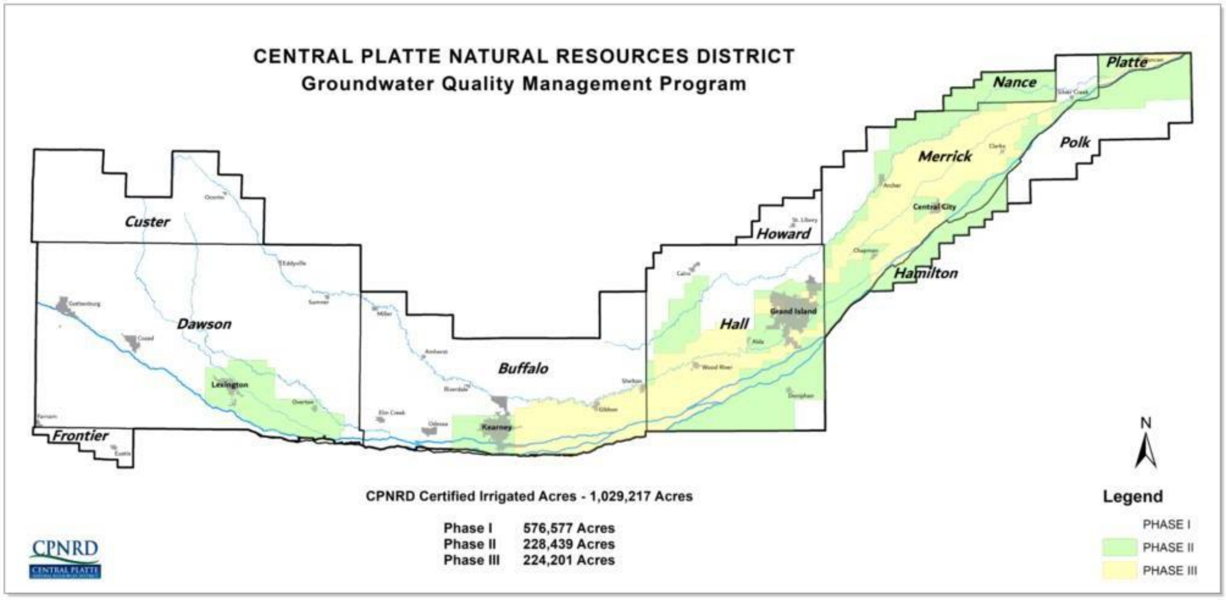

Figure 9 Map showing certified irrigated acres in a water quality Phase I, II or III area (CPNRD 2022b).

5. GROUNDWATER GOALS AND OBJECTIVES

5.1 Goals, Objectives, and Proposed Actions

The CPNRD's Groundwater Management Quantity goal is to assure an adequate supply of water for feasible and beneficial uses through proper management, conservation, development and utilization of the District's water resources. The "life" goal is to maintain a sustained groundwater reservoir life, having no targeted demise, and use monitoring to trigger controls. CPNRD collects groundwater level observations and administers programs for irrigation runoff, groundwater quantity, groundwater quality, groundwater modeling, as part of a comprehensive groundwater management program.

5.2 Original GMP Water Quantity Objectives

In the 1985 GMP, a phased program to implement controls was developed based on a specified maximum acceptable decline for each GWMA. The maximum acceptable decline ranges from 10' in the eastern end of the District to 30' in portions of the western end of the District. If the water table falls to 50% of that maximum decline (5 and 15 feet respectively for each of the range parameters), Phase II would go into effect for any area or areas affected, triggering mandatory reductions in irrigated acres and establishing spacing limits for new irrigation wells. Further declines to 70%, 90% & 100% of the maximum acceptable decline will trigger Phase III, IV and V controls respectively, mandating additional cutbacks in irrigated acreage and increased spacing limits for new wells.

Complete details of the controls are available in District publications. Because of the differences in the aquifer depth and conditions, it is conceivable that some areas could be in the higher phases while other areas may always be in Phase I.

The original CPNRD GMP was formulated around a concept of limiting the decline of the water table within each management subarea. With the exception of subareas 4, 5, 11, 22, 23, and 24 (all generally located along the Platte River) groundwater declines between 1982 and 2020 were expected to be significant, generally ranging from 30 to 100 feet. This was considered to be an undesirable outcome, therefore a “maximum acceptable decline” (MAD) was defined for each subarea, determined by agreement of the members of the committee formulating the GMP. Following this determination, a reduction in irrigated acres was determined, based upon use of a groundwater model, that would limit the water table declines to the MADs. For five of the management subareas this could not be accomplished as those subareas fell outside of the existing groundwater model. Also, the management areas noted above (located along the Platte River) were not expected to require any reduction of acres. The remaining subareas, and the level of irrigated acres in 1982, are listed in **Table 12** below.

Table 12 The number of irrigated acres by GWMA in 1982.

GWMA	1982 Irrigated Acres
1	28,617
2	10,246
3	60,575
6	29,597
7	26,290
8	19,788
9	50,012
10	23,756
12	8,565
13	31,009
14	64,624
16	17,765
17	56,969
18	45,413
Total	473,226

Table 13 lists the estimated percentage of these irrigated acre totals that would be able to occur without exceeding the MADs, along with the number of acres this percentage corresponds to.

