2019 PGCD MANAGEMENT PLAN DRAFT

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CHAPTER 1 DISTRICT MISSION AND OVERVIEW

The Panhandle Groundwater Conservation District (the District) will strive to develop, promote, and implement water conservation, preservation, recharging, augmentation through precipitation enhancement, prevention of waste, and management strategies to protect water resources for the benefit of the citizens, economy, and environment of the District.

The District seeks cooperation in the implementation of this plan and the management of groundwater supplies within the District. All activities of the District will be undertaken in cooperation and coordination with local owners and the appropriate state, regional or local water management entities.

The District will work to treat all citizens uniformly. The District will enforce the permit terms and conditions and the District rules by enjoining the permit holder in a court of competent jurisdiction, as provided for in Texas Water Code Section 36.102, if required, after exhausting all other remedies.

The District consists of all of Carson, Donley, Gray, Roberts and Wheeler counties, along with parts of Armstrong, Hutchinson, and Potter counties. The District was created by the Legislature in 1955, when it began operating in portions of Gray, Carson, Potter, and Armstrong counties. Elections were held in 1988, 1991, 1994, 1997 and 2000 to annex the remaining portions of the District within the present boundaries.

The District's areal extent is 6,309 square miles or approximately four million acres located in the Panhandle region of Texas, extending from west of Amarillo to the Oklahoma border. The Canadian River to the north and Salt Fork of the Red River to the south generally border the District. The District's economy is dominated by agricultural production and petrochemical production. The agricultural income sources include beef cattle production, wheat, corn, milo, peanuts, soybeans, sunflowers, hay crops and cotton. Petrochemical production also contributes significantly to the income of the District. There are also chemical, manufacturing, and nuclear weapons industries located in the District.

There are over 4,676 irrigation wells capable of producing water to meet the needs of the agricultural community within District boundaries. The District also has more than 470 municipal or public supply wells, and over 450 wells for industrial use and oil and gas secondary recovery (water flood) operations. The remaining wells are registered wells providing water supplies for household, livestock consumption, and oil and gas exploration.

The area contains rolling plains that are used for cattle production, cultivation and oil and gas activities. There is a substantial area of flat plains that contain numerous playa basins. This area is used primarily for crop production. The altitude of the land surface ranges from 2,005 feet to 3,800 feet above mean sea level. The District lies within, and between, the drainage systems of both the Canadian River Basin and the Red River Basin.

All statutorily required elements for this Management Plan, as stipulated in Texas Water Code Section 36.1071 have been addressed herein, and for ease of review, are referenced in the Texas Water Development Board's Groundwater Conservation District Management Plan Checklist included as Appendix 1. Documentation that the Management Plan was adopted after public notice is presented in Appendix 2. A copy of the executed Resolution approved by the Panhandle Groundwater Conservation District Board of director's is included in Appendix 3.

CHAPTER 2 GROUNDWATER MANAGEMENT IN TEXAS

The authority of groundwater conservation districts (GCDs) to conserve, preserve, and protect groundwater through necessary regulation dates to the Underground Water Conservation Districts Act passed by the Texas Legislature in 1949 (Vernon's Civil Statutes, Article 7880-3c). Included in this landmark legislation, which for the most part, remains substantively unchanged today, GCDs receive the following legislative directive, "Such districts shall and are hereby authorized to exercise any one or more of the following:

(8) develop comprehensive plans for the most efficient use of the underground water of the underground reservoir or subdivision thereof and for the control and prevention of waste of such underground water, which plans shall specify in such detail as may be practicable, the acts, procedure, performance and avoidance which are or may be necessary to effect such plans, including specifications therefore; to carry out research projects, develop information and determine limitations, if any, which should be made on the withdrawal of underground water from the underground reservoir or subdivision thereof; to collect and preserve information regarding the use of such underground water and the practicability of recharge of the underground water subdivision thereof; to publish such plans and information, bring them to the notice and attention of the users of such underground water within the District, and to encourage their adoption and execution;"

In 1997 the Texas Legislature approved one of the more significant amendments to the Water Code by expanding the groundwater planning process, requiring all GCDs to develop and adopt management plans. Once adopted, management plans are then to be reviewed and approved by the Executive Administrator at the Texas Water Development Board (TWDB). This review and approval are designed to ensure that certain technical and administrative requirements are met.

Substantial changes in the planning and management of groundwater were put in place in 2005 with the passage of House Bill 1763, which requires GCDs in the same Groundwater Management Area (GMA) to conduct joint planning and establish Desired Future Conditions (DFCs) for all relevant aquifers in the GMA. The first round of joint planning concluded on September 1, 2010. Since the passage of House Bill 1763 in 2005, the District has been an active participant in the joint planning process for GMA 1. GMA 1 adopted DFCs for the Ogallala Aquifer on July 7, 2009, and DFCs for the Dockum and Blaine aquifers on June 3, 2010.

No other aquifers were determined to be relevant during the first round of joint planning in the District. By law, GCDs are required to meet at least annually to continue joint planning and to review and readopt (with amendments as necessary) DFCs at least every five years.

In 2011, the Texas Legislature again made significant changes to the planning and management of groundwater resources with the passage of Senate Bill 660 (SB 660). One of the primary elements of SB 660 was the identification of nine specific criteria that must be considered with respect to any DFCs being proposed for adoption (Texas Water Code Section 36.108 (d) (1-9). Other changes made by SB 660 included requirements that GCDs in a GMA must provide a balance between the highest practicable level of groundwater production and the conservation, preservation, protection, recharging, and prevention of waste of groundwater and control of subsidence in the GMA (Texas Water Code Section 36.108 (d-2)), development of an explanatory report to accompany adopted DFCs when submitted to the TWDB for review (Texas Water Code Section 36.108 (d-3), and also transfer of the petition process from the TWDB to the State Office of Administrative Hearings (Texas Water Code Section 36.1083). Based on the new requirements of SB 660, the District, along with the other GCDs in GMA 1, adopted updated DFCs on November 1, 2016, as required by Texas Water Code Section 36.108 (d). DFCs were adopted for the Ogallala and Dockum aquifers in the District. The Blaine Aquifer, located in Wheeler County in GMA 1 was classified by GMA 1 District Representatives as being non-relevant for the purposes of joint planning.

CHAPTER 3 DESIRED FUTURE CONDITIONS AND THE PANHANDLE GROUNDWATER CONSERVATION DISTRICT

Long before the State of Texas first considered the concept of "Desired Future Conditions" or DFCs in the 2002 State Water Plan[1], or codified the concept in statute in House Bill 1763 in 2005 (Texas Water Code Section 36.108(d)), the District Board of Directors spent countless hours deliberating approaches to better manage and balance current water demands with future water needs. The result of this deliberation that began in 1995 was the District's adoption of the 50/50 Management Standard in 1998. This landmark decision in 1998 to adopt the 50/50 Management Standard represents the first DFC adopted by a GCD anywhere in Texas.

The District's 50/50 Management Standard is the goal to have at least 50 percent of current volume in the Ogallala Aquifer, still available 50 years after the first certification of this plan (which occurred in 1998). This standard was subsequently adopted for the Ogallala Aquifer for the District during both the first and second rounds of joint planning (2005 – 2010 and 2010 - 2016).

[1] Texas Water Development Board, 2002, Water for Texas – The Texas State Water Plan, P.5.

For the purposes of the DFC adopted for the District by the member districts in GMA 1, this Management Plan and District rules, and the 50/50 Management Standard, 50 percent of the current saturated thickness remaining in 50 years, is indistinguishable from 50 percent of the volume of groundwater remaining in the Ogallala Aquifer. The 50/50 Management Standard, originally adopted by the District for the planning period of 1998 – 2048, has now been extended to 2070 in order to fully represent the current planning horizon (Figure 1). An examination of Figure 1 illustrates that as more time passes during the 50-year planning horizon, the reduction in saturated thickness of the Ogallala Aquifer each year becomes less and less.

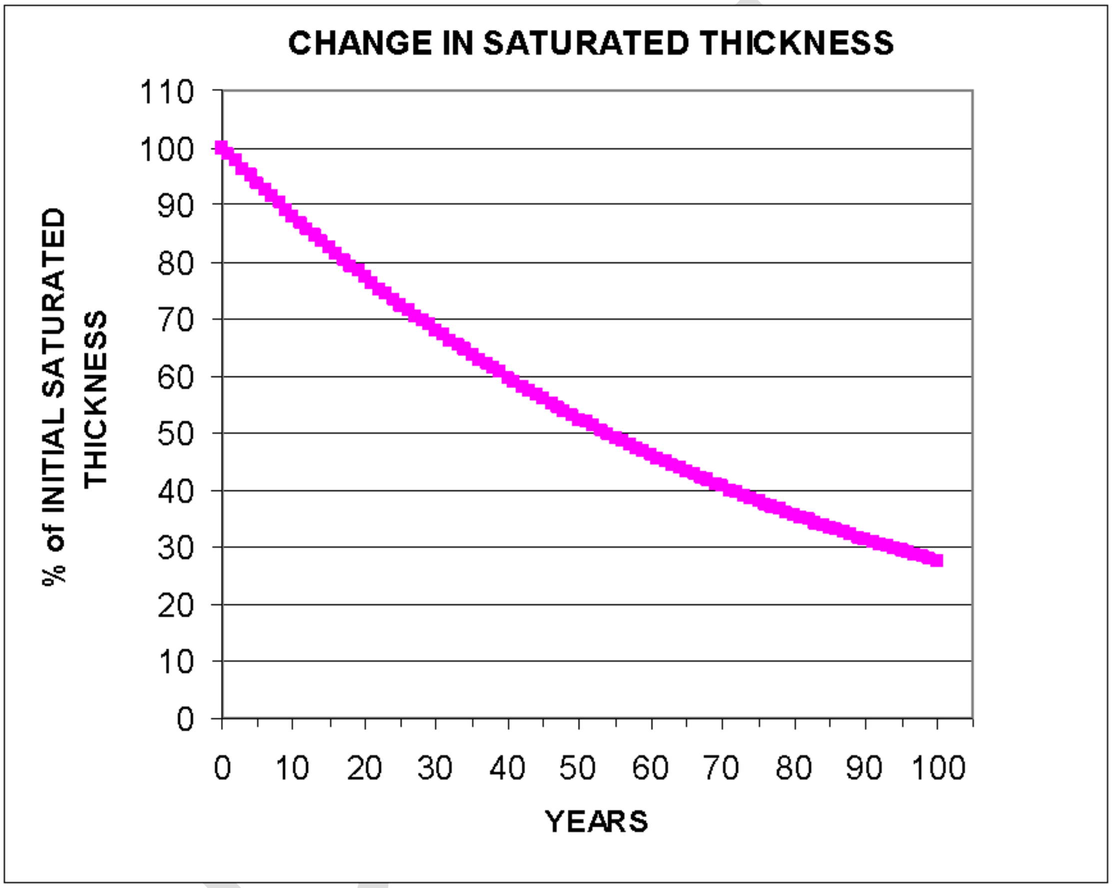

Figure 1 – Illustration of change in saturated thickness as a result of the 50/50 Management Standard.

