Draft: Review of Management Strategies Used by the Post Oak Savannah Groundwater Conservation District to Accomplish District Goals

Prepared for:

Post Oak Savannah Groundwater Conservation District
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Milano, TX 76556

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Version 3.0

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Version 2.0

EXECUTIVE SUMMARY

Since its creation in 2001, the District has developed a comprehensive approach for managing groundwater that includes programs that focus on conservation, conducting aquifer research, monitoring groundwater, modeling future conditions, permitting groundwater wells, conducting groundwater conferences, supporting legislations, and operating a groundwater assistance program. To help the District review, vet, and integrate the Districts management of groundwater resources, the report was written to accomplish three objectives:

- Describe and formalize the District structure for managing groundwater resources;
- Identify factors that could impact the District ability to implement management strategies to accomplish District goals;
- Identify actions that would improve the District's ability to implement strategies to accomplish goals

The District's management structure is described using the following eight components: (1) Regulatory authority, (2) Board of Directors, (3) Major Goals, (4) Management Documents; (5) Management Strategies; (6) Science, (7) District GM & Staff; and (8) Daily Management Operation. The report describes each of the components and provides a flowchart to show how the components are interconnected. The flowchart illustrates two key points regarding groundwater management. One point is that the Board of Directors is the primary decision maker regarding the development and implementation of groundwater management. The other point is that Management Strategies have a central and pivotal role with the District approach to groundwater management.

Management Strategies are defined as the formulation and promotion of policies and actions for the purpose of achieving District goals. The report identifies and discusses ten Management Strategies related to groundwater resources. These ten Management Strategies are: (1) *Education and Public Outreach, (2) Regional Planning, (3) Compliance Evaluations for Desired Future Conditions (DFCs) and Protective Drawdown Limits (PDLs), (4) Management Zones, (5) Well Monitoring Program, (6) District Action Triggered by Exceedances of Tiered Thresholds, (7) Well Permitting Requirements, (8) Production Limitations, (9) Curtailment of Permitted Production, and (10) Conservation of Groundwater.*

An important and necessary attribute of any management strategy is that it helps achieve District goals in a manner that is both legally and scientifically defensible. Legally defensible means the management strategy is aligned and supported by legislative statutes and especially those responsible for the creation of the District. Similarly, scientifically defensible means that the management strategy is aligned with and supported by the science. In addition, Texas Water Code ("TWC") § 36.0015 states that groundwater conservation districts (GCDs) need to "use the best available science in the conservation and development of groundwater through rules developed, adopted, and promulgated by a district in accordance with the provisions of this chapter." TWC §36.0015 defines "best available science" as follows:

> "best available science" means conclusions that are logically and reasonably derived using statistical or quantitative data, techniques, analyses, and studies that are publicly available to reviewing scientists and can be employed to address a specific scientific question.

Most Management Strategies will be dynamic and will change in response to changes in aquifer conditions, water demands, and analyses techniques. The report discusses the eight factors that have the potential to impact the District ability to implement its management strategies. These eight factors are: (1) Regulatory Authority; (2) Science; (3) Joint Planning; (4) Adjacent District Policies; (5) State Water Needs; (6) Interests of Landowners and Well Owners; (7) Modifications to the Water Code; and (8) Court Findings. In order to improve the resiliency and technical defensibility of Management Strategies with changing conditions, the report recommends that the District consider the following:

- Ensure that the requirements in TWC §36.0015 are satisfied
- Fill data gaps in Science to reduce uncertainty associated with changes in science over time
- Strengthen the connection between science and Management Strategies as much as practicable

To help insure that the Management Strategies and rules are well integrated, provide clear concise messaging, and have account for recent changes in aquifer conditions and best available science, the District should conduct regular reviews to identify and amend rules that may not be adequately supported by best available science, may contain words that are not sufficiently defined, or are in conflict with other rules or Management Strategies. For this section, the report identifies several issues that affect Management Strategies and rules and may benefit from a thorough vetting by the District. Six of these issues are:

- Maximum Production Volumes Based on Permitted Acreage
- Operating & Transport Permit Fees
- Management Zones Associated with DFCs
- Time Intervals Associated with DFCs
- Compatibility Between DFCs and PDLs
- Enforcement of DFCs and PDLs
- Definition of Unreasonable Impact to Groundwater and Surface Water

Study Limitations

The findings contained in this report represent INTERA's professional opinion arrived at in accordance with applicable professional standards and based upon analysis of information available at the time the report was produced. The report was prepared at the request of the Post Oak Savannah Groundwater Conservation District (POSGCD) to support on-going assessment of the District's aquifers, groundwater resources, and management policies. This report is a technical analysis and may or may not be partially or wholly consistent with the POSGCD Board's policies or current thinking. Because groundwater management is an adaptive process, updates and changes to the report may be appropriate as conditions change and new information becomes available.

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ACROYNMS AND ABBREVIATIONS

%	percent
AFY	acre-feet per year
AFY/acre	acre-feet per year per acre
DFC	Desired Future Condition
ft	feet
GAM	groundwater availability model
GCD	groundwater conservation district
GMA	groundwater management area
HB	house bill
PDL	Protective Drawdown Limit
PFD	Proposal for Decision
POSGCD	Post Oak Groundwater Conservation District
SOAH	State Office of Administrative Hearings
TWC	Texas Water Code
TWDB	Texas Water Development Board

1.0 INTRODUCTION

The Post Oak Savannah Groundwater Conservation District (POSGCD) was created in Milam and Burleson counties by House Bill (HB) 1784, 77th Legislature, 2001, and a local confirmation election in November 2002. The purpose of this bill was to provide a locally controlled groundwater district "to protect and recharge groundwater and to prevent pollution or waste of groundwater in the central Carrizo-Wilcox area, to control subsidence caused by withdrawal of water from the groundwater reservoirs in that area, and to regulate the transport of water out of the boundaries of the district (§ 1.02)."

Since its creation and confirmation in 2001, the District has developed a comprehensive approach for managing groundwater that includes programs that focus on conservation programs, conducting aquifer research, monitoring groundwater, modeling future conditions, permitting groundwater wells, conducting groundwater conferences, supporting legislations, and operating a groundwater assistance program. To help manage and monitor the change in aquifer conditions, the District has established threshold levels that are based on drawdown and production. These threshold levels are provided in Rule 16.4. The District monitors its water levels and production on a regular basis to determine if any of the threshold levels have been exceeded. If District determines that a threshold levels has been exceeded, Rule 16.4 specifics the type of actions that the District should perform in order to help preserve and protect the groundwater. The District actions may include one or more of the following: performing hydrogeologic studies, rule modification, and curtailment of permits or production amounts.

In Spring 2020, the District requested INTERA to develop three reports in response to exceedances to threshold levels. Two of these three reports are described in **Table 1-1**. These two reports use information from the District's monitoring program and groundwater models to assess the impact caused by pumping on the operation of existing wells and water levels in the District aquifers. The third report to be prepared by INTERA is this report, which will review the District's Management Strategies for accomplishing its goals.

Table 1-1 Overview of reports recently prepared for the District to document the impacts of current and planning pumping on existing well owners and groundwater resources

Report Title	Purpose and Summary
Groundwater Assistance Program Annual Needs Assessment 2020 (INTERA, 2021a)	The purpose of the report is performed the requirement to identify high-priority wells that are projected to experience water level declines below the pump setting within the next 10 years. This requirement is identified in the District's Groundwater Assistance Program (POSGCD, 2020). The report identified a total of 41 wells as high-priority wells. Of the 41 wells, 36 are completed in the Carrizo Aquifer with the remaining 5 in the Calvert Bluff (n=3), Queen City (n=1), and Simsboro (n=1). The large decline of water levels in the vast majority of the high-priority wells are a result of the initiation of pumping from the Vista Ridge Wellfield in April 2020.
Assessment of Compliance With Desired Future Conditions and Protective Drawdown Limits, Post Oak Savannah Groundwater	The purpose of the report is to document the 2020 assessment of compliance with the District's Desired Future Conditions (DFCs) and its Protective Drawdown Limits (PDLs). A review of POSGCD compliance with DFCs found that significant trends of increasing average drawdown can be seen in both the Sparta

Report Title	Purpose and Summary
Conservation District (INTERA, 2021b)	and the Carrizo and in for 2019, and several other years, the average drawdown is equal to or greater than 50 percent (%) of the DFC (Threshold Level 1). In 2019, the average drawdown is equal to or greater than 60% of the DFC (Threshold Level 2) for the Carrizo Aquifer. A review of POSGCD compliance with PDLs found that no aquifers are currently exceeding 50% of their respective PDLs.