As some of these reductions are fairly large and would be larger in the future if there were an expansion in irrigated acres (i.e., including acres developed after 1982), a phased system was developed in order to implement the reductions more gradually. The plan envisioned a scenario whereby the irrigated acres would stay the same until 1995, be reduced by 25% of the reduction target in 1996, then reduced to 50% of the reduction target in 2001, then reduced to 75% of the reduction target in 2006, and finally getting to the full reduction target in 2010.

Table 13 Level of development that was determined achievable without exceeding the MAD.

GWMA	Predicted Stable Percent	Final Irrigated Acres
1	80%	22,894
2	80%	8,197
3	95%	57,546
6	80%	23,678
7	80%	21,032
8	90%	17,809
9	60%	30,007
10	75%	17,817
12	70%	5,996
13	80%	24,807
14	50%	32,312
16	90%	15,989
17	75%	42,727
18	80%	36,330
Average/Total	**78%**	**357,140**

Modeling simulations suggested that most MADs would not be exceeded under this type of scenario. Therefore, the plan has phase triggers that restrict the number of irrigated acres, starting with Phase II, to some percentage of the difference between 100% of the 1982 irrigated acres, decreasing as each phase trigger has hit by 25% of that difference in Phase II, 50% in Phase III, 75% in Phase IV, and 100% in Phase V. The percentages that would apply to each subarea under each phase are outlined in **Table 14.**

Table 14 Reduction percentage needed by GWMA to hit allowable number of irrigated acres.

GWMA	Phase II	Phase III	Phase IV	Phase V
1	95%	90%	85%	80%
2	95%	90%	85%	80%
3	99%	98%	96%	95%
6	95%	90%	85%	80%
7	95%	90%	85%	80%
8	98%	95%	93%	90%
9	90%	80%	70%	60%
10	94%	88%	81%	75%
12	93%	85%	78%	70%
13	95%	90%	85%	80%
14	88%	75%	63%	50%
16	98%	95%	93%	90%
17	94%	88%	81%	75%
18	95%	90%	85%	80%
Average	**94%**	**89%**	**83%**	**78%**

Table 15 outlines the allowable number of irrigated acres by management subarea under each phase of increased management.

Table 15 Number of allowable acres by GWMA during each phase of the acre reduction plan outlined in the original GMP.

GWMA	Phase II	Phase III	Phase IV	Phase V
1	27,186	25,755	24,324	22,894
2	9,734	9,221	8,709	8,197
3	59,818	59,061	58,303	57,546
6	28,117	26,637	25,157	23,678
7	24,976	23,661	22,347	21,032
8	19,293	18,799	18,304	17,809
9	45,011	40,010	35,008	30,007
10	22,271	20,787	19,302	17,817
12	7,923	7,280	6,638	5,996
13	29,459	27,908	26,358	24,807
14	56,546	48,468	40,390	32,312
16	17,321	16,877	16,433	15,989
17	53,408	49,848	46,287	42,727
18	43,142	40,872	38,601	36,330
Average	**444,205**	**415,183**	**386,162**	**357,140**

It’s important to emphasize that this management scheme was developed around an understanding that in the absence of enhanced management, groundwater levels would continue to decline beyond the MADs, in some places many times the value of the MADs. There was little question whether these phases would be reached and need to be implemented, only some uncertainty over when they would be reached and if these acreage limits would really be enough.

However, none of these management actions have ever been implemented. The status of each subarea was Phase I in 2020. This remained the case although current irrigation development is significantly greater than the 1982 level of development. **Table 16** lists the expected reductions in irrigated acres in each subarea as compared to the actual change relative to the 1982 level of development.

Table 16 Actual change in irrigated acres compared to reductions proposed in the original GMP.

GWMA	Predicted Stable Percent	Actual change
1	80%	63%
2	80%	341%
3	95%	168%
6	80%	38%
7	80%	137%
8	90%	161%
9	60%	149%
10	75%	164%
12	70%	226%
13	80%	137%
14	50%	142%
16	90%	122%
17	75%	142%
18	80%	113%
Average/Total	**78%**	**150%**

5.3 Groundwater Quantity Management Area Recommendations

The original 24 GWMAs were first established in the 1985 GMP based on soil types and political boundary divisions. During the development of this plan, it was determined that two of the existing GWMAs be split into smaller areas to form a total of 26 GWMAs. GWMA 7 and 9 were split into 7a, 7b, 9a, and 9b based on level of development, hydrologic, and political boundaries (**Map 16**). It is recommended that these areas be managed in the same way as the existing GWMAs (i.e., each subdivided GWMA should be managed using the MAD from the original GWMA). The stratigraphic boundary of the proposed GWMAs is the entire High Plains Aquifer as referenced in **Table 2**. No other changes to the configuration of the GWMAs are recommended at this time. While this plan represents the best science by using models to project future conditions in each GWMA, it is acknowledged that the future is inherently unknown. As such, the CPNRD may need to make further changes to GWMA boundaries as needs arise. Decisions to alter GWMA boundaries will be made upon recommendation by a consultant or groundwater modeling expert.

As evidenced by the fact that the current Phase II trigger has never been encountered, it seems that the future management of the GWMAs would benefit from a somewhat more pro-active approach. Therefore, it is recommended that the Phase II trigger be changed to reflect 25% of the MAD, with Phase III and Phase IV occurring at 50% and 75% of the MAD, respectively. The way these phase triggers would interact with required water management is outlined in Section 6.