Texas groundwater law is currently based on a conceptual three-step sequence that a GCD is to follow in accomplishing statutory responsibilities related to the conservation and management of groundwater resources within a GCD. The three primary steps, which are to occur at least every five years, are to: (1) adopt DFCs (Texas Water Code Section 36.108(c), (2) develop and adopt a management plan that includes goals, management objectives, and performance standards, designed to achieve the DFCs (Texas Water Code Section 36.1071(a)(8), and (3) amend and adopt rules necessary to achieve goals, management objectives, and performance standards, included in the management plan (Texas Water Code Section 36.101(a)(5).

While in concept these three steps are presented as a sequential process, from a practical perspective, all three steps are often ongoing concurrently. This management plan update was developed concurrently with the development of substantive rule amendments adopted by the Panhandle GCD Board of Directors on December 20, 2018, in order to better achieve adopted DFCs. This management plan is a revision of the management plan adopted by the Panhandle GCD Board of Directors on February 23, 2017. This revised management plan will remain in effect until an amended plan is adopted by the district and approved by the Texas Water Development Board, or until five years from the date the Executive Administrator of the Texas Water Development Board approves the plan, whichever is earlier.. The Board of Directors will review and adopt the management plan at least every five years, as required by Texas Water Code Section 36.1072(e). The District Management Plan and any amendments thereto, shall be forwarded to the Panhandle Water Planning Group for consideration in their regional water planning process.

CHAPTER 4 GOALS, MANAGEMENT OBJECTIVES, AND PERFORMANCE STANDARDS

For over 60 years, the District has worked to manage and conserve groundwater resources within its jurisdictional boundaries. With the adoption of the 50/50 Management Standard by the District Board of Directors in 1998, this all-encompassing goal for the District to manage and conserve groundwater resources was established. All other goals, management objectives, and performance standards required for inclusion in this management plan by Texas Water Code Section 36.1071(a) have been developed and adopted to ensure that District programs and activities work directly or indirectly in an integrated and comprehensive manner in order to achieve the 50/50 Management Standard. The 50/50 Management Standard is specifically designed to ensure the management and conservation of the finite water resources within the District while seeking to maintain the economic viability of all water resource user groups, both public and private.

Texas Water Code Section 36.1071(a)(1-9) requires that all management plans address the following management goals, as applicable:

- addressing the desired future conditions adopted by the District,
- providing the most efficient use of groundwater;
- controlling and preventing waste of groundwater;
- controlling and preventing subsidence;
- conjunctive surface water management issues;
- natural resource issues;

- drought conditions, and;
- conservation, recharge enhancement, rainwater harvesting, precipitation enhancement, or brush control, where appropriate and cost-effective.

Goals, management objectives, and performance standards included in this management plan have been developed and adopted to ensure the management and conservation of groundwater resources within the District's jurisdiction.

SECTION 4.1 ACTIONS, METHODOLOGIES, PROCEDURES, PERFORMANCE, AND AVOIDANCE NECESSARY TO EFFECTUATE THE PLAN

In order to achieve the goals, management objectives, and performance standards adopted in this management plan, the District continually works to develop, maintain, review, and update rules and procedures for the various programs and activities contained in the management plan. As a means to monitor performance, (a) the General Manager routinely meets with District Staff to track progress on the various management objectives and performance standards adopted in this management plan and, (b) on an annual basis; the General Manager prepares and submits an annual report documenting progress made towards implementation of the management plan to the Board of Directors for their review and approval. In addition, District Staff reviews District rules to ensure that all provisions necessary to implement the management plan are contained in the rules. Reviews of the rules are conducted annually and on an as needed basis. The District Board of Directors will make revisions to the rules as needed to manage and conserve groundwater resources within the District more effectively and to ensure that the duties prescribed in the Texas Water Code and other applicable laws are carried out. Amendments to District rules adopted on December 20, 2018, and this amended management plan are the direct result of this review process between the General Manager, District staff and the District Board of Directors. A copy of this management plan and the District's rules may be found on the District website at www.pgcd.us.

SECTION 4.2 GOAL 1 ADDRESS THE DESIRED FUTURE CONDITIONS ADOPTED BY THE PANHANDLE GCD

The main purpose of a management plan is to develop goals, management objectives, and performance standards that, when successfully implemented, will work together to achieve the adopted DFCs. Goals 2 through 10 directly and/or indirectly support Goal 1. DFCs adopted for the Ogallala and Dockum aquifers by GMA 1 on November 1, 2016, and subsequently adopted by the Panhandle GCD Board of Directors on July 14, 2016, for the District are described below (note, the Blaine Aquifer in Wheeler County is now classified by GMA 1 as non-relevant for joint planning). A 50-year planning horizon was used in setting the DFCs. Throughout the joint planning process, the District actively worked with the other District Representatives and stakeholders within GMA 1 to determine the DFCs for each relevant aquifer located within each district.

Subsection 4.2.1 Ogallala Aquifer DFC

The primary water resource in the District is the Ogallala Aquifer, which is a finite resource and must be managed and conserved for the benefit of future generations. The DFC for the Ogallala Aquifer within the boundaries of the District is to have at least 50 percent of the volume in storage (as discussed above, volume is equivalent to saturated thickness) remaining in 50 years (50/50 DFC). As discussed above, for the District, the 50/50 DFC (goal) is synonymous and interchangeable with the 50/50 Management Standard. Successful attainment of the 50/50 DFC is accomplished using the District's integrated programs focused on conservation, education, regulation, and permitting which are designed to achieve this umbrella goal. Texas Water Code Section 36.1132(a) states that "a district, to the extent possible, shall issue permits up to the point that the total volume of exempt and permitted groundwater production will achieve an applicable desired future condition under Section 36.108." The District's permitting program has been designed in order to achieve this DFC.

The requirement for inclusion of estimates of modeled available groundwater in the management plan is a requirement resulting from the passage of Senate Bill 660 by the 82nd Texas Legislature in 2011. The term "modeled available groundwater" is defined in Texas Water Code Section 36.001(a)(25) as "the amount of water that the executive administrator determines may be produced on an average annual basis to achieve a desired future condition…" This change in terms is included to clarify that the estimates presented in Table 1 represent both exempt and permitted groundwater production. Estimates of modeled available groundwater for the Ogallala Aquifer within the District, based on the updated High Plains Aquifer System Groundwater Availability Model (Deeds and Jigmond, 2015)[2] and Deeds (2016)[3] and further analyses by Goswami (2017)[4] are presented in Table 1 on the next page.

[2] Deeds, N. E., and Jigmond, M., 2015, Numerical Model Report for the High Plains Aquifer System Groundwater Availability Model, 640 p.,http://www.twdb.texas.gov/groundwater/models/gam/hpas/HPAS_GAM_Numerical_Report.pdf.

[3] Deeds, N. E., 2016, Delivery of GMA 1 Predictive Runs: Draft Technical Memorandum prepared for North Plains Groundwater Conservation District and Groundwater Management Area 1 for submission to Texas Water Development Board as part of Desired Future Conditions Submission Package, 18 p.:

[4] Goswami, R. R., 2017, GAM RUN 16-029 MAG: Modeled Available Groundwater for the aquifers in Groundwater Management Area 1: Texas Water Development Board, 17 pg.

Table 1- Estimates of Modeled Available Groundwater for the Ogallala Aquifer in the District (Goswami, 2017)[4].

Ogallala						
County	**2020**	**2030**	**2040**	**2050**	**2060**	**2062**
Armstrong	57,984	53,414	48,170	43,462	38,860	38,080
Carson	192,135	184,263	169,931	153,767	137,215	134,055
Donley	74,808	76,289	72,962	67,873	62,058	60,901
Gray	181,105	175,267	162,653	148,713	134,431	131,744
Hutchinson	15,734	16,740	15,156	13,324	11,742	11,455
Potter	16,969	15,820	14,442	13,162	11,836	11,609
Roberts	430,618	455,129	427,218	390,247	350,459	342,748
Wheeler	130,425	138,810	137,385	132,312	124,778	123,309
District Total	1,099,778	1,115,732	1,047,917	962,860	871,379	853,901

4.2.1.1 Management Objective 1.1

The cornerstone of the many programs and activities of the District is the 50/50 Management Standard which drives its Rules and this Management Plan. The 50/50 Management Standard states that 50 percent of the current volume within the Ogallala Aquifer will remain in 50 years. This 50/50 Management Standard is the tool by which the District will ensure that it meets or exceeds the 50/50 DFC outlined in Rule 1, 3, and 4, which states the maximum allowable volume of pumping from the Ogallala Aquifer is 1-acre foot per acre per year. In order to ensure that the 50/50 Management Standard is being met, the District goes through an annual review process to identify and act upon Contiguous Acreage Tracts exceeding the maximum allowable volume of pumping from the Ogallala Aquifer utilizing flow meter data. Management Objective 1.1 is for the District to successfully undergo and complete the annual flow meter data evaluation and review process for each Contiguous Acreage Tract each year by December 1st of the year following the year for which pumping data is collected. The results of this process will be published in the District's Annual Report which, upon approval by the District Board of Directors, will be published on the District's website.

The District also conducts a systematic winter water level program so as to collect data necessary to evaluate achievement of the District's Desired Future Conditions. Results from the District's winter water level monitoring program are presented to the Board of Directors on an annual basis and published in the District's newsletter.

In order to complete Management Objective 1.1, the following Performance Standards will be met. Actions by the District Board of Directors that may result from this review include the enforcement actions stipulated in Rule 3.3, as required.

4.2.1.1.1 *Performance Standards*

1.1a Based on flow meter readings, quantify all permitted pumping volumes annually for individual Contiguous Acreage Tracts and report results to the Board of Directors in the Annual Report by December 1st of each year.

1.1b Evaluate all Ogallala Aquifer water level measurements collected during the District's annual winter water level monitoring program. This information will be provided to the District Board of Directors at a regularly scheduled meeting by August 31st of each year.

1.1c The District will conduct a Sunset Review of the maximum allowable volume of production contained in Rule 4.2. This review will be concluded no later than January 1, 2025, and the maximum allowable production volume will then be reviewed every 5 years thereafter. Using annual production data, the Board will evaluate the effect of Rule 4.2 on the ability to achieve the District's Desired Future Conditions.

4.2.1.2 Management Objective 1.2

The District maintains an integrated geodatabase system based on the District's Observation Well Network and computer mapping programs to annually track and evaluate current supplies by a baseline (1998) Ogallala Aquifer saturated thickness dataset in the District. This analysis is utilized to track and review changes in water supplies.

4.2.1.2.1 *Performance Standards*

1.2a Update and publish at least once every five years, beginning in 2020, on the District's website the latest updated Ogallala Aquifer saturated thickness map.

Subsection 4.2.2 Dockum Aquifer DFC

The Dockum Aquifer is classified by the TWDB as a minor aquifer that is present primarily in the western portions of the District and is generally under confined (artesian) conditions. Based on our current understanding of water resources in the Dockum Aquifer, DFCs have been adopted for Armstrong, Carson, and Potter counties within the District. Due to the predominantly confined nature of the Dockum Aquifer, a different approach was taken in adopting DFCs for the Dockum Aquifer. The DFCs adopted for the Dockum Aquifer in GMA 1 are that the average decline in water levels will be no more than 30 feet within the District over the next 50 years.

The estimates of modeled available groundwater for the Dockum Aquifer were extracted from predictive simulations performed for GMA 1 using the updated High Plains Aquifer System.

Groundwater Availability Model (Deeds and Jigmond, 2015)[5] and Deeds (2016)[6] and further analyses by Goswami (2017)[7] are presented in below.