1.1 Report Objectives

The report has three objectives:

- describe and formalize the District Management Structure
- identify factors that could impact the District ability to implement Management Strategies to accomplish District goals
- identify actions that could improve the District's ability to implement Management Strategies to accomplish goals

1.2 Report Organization

The report consists of seven additional sections following this introduction. Section 2 overviews the District's hydrogeology and management zones. Section 3 identifies the District's major management goals as stated in its primary governing documents. Section 4 describes the organizational framework used by the District to manage groundwater resources. Section 5 describes the major District Management Strategies that are related to groundwater resources. Section 6 identifies factors that could impact the District's ability to accomplish District goals. Section 7 identifies options to strengthen the District's position to implement Management Strategies to accomplish management goals. Section 8 lists the cited references.

2.0 OVERVIEW OF DISTRICT HYDROGEOLOGY AND MANAGEMENT ZONES

This section provides a short description of the hydrostratigraphic and hydrogeologic units that are managed by the District. The section also introduces and describes the District's management zones.

2.1 Hydrogeology

Table 2-1 provides a stratigraphic column listing the formations and relevant aquifers located within the District boundaries. **Figure 2-1** shows the locations of the outcrops of these formation and aquifers based on the surface geology mapped by Young and others (2018), Ewing and Jigmond (2016), and Deeds and others (2010). An outcrop is where an aquifer is present at ground surface. The aquifers in the District generally dip to the southeast from their outcrops to the subsurface at dips of approximately 100 to 150 feet (ft) per mile. Within the District, the Trinity Aquifer does not outcrop and is overlaid primarily by the Midway Formation. The Midway Formation outcrops in the northwestern portion of Milam County. The Midway Formation is an aquitard separating the older Northern Trinity Aquifer from the younger Carrizo-Wilcox Aquifer. An aquitard is a formation that is composed primarily of clayey deposits. Although an aquitard may yield small amounts or sustainable water, the formation has insufficient groundwater available for production to be considered and managed by the District as a relevant aquifer. Two other aquitards listed in Table 2-1 are the Reklaw and Weches formations.

Table 2-1 Generalized stratigraphic column and list of Relevant Aquifers for POSGCD

ERA	Period	Age (million years)	Hydrostratigraphic Unit	Declared as a Relevant Aquifer	Hydrogeologic Unit
Cenozoic	Tertiary	33.9	Jackson	yes	Yegua-Jackson Aquifer
			Yegua	yes	
			Sparta	yes	Sparta Aquifer
			Weches	no	Aquitard
			Queen City	yes	Queen City Aquifer
			Reklaw	no	Aquitard
		55.8	Carrizo	yes	Carrizo-Wilcox Aquifer
			Upper Wilcox/Calvert Bluff	yes	
			Middle Wilcox/Simsboro	yes	
			Lower Wilcox/Hooper	yes	
		65.5	Midway	no	Aquitard
Mesozoic	Cretaceous		Trinity	yes	Trinity Aquifer

2.2 Management Zones

The District uses groundwater management zones for the purpose of evaluating and managing groundwater resources because of the different characteristics and anticipated future development of the aquifers in the District. For each of the relevant aquifers in Table 2-1, the District has defined a management zone, which covers the entire aquifer within the District boundaries. For each of the management zones associated with a relevant aquifer, the District has adopted DFCs as part of the joint planning process.

The POSGCD is a member of groundwater management areas (GMAs) 8 and 12, whose areal extents are shown in **Figure 2-2**. As part of the joint planning process for GMAs 8 and 12, the District has established DFCs for its relevant aquifers. The management zones associated with the entire aquifer and for which a DFC has been developed are referred to as Total Aquifer Management Zones. **Figure 2-3** shows Total Aquifer Management Zones for the Yegua-Jackson, Queen City, Sparta, Carrizo, Calvert Bluff, Simsboro and Hooper aquifers.

In addition to Total Aquifer Management Zones, the District has also designated Shallow Aquifer Management Zones. The Shallow Aquifer Management Zones are defined as the portion of an aquifer that is shallower than 400 ft depth. **Figure 2-4** shows Shallow Aquifer Management Zones for the Yegua-Jackson, Queen City, Sparta, Carrizo, Calvert Bluff, Simsboro and Hooper aquifers. The PDLs were established by the District to protect production capacity of existing wells in the shallow unconfined portions of the aquifer where the water level above the well screen tends to be less than in the deep confined portions of the aquifer. The District has not created shallow management zones for either the Brazos River Alluvium Aquifer or the Trinity Aquifer.