The MAD for each GWMA was determined during the writing of the original GMP in 1985. Generally, the MAD of each GWMA represents approximately 10% or less of the average saturated thickness in each subarea. Since the MADs are relatively small when compared to saturated thickness, they truly are “acceptable.” Given that the MADs have never been reached in any GWMA, it is recommended that the MADs determined in the original Plan stay consistent into the future.

5.4 Future Scenario Modeling Results

In the years since the original GMP was written, the COHYST groundwater model was developed to simulate the historical, current, and future water budget of central Nebraska in the Platte River Basin. COHYST has been used as the evaluation tool for the NeDNR to determine whether the CPNRD has met the goals and objectives set forth in their IMP. While the GMP exists as a separate document with a different purpose, it seems that it should maintain consistency with the IMP. For this reason, the COHYST model will be used to evaluate the likely future change in groundwater levels within each GWMA. Specifically, the COHYST future simulation recently completed to update the IMPs in 2019 (the “Robust Review”) will be the basis for this examination. This represents the best currently available science to perform this evaluation.

The most current version of the COHYST model includes land use through 2010 and the CPNRD’s water management activities through 2013. The Robust Review model simulations included a baseline run that repeats the historical climate data from 1989-2013. Land use from 2010 was held constant. The average annual water budget from this groundwater model simulation is summarized below. Water budget calculations were determined by taking the water budget term difference over the 50-year model run, dividing by 50 to find the annual rate of change, converting to inches, and dividing by the GWMA area to get an estimate of inches per acre.

Recharge indicates the contribution of water to the aquifer from precipitation, canal seepage, and seepage of water applied to irrigated parcels (i.e., portion of applied water not consumed). Pumping represents the gross withdrawal of groundwater from the aquifer for irrigation and municipal and industrial uses. Stream discharge is the flow of water out of the aquifer into streams within that GWMA, if present. Evapotranspiration (ET) represents the amount of water consumed by riparian vegetation, if present. The Storage term is the net ***loss*** of water from aquifer storage. Somewhat counterintuitively, a positive value for the storage term represents a reduction of aquifer storage, and a negative value for the storage term represents an increase in aquifer storage. In other words, when a value is greater than zero, the model is predicting a reduction of water levels over time, when a value is less than zero, the model is predicting an increase of water levels over time, and when the value is approximately zero, the model is predicting a stable water level over time. The Flow Out budget term represents the amount of water that flows from the GWMA to other GWMAs or to neighboring NRDs.

In addition to the water budget summaries, the average rate of water level change was computed from this model simulation. By combining the predicted average water level change with the most recent water level change assessment from 2021, the likelihood of each GWMA reaching a Phase II (25% decline), Phase III (50% decline), or Phase IV (75% decline) status in the future is assessed. For each Phase trigger, a semi-qualitative label is assigned to each GWMA indicating if the trigger is unlikely to be reached, somewhat likely to be reached, likely to be reached, or very likely to be reached. Finally, an assessment is also made regarding the potential that the GWMA would experience water level declines that exceed the MAD.

As noted above in Section 2.1, future climate could result in increased demands for the groundwater resource in the CPNRD. While the future groundwater use in the CPNRD could vary from the recent past in a number of ways for a number of reasons, it is useful to understand how increased groundwater withdrawals might change the predictions from the baseline future scenario regarding the likelihood that a GWMA might experience a given Phase trigger. Therefore, three additional simulations were made that simply increase the groundwater pumping in the CPNRD by 10%, 20%, and 30% to represent a Moderate Increase Scenario, a High Increase Scenario, and an Extreme Increase Scenario, respectively. The results of these simulations and subsequent likelihood designations are summarized in **Maps 17-21** and discussed by GWMA below. The following initial description of each GWMA comes directly from the original GMP.

GWMA 1

Upland soils area of southwestern Custer County and northwestern Dawson County. This area has a considerable amount of tableland and several of the larger valleys developed for irrigation.

GWMA	% Irrigated	Recharge (in/ac)	Pumping (in/ac)	Stream Discharge (in/ac)	ET (in/ac)	Storage (in/ac)	Flow Out (in/ac)
1	16%	1.77	-1.18	-	-	0.18	0.77

In this GWMA, aquifer inputs and outputs are well balanced. Pumping is less than recharge on a per acre basis, which bodes well for the long-term sustainability of the aquifer in this GWMA. As indicated by the Flow Out term, water is leaving this GWMA for other GWMAs to the south and east. This GWMA is only somewhat likely to reach the Phase II trigger in the future, and unlikely to hit any other Phase triggers, under the baseline scenario. Under the Modest Increase Scenario, a Phase II trigger is likely, and a Phase III trigger increases to somewhat likely. Under the High Increase Scenario, a Phase II trigger is likely, and a Phase III trigger is somewhat likely. Under the Extreme Increase Scenario, a Phase II trigger is very likely, a Phase III trigger is likely, a Phase IV trigger is somewhat likely, and a Phase V trigger is somewhat likely if management actions are not initiated as prescribed in this plan.

GWMA 2

Terrace soils area of northwest Dawson County lying above the Gothenburg Canal.