Table 2 - Estimates of Modeled Available Groundwater for the Dockum Aquifer in the District (Goswami (2017)[8].

Dockum						
County	2020	2030	2040	2050	2060	2062
Armstrong	7,131	9,024	9,588	9,704	9,535	9,494
Carson	68	108	140	169	198	204
Potter	38,803	39,113	36,937	34,505	32,008	31,558
District Total	46,002	48,245	46,665	44,378	41,741	41,256

4.2.2.1 Management Objective 1.3

While there are tens of thousands of data points collected over time relative to the Ogallala Aquifer, the opposite is the case for the Dockum Aquifer. This can primarily be attributed to dominance of the Ogallala Aquifer in the region and the general prevalence of poor water quality and yields from the Dockum Aquifer. Due to declining water levels in the Ogallala Aquifer, there are areas where the Dockum Aquifer is becoming a more important water resource. There are localized areas of good water quality and where technological advances are being made using brackish groundwater desalination.

Due to the scarcity of data regarding the Dockum Aquifer, the District is primarily focused on data collection and trend analysis on wells completed in the Dockum Aquifer currently included in the District's Observation Well Network. This management objective is to monitor and report on Dockum Aquifer wells in the District's Observation Well Network that are experiencing declines for which the trend is in excess of the DFC of 30 feet.

[5] Deeds, N. E., and Jigmond, M., 2015, Numerical Model Report for the High Plains Aquifer System Groundwater Availability Model, 640 p.,http://www.twdb.texas.gov/groundwater/models/gam/hpas/HPAS_GAM_Numerical_Report.pdf.
[6] Deeds, N. E., 2016, Delivery of GMA 1 Predictive Runs: Draft Technical Memorandum prepared for North Plains Groundwater Conservation District and Groundwater Management Area 1 for submission to Texas Water Development Board as part of Desired Future Conditions Submission Package, 18 p.:
[7] Goswami, R. R., 2017, GAM RUN 16-029 MAG: Modeled Available Groundwater for the aquifers in Groundwater Management Area 1: Texas Water Development Board, 17 pg.
[8] *Id.*

4.2.2.1.1 *Performance Standard*

1.3a Results from data collection and trend analysis will be presented to the Board of Directors during the annual review of depletion in the District by August 31st of each year.

SECTION 4.3 GOAL 2 PROVIDING FOR THE MOST EFFICIENT USE OF GROUNDWATER

Throughout its history, the District has operated on the core principle (or goal) that groundwater should be used as efficiently as possible for beneficial purposes. In order to achieve this goal, the District maintains a qualified staff to assist water users in protecting, managing, and conserving groundwater resources. The Board of Directors has in the past and continues today to base its decisions on the best data available to treat all water users as equitably as possible. Once data is collected, the District utilizes a wide variety of forums to provide important information to water users throughout the District so that sound decisions regarding the efficient use of groundwater can be made. The District's Observation Well Network will continuously be reviewed and maintained in order to monitor changing storage conditions of groundwater supplies within the District. The District will continue to undertake and cooperate with technical investigations of groundwater resources within the District. The following management objectives and performance standards have been developed and adopted to collect needed information, disseminate information, and provide opportunities through the District's Agricultural Water Conservation Equipment Loan Program to ensure the efficient use of groundwater.

4.3.1.1 Management Objective 2.1

The Observation Well Network, with approximately 850 water wells located throughout the District is continuously maintained and monitored. Wells in the Observation Well Network produce groundwater from the Ogallala Aquifer, the Dockum Aquifer, and also other minor aquifers in the area. Water levels are measured by District staff in as many wells as possible, with the management objective being to measure water levels in at least 90 percent of the wells in the Observation Well Network each year. This data is then processed for quality assurance/quality control, entered into the District's geodatabase, analyzed, mapped, and used to make decline calculations and update historic trend lines (hydrographs).

Water level measurements from wells in the District's Observation Well Network are used to generate annual decline maps. The District will strive to install additional monitoring wells in locations when necessary in order to evaluate the effects of high-impact pumping operations as necessary.

4.3.1.1.1 *Performance Standard*

2.1a Measure water levels in at least 90 percent of the operational water wells in the District's Observation Well Network annually by April 1st.

2.1b Using water level measurements collected from November to April from wells in the Observation Well Network, prepare an annual decline map based on changes in water levels observed in the last 12 months by July 31st and publish in next available District newsletter, Panhandle Water News (PWN).

2.1c Using water level measurements collected each year from wells in the Observation Well Network and historical information from the District's geodatabase, prepare an Ogallala Aquifer water table decline map for use in the Internal Revenue Service (IRS) annual depletion program. Provide results of IRS Ogallala Aquifer allowable depletion levels to participating producers by January 31st of each year.

4.3.1.2 Management Objective 2.2

The District encourages efficient groundwater use by continued promotion of low pressure and other efficient sprinkler systems, drip irrigation systems, and other recognized water conservation measures, which will decrease the utilization of less efficient row irrigation techniques. This will be accomplished by increasing the use of the District's Agricultural Water Conservation Equipment Loan Program, as long as TWDB Agricultural Loan Program funds are available and economically competitive. The District will enhance awareness of the loan program by utilizing local newspapers and the PWN. The District website will have information on availability of funds and guidelines for applicants. The District will strive to provide timely responses to loan applicants.

4.3.1.2.1 *Performance Standard*

2.2a The District will include a reminder about the District's Agricultural Water Conservation Equipment Loan Program at least bi-annually in the PWN, as long as funds are available at competitive rates.

2.2b District staff strives to complete the District review process for all loan applications and prepare for Board of Director consideration within 60 days of receipt of administratively complete loan applications.

4.3.1.3 Management Objective 2.3

The District encourages the efficient use of groundwater by disseminating educational information regarding current best management practices and trends in water conservation for agricultural, municipal, and industrial applications. The District publishes a newsletter quarterly that contains resources for water users interested in water conservation. In addition, the District also attends and participates in public events throughout the District including the annual Amarillo Farm and Ranch Show as often as possible.

4.3.1.3.1 *Performance Standard*

2.3a The District will publish Panhandle Water News (PWN) on a quarterly basis.

2.3b Each year the District will participate in the Amarillo Farm and Ranch Show, when held.

4.3.1.4 Management Objective 2.4

In order to ensure that the Board of Directors and District constituents are aware of and informed on the most current information on water conservation, groundwater management, and emerging policy issues related to groundwater resources, District staff actively participate in a broad grouping of professional associations that focus on water resource issues. District staff will report at the next available regularly scheduled Board of Directors meeting in the General Manager's Report on any activities resulting from participation with the following active affiliations:

- Texas Alliance of Groundwater Districts (TAGD)
- Texas Water Conservation Association (TWCA), and,
- Groundwater Management Districts Association (GMDA).

4.3.1.4.1 *Performance Standard*

2.4a District staff will attend and participate in 75 percent of the cumulative number of regularly scheduled TAGD, TWCA and GMDA general meetings and report on noteworthy presentations and issues from these meetings at the next available regularly scheduled Board of Directors meeting in the General Manager's Report.

4.3.1.5 Management Objective 2.5

The District has adopted rules that require an approved metering method on all wells producing more than 35 gallons per minute. The District believes that when a water user understands the volume of groundwater being used, they are better able to adopt best management practices that result in the efficient use of groundwater. Therefore, the District is committed to continuing the program focused on requiring metering method for permitted wells, flow meter monitoring, and data collection and analysis of water use by crop and irrigation type. To achieve this objective the District will read and record meter data from installed, registered, and accessible, meters in the District annually. The information from the District's metering program will be published in the District's Annual Report. Additionally, individual's meter data reports may be viewed on the District's website via a password protected account. Finally, the Board will consider flow meter data with respect to individual Contiguous Acreage Tracts in order to document compliance with the District maximum allowable production rate.

4.3.1.5.1 *Performance Standard*

2.5a Read and record meter data for 90 percent of approved metering methods at least annually.

2.5b Meter reports will be uploaded to an individual's password protected web account and updated annually.

2.5c Review and prepare revised estimates to TWDB annual draft agricultural water use estimates based on District meter data and other relevant information and submit to designated TWDB staff within the timeframe requested.

SECTION 4.4 GOAL 3 CONTROLLING AND PREVENTING WASTE OF GROUNDWATER.

Another core principle adopted by the District since its inception in order to conserve groundwater resources of the region is by controlling and preventing the waste of groundwater. The following management objectives and performance standards have been developed and adopted as an integral component of the District's umbrella goal to achieve the 50/50 Management Standard.

4.4.1.1 Management Objective 3.1

The District is continuously working to take positive and prompt action to identify and address all reported wasteful practices and instances of waste located by District staff within the District. This effort involves the following actions to be taken by the District.

- Report each complaint to the landowner and/or operator within five working days.
- Resolve the complaint and note the corrective action taken.
- Report resolution of each complaint to the landowner/operator and to the Board at the next regularly scheduled meeting during the General Manager's Report.

4.4.1.1.1 *Performance Standards*

3.1a All notices or complaints will be recorded, investigated and reported to the landowner/operator within five working days.

3.1b Report each complaint and staff resolution to the Board of Directors at the next regularly scheduled meeting.

SECTION 4.5 GOAL 4 IMPLEMENT STRATEGIES TO ADDRESS DROUGHT CONDITIONS

In order to address drought conditions, the District has implemented a number of programs that are designed to positively support constituents in the District when drought conditions exist. While one of these efforts is described below in Management Objectives 4.1, others are documented elsewhere in the management plan. For example, the District operates a state-permitted precipitation enhancement program, described below in Goal 8.

4.5.1.1 Management Objective 4.1

In order to provide ongoing information regarding water conditions in the District, establish and maintain links to National Oceanic and Atmospheric Administration Drought Monitor indices are on the District website.

4.5.1.1.1 *Performance Standard*

4.1a Annually, the District will update links to the National Oceanic and Atmospheric Administration Drought Monitor indices are available for use on the District's website.

SECTION 4.6 GOAL 5 IMPLEMENT STRATEGIES TO ADDRESS CONJUNCTIVE SURFACE WATER MANAGEMENT ISSUES

The Canadian River Municipal Water Authority (CRMWA) supplements member city allocations of groundwater with supplies from Lake Meredith. The CRMWA system is the largest conjunctive use water provider in the State of Texas, providing a combination of groundwater and surface water to 11 member cities. All current CRMWA groundwater supplies are produced within the boundaries of the District.

The Greenbelt Water Authority (GWA) is the second surface water user with supplies inside the boundaries of the District. GWA is now also utilizing groundwater resources from the Ogallala Aquifer. The District will communicate with regards to rules and technical data as it applies to conjunctive use within the District.

4.6.1.1 Management Objective 5.1

In order to continually monitor the impact of declining surface-water availability on groundwater resources within the District, the General Manager or designee will participate in the Panhandle Water Planning Group (PWPG) with the two surface-water entities currently operating within the District. This activity helps facilitate regular communication and cooperation with regards to conjunctive use issues in the District.

4.6.1.1.1 *Performance Standard*

5.1a The District General Manger or designee will participate in at least 75 percent of the regularly scheduled PWPG meetings and activities throughout the current regional water planning cycle (2017 – 2022).