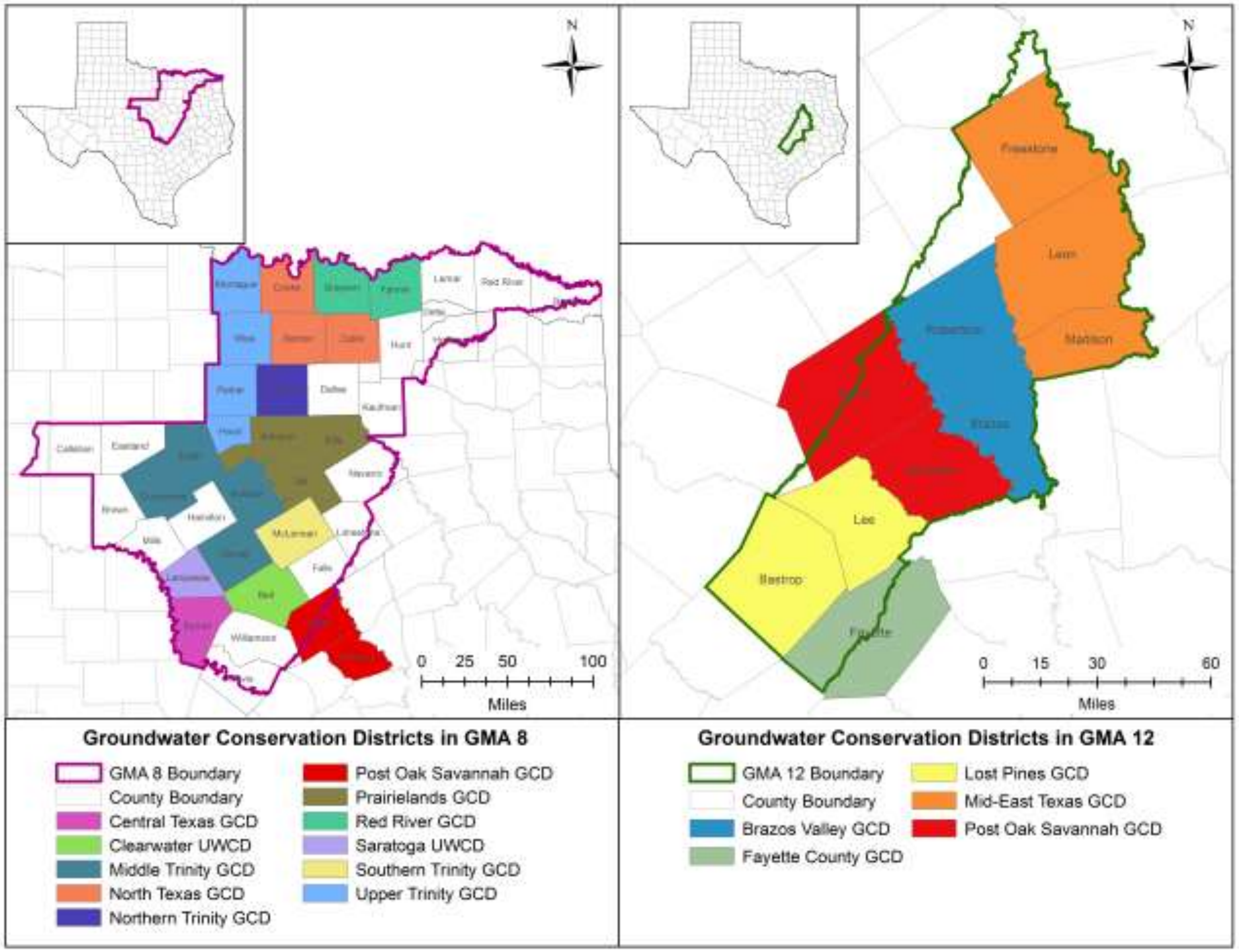


Figure 2-1 Counties and groundwater districts associated with GMAs 8 and 12

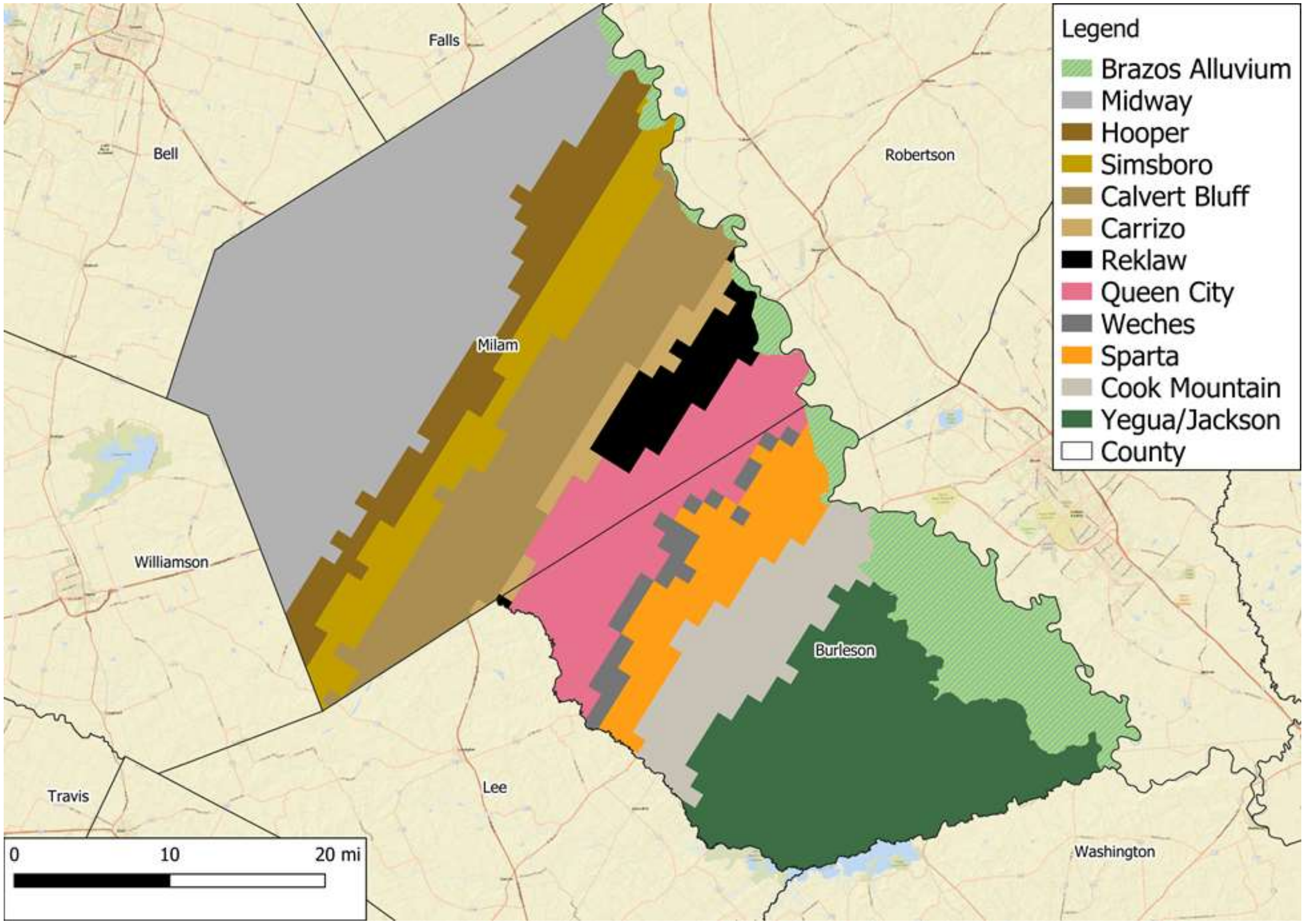


Figure 2-1 Map of aquifer outcrops based on information extracted from groundwater availability models