GWMA	% Irrigated	Recharge (in/ac)	Pumping (in/ac)	Stream Discharge (in/ac)	ET (in/ac)	Storage (in/ac)	Flow Out (in/ac)
2	80%	2.12	-5.76	-	-	0.42	-3.21

This GWMA is highly developed for irrigation and small future drawdowns are predicted. Pumping is much higher than recharge on a per acre basis, but the negative Flow Out term indicates that supplemental water comes from neighboring GWMA’s to offset the imbalance. This GWMA is very likely to reach the Phase II trigger in the future, likely to reach the Phase III trigger, and somewhat likely to reach the Phase IV trigger, under the baseline scenario. The results are very similar under the Modest Increase Scenario, though a Phase V trigger is somewhat likely if management actions are not initiated as prescribed in this plan. Under the High Increase Scenario, a Phase II trigger is also very likely, and a Phase III-V trigger is likely. Under the Extreme Increase Scenario, a Phase II-IV trigger is very likely, and a Phase V trigger is likely if management actions are not initiated as prescribed in this plan.

GWMA 3

Terrace soils area of Central Dawson County lying between Highway 30 and the Upland areas and below the Gothenburg Canal. The area extends from the Lincoln County line eastward to five miles east of Highway 21 and has groundwater recharge from the Gothenburg, Cozad and Dawson County Canals as well as from rainfall.

GWMA	% Irrigated	Recharge (in/ac)	Pumping (in/ac)	Stream Discharge (in/ac)	ET (in/ac)	Storage (in/ac)	Flow Out (in/ac)
3	80%	6.45	-5.68	-0.34	-0.02	0.11	0.53

In the original GMP, this GWMA was identified as well-balanced although highly developed. Aquifer inputs and outputs are almost equal, which should contribute to the long-term stability of this GWMA. This GWMA is unlikely to reach any Phase trigger in the future under the baseline scenario, the Modest Increase Scenario, or the High Increase Scenario. Under the Extreme Increase Scenario, a Phase III and IV trigger is only somewhat likely to occur.

GWMA 4

Bottomland soils adjacent to the Platte River in Dawson County and Buffalo County west of Kearney. The groundwater is recharged in some areas from the Platte River and from irrigation canals as well as from rainfall. The area is highly developed south of the Platte as well as north of Interstate 80 and historically has had a "balanced" water system.

GWMA	% Irrigated	Recharge (in/ac)	Pumping (in/ac)	Stream Discharge (in/ac)	ET (in/ac)	Storage (in/ac)	Flow Out (in/ac)
4	52%	5.62	-4.71	-4.15	-3.45	0.01	-6.68

Recharge is larger than pumping on a per acre basis in this GWMA, thanks in large part to the canal system that runs along the south side of the Platte River. Future water level declines are not a serious concern in this GWMA. Flow comes from the south (GWMA 5) as evidenced by the negative Flow Out term. This GWMA is unlikely to reach any Phase trigger in the future under any of the modeling scenarios.

GWMA 5

Upland soils area of southwestern Dawson County. Groundwater recharge is received from the Central Nebraska Public Power and Irrigation District (Tri-County) as well as rainfall.

GWMA	% Irrigated	Recharge (in/ac)	Pumping (in/ac)	Stream Discharge (in/ac)	ET (in/ac)	Storage (in/ac)	Flow Out (in/ac)
5	23%	6.30	-1.80	-	-	-0.27	4.23

Similar to GWMA 4, recharge heavily outweighs pumping in this area due to canal recharge. The Flow Out term shows that flows leave this GWMA to the north (GWMA 4). Future water level declines are not a serious concern for this GWMA. This GWMA is unlikely to reach any Phase trigger in the future under any of the modeling scenarios.

GWMA 6

Upland soils area of southern Custer County and northeastern Dawson County including the Wood River Valley in both counties. Most irrigation development to date has been in the Wood River Valley but some development has extended to tablelands and some of the larger drainage bottoms.

GWMA	% Irrigated	Recharge (in/ac)	Pumping (in/ac)	Stream Discharge (in/ac)	ET (in/ac)	Storage (in/ac)	Flow Out (in/ac)
6	12%	1.80	-1.17	-	-	-0.15	0.47

The original GMP identified this area as an area of potential future decline, but additional development has been limited and declines have not come to fruition. Pumping remains less than the recharge term, resulting in a well-balanced hydrologic system for this GWMA. This GWMA is unlikely to reach any Phase trigger in the future under any of the modeling scenarios.

GWMA 7a

Upland soils areas of Dawson and Buffalo Counties between the Wood River Valley and the Platte River terrace. Irrigation development is minimal in this area. The eastern boundary of 7a follows the watershed boundaries of Crooked Creek and the Dry Fork Wood River.

GWMA	% Irrigated	Recharge (in/ac)	Pumping (in/ac)	Stream Discharge (in/ac)	ET (in/ac)	Storage (in/ac)	Flow Out (in/ac)
7a	5%	1.76	-0.32	-	-	-0.02	1.41

This GWMA is not very developed for irrigation, and recharge is greater than pumping. Future water level declines are not a serious concern in this GWMA. This GWMA is unlikely to reach any Phase trigger in the future under any of the modeling scenarios.

GWMA 7b

Upland soils areas of Dawson and Buffalo Counties between the Wood River Valley and the Platte River terrace. Irrigation development to date has been concentrated primarily in the Elm Creek and Turkey Creek valleys and the adjacent table lands. The western boundary of this area follows the watershed boundary of the headwaters of Elm Creek.