SECTION 4.7 GOAL 6 IMPLEMENT STRATEGIES THAT WILL ADDRESS NATURAL RESOURCE ISSUES

As part of the umbrella goal of achieving the adopted DFCs, the District recognizes that the protection of water quality is equally as important as working to ensure adequate water quantity. In order to protect the District's most important natural resource, the abundant, high quality groundwater resources, the District has for many years maintained and operated a water quality sampling program sampling different areas each summer which yields a complete set of data biennially.

4.7.1.1 Management objective 6.1

In order to control and prevent the contamination of groundwater, the District maintains and works to expand the groundwater quality monitoring. As part of this effort, an annual sampling program will be conducted within the District's Water Quality Network. The objective will be to sample at least 80 percent of the wells in the District's Water Quality Network on a biennial basis. Also, upon request the District will conduct analysis of water within current District sampling capabilities, including sites near oil and gas industry injection well sites.

4.7.1.1.1 *Performance Standards*

6.1a Sample 80 percent of the wells in the District's Water Quality Network on a biennial basis and report program status to the Board of Directors each year.

6.1b Record all water quality measurement data in the District's water quality database within 30 days of sampling.

SECTION 4.8 GOAL 7 IMPROVE OPERATING EFFICIENCY AND CUSTOMER SERVICE

4.8.1.1 Management Objective 7.1

Customer service is of great importance to the Board of Directors and Staff of the District. As detailed in the corresponding performance standards, the District will continue to provide timely response to customer assistance requests in the following areas:

- Pump flow tests.
- Processing of well drilling permits.
- Review and revision of District Rules, as necessary, to incorporate revisions required by new legislation and as necessary to achieve adopted Desired Future Conditions.
- Well camera recordings.

4.8.1.1.1 *Performance Standard*

7.1a Provide requested flow tests annually within five working days of the landowners requested date and report to the Board in the Annual Report.

7.1b General Manager's action on administrative completeness of well drilling permits taken and permit returned to customer within 10 working days of approval.

7.1c Provide the well camera service within five working days of request or the landowners requested date and return the information to the well operator within five working days, and archive a copy of the DVD into the District library and report to the Board in the Annual Report.

SECTION 4.9 GOAL 8 ADDRESSING PRECIPITATION ENHANCEMENT

Texas Water Code Section 36.1071(a)(7) requires groundwater conservation districts to include in the management plan a goal addressing precipitation enhancement. The District has one of the longest continuous precipitation enhancement programs in the Texas.

4.9.1.1 Management Objective 8.1

The District will continue to operate its Precipitation Enhancement Program throughout the planning horizon of this management plan. The program will operate within budget. A rain gauge network will be maintained and monitored to confirm precipitation enhancement results. Flight records will be collected and archived.

The program will abide by Texas Department of Licensing and Regulation requirements for testing, monitoring, and reporting in order to ensure compliance with permit guidelines. Results of the District's Precipitation Enhancement Program will be presented to the Board of Directors and included in the Annual Report each year.

4.9.1.1.1 Performance Standard

8.1a Annually conduct the Precipitation Enhancement Program from April 1st to September 30th.
8.1b Calculate the baseline costs for Precipitation Enhancement Program each year.

8.1c Collect and record rain gauge readings at least once a quarter.

8.1d Annually maintain all flight records on all precipitation enhancement operations and make available for review upon request.

8.1e. Provide precipitation enhancement annual report to Texas Department of Licensing and Regulation.

4.9.1.2 Management Objective 8.2

Educate the public with regards to the benefits of the District's Precipitation Enhancement Program through informational articles in the PWN and local newspapers, public presentations, and program summaries in the District's Annual Report each year.

4.9.1.2.1 Performance Standard

8.2a Publish an article about the Precipitation Enhancement Program in at least 2 of the quarterly issues of PWN.
8.2b Provide at least one article about the Precipitation Enhancement Program to all local newspapers annually.

8.2c District staff will give at least two presentations annually to a public or civic group regarding the Precipitation Enhancement Program.

8.2d Complete the Program Summary Report and include in District's Annual Report each year.

SECTION 4.10 GOAL 9 ADDRESSING CONSERVATION

Texas Water Code Section 36.0015 states, in part, that, "In order to provide for the conservation, preservation, protection, recharging, and prevention of waste of groundwater….Groundwater conservation districts may be created…are the state's preferred method of groundwater management through rules developed, adopted, and promulgated by a district in accordance with the provisions of this chapter." It is noteworthy that in this overview section of Texas water law addressing groundwater management that "conservation" is the first action groundwater conservation districts are to pursue. The 50/50 Management Standard can only be achieved if our groundwater resources are conserved in a manner that ensures adequate water resources will be available for future generations. While water conservation is a fundamental component of many of the District's programs, the following represent management objectives most focused on water conservation.

4.10.1.1 Management Objective 9.1

Continue and expand, when possible, the District's Groundwater Conservation Education Program. District staff will make presentations on the importance of water conservation to at least 5 civic organizations and in at least 30 educational settings. Annually, the District will award at least three college scholarships to students in the District based on participation in a water conservation essay competition. The District will maintain an Internet information page and launch an aggressive conservation education initiative called "Water Warriors", as well as work with other entities to present an ongoing Panhandle area water conservation symposium.

4.10.1.1.1 Performance Standards

9.1a Annually make a minimum of five civic educational presentations.

9.1b Annually make 30 presentations in educational settings.

9.1c Annually provide at least three scholarships to students residing within the District that have participated in the District's water conservation essay competition.

9.1d Continue Water Warrior Program as part of aggressive public relations and education campaign encouraging all users to make water conservation a high priority in at least three public presentations outside of school settings.

SECTION 4.11 GOAL 10 RAINWATER HARVESTING

Rainwater harvesting is becoming an increasingly important strategy for meeting water supply needs, especially in the more rural areas of Texas. While rainwater harvesting is one of the many topics included in the District's water conservation education programs, the following management objective and performance standards are specifically focused on rainwater harvesting.

4.11.1.1 Management Objective 10.1

The District has established and maintains a rainwater harvesting system and provides educational tours to the public regarding the many benefits of the system. Tours of the District office rainwater harvesting system are provided upon request. A link to an informational page highlighting the rainwater harvesting system will be maintained and updated as necessary on the District's website. In addition, a link to the TWDB website on rainwater harvesting will also be maintained on the District's website.

4.11.1.1.1 Performance Standard

10.1a Webpage highlighting the District's rainwater harvesting system along with information regarding availability of tours to the public is maintained and updated as necessary.

10.1b Link to the TWDB Rainwater Harvesting webpage is maintained on the District's webpage.

CHAPTER 5 GOALS DETERMINED NOT-APPLICABLE

SECTION 5.1 GOAL 11 RECHARGE ENHANCEMENT

The District has been a long-standing participant and supporter of recharge enhancement efforts, primarily in partnership with the Texas Water Development Board. However, lack of financial support from the Texas Legislature for this program has resulted in the suspension of this program on an indefinite basis. Due to the scale and nature of a recharge enhancement program and lack of participating support from either state or federal partners, the District has determined that a program addressing recharge enhancement by the District is not feasible at this time

SECTION 5.2 GOAL 12 CONTROL AND PREVENTION OF SUBSIDENCE

Although Furnans and others (2017)[9] classified the Ogallala Aquifer in the High Plains as having a high subsidence risk, and the Dockum Aquifer as having medium subsidence risk potential, the absence of any measured subsidence in the District over the extensive historical period of pumping and he geologic framework and unconfined nature of the Ogallala Aquifer in the region led to the District's determination that the risk of significant subsidence from occurring due to groundwater pumping is not sufficient to warrant the adoption of a goal, management objective, or performance standard to meet a subsidence goal.

[9] Furnans, J., Keester, M., Colvin, D., Bauer, J., Barber, J., Gin, G. Danielson, V., Erickson, L., Ryan, R., Khorzad, K., Worsley, A., Snyder, G., 2017, Final Report: Identification of the Vulnerability of the Major and Minor Aquifers of Texas to Subsidence with Regard to Groundwater Pumping TWDB Contract Number 1648302062, 434 pg.

SECTION 5.3 GOAL 13 BRUSH CONTROL

The Canadian River Municipal Water Authority has a large brush control project along the Canadian River in the District, and the District encourages that action, but the District has determined that a program addressing brush control by the District is not feasible at this time.

CHAPTER 6 POPULATION, WATER USE, AND WATER DEMANDS

Primary activities involved in the development of a water resources management plan include the analysis and development of projections of population, historical and current water use, and projections of water demands in the future (for a defined period of time). In order to develop projections for how much water supply we will need in the future, three questions must be answered: (1) how many people are there now and how much water has been used in the recent past, (2) how many people will there be in the future (population projections), and (3) how much water will be required to meet the needs of the projected population and other water use sectors in the future. These analyses to develop water demand projections are primarily conducted in Texas as part of the regional water supply planning process (created by the 75th Texas Legislature through the passage of Senate Bill 1 in 1997). Water demand projections are developed for the following water user categories; municipal, rural (county-other), irrigation, livestock, manufacturing, mining, and steam-electric power generation. These three tasks are then followed by the evaluation of current water supplies, comparison of water demands to water supplies in order to determine needs for additional water supplies, and finally the identification, evaluation, and selection of water management strategies to meet any water supply needs that identified. This section addresses population projections, water use, and water demands.

Based on information developed for the 2017 Texas State Water Plan, population projections for the District range from 170,045 in 2020 to 264,700 in 2070. This represents a 56 percent increase in population over the 50-year planning horizon. (Table 3, Figure 2).

Table 3 - Decadal population projections for Panhandle GCD included in the 2017 Texas State Water Plan.[10]

County	2020	2030	2040	2050	2060	2070
Armstrong	1,911	1,911	1,911	1,911	1,911	1,911
Armstrong - District *	1,764	1,764	1,764	1,764	1,764	1,764
Carson	6,354	6,520	6,632	6,632	6,632	6,632
Donley	3,788	3,788	3,788	3,788	3,788	3,788
Gray	24,439	27,046	30,168	34,186	37,388	40,730
Hutchinson	22,957	23,779	23,990	23,990	23,990	23,990
Hutchinson - District **	987	1,022	1,032	1,032	1,032	1,032
Potter	134,031	148,960	164,757	180,486	197,638	215,701
Potter - District ***	126,123	140,171	155,036	169,837	185,977	202,975
Roberts	1,003	1,047	1,047	1,047	1,047	1,047
Wheeler	5,587	5,809	6,019	6,239	6,478	6,733
Total	170,045	187,168	205,486	224,525	244,106	264,700

* - county total multiplied by apportioning factor (land area of District in county/land area of county) of 0.923.

** - county total multiplied by apportioning factor (land area of District in county/land area of county) of 0.043.

*** - county total multiplied by apportioning factor (land area of District in county/land area of county) of 0.941.

District total represents the sum of population projections for Carson, Donley, Gray, Roberts, and Wheeler counties and the proportional population estimate based on the proportional amount of area in the county that is within the boundaries for counties partially within the jurisdictional boundaries of the District.

[10] Texas Water Development Board, 2017, Water for Texas, Texas State Water Plan, variously paginated.