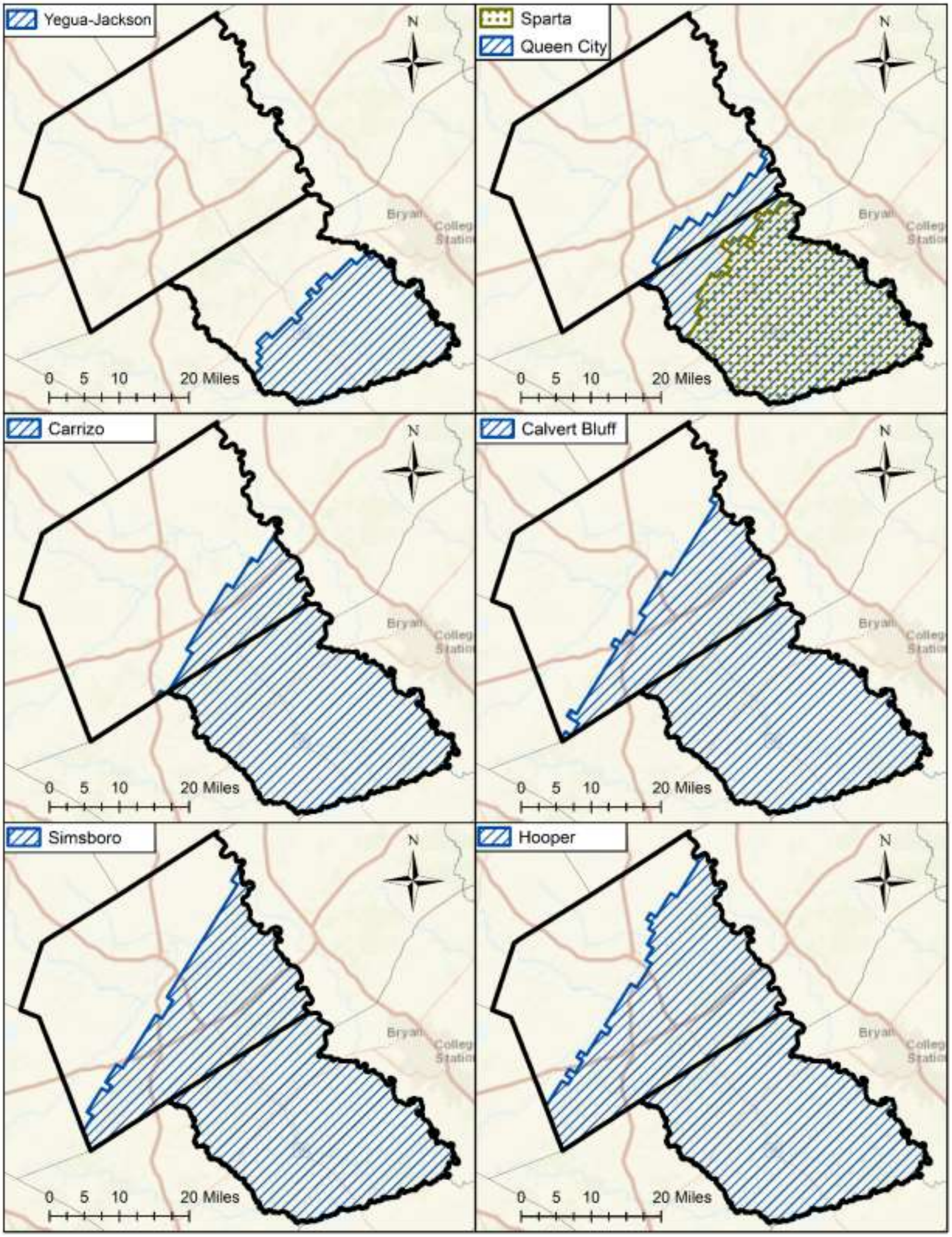


Figure 2-3 POSGCD total aquifer management zones for evaluating GMA 12 DFCs

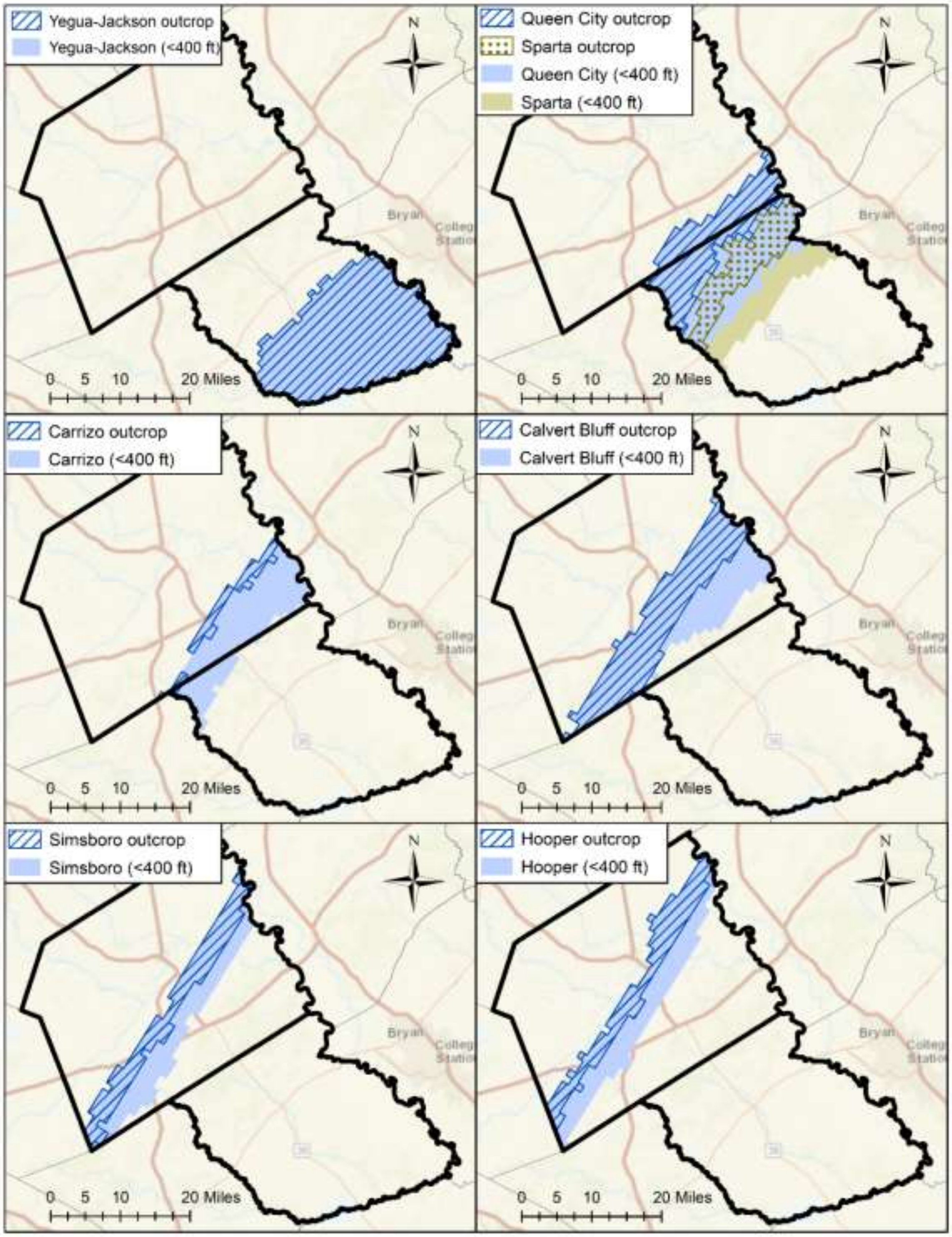


Figure 2-4 POSGCD shallow aquifer management zones for evaluating District PDLs

3.0 DISTRICT MANAGEMENT GOALS

The District's management primary goals are described in Chapter 36 of the Texas Water Code (TWC), its enabling legislation, its management plan, and its mission statement. In this section, these four items and their associated goals are discussed.

3.1 Chapter 36 of the Texas Water Code

A groundwater conservation district (GCD) is a local unit of government authorized by the Texas Legislature and ratified at the local level to manage and protect groundwater. In 1985, 1997 and 2001, the Texas Legislature passed additional laws to encourage the establishment of more GCDs. This legislation is codified in Chapter 36 of the TWC.

TWC § 36.0015 states that GCDs created as provided by this chapter are the state's preferred method of groundwater management in order to:

- Protect property rights,
- Balance the conservation and development of groundwater to meet the needs of this state, and
- Use the best available science in the conservation and development of groundwater through rules developed, adopted, and promulgated by a district in accordance with the provisions of this chapter.

3.2 Enabling Legislation

Chapter 36 of the TWC provides three procedures for the creation of a GCD. The three procedures are: (1) action of the State Legislature; (2) petition by property owners; (3) initiation by the Texas Commission on Environmental Quality. For each of these three methods, a local election is held for voters to determine whether to approve a GCD and whether to approve a tax to fund the GCD. The majority of voters in each county sought to be included in the GCD must approve the creation of a district.

POSGCD was created in Milam and Burleson counties by HB 1784, 77th Legislature, 2001, and a local confirmation election in November 2002. POSGCD was codified as Chapter 8865, Special District Local Laws Code. The purpose of creation of POSGCD is to provide a locally controlled groundwater district to

- Protect and recharge groundwater
- Prevent pollution or waste of groundwater in the central Carrizo-Wilcox area
- Control subsidence caused by withdrawal of water from the groundwater reservoirs in that area
- Regulate the transport of water out of the boundaries of the district.

3.3 Management Plan

TWC § 36.1071 requires that a GCD develop a management plan that addresses the following management goals, as applicable:

- Providing the most efficient use of groundwater
- Controlling and preventing waste of groundwater
- Controlling and preventing subsidence

- Addressing conjunctive surface water management issues
- Addressing natural resource issues
- Addressing drought conditions
- Addressing conservation, recharge enhancement, rainwater harvesting, precipitation enhancement, or brush control, where appropriate and cost-effective
- Addressing the desired future conditions adopted by the district under § 36.108

3.4 Mission Statement

The District's mission statement states:

> "The Post Oak Savannah Groundwater Conservation District (POSGCD) mission is to adopt and enforce Rules consistent with State law and based on best available science, which provide for the conservation, preservation, protection, recharging, and prevention of waste of groundwater, while supporting the ownership of groundwater and the owner's right to assign or produce that property."

4.0 GROUNDWATER MANAGEMENT

This section provides a general discussion of the components that contribute to the District's overall approach to managing groundwater resources.

4.1 Components of Groundwater Management

Figure 4-1 identifies the components of groundwater management that provide constraints and guidance to the District management of groundwater resources. The figure shows eight components, which are described below.

Regulatory Authority & Responsibility - This component includes the governing documents that provide the foundation and purpose for District. These documents which were created by the Texas legislature cannot be changed by the District. They set limitations on the District's authority and establish responsibilities. Important documents are sections in the TWC that pertain to GCDs and the District's enabling legislation.

Board of Directors - The Board of Directions is the primary decision makers regarding the development and implementation of groundwater management. The Board of Directors has an active group of committees that have direct involvement with the development of documents, policies, budgets, and priorities before they are presented to the Board of Directors for approval. The Board has either direct or indirect control over all aspects of groundwater management with the exception science. However, the Board of Directors has the ability to impact the role of science in the District's approach to groundwater management.

Major Goals - This component frames the District's vision and approach for how it will manage groundwater resources. The District's most important document related to identifying management goals is its Management Plan.