GWMA	% Irrigated	Recharge (in/ac)	Pumping (in/ac)	Stream Discharge (in/ac)	ET (in/ac)	Storage (in/ac)	Flow Out (in/ac)
7b	21%	2.43	-1.56	-	-	0.07	0.94

This area is more developed for irrigation than 7a, but also shows a good balance between recharge and pumping. Future water level declines are not a serious concern for this GWMA. This GWMA is unlikely to reach any Phase trigger in the future under the baseline or Moderate Increase Scenario. This GWMA is somewhat likely to reach the Phase II trigger under the High Increase Scenario, and under the Extreme Increase Scenario this GWMA is likely to reach the Phase II trigger and somewhat likely to reach to the Phase III trigger.

GWMA 8

Terrace soils area of eastern Dawson County and southwestern Buffalo County north of Highway 30 and the Kearney Canal and south of the uplands. An area of high irrigation development.

GWMA	% Irrigated	Recharge (in/ac)	Pumping (in/ac)	Stream Discharge (in/ac)	ET (in/ac)	Storage (in/ac)	Flow Out (in/ac)
8	79%	2.43	-5.10	-	-	0.09	-2.59

Although this area is highly developed and pumping is greater than recharge, this area receives flow from neighboring GWMA’s as shown by the negative Flow Out term. This area may see slight declines in the future, but it is not likely to be significant due to its proximity to the Platte River. This GWMA is unlikely to reach any Phase trigger in the future under the baseline scenario. Under the Moderate Increase Scenario this GWMA is somewhat likely to reach the Phase II trigger. This GWMA is somewhat likely to reach the Phase II and III triggers under the High Increase Scenario, and under the Extreme Increase Scenario this GWMA is likely to reach the Phase II trigger and somewhat likely to reach to the Phase III and IV triggers.

GWMA 9a

Upland soils area of Buffalo County including the Wood River Valley west of Range 15 West. The dividing line between 9a and 9b follows the approximate boundary of the Armada Cemetery-Wood River watershed upstream of Amherst, Nebraska.

GWMA	% Irrigated	Recharge (in/ac)	Pumping (in/ac)	Stream Discharge (in/ac)	ET (in/ac)	Storage (in/ac)	Flow Out (in/ac)
9a	28%	2.13	-1.89	-0.24	-	-0.05	-0.06

Although the original GWMA 9 has experienced some declines, it is not likely that the new GWMA 9a will continue to see declines to that degree. The water budget for 9a shows a good balance between recharge and pumping and is far less developed than the neighboring GWMA 9b. This GWMA is unlikely to reach any Phase trigger in the future under the baseline scenario or the Moderate Increase Scenario. This GWMA is likely to reach the Phase II trigger under the High Increase Scenario, and under the Extreme Increase Scenario this GWMA is very likely to reach the Phase II trigger and somewhat likely to reach to the Phase III trigger.

GWMA 9b

Upland soils area of Buffalo County including the Wood River Valley west of Range 15 West.

GWMA	% Irrigated	Recharge (in/ac)	Pumping (in/ac)	Stream Discharge (in/ac)	ET (in/ac)	Storage (in/ac)	Flow Out (in/ac)
9b	51%	2.64	-3.49	0.17	-	0.42	-0.26

This area includes considerable irrigation development and a skewed water balance that will likely result in continued declines. This area's isolation from the Platte River results in groundwater withdrawals affecting storage rather than baseflow, thus making this area more susceptible to declining groundwater levels. This GWMA is very likely to reach the Phase II and III triggers in the future under the baseline scenario, and somewhat likely to hit the Phase IV and V triggers. Results are similar under the Moderate Increase Scenario, with the likelihood of the Phase IV and V trigger increasing to likely. Under the High Increase Scenario and the Extreme Increase Scenario this GWMA is very likely to reach the Phase IV trigger and likely to reach to the Phase V trigger if management actions are not initiated as prescribed in this plan.

GWMA 10

Terrace soils area of eastern Buffalo County lying north of Highway 30 and south of the upland breaks and extending from Kearney on the west to the Hall County line on the east.

GWMA	% Irrigated	Recharge (in/ac)	Pumping (in/ac)	Stream Discharge (in/ac)	ET (in/ac)	Storage (in/ac)	Flow Out (in/ac)
10	77%	2.24	-5.18	0.00	-	0.18	-2.76

In the original GMP, serious future declines were predicted for this GWMA. While there is heavy irrigation development and pumping in this area, these activities are offset by recharge and contributing flow from surrounding GWMAs. Future declines are somewhat likely in this area, but not to the degree as originally predicted. This GWMA is only somewhat likely to reach the Phase II trigger in the future under the baseline scenario. Under the Modest Increase Scenario, a Phase II trigger is likely, and a Phase III trigger increases to somewhat likely. Under the High Increase Scenario, a Phase II trigger is likely, and a Phase III and IV trigger is somewhat likely. Under the Extreme Increase Scenario, a Phase II trigger is very likely, a Phase III trigger is likely, a Phase IV trigger is somewhat likely, and a Phase V trigger is somewhat likely if management actions are not initiated as prescribed in this plan.

GWMA 11

Bottomland soils area of eastern Buffalo County and Hall County. An area of relatively high development especially north of Interstate 80.

GWMA	% Irrigated	Recharge (in/ac)	Pumping (in/ac)	Stream Discharge (in/ac)	ET (in/ac)	Storage (in/ac)	Flow Out (in/ac)
11	50%	4.47	-5.93	8.58	-3.83	0.03	3.32

This area is not anticipated to have serious issues with future declines, as pumping is offset by recharge and proximity to the Platte River. This GWMA is unlikely to reach any Phase trigger in the future under any of the modeling scenarios.