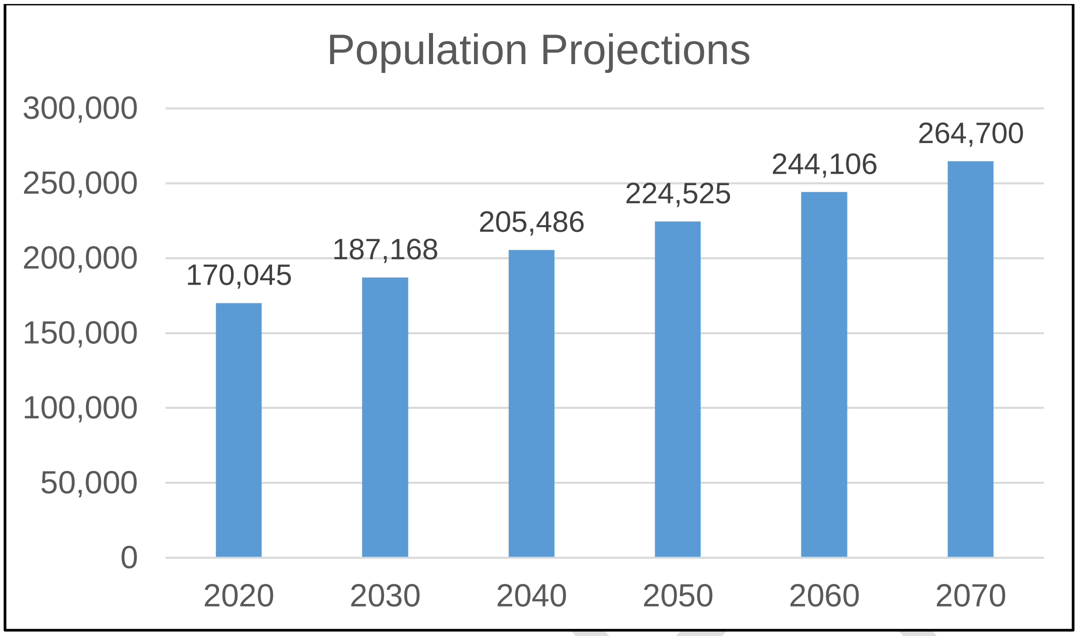

Figure 2 – Decadal population projections for Panhandle GCD included in the 2017 Texas State Water Plan.[11]

[11] Texas Water Development Board, 2017, Water for Texas, Texas State Water Plan, variously paginated

The next important component in planning for and management of water resources is an understanding of water use. The methods used to estimate groundwater use in the District have changed and improved over time, so that flow meters are now available and being used throughout the District to improve estimates of groundwater use. Groundwater use in the District for the six major water use sectors in 2016 (most currently available year) is estimated to be approximately 250,057 acre-feet (see Table 4 and

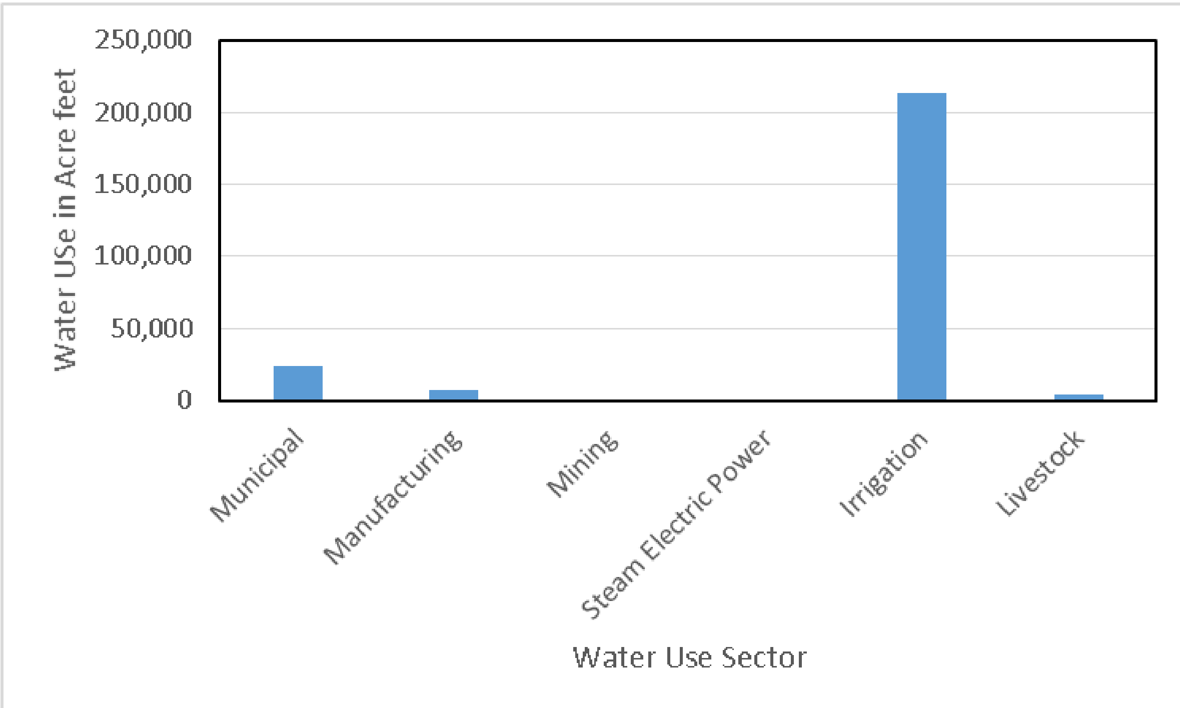

Figure 3 – Groundwater use in the District by water use sector (as defined in regional water planning) in 2016. Groundwater use estimates from Texas Water Development Board.)[12]. In 2016, irrigation continued to be the largest water use sector, representing 85.2 percent of the total groundwater pumpage. Historic estimates of both groundwater and surface water use from 2000 – 2016 are included in Appendix 4. Throughout the period of record, groundwater for irrigated agriculture in the District has been the largest use of groundwater from the Ogallala Aquifer.

[12] Allen, S., 2019, Estimated Historical Groundwater Use and 2017 State Water Plan Datasets: Panhandle Groundwater Conservation District: Texas Water Development Board Technical Report, 29 pg.

Table 4 - Water use estimates for the District in 2016[13]. (In acre-feet per year)

County	Municipal	Manufacturing	Mining	Steam Electric Power	Irrigation	Livestock	Total
Armstrong	305	0	0	0	6,292	243	6,840
Carson	834	987	0	0	104,042	314	106,177
Donley	78	0	0	0	29,946	692	30,716
Gray	736	264	0	0	41,766	1,584	44,350
Hutchinson	258	415	4	0	2,722	12	3,411
Potter	19,906	6,173	84	811	1,438	383	28,795
Roberts	170	0	16	0	9,545	300	10,031
Wheeler	1,389	0	90	0	17,381	877	19,737
District Total	23,676	7,839	194	811	213,132	4,405	250,057

Note - water use estimates for Armstrong, Hutchinson, and Potter counties are proportional to the area of the county within the District. Also, these water use estimates are for water use within the county, and not for water pumped within the county and transported outside of a county for use elsewhere. District total represents the sum of water use estimates for Carson, Donley, Gray, Roberts, and Wheeler counties and the proportional water use estimate based on the proportional amount of area in the county that is within the boundaries for counties partially within the jurisdictional boundaries of the District.

[13] Allen, S., 2019, Estimated Historical Groundwater Use and 2017 State Water Plan Datasets: Panhandle Groundwater Conservation District: Texas Water Development Board Technical Report, 29 pg.

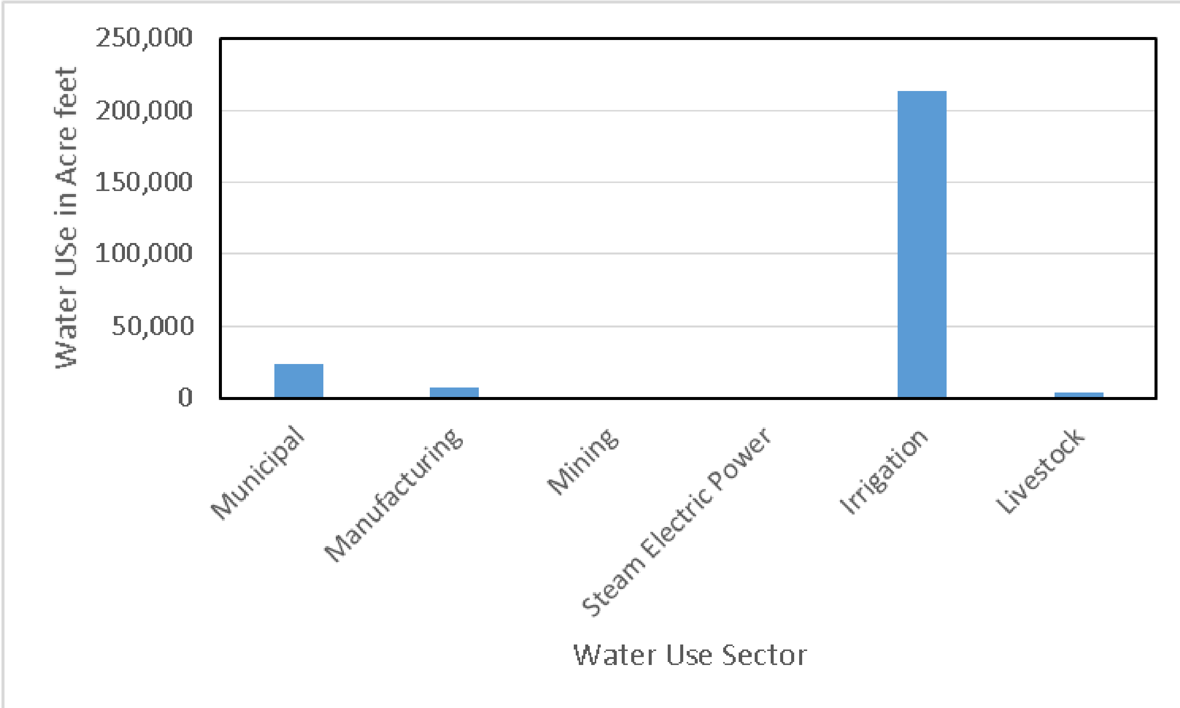

Figure 3 – Groundwater use in the District by water use sector (as defined in regional water planning) in 2016. Groundwater use estimates from Texas Water Development Board. (In acre-feet per year)[14]

The next step in the planning process is the development of water demand projections for the various water use sectors and water user groups over the course of the 50-year planning horizon. Water demand projections are updated for the regional water planning process every five years and are based on changes in population trends including information from the most recent U.S. Census, water use patterns, and changes in technology (for example, anticipated savings from drought tolerant crops in the future). Appendix 4 provides water demand projections for the six water use categories throughout the 50-year planning horizon and Table 5 along with Figure 4 provides summary information on water demands by county in the District. Water demands decrease from 218,939 acre-feet per year in 2020 to 200,513 acre-feet per year in 2070, representing an 8.4 percent decrease in water demands over the 50-year planning horizon.

[14] Allen, S., 2019, Estimated Historical Groundwater Use and 2017 State Water Plan Datasets: Panhandle Groundwater Conservation District: Texas Water Development Board Technical Report, 29 pg.