Management Documents - This component includes the District regulations regarding groundwater production and how the regulations will be administered and enforced. The District's two key management documents are the Management Plan and the District Rules.

Management Strategies - This component includes the District strategies associated with the development and implementation of conservation, production, protection, education, monitoring, and compliance. For this report, Management Strategies include the formulation and promotion of policies and actions for the purpose of achieving District goals.

Science - This component includes all studies, analyses, data, information, techniques, and models related to the aquifers, groundwater systems, wells, and recharge areas within Burleson and Milam counties. Among the District's important science items are measured water levels, measured production rates, and the conceptual and numerical groundwater models of groundwater flow.

District GM & Staff - This component includes the District's General Manager, Water Resources Management Specialist, and staff. The District General Manager, participates in workshops and Board committee meetings, manages the District involvement with the Texas Alliance of groundwater districts and state conferences, review and presents permits to the Board, responds to well owner requests, develops work tasks for the District's legal and hydrogeologic consultants, and is responsible for managing and monitoring the District's annual budget. The Water Resources Management Specialist supports the general manager in all tasks, is the primary person responsible for the planning, managing, and executing field activities, for presenting rainfall harvesting and conservation workshops, and managing the HALFF database.

Daily Management Operations - This component includes all daily activity associated with managing the District groundwater resources.

4.2 Connectivity of Groundwater Management Strategies to Other Groundwater Management Components

Besides identifying components that comprise groundwater management, Figure 4-1 also shows how components are interconnected. The arrows in the figure indicate which components can directly influence change in another component. One-way arrows indicate where a component, designated by where the arrow begins, has the ability to cause change to the component where the arrow ends. Two-way arrows pair components that have the ability to cause change to each other. The arrows in Figure 4-1 show that Management Strategies have a central and pivotal role with the District approach to groundwater management.

Most Management Strategies will be dynamic and will change in response to changes in aquifer conditions, water demands, and analyses techniques. For example, as science develops and the District's understanding of the aquifer production capabilities change, so should changes occur with the strategies associated with characterization and monitoring of the aquifer. Similarly, as the daily management operations change as population and water demands increase, so should changes occur in the strategies associated with groundwater production, protection, preservation, and conservation.

An important and necessary attribute any management strategy is that it helps achieve District goals in a manner that is both legally and scientifically defensible. Legally defensible means the management strategy is aligned and supported by legislative statutes and administrative codes, especially those responsible for the creation of the District. Similarly, scientifically defensible means that the management strategy is aligned and supported by the science.

As discussed in Section 3, Chapter 36 states that GCDs were created in order to use best available science for developing rules associated with the conservation and production of groundwater. Consequently, the District should use best available science to develop and implement all Management Strategies. TWC § 36.0015 defines "best available science" as follows:

> "best available science" means conclusions that are logically and reasonably derived using statistical or quantitative data, techniques, analyses, and studies that are publicly available to reviewing scientists and can be employed to address a specific scientific question.

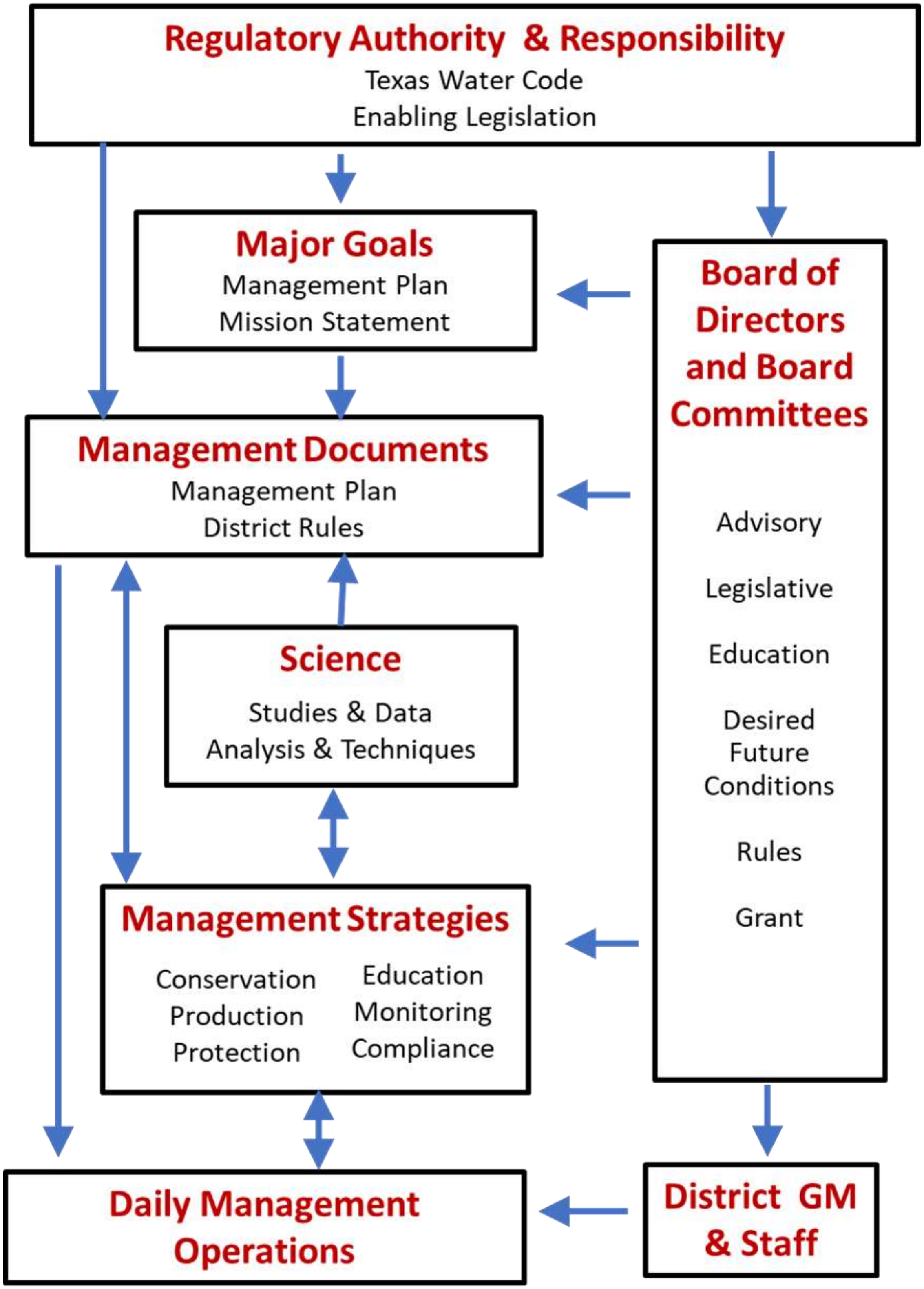


Figure 4-1 Components that comprise the structural framework for the District's groundwater management

5.0 MANAGEMENT STRATEGIES RELATED TO GROUNDWATER RESOURCES

This section describes several of the District's strategies for groundwater management and their potential importance to the District's overall groundwater management approach. An important attribute of Management Strategies is that they be scientifically defensible so the District will develop rules to manage groundwater that can be shown to be based on best available science, which is required per Chapter 36 in the TWC.