GWMA 12

Prairie Creek upland soils area of eastern Buffalo and northwestern Hall counties.

GWMA	% Irrigated	Recharge (in/ac)	Pumping (in/ac)	Stream Discharge (in/ac)	ET (in/ac)	Storage (in/ac)	Flow Out (in/ac)
12	39%	2.31	-2.90	-	-	0.80	0.21

This area was identified in the original GMP as having the potential for serious future declines. Updated modeling results and the water budget show that continued declines are very likely. Pumping in this area affect aquifer storage rather than baseflow, resulting in water level drawdown. This GWMA is very likely to reach the Phase II and III triggers in the future under the baseline scenario, and likely to hit the Phase IV and V triggers. Results are similar under the Moderate Increase Scenario, with the likelihood of the Phase IV and V trigger increasing to very likely. Under the High Increase Scenario and the Extreme Increase Scenario this GWMA is very likely to reach the Phase IV trigger and likely to very likely to reach to the Phase V trigger if management actions are not initiated as prescribed in this plan.

GWMA 13

Sandy upland and terrace areas of Hall County and Howard County. An area of relatively high development in the eastern part.

GWMA	% Irrigated	Recharge (in/ac)	Pumping (in/ac)	Stream Discharge (in/ac)	ET (in/ac)	Storage (in/ac)	Flow Out (in/ac)
13	51%	4.74	-3.60	-	-	0.33	1.47

This area is likely to see water level declines even though recharge occurs at a higher rate than pumping on a per acre basis. Due to this area's isolation from the Platte River and heavy pumping in nearby GWMAs, it is predicted that water levels will drop over the next 50 years. This GWMA is somewhat likely to reach Phase II and III triggers in the future under the baseline scenario, but unlikely to hit Phases IV and V. Under the Moderate Increase Scenario, this GWMA is likely to hit Phase II and III triggers, and somewhat likely to hit the Phase IV trigger. The High Increase and Extreme Increase Scenarios show similar results—with the GWMA likely to hit Phase III and IV triggers. Under the Extreme Increase Scenario, this GWMA is likely to hit the Phase V trigger if management actions are not initiated.

GWMA 14

Silty terrace soils area of central and western Hall County.

GWMA	% Irrigated	Recharge (in/ac)	Pumping (in/ac)	Stream Discharge (in/ac)	ET (in/ac)	Storage (in/ac)	Flow Out (in/ac)
14	85%	2.34	-6.00	-	-	0.41	-3.25

The original GMP identified this area as one that will experience serious future declines likely forcing some farmers to convert to dryland. Declines have not been nearly as serious as first predicted. Although the high degree of development for irrigation and lopsided recharge-pumping balance paints a poor picture, this GWMA is supplemented by incoming flow from neighboring GWMAs. A positive storage value in the water budget does show that some degree of future declines is predicted. The modeling scenarios confirm these results, with GWMA 14 somewhat likely to reach Phase II and III triggers under the baseline scenario. Under the Moderate and High Increase Scenarios, the likelihood increases of hitting Phase II and III. The chances of reaching Phase IV increases from somewhat likely to likely between the Moderate and High Increase Scenarios. The Extreme Increase Scenario shows that this GWMA is very likely to hit Phase II, III, and IV triggers and likely to hit Phase V if no management actions are taken.

GWMA 15

Upland soils area of southern Hall County (south of the Platte).

GWMA	% Irrigated	Recharge (in/ac)	Pumping (in/ac)	Stream Discharge (in/ac)	ET (in/ac)	Storage (in/ac)	Flow Out (in/ac)
15	78%	3.63	-5.02	-	-	0.13	-1.27

Although this area is highly developed for irrigation, pumping is offset by recharge and flow from neighboring GWMAs. Future declines are not a serious issue for this GWMA. This GWMA is unlikely to hit any Phase triggers under the baseline and Moderate Increase Scenario. Probability of hitting Phase II is somewhat likely under the High Increase and Extreme Increase Scenario. This GWMA is somewhat likely to hit Phase III in the Extreme Increase Scenario.

GWMA 16

Sandy upland soils area of northwestern Merrick County. An area that has considerable development on the less hilly (steep) lands.

GWMA	% Irrigated	Recharge (in/ac)	Pumping (in/ac)	Stream Discharge (in/ac)	ET (in/ac)	Storage (in/ac)	Flow Out (in/ac)
16	49%	4.70	-3.03	-0.59	-0.19	0.10	0.98

Future declines were predicted for this area in the original GMP. However, a much higher rate of recharge than pumping has helped this area stay relatively stable long term. It is anticipated that future groundwater declines will not be a serious issue for this GWMA, but modeling results show that some degree of declines are predicted. Under the baseline scenario, GWMA 16 is unlikely to hit any trigger. It’s somewhat likely to hit the Phase II trigger under the Moderate Increase Scenario. The High Increase Scenario results show the area is likely to hit Phase II and somewhat likely to hit Phase III. Under the Extreme Increase Scenario, this increases to very likely to hit Phase II, likely to hit Phase III, and somewhat likely to hit Phase IV. This GWMA is unlikely to hit Phase V under any scenario.

GWMA 17

Terrace land soils area of Merrick County lying north of the Silver Creek watershed and containing a large part of the Prairie Creek drainages.