Table 5 - Cumulative water demand projections for Panhandle GCD included in the 2017 Texas State Water Plan[15]. (In acre-feet per year)

County	2020	2030	2040	2050	2060	2070
Armstrong*	4,910	4,716	4,453	4,073	3,695	3,317
Carson	58,106	55,294	51,273	45,880	40,508	35,140
Donley	26,033	25,141	23,771	21,338	18,912	16,486
Gray	33,086	33,051	32,205	31,540	30,024	28,652
Hutchinson **	7,664	7,697	7,598	7,474	7,389	7,320
Potter ***	66,843	71,545	76,613	81,549	89,596	97,437
Roberts	8,102	7,295	6,408	5,413	4,672	4,083
Wheeler	14,195	13,156	11,711	10,014	8,872	8,078
District Total	218,939	217,895	214,032	207,281	203,668	200,513

* County total multiplied by apportioning factor (land area of district in county/land area of county) of 0.9236

** county total multiplied by apportioning factor (land area of district in county/land area of county) of 0.0424

*** County total multiplied by apportioning factor (land area of district in county/land area of county) of 0.9412

District total represents the sum of water demand projections for Carson, Donley, Gray, Roberts, and Wheeler counties and the proportional water demand estimate based on the proportional amount of area in the county that is within the boundaries for counties partially within the jurisdictional boundaries of the District.

[15] Allen, S., 2019, Estimated Historical Groundwater Use and 2017 State Water Plan Datasets: Panhandle Groundwater Conservation District: Texas Water Development Board Technical Report, 29 pg.

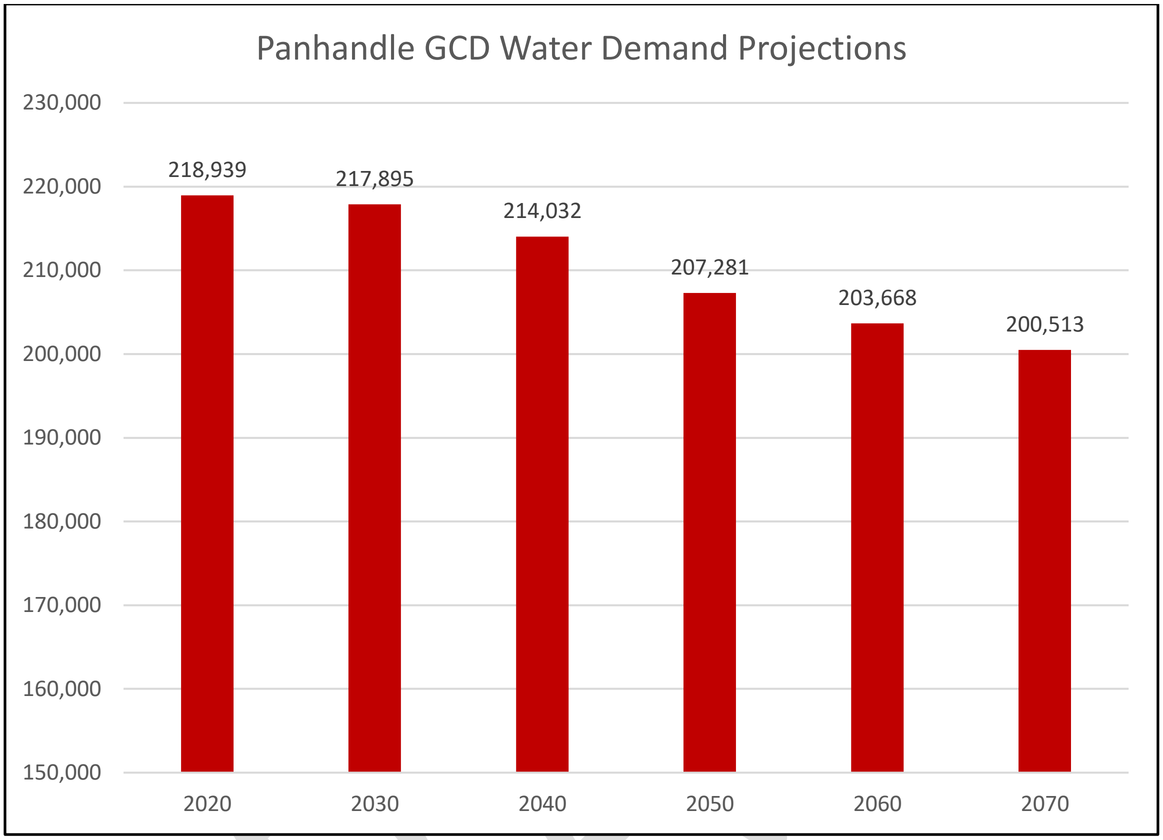

Figure 4 – Cumulative water demand projections for Panhandle GCD for the 50-year planning horizon approved by the Texas Water Development Board for the 2017 Texas State Water Plan. (In acre-feet per year)

CHAPTER 7 GROUNDWATER RESOURCES

The District has invested significant time and resources in an effort to improve the science and understanding of groundwater resources in the Panhandle of Texas. Most significantly, the District participated in the most recent update of the High Plains Aquifer System Groundwater Availability Model (High Plains GAM) approved by the Texas Water Development Board in 2015. This effort culminated in the publication of the High Plains GAM Report by Deeds and Jigmond (2015).[16] The District worked with the Texas Water Development Board during this effort to update the High Plains GAM through financial support, provision of meter data and new well logs, and technical reviews on draft reports. This updated planning and water resources evaluation tool has made significant improvements to the science available to the Board of Directors and Staff at the District, especially with regards to improved historic and current pumping estimates, hydrostratigraphy, and aquifer properties. The updated High

[16] Deeds, N. E., and Jigmond, M., 2015, Numerical Model Report for the High Plains Aquifer System Groundwater Availability Model, 640 p.,http://www.twdb.texas.gov/groundwater/models/gam/hpas/HPAS_GAM_Numerical_Report.pdf.

Plains GAM was most recently used by District Representatives in Groundwater Management Area 1 to evaluate potential predictive simulation scenarios and to establish estimates of modeled available groundwater resulting from the adoption of the 50/50 Management Standard and the 30-foot decline in the Dockum Aquifer.

The Ogallala Aquifer is the primary aquifer within the District and is located in sediments of the Ogallala Formation of Neogene (Pliocene) Period. The Ogallala Aquifer yields water from the mostly unconsolidated gravels, sands, silts, and clays of the Ogallala Formation. Groundwater movement is generally to the northeast, away from groundwater and topographic highs and towards the surface drainage system of the Canadian River basin (Figure 5). There are areas where flow is toward groundwater lows that have developed as a result of production in large well fields. Areas where irrigation wells are co-located with municipal well fields have experienced significant water table declines. Other irrigated areas have demonstrated varying water level declines.

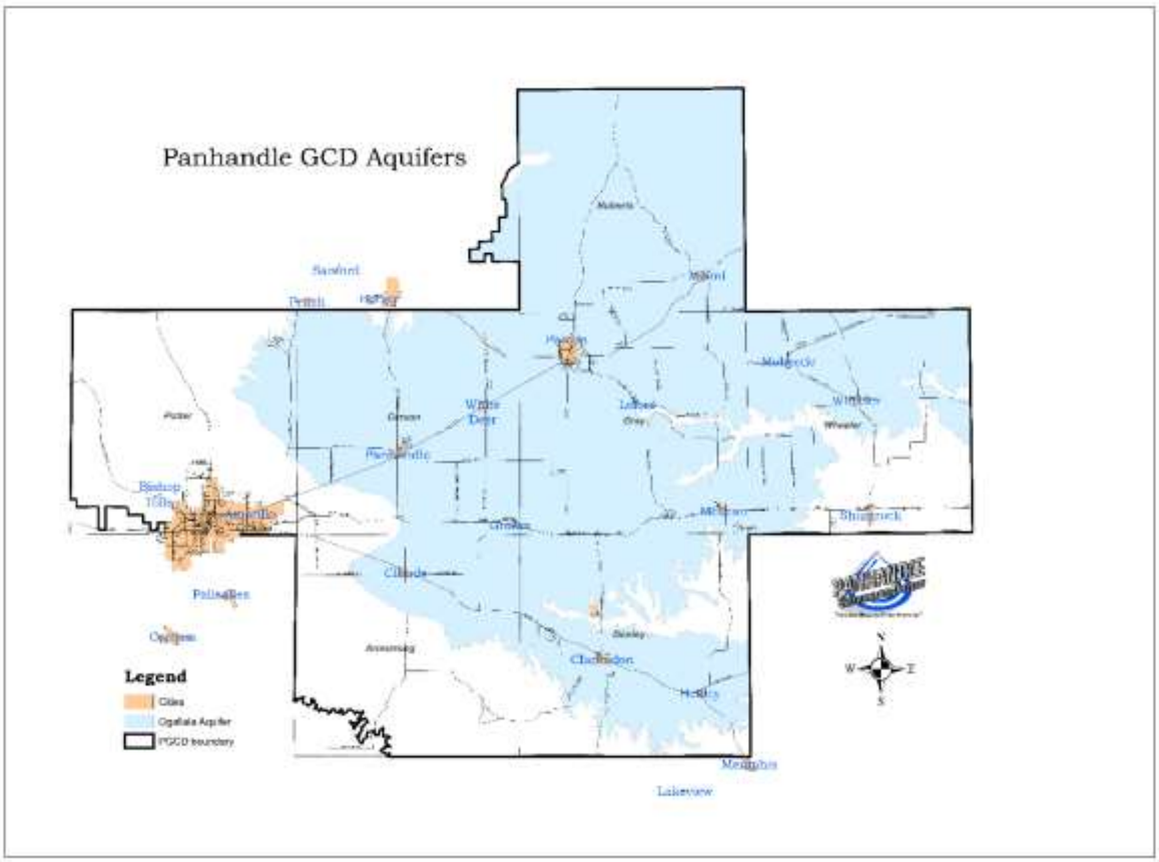

Figure 5 – Map illustrating the areal extent of the Ogallala Aquifer in the District.

In addition to the Ogallala Aquifer, there are three minor aquifers within the District. The Dockum Aquifer furnishes limited amounts of household, livestock and irrigation water within the District. The Dockum Aquifer is present in Triassic age shales, sandstones and siltstones where it is found within the District. Water production from the Dockum Aquifer occurs in Armstrong, Potter and southwest Carson counties (Figure 6).