5.1 Description of Management Strategies

As previously stated in Section 4, Management Strategies are defined as the formulation and promotion of policies and actions for the purpose of achieving District goals. Listed below are ten Management Strategies that are important to the District's management of groundwater:

1. *Education and Public Outreach* – To better promote water conservation, community support for groundwater management, and education of groundwater-related issues, the District participates in and supports programs focused on public education and communication.
2. *Regional Planning* – To promote and improve management of groundwater with nearby GCDs, river authorities and the state, the District is actively engaged with GMA 8, GMA 12, Region G, and the Brazos River Authority.
3. *Compliance Evaluations for DFC and PDLs* – To provide for the conserving, preserving, and protecting of groundwater, the District has established criteria for evaluating the allowable average amount of drawdown of water or the reduction of artesian pressure for management zones.
4. *Management Zones* – For better management of groundwater resources, the District has created management zones based on different conditions in the subsurface associated with aquifer properties, aquifer use, or geographic area.
5. *Well Monitoring Program* - To monitor changes in aquifer conditions and the impact of production on groundwater levels, the District operates a well monitoring program that measures water levels and groundwater production on a regular basis.
6. *District Action Triggered by Exceedances of Tiered Thresholds* – To provide for the conserving, preserving, and protecting of groundwater, the District has established a tiered system of thresholds, which are based on aquifer conditions. Exceedances of those thresholds trigger a District response that is commensurate to the magnitude of the violation.
7. *Well Permitting Requirements* – To minimize as far as practicable the interference between wells, the district has established permitting requirements for well spacing, aquifer testing, hydrogeology study, and monitoring.
8. *Production Limitations* – To minimize as far as practicable the drawdown of water or the reduction of artesian pressure, and to prevent interference between wells, or to prevent degradation of water quality, the District has limited the amount of water that can be produced based on acreage on the basis of acre-feet per acre.
9. *Curtailment of Permitted Production* - To provide for the conserving, preserving, and protecting of groundwater, the District will use curtailment of groundwater production in management zone(s) to accomplish one of the two following objective. One objective is to prevent pumping from causing unreasonable impacts or exceeding regulatory limits on drawdown. The other

objective is to restore aquifer water levels to acceptable levels if groundwater production was responsible for creating unacceptable drawdowns levels.

10. *Conservation of Groundwater* – To reduce the demand for groundwater production, the District has developed programs to assist individuals and municipalities to conserve groundwater. These programs include rainfall harvesting for landowners, grant programs to municipalities, and the aquifer conservancy program.

5.2 Role of Science in Management Strategies

TWC §36.0015 states that GCDs "use the best available science in the conservation and development of groundwater through rules developed, adopted, and promulgated by a District." TWC §36.0015 makes quite clear that, if a District desires to create a solid set of enforceable rules, the District needs to use best available science in developing and implementing its Management Strategies and rules. TWC §36.0015 defines "best available science" as follows:

> "best available science" means conclusions that are logically and reasonably derived using statistical or quantitative data, techniques, analyses, and studies that are publicly available to reviewing scientists and can be employed to address a specific scientific question.

Except for the requirement that it be based on information that is publicly available and be derived in a logically and reasonable manner, the definition of best available science allows considerable leeway for criteria for evaluating if a GCD has properly satisfied the requirements set forth in TWC §36.0015 in their rule making. Moreover, the definition does provide clear criteria for courts to use for determining what is best available science when opposing parties present their own set of science, which achieves the standard set forth in TWC §36.0015, but support different conclusions.

A concern associated with TWC §36.0015 is that science is continually evolving and changing with the advent of new data. Among the consequences to the District of changes in science is that predictions of drawdown for specific future scenarios vary among different versions of groundwater availability models. The avenues for the District to improve the technical defensibility of its Management Strategies is threefold:

- Ensure that the requirements in TWC §36.0015 are satisfied.
- Fill data gaps in science in order to reduce uncertainty associated with changes in science over time
- Strengthen the connection between science and Management Strategies as much as practicable

Tables 5-1 and **5-2** were generated to assist the District with understanding the connection between science and Management Strategies. The tables provide: (1) examples of quantitative data, analysis, and techniques, (2) applications of science to address a specific type of hydrogeologic issue, and (3) connections between a science application and specific Management Strategies.

Table 5-1 Interconnection among scientific data, hydrogeological applications, and Management Strategies

Quantitative Data	Example Hydrogeological Application	Management Strategy with Possible Overlap with Example Applications
Measured Water Level and Water Quality Data	• Maps of water level contours and elevations • Estimates of vertical hydraulic gradients • Measure change in water levels over time • Determine an average water for DFC zones • Maps of water quality including brackish zones	1. Education and Public Outreach 2. Regional Planning 3. Compliance Evaluations for DFC and PDLs 5. Well Monitoring Program 6. District Action Triggered by Exceedances of Tiered Thresholds 9. Curtailment of Permitted Productions
Reported Pumping Rates	• Track compliance with individual operating permits • Track compliance with modeled available groundwater • Provide pumping rates for GAM update • Establish water budgets for management zones	2. Regional Planning 5. Well Monitoring Program 6. District Action Triggered by Exceedances of Tiered Thresholds 7. Well Permitting Requirements 9. Curtailment of Permitted Productions
Aquifer Pumping Tests	• Estimate Transmissivity at District well locations • Use to help identify fault locations • Validate and test groundwater models	2. Regional Planning 3. Compliance Evaluations for DFC and PDLs 7. Well Permitting Requirements 9. Curtailment of Permitted Productions
Driller Logs & Geophysical Logs	• Identify total depth and screen intervals for wells to support aquifer assignment • Identify pump settings • Identify boundaries between aquifers • Locate faults and fault zones • Identify and quantify clay and sand interval	2. Regional Planning 3. Compliance Evaluations for DFC and PDLs 5. Well Monitoring Program 6. District Action Triggered by Exceedances of Tiered Thresholds 7. Well Permitting Requirements

Table 5-2 Interconnection among scientific analysis & techniques, hydrogeological applications, and Management Strategies

Analysis & Techniques	Example Hydrogeological Application	Management Strategy with Possible Overlap
Groundwater Availability Models	• Evaluate operation permits • Evaluate Possible DFC for GMA • Evaluate Possible DFCs & PDLs for District • Develop water budgets for Management Plans • Provide aquifer properties for local-scale analysis • Provide aquifer tops and bottom to assign wells to aquifers	1. Education and Public Outreach 2. Regional Planning 3. Compliance Evaluations for DFC and PDLs 4. Management Zones 5. Well Monitoring Program 6. District Action Triggered by Exceedances of Tiered Thresholds 7. Well Permitting Requirements 8. Production Limitations 9. Curtailment of Permitted Productions
Modified Groundwater Availability Models	• Site specific analysis of pumping impacts when GAM is improved by updating or extending pumping rates and by updating aquifer properties	3. Compliance Evaluations for DFC and PDLs 7. Well Permitting Requirements 9. Curtailment of Permitted Productions
Analytical Models for Groundwater Flow (examples Theis Equations, TTIM	• Calculate transmissivity values from district pumping tests • Predict drawdown from pumping scenarios to support the development of well spacing rules	7. Well Permitting Requirements
Software to Interpolate Monitoring Data	• Perform analysis on measured water levels to evaluate compliance with DFCs and PDLs	3. Compliance Evaluations for DFC and PDLs 5. Well Monitoring Program 6. District Action Triggered by Exceedances of Tiered Thresholds 9. Curtailment of Permitted Productions

6.0 EXTERNAL FACTORS OF POTENTIAL IMPORTANCE TO THE DISTRICT'S IMPLEMENTATION OF MANAGEMENT STRATEGIES

There are many factors that can have an effect or be of potential importance to a district's Management Strategies. A list of the types of factors that may impact management within a district are listed below:

- Regulatory Authority
- Science
- Joint Planning
- Adjacent District Policies
- State Water Needs
- Interests of Landowners and Well Owners
- Environmental Impacts
- Modifications to the Water Code
- Court Findings

While this list of potential factors is surely incomplete, it likely lists the primary factors. Because these factors can and will have a direct impact on current and future management practices, the remainder of this section will briefly discuss these factors and discuss how they could possibly be relevant to the District.

6.1 Regulatory Authority

As noted above, each GCD operates with regulatory authority derived from Chapter 36 of the TWC, the specific enabling legislation and District Rules and Management Plan. As also noted, the POSGCD was created in Milam and Burleson counties by the enabling legislation (HB-1784, 77th Legislature, 2001) with a local confirmation election in November 2002. HB-1784, Article 3 prevails over any provision of general law, including Chapter 36 of the TWC, found in conflict. The enabling legislation allows the POSGCD to assess reasonable fees on production from non-exempt wells and it also allows the POSGCD to assess a reasonable fee or surcharge on the export of groundwater outside of the boundaries of the District. If the regulatory authority vested in the POSGCD through Chapter 36 of the TWC or the enabling act were to be modified regarding the responsibilities and authority of the POSGCD, the District Rules and Management Plan would require review and potentially modified.