GWMA	% Irrigated	Recharge (in/ac)	Pumping (in/ac)	Stream Discharge (in/ac)	ET (in/ac)	Storage (in/ac)	Flow Out (in/ac)
17	74%	4.03	-4.45	0.04	-0.12	0.04	-0.47

This area was identified in the original GMP as an area where future serious declines were projected. These declines have not come to fruition since the original plan's inception and this area continues to stay in balance. However, a high degree of development for irrigation and slightly higher pumping than recharge could result in future declines should drought conditions occur. Additionally, saturated thickness tends to thin out towards the eastern edge of this GWMA. Modeling results show this area is unlikely to hit any phase triggers under the baseline, and only somewhat likely to hit Phase II under the Moderate Increase Scenario. The High Increase Scenario shows the area is likely to hit Phase II and III triggers, and somewhat likely to hit Phase IV and V. This GWMA is very likely to hit Phase II, likely to hit Phase III and IV, and somewhat likely to hit Phase V under the Extreme Increase Scenario with no management action.

GWMA 18

Bottomland soils area of Merrick County lying north of Highway 30 from the Hall County line to five miles east of Clarks, Nebraska.

GWMA	% Irrigated	Recharge (in/ac)	Pumping (in/ac)	Stream Discharge (in/ac)	ET (in/ac)	Storage (in/ac)	Flow Out (in/ac)
18	70%	3.57	-4.00	-0.34	-0.07	0.00	-0.83

This area experiences more pumping than recharge, but also receives flow from neighboring GWMAs as evidenced by the negative Flow Out term in the water budget. It is not likely that this area will see serious future declines, which is confirmed by modeling results. The baseline and Moderate Increase Scenarios show this area is unlikely to hit any phase triggers. The High Increase Scenario show this GWMA is somewhat likely to hit Phase II and III. Chances of hitting Phase III, IV, and V triggers are also somewhat likely to occur under the Extreme Increase Scenario in the absence of management action.

GWMA 19

Bottomland soils area of southern Merrick County (south of Highway 30) and Northern Hamilton county. An area that receives recharge from the Platte River as well as from rainfall.

GWMA	% Irrigated	Recharge (in/ac)	Pumping (in/ac)	Stream Discharge (in/ac)	ET (in/ac)	Storage (in/ac)	Flow Out (in/ac)
19	48%	4.43	-3.97	0.87	-3.46	0.01	-2.13

This area runs along the Platte River and experiences high recharge in comparison with pumping. Future declines are not predicted to be a serious issue in this GWMA and is confirmed by the modeling results. This area is only somewhat likely to hit Phase II under the Extreme Increase Scenario, but not expected to hit any triggers under the other scenarios.

GWMA 20

Sandy upland area of Nance, Merrick and Platte Counties.

GWMA	% Irrigated	Recharge (in/ac)	Pumping (in/ac)	Stream Discharge (in/ac)	ET (in/ac)	Storage (in/ac)	Flow Out (in/ac)
20	35%	4.38	-2.10	-0.56	-0.11	0.01	1.62

This GWMA experiences high recharge in comparison with pumping and a low level of irrigation development. This area does experience flow leaving the GWMA to neighboring GWMAs or to the north. Modeling results show the area is very likely to hit Phase II but unlikely to hit Phase III and IV in the baseline, Moderate, and High Increase Scenario Results. In the Extreme Increase Scenario, the area is very likely to hit Phase II, likely to hit Phase III, and somewhat likely to hit Phase IV.

GWMA 21

Upland soils area of Northern Hamilton and of Polk County lying adjacent to the Big Blue Basin.

GWMA	% Irrigated	Recharge (in/ac)	Pumping (in/ac)	Stream Discharge (in/ac)	ET (in/ac)	Storage (in/ac)	Flow Out (in/ac)
21	39%	2.88	-1.96	0.41	-0.01	0.07	1.40

This area was predicted in the original GMP to experience serious declines. However, declines have been slight and recovered during wet periods. The balance of recharge and pumping in this area indicates that future serious declines are unlikely. This is confirmed by modeling results.

GWMA 22

Bottomland soils area of eastern Merrick County and Platte County lying north of the Platte River. This area is subject to recharge from the Platte River and the sandy upland hills to the north as well as from rainfall.

GWMA	% Irrigated	Recharge (in/ac)	Pumping (in/ac)	Stream Discharge (in/ac)	ET (in/ac)	Storage (in/ac)	Flow Out (in/ac)
22	50%	3.96	-3.95	-1.23	-1.95	0.00	-3.16

This area's proximity to the Platte River and high recharge indicates that this GWMA is not likely to experience serious future declines. Modeling results show this area is unlikely to hit any phase triggers under any of the analyzed scenarios.

GWMA 23

Bottomland soils of Polk County adjacent to the Platte River.

GWMA	% Irrigated	Recharge (in/ac)	Pumping (in/ac)	Stream Discharge (in/ac)	ET (in/ac)	Storage (in/ac)	Flow Out (in/ac)
23	47%	5.15	-3.81	-4.58	-1.00	0.03	-6.40

This area receives high recharge and flow from neighboring GWMAs. Future declines are not predicted to be a serious issue for this area, but some level of declines are predicted. The area is somewhat likely to hit the Phase II trigger under the baseline scenario, and likely to hit the Phase II trigger under the Moderate and High Increase Scenarios. The Extreme Increase Scenario shows the area is likely to hit Phase II, somewhat likely to hit Phase III, and unlikely to hit Phase IV.