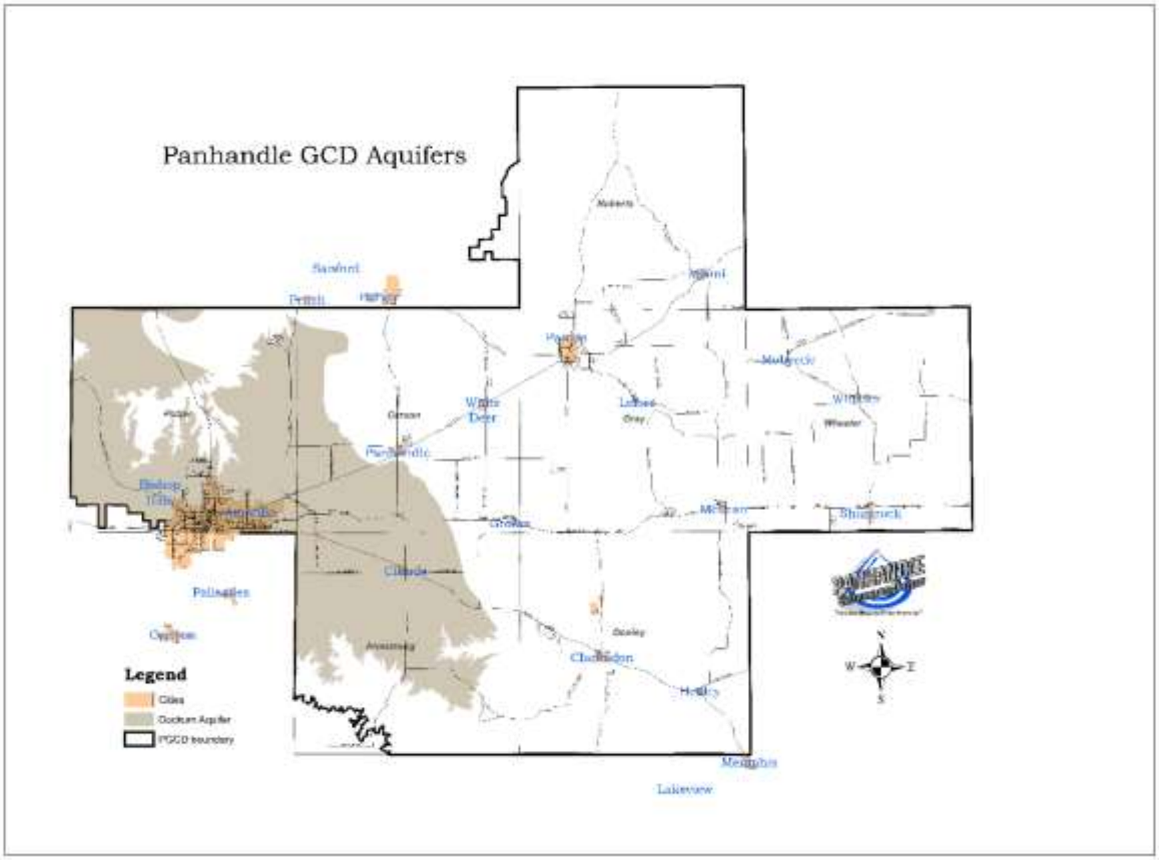

Figure 6 – Map illustrating the areal extent of the Dockum Aquifer in the District.

The Blaine Aquifer is a minor aquifer located in the southern portion of Wheeler County (Figure 7). For the purposes of joint planning, District Representatives classified the Blaine Aquifer as non-relevant. As such, no goals, management objectives, or performance standards are adopted in this management plan for the Blaine Aquifer. The aquifer is contained in the Permian age Blaine Formation. The water is found in solution channels formed by dissolving deposits of anhydrite and halite within the formation. The dissolving salts raise the total dissolved solids to levels above drinking water standards, so the Blaine Aquifer is used mainly for agricultural purposes.

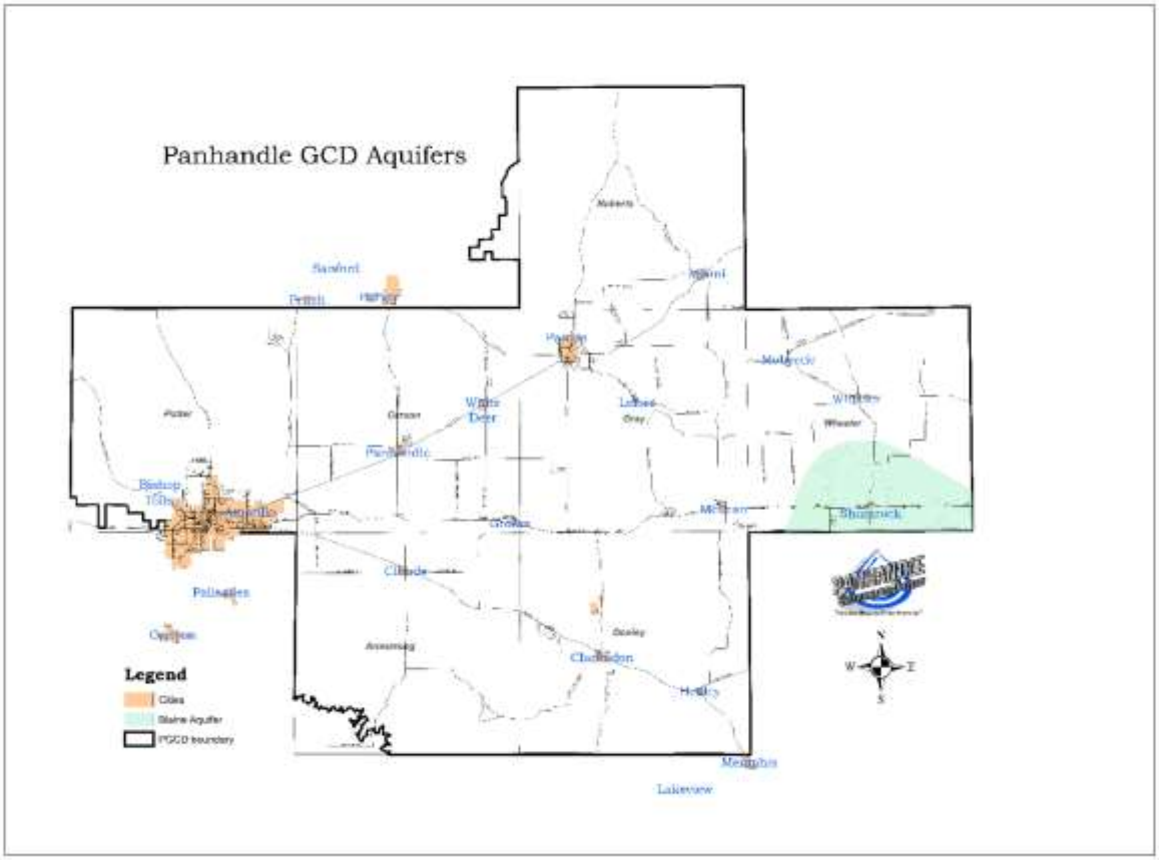

Figure 7 – Map illustrating the areal extent of the Blaine Aquifer in the District.

Texas Water Code Section 36.1071 requires groundwater conservation districts to consider and utilize information from the current groundwater availability model and site-specific information during development of the management plan. As part of this requirement, groundwater conservation districts are to consider estimates of (1) the annual amount of recharge from precipitation to the groundwater resources within the district, if any;(2) for each aquifer within the district, the annual volume of water that discharges from the aquifer to springs and any surface water bodies, including lakes, streams, and rivers; and (3) the annual volume of flow into and out of the district within each aquifer and between aquifers in the district. This information was provided by the Texas Water Development Board in Wade (2016)[17] to the District for this management plan and is included herein as Appendix 5. The required estimates for the Ogallala, Dockum, and Blaine aquifers are included in Table 6, Table 7, and Table 8.

[17] Wade, S., 2016, GAM RUN 16-001: Panhandle Groundwater Conservation District Management Plan, Texas Water Development Board, 15 p.

Table 6 – Estimates of recharge, discharge, flow into and out of the District and between each aquifer of the District for the Ogallala Aquifer.[18] (In acre-feet per year)

Management Plan requirement	Aquifer or confining unit	Results
Estimated annual amount of recharge from precipitation to the district	Ogallala Aquifer	113,864
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Ogallala Aquifer	129,654
Estimated annual volume of flow into the district within each aquifer in the district	Ogallala Aquifer	39,686
Estimated annual volume of flow out of the district within each aquifer in the district	Ogallala Aquifer	26,155
Estimated net annual volume of flow between each aquifer in the district	From the Ogallala Aquifer into Underlying units	2,663

[18] Wade, S., 2016, GAM RUN 16-001: Panhandle Groundwater Conservation District Management Plan, Texas Water Development Board, 15 p.

Table 7 - Estimates of recharge, discharge, flow into and out of the District and between each aquifer of the District for the Dockum Aquifer. (In acre-feet per year)

Management Plan requirement	Aquifer or confining unit	Results
Estimated annual amount of recharge from precipitation to the district	Dockum Aquifer	2,333
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Dockum Aquifer	7,937
Estimated annual volume of flow into the district within each aquifer in the district	Dockum Aquifer	4,111
Estimated annual volume of flow out of the district within each aquifer in the district	Dockum Aquifer	1,337
Estimated net annual volume of flow between each aquifer in the district	From overlying units into the Dockum Aquifer	2,663

Table 8 - Estimates of recharge, discharge, flow into and out of the District and between each aquifer of the District for the Blaine Aquifer. (In acre-feet per year)

Management Plan requirement	Aquifer or confining unit	Results
Estimated annual amount of recharge from precipitation to the district	Blaine Aquifer	3,702
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Blaine Aquifer	5,165
Estimated annual volume of flow into the district within each aquifer in the district	Blaine Aquifer	0
Estimated annual volume of flow out of the district within each aquifer in the district	Blaine Aquifer	5,096
Estimated net annual volume of flow between each aquifer in the district	Blaine Aquifer	0*

*This model assumes a no-flow boundary at the base of the Blaine Aquifer.

Over the past century, there have been many hydrogeologic investigations focused on the Ogallala Aquifer and to a much lesser extent, the Dockum Aquifer. A detailed discussion of the hydrogeology of the District based on the published scientific literature is clearly beyond the scope of this management plan. For those interested in additional information, the following technical publications are recommended; Johnson (1901)[19], White and others (1946)[20], Seni (1980)[21], Knowles and others (1984)[22], Gutentag and others (1984)[23], Bradley and Kalaswad (2003)[24], Dutton and Simpkins, (1986)[25], Dutton and others, (2001)[26], Dutton (2004)[27]; Gustavson and others (1995)[28], Nativ (1988)[29], Wood and Osterkamp, (1987)[30]; Wood and

[19] Johnson, W. D., 1901, The High Plains and their utilization: U. S. Geological Survey 21st Annual Report, 1890-1900, pt. 4, p. 601-741.

[20] White, W. N., Broadhurst, W. L. and Lang, J. W., 1946, Ground water in the High Plains of Texas: T. S. Geological Survey Water-Supply Paper 889-F, p. 381-420.

[21] Seni, S. J., 1980. Sand-body geometry and depositional systems, Ogallala Formation, Texas. The University of Texas at Austin, Bureau of Economic Geology Report of Investigations No. 105, 36 p.

[22] Knowles, T. R., Nordstrom, P., and Klempt, W. B., 1984, Evaluating the ground-water resources of the High Plains of Texas: Texas Department of Water Resources Report 288, v. 1, 119 p.

[23] Gutentag, E. D., Heimes, F. J., Krothe, N. C., Luckey, R. R., and Weeks, J. B., 1984, Geohydrology of the High Plains Aquifer in parts of Colorado, Kansas, Nebraska, New Mexico, Oklahoma, South Dakota, Texas, and Wyoming: U. S. Geological Survey Professional Paper 1400-B, 63 p.

[24] Bradley, R. G., and Kalaswad, S., 2003, The groundwater resources of the Dockum Aquifer in Texas: Texas Water Development Board Report 359, 73 p.

[25] Dutton, A.R., and Simpkins, W. W.,, 1986, Hydrochemistry and water resources of the Triassic Lower Dockum Group in the Texas Panhandle and Eastern New Mexico; of Economic Geology, The University of Texas at Austin, Report of Investigations No. 161, 51 p.

[26] Dutton, A. R., Reedy, R. C., and Mace, R. E., 2001, Saturated thickness in the Ogallala Aquifer in the Panhandle Water Planning Area—simulation of 2000 through 2050 withdrawal projections: Final Contract Report prepared for the Panhandle Water Planning Group, Panhandle Regional Planning Commission (contract number UTA01-462) by the Bureau of Economic Geology, The University of Texas at Austin, 130 p.