6.2 Science

TWC §36.0015 requires GCDs to use best available science in their rule making. Among the benefits of using best available science in rule making is that knowledge about the District's aquifers and groundwater flow systems will help ensure that the District rules will perform as intended. Because the District recognizes the importance of science to groundwater management, the District has been a leader among the GCDs to actively fund and participate in research and improvements.

Despite the recent advancement in science by the POSGCD, there remain considerable data gaps in the District knowledge and understanding about predictions of how future changes in pumping and recharge affect drawdowns, groundwater availability, the interaction between groundwater and surface water, recharge rates, and the mapping of aquifer surfaces. In addition, there remains differences in the science used by the different GCDs in GMA 12 for evaluating impacts from permit applicants and demonstrating compliance to Desired Future Conditions. As a result of the data gaps in science and the different approaches used by the districts in GMA 12, the District should expect that what is deemed "best available science" will continue to evolve and change. Because of the evolving nature of science, the District should be continually reviewing their Management Strategies to made them as resilient to these changes as possible. In addition, it would be advantageous for the District to be in a strong position to anticipate the changes in science as much as possible.

6.3 Joint Planning

The POSGCD enabling legislation (HB-1784, 77th Legislature, 2001) was titled as the Central Carrizo-Wilcox Groundwater Management Act ("CWGM Act"). A key purpose of that CWGM Act was to coordinate regional management of the Carrizo-Wilcox Aquifer among GCDs. Similar to the CWGM Act, TWC Chapter 36, Section §36.108 requires joint planning among the GCDs in a GMA The Management Plans (36.1071) developed by GCDs must include the DFCs adopted by GMAs during the joint planning process. While DFCs adopted by a GMA are binding to each GCD, the adoption of the DFCs by a GMA does not require unanimous agreement. The adoption of a DFCs requires a two-thirds approval of the voting GCDs. In a situation where POSGCD is not in agreement with how to manage the groundwater resources in GMA 12, there is a possibility that the DFCs for POSGD could be set by the four other GMA districts.

One of the objectives of joint planning is to develop DCFs that represent an agreed upon goal for the future condition of aquifers. TWD §36.108(8) requires that the GMA consider the feasibility of achieving each DFC. Although the meaning of feasible is in the eye of the beholder until determined by additional legislation or a court decision, the meaning of feasible has thus far been interpreted by GAM 12 to mean that DFC should be compatible with all other DFCs. Or, in other words, no DFCs should prevent the attainment of another DFC. As a result of TWD §36.108(8), all GCDs in GMA 12 cannot develop a DFC that is independent of the pumping that has and will occurred in adjacent GCDs.

6.4 Adjacent District Policies and Pumping

Neither Williamson County nor Washington County have a GCD. As a result, the rule of capture is in effect. In Williamson County, there are several wells including municipal wells located in the Hooper Aquifer near the Milam County line. The unregulated pumping from Hooper wells in Williamson County will impact the groundwater availability from the Hooper Aquifer in Milam County. In Washington County, there are several wells located in the Yegua-Jackson aquifer located near the Burleson County line. The unregulated pumping from Yegua-Jackson wells in Washington County will impact the groundwater availability from the Yegua-Jackson Aquifer in Washington County.

Pumping in four of the counties adjacent to Milam and Burleson counties is managed by either the Lost Pines GCD or the Brazos Valley GCD. Both of these districts have different permitting rules than those used by POSGCD. In addition, the cities of Bryan and College Station in Brazos Valley GCD have been heavily dependent of groundwater for the last 30 years and have no plans to reduce their pumping over next 50 years. The influence of the historical pumping in BVGCD on groundwater resources in Milam County is well documented by the measured water levels in the "Gause" well, which are shown in **Figure 6-1**. The Gause well is located approximately 24 miles from the City of Bryan and its decline of over 100 ft of artesian pressure since 1980 is attributed to the pumping from the Simsboro Aquifer from both the City of Bryan and College Station.

The impact of pumping outside of the District on water levels and drawdowns inside the District has been investigated several times by the District using the Groundwater Availability Models (GAMs). These investigations have shown that for some aquifers, more than half of the drawdown that has occurred in the District the last few decades in several aquifers has been caused by pumping that occurs from outside of the District.

6.5 State Water Needs

The Carrizo-Wilcox Aquifer, which includes the both the Carrizo and Simsboro aquifers, is one the most prolific aquifers in the state. Because much of it is located in rural areas of Texas, the Carrizo-Wilcox Aquifer has not been heavily pumped the last few decades and thus has tremendous potential for providing water to the high-growth area in central Texas. Several major water suppliers have already or will soon be targeting the transmission of Carrizo-Wilcox groundwater to meet the state's increasing demand for water. The Vista Ridge Project is currently exporting appropriately 50,000 acre-feet per year (AFY) of Carrizo-Wilcox groundwater to San Antonio from Burleson County and other operating permits exist in GMA 12 for the purpose of exporting groundwater outside of GMA 12. As the demand for water becomes much greater in the central Texas, the District's task of balancing the conservation and development of groundwater to meet the needs of this state per TWC §36.0015 will become increasingly difficult.

6.6 Interests of Landowners and Well Owners

The District was created to serve the citizens of Milam and Burleson counties. TWC Chapter 36 identifies several responsibilities that the District has to its landowners and well owners. TWC § 36.0015 states that one of the considerations for the creation of GCDs is to protect property rights. Groundwater is a property right of landowners in Milam and Burleson counties. In addition, before granting or denying a permit or permit amendment, TWC §36.113 requires whether or not the proposed use of water unreasonably affects existing groundwater permit holders and will impact existing use. During the last decade, the public has been actively engaged and vocal during Board meetings and public hearings concerning several large well operating permits, the groundwater well assistance program, transport permits, DFCs, and compliance monitoring. As the population and water demand in the District increases, there may be a need to change rules to achieve an acceptable balance between development and conservations. The impetus for these changes could arise from either within or outside of the District.

6.7 Environmental Impacts

Groundwater pumping can cause environmental impacts by reducing spring flow or reducing stream baseflow. Examples of these types of environmental impacts include problems associated with complying with the Endangered Species Act (ESA), implementing environmental flow recommendations, or with obtaining bed and banks permits (Young and others, 2018). The potential importance of the nexus between groundwater pumping and environmental issues is underscored by the creation of the

Edwards Aquifer Authority (EAA). The EAA Act (Act) was adopted by the Texas Legislature in 1993 in response to the legal threat of federal takeover of the aquifer under the ESA. By mandating a capped permitting system that limits withdrawals from the Edwards Aquifer, the Act was intended to preserve the resource while also protecting threatened and endangered species in the aquifer-fed Comal and San Marcos springs to the extent required by federal law.

Because of concerns that groundwater pumping can cause environmental impacts, the last two Texas legislative sessions have conducted hearing and introduced bills to promote improved conjugate management of groundwater and surface water resources. During the last decade, environment concerns caused by groundwater pumping have been expressed in GMA 12 meetings by the public and groups such as Environmental Stewardship, Save our Springs, and the Sierra Club. Two the obstacles for developing DFCs in GMA 12 based on environmental impacts is that difficulties associated with both modeling them and measuring them. As the science and measuring techniques improve, there is a possibility that POSGCD may be required to constrain groundwater pumping so that it does not create undesirable environmental impacts.

6.8 Modifications to the Water Code

TWC Chapter 36 defines the statutory framework for districts. Modifications to TWC are made every legislative session. As the sections of the TWDC governing GCD evolve, the management of groundwater and the Management Strategies used by POSGD rules will need to be reviewed and adapted to account for changes in the District regulatory authority.

6.9 Court Findings

There are many issues relevant to groundwater management under Chapter 36 which are being litigated. Most issues go through the State Office of Administrative Hearings (SOAH). After the hearing process, the SOAH judge issues a Proposal for Decision (PFD), which provides a summary of arguments and establishes the court's rulings. In the PFD, the judge also makes Conclusions of Law on legal issues contested. For example, in the recent Lower Colorado River Authority SOAH hearing in Bastrop County, one conclusion of law was that authorized discharge of groundwater pursuant to a bed and banks permits issued under the TWC is not waste and the district cannot prohibit transport of water via a bed and banks permit as part of its authority under Chapter 36.