GWMA 24

Terrace soils area of Polk County.

GWMA	% Irrigated	Recharge (in/ac)	Pumping (in/ac)	Stream Discharge (in/ac)	ET (in/ac)	Storage (in/ac)	Flow Out (in/ac)
24	73%	4.43	-3.49	-	-0.02	0.06	0.98

This area was predicted to experience declines in the original GMP. However, small declines have been offset by patterns of wet periods and this area has stayed relatively stable. Recharge outweighs pumping this area, so future declines are not expected to be a serious issue. The area is only somewhat likely to hit the Phase II trigger under the High and Extreme Increase Scenarios. Otherwise, this area is not expected to hit any of the higher triggers under any modeling scenario.

6. GROUNDWATER RULES AND REGULATIONS

The first five sections of this plan defined the current groundwater supply, demand, and areas with concern. The five sections described some of the pressures that future demand and contamination may place on the resource. Based on the scientific information gathered during development of this plan, this section provides a description of the proposed changes to the 1985 GMP. This section describes the specific authorities that the NRD is operating under followed by the proposed changes to the groundwater management program currently implemented by CPNRD.

6.1 NRD Authority to Implement Rules, Regulations, and Controls

As described in Section 1.3, Nebraska's Groundwater Management and Protection Act recognized groundwater as a valuable natural resource that requires sound management practices to ensure future sustainability. The legislation established local control through delegated authority to the NRDs. The CPNRD submitted its initial GMP in 1985. Subsequent legislation in 1991 required each NRD to amend the groundwater quality section of its groundwater management to "…identify…levels and sources of ground water contamination within the District...and practices recommended to stabilize, reduce, and prevent the occurrence, increase, or spread of ground water contamination" (Neb. Rev. Stat. § 46-709). The revised GMP was submitted and accepted in 1993 (CPNRD 1993).

The CPNRD will continue to identify management, control, and/or special protection areas within the District as pertains to groundwater quality. No changes to those programs or activities are proposed under this revised GMP. Proposed revisions to the current groundwater management program rules and regulations pertaining to groundwater quantity management are presented below, after a brief discussion of current rules pertaining to groundwater quantity management.

6.2 Current Rules and Regulations

The CPNRD established a moratorium on the expansion of irrigated acres in 2004. All acres that are allowed to be irrigated are currently certified and the CPNRD has monitoring protocols in place to detect the irrigation of non-certified acres. Under certain conditions, an irrigator may transfer irrigated acres from one location to another location. As it pertains to groundwater management, when groundwater levels fall more than 25% of the MAD, transfers are no longer allowed into the GWMA, and this restriction remains in effect unless the water levels rise to less than 25% of the MAD for five consecutive years. Furthermore, the drilling of supplemental irrigation wells, or wells needed to supplement the supply available from existing wells, is not allowed if the groundwater levels fall more than 25% of the MAD.

Remaining rules regarding groundwater management mirror the structure of the requirements under the 1985 GMP, increasing required well spacing and reducing allowable irrigated acres.

6.3 Proposed Groundwater Triggers and Related Controls

This revised GMP will somewhat modify the pre-existing set of Phases and Triggers from the 1985 version of the GMP (**Table 17**). Phase I will change to a range of zero to 25%, with no additional management requirements beyond those already in the CPNRD rules. Phase II would apply to any area with declines between 25% and 50% of the MAD. The management actions required for this phase would be the same as the current rules that apply to areas with a decline of greater than 25% MAD.

The largest change in this GMP relative to the 1985 GMP would be a shift away from well spacing requirements and acreage reductions. The current moratorium on the expansion of acres is somewhat inconsistent with this management approach, particularly the well spacing requirement. The preferred option going forward would be to modify the remaining triggers so that measuring devices could be installed and a limit on the volume of groundwater pumped would be imposed to manage each GWMA. Phase III would be changed to a 50% decline in water levels relative to the MADs. When this trigger is reached, measurement devices will be required on all active irrigation wells in the GWMA and the owner or operator of every active well will be required to report annual water usage to the CPNRD.

Following this, if water levels in a given GWMA continued to decline and reached 75% of the MAD, the GWMA would be in a Phase IV level and the CPNRD would allocate total allowable groundwater use to a level that would be expected to prevent the GWMA from reaching the MAD. If, due to unforeseen circumstances, the initial allocation is insufficient to prevent reaching the MAD in a given GWMA, and that MAD is reached or exceed, this would trigger a Phase V designation, requiring reduction of the allocation such that the groundwater levels in that particular GWMA recover and stay at or above the MAD on average over time. As conditions change over time the CPNRD may make ongoing adjustments to the allocation in any manner expected to be consistent with the maintenance of water levels within the GWMA at or above the MAD.

Table 17 Triggering Criteria and Associated Management Actions.

Phase Level	Percent of “Maximum Acceptable” Water Level Decline	Management Action
Phase I	Decline is < 25 percent	None required
Phase II	25 percent	Limits to transfers and supplemental wells
Phase III	50 percent	Installation of groundwater extraction measuring devices
Phase IV	75 percent	Establish an allocation of allowable use
Phase V	100 percent	Reduction of existing allocation until water levels stabilize at MAD

Once this GMP is approved, the CPNRD will modify their current Rules and Regulation in such a manner as to ensure consistency between this document and those rules.

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GROUNDWATER MANAGEMENT PLAN

Central Platte Natural Resources District

January 2023