[27] Dutton, A. R., 2004, Adjustments of parameters to improve the calibration of the Og-N model of the Ogallala aquifer, Panhandle Water Planning Area: Bureau of Economic Geology, The University of Texas at Austin, 9 p.

[28] Gustavson, T. C. Holliday, V. T., and Hovorka, S. D., 1995, Origin and de4velopment of playa basins, sources of recharge to the Ogallala aquifer, Southern High Plains, Texas and New Mexico; The University of Texas at Austin, Bureau of Economic Geology, Report of Investigations No. 229, 44 p.

[29] Nativ, R., 1988, Hydrology and hydrochemistry of the Ogallala Aquifer, Southern High Plains, Texas Panhandle and Eastern New Mexico: The University of Texas at Austin, Bureau of Economic Geology Report of Investigations No. 177, 64 p.

[30] Wood, W. W., and Osterkamp, W. R., 1987, Playa-lake basins on the Southern High Plains of Texas and New Mexico: Part II, A hydraulic model and mass-balance argument for their development: Geological Society of America Bulletin, v. 99, no. 2, p. 224-230.

Sanford, (1995)[31]; Mullican and others, (1997)[32]; Scanlon and Goldsmith, (1997)[33], Scanlon and others (1997)[34], McMahon and others, (2006)[35], and Deeds and Jigmond, (2015)[36].

Primary sources of recharge to the Ogallala Aquifer are infiltration of water from playa lakes and infiltration of precipitation. Localized infiltration of water from playa lakes is the main recharge mechanism in the part of the District located "above the Caprock."

The District has determined that the most feasible method of increasing natural recharge is to increase rainfall by initiating a rainfall enhancement program. The objective of this program is to decrease irrigation demand and increase recharge in those areas where recharge takes place. Cloud seeding operations began in May 2000. The purpose of the cloud seeding program is to add additional rainfall over an extended period. One additional inch of rainfall could provide 2300 acre-feet of additional recharge within the District each year (PGCD, 2001)[37].

CHAPTER 8 SURFACE WATER RESOURCES

While groundwater clearly provides the vast majority of water supplies within the District, it is still important to consider surface water resources during the development of this management plan. Also, Texas Water Code §36.1071(e)(3)(F) requires the inclusion of estimates of projected surface water supplies in the District based on the most recently adopted Texas State Water Plan. These estimates summarized at the county level are presented below in Table 9 and increases slightly from 4,349 acre-feet per year in 2020 to 4,394 in 2070. (Readers note – estimates of groundwater resources as represented by estimates of modeled available groundwater (MAG), as determined based on the adopted desired future conditions, are included in Tables 1 and 2.

[31] Wood, W. W., and Sanford, W.E., 1995. Chemical and isotopic methods for quantifying ground-water recharge in a regional semi-arid environment. Ground Water 33, 458-468.

[32] Mullican, W. F., III. Johns, N. D., and Fryar, A. E., 1997, Playas and recharge of the Ogallala Aquifer on the Southern High Plains of Texas – An examination using numerical techniques; The University of Texas at Austin, Bureau of Economic Geology Report of Investigations No. 242, 72 p.

[33] Scanlon, B.R., and Goldsmith, R.S., 1997. Field study of spatial variability in unsaturated flow beneath and adjacent to playas. Water Resources Research 33, 2239-2252.

[34] Scanlon, B. R., Goldsmith, R. S., and Mullican, W. F., III, 1997, Spatial variability in unsaturated flow beneath playa and adjacent interplay settings and implications for contaminant transport, Southern High Plains, Texas: The University of Texas at Austin, Bureau of Economic Geology Report of Investigations No. 243, 68 p.

[35] McMahon, P.B., Dennehy, K.F., Bruce, B.W., Bohlke, J.K., Michel, R.L., Gurdak, J.J., Hurlbut, D.B., 2006. Storage and transit time of chemicals in thick unsaturated zones under rangeland and irrigated cropland, High Plains, United States. Water Resources Research 42, Article No. 34013.

[36] Deeds, N. E., and Jigmond, M., 2015, Numerical Model Report for the High Plains Aquifer System Groundwater Availability Model, 640 p.,http://www.twdb.texas.gov/groundwater/models/gam/hpas/HPAS_GAM_Numerical_Report.pdf.

[37] Panhandle Groundwater Conservation District, 2001, Annual Evaluation Report on the District's Precipitation Enhancement Program, 15 p.

A detailed breakdown of the summary information provided in Table 9 is included in Appendix 4. The volume of surface water resources identified in the 2017 Texas State Water Plan that is available to the District was reduced significantly from the 2012 Texas State Water Plan (for example, from 22,070 acre-feet per year in 2020 in the 2012 Texas State Water Plan to 4,349 acre-feet per year in 2020 in the 2017 Texas State Water Plan), primarily due to the reductions in firm yield available from Lake Meredith resulting from the impact of the severe drought in 2011. As a result of reduced surface water in storage in Lake Meredith during 2011, no surface water was pumped form the reservoir from late summer in 2011 through the spring of 2014. This interruption in surface water supply from Lake Meredith during the drought of 2011 led to the significant reduction in firm supply that can be relied upon during the regional water planning process.

Lake Meredith and Lake Greenbelt are the two major surface impoundments used to supply water to cities inside and outside the District. There are also numerous other small reservoirs used for agricultural purposes and environmental needs. Lake Meredith is located in parts of Hutchinson, Moore, and Potter counties, and is operated by the Canadian River Municipal Water Authority (CRMWA) as a municipal and industrial water supply for 11 member cities of the Authority. The lake is owned by the United States Bureau of Reclamation and is operated as a National Recreation Area by the National Park Service. Water rights to impound water in the lake (up to 500,000 acre-feet may be held in conservation storage), and to divert water from it for municipal and industrial uses, are held by the Authority under certificates of adjudication issued by the State of Texas. The Ogallala Aquifer now provides most of the water that CRMWA delivers to its member cities. Supplemental water is obtained from Lake Meredith to fulfill the annual CRMWA allocations, however, for the first time since opening, there were no deliveries of surface water to member cities from Lake Meredith in 2012 - 2013. Water from the lake is blended with local groundwater from individual municipality well fields by several cities. Member cities use the water from CRMWA to supply their base demand, and rely upon their localized groundwater supplies to meet their peak demands. Pampa and Amarillo, two of the CRMWA member cities, within the boundaries of the District, follow the latter procedure. The second surface impoundment is Greenbelt Lake, located in Donley County. Greenbelt Municipal & Industrial Water Authority (Greenbelt) is the proprietor and operator.

Table 9 - Projected surface water supplies included in the 2017 Texas State Water Plan[38] (In acre-feet per year)

County	2020	2030	2040	2050	2060	2070
Armstrong	113	113	113	113	113	113
Carson	411	411	411	411	411	411
Donley	766	773	781	790	801	811
Gray	855	855	855	855	855	855
Hutchinson	16	16	16	16	16	16
Potter	529	529	529	529	529	529
Roberts	211	211	211	211	211	211
Wheeler	1,448	1,448	1,448	1,448	1,448	1,448
District Total	4,349	4,356	4,364	4,373	4,384	4,394

CHAPTER 9 WATER MANAGEMENT PLAN

During the regional water planning process in Texas, a water supply need is identified if the projected demands exceed the supply for an individual water user group or wholesale water provider. Water supply needs are quantified on an individual water user group basis, then summarized at the county, groundwater conservation district, regional water planning area, and statewide basis. If no water user group is determined to have a need for additional water supply during drought conditions, then the need for additional supply will be recorded as “0”. A review of summary data for counties in the District documents that six of the eight counties in the District have a need for additional water supply throughout the 50-year planning horizon (see Table 10). Only Donley and Roberts counties do not have at least some need for additional water supplies during the 50-year planning horizon. Potter County has the most significant need for additional water supplies, projected to be 39,238 acre-feet per year by 2070. For a complete breakdown of water supply needs by water user groups see Appendix 4.

[38] Allen, S., 2016, Estimated Historical Groundwater Use And 2017 State Water Plan Datasets for the Panhandle Groundwater Conservation District: Texas Water Development Board, 25 p.

Table 10 - Projected water supply needs in the District from the 2017 Texas State Water Plan[39]. Values in red (-) indicate that water user groups in the county have been identified with water supply needs. A value of zero indicates that no water supply need has been identified for the county for the decade listed. (In acre-feet per year)

County	2020	2030	2040	2050	2060	2070
Armstrong		0	0	-35	-72	-110
Carson	-89	-521	-582	-577	-576	-576
Donley	0	0	0	0	0	0
Gray	0	-1,752	-2,491	-2,279	-3,120	-3,988
Hutchinson	-167	-1,642	-3,066	-4,538	-5,834	-7,128
Potter	-5,270	11,415	18,509	25,526	32,001	39,238
Roberts	0	0	0	0	0	0
Wheeler	-184	-249	-308	-365	-412	-453
District Total	-5710	-15579	-24956	-33320	-42015	-51493

The final step in the Texas regional water planning process is to identify, evaluate, and then recommend or select water management strategies to meet all identified needs for additional water supply. Basically, any water user group, whether it is a city or irrigated agriculture or mining (at a county aggregate level) for example, that is determined to have a need for additional water supply for any decade during the 50-year planning horizon will go through a deliberate process of identifying all potentially feasible water management strategies to meet the identified need, evaluate the cost, reliability, yield, impact to the environment and water quality, and then recommend the most appropriate strategy or combination of water management strategies to meet the identified needs. Table 11 provides a summation by county of the projected volume of water supply that will result from implementation of all recommended water management strategies. Appendix 4 includes the individual water management strategies recommended in the 2017 Texas State Water Plan to meet the identified needs for additional water supply. An examination of more significant water management strategies recommended for water user groups in the District includes:

- Agricultural water conservation strategies,
- Municipal water conservation,
- Development of additional groundwater supplies,
- Weather modification,
- Water audits and leak repairs,
- Conjunctive use, and
- Expand infrastructure capacity (CRMA II).

[39] Allen, S., 2016, Estimated Historical Groundwater Use And 2017 State Water Plan Datasets for the Panhandle Groundwater Conservation District: Texas Water Development Board, 25 p.

Table 11 - Summation of water supplies resulting from recommended water management strategies included for the District in the 2017 Texas State Water Plan[40]. (In acre-feet per year)

County	2020	2030	2040	2050	2060	2070
Armstrong	637	856	1,551	1,630	1,699	1,730
Carson	9,502	12,434	18,271	19,534	20,298	20,670
Donley	2,716	3,363	4,315	4,608	4,944	5,138
Gray	5,763	7,663	9,614	11,898	12,351	12,712
Hutchinson	13,163	18,835	22,749	23,937	24,715	25,272
Potter	9,713	24,948	32,701	32,369	34,383	42,360
Roberts	921	1,204	1,825	1,961	2,036	2,076
Wheeler	1,884	2,196	2,721	2,856	2,974	3,039
District Total	44,299	71,499	93,747	98,793	103,400	112,997

[40] Allen, S., 2016, Estimated Historical Groundwater Use And 2017 State Water Plan Datasets for the Panhandle Groundwater Conservation District: Texas Water Development Board, 25 p.