Decisions under the SOAH hearing process as well as rulings from the Texas Supreme Court are directly relevant to the powers and authority of districts. The POSGCD monitors legal proceedings relevant to the district regularly. As the groundwater law in Texas evolves, district Management Strategies will have to undergo review and possible revision to ensure that the districts activities will stand up in legal proceedings.

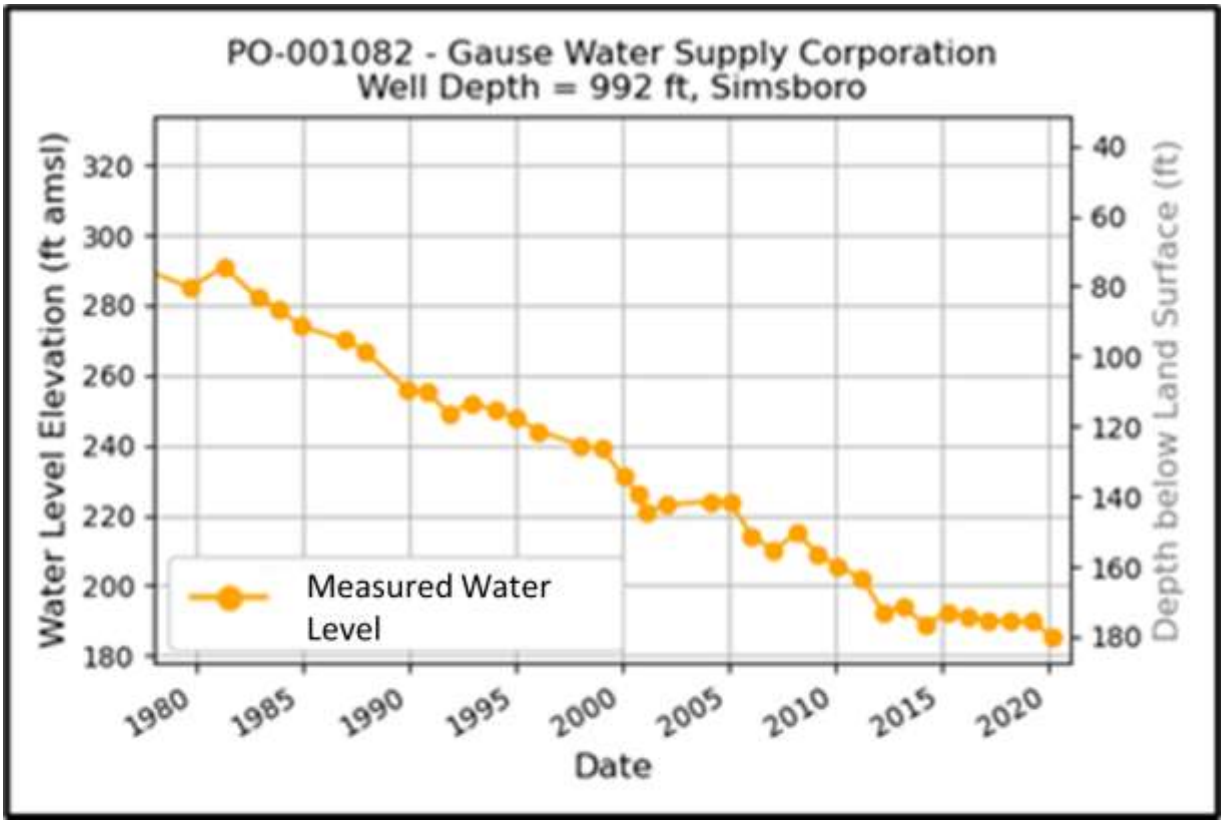


Figure 6-1 Measured water levels in the Gause Well in Milam County

7.0 OBSERVATIONS AND MANAGEMENT ISSUES OF IMPORTANCE TO THE DISTRICT'S ACHIEVEMENT OF ITS MANAGEMENT GOALS

This section discusses observed impacts of recent pumping on water levels and implications to the District achievement of its management goal. The section also documents that declines in water levels in 2020 have exceeded several monitoring threshold established by the District, which have triggered the District to review its Management Strategies and rules.

7.1 Rule 16.4 and Threshold Levels

To help manage and monitor the change in aquifer conditions, the District's Rule 16.4 establishes three threshold levels, which are based on measured drawdown and production. **Table 7-1** summarizes the main criteria associated with each of the three thresholds. The District monitors its water levels and production on a regular basis to determine if any of the threshold levels have been exceeded. If the District determines that a threshold levels has been exceeded, Rule 16.4 specifics the type of actions that the District should perform in order to help preserve and protect the groundwater. The District actions may include one or more of the following: performing hydrogeologic studies, rule modification, and curtailment of permits or production amounts. **Table 7-2** lists the District response that Rule 16.4 requires for exceedances associated with the different thresholds.

Table 7-1 Threshold limits associated with POSGCD Rule 16.4

Criteria	Threshold Level		
	1	2	3
Total annual groundwater production (AFY)	> 60% of MAG in Management Plan	>70% of MAG in Management Plan	NA
Average drawdown in a Management Plan	> 50% of PDLs	> 60% of DFCs	> 75% of PDLs
	> 50% of DFCs	> 60% of DFCs	> 75% of DFCs
Projected Average drawdowns calculated with a District	> PDLs in 15 years	NA	NA
	> DFC in 15 years	NA	NA

Note: DFC = Desired Future Condition
PDL = Protective Drawdown Limit
MAG = Modeled Available Groundwater

Table 7-2 Possible list of District action triggered by exceedance(s) of threshold levels

Threshold Level	District Actions if Threshold is Exceeded
1	• Perform studies to improve quantification of pumping effects, characterization of aquifer, and prediction of changes in future water levels. The studies will suggest possible schedules for reducing groundwater production in the affected management zones. • Conduct public meetings to discuss the Level 1 exceedance(s). •
2	• Re-evaluate the Management Plan and rules regarding management zones, collection and analysis of monitoring data, and DFCs. • Notify well owners of possible plans for curtailing groundwater production. • Will conduct public meetings to discuss the Level 2 exceedance(s).

Threshold Level	District Actions if Threshold is Exceeded
3	• Conduct public hearing to discuss aquifer conditions. Develop a Response Action Work Plan to achieve DFCs and PDLs. • Reduce the maximum water production permitted per acre for the Management Zone and the water authorized to be produced under any permit issued by the District , if the data analysis supports that action
Note: DFC = Desired Future Condition PDL = Protective Drawdown Limit	

Table 7-3 lists ten threshold level that were exceeded in 2020. The ten exceedances occurred in six aquifers. Eight of the exceedances were associated with a Level 1 threshold and the remaining two exceedances were associated with a Level 2 threshold. The Level 2 threshold exceedances are associated calculating an average drawdown that is more than 60% of the DFC. Table 7-3 indicates that the Carrizo aquifer is the aquifer with the most threshold exceedances. One of these threshold exceedances is associated drawdown levels that are more than 60% of the DFCs. The results of the threshold analysis indicate the Carrizo Aquifer in the District will have the some of its greatest challenges for accomplishing its goals.

Table 7-3 Threshold levels that were exceeded in 2020

Threshold	Description	Aquifer
Level 1	>60% of MAG	Queen City
Level 1	>60% of MAG	Carrizo
Level 1	>50% of DFCs	Sparta
Level 1	>50% of DFCs	Carrizo
Level 1	>PDL in 15 years	Carrizo
Level 1	>PDL in 15 years	Calvert Bluff
Level 1	>PDL in 15 years	Simsboro
Level 1	>PDL in 15 years	Queen City
Level 2	>60% of MAG	Queen City
Level 2	>60% of MAG	Carrizo

Note: DFC = Desired Future Condition
PDL = Protective Drawdown Limit
MAG = Modeled Available Groundwater

7.2 Findings from the Groundwater Assistance Program Annual Needs Assessment

The Groundwater Assistance Program (GWAP) Annual Needs Assessment (GANA) identifies forty-one (41) wells where water levels are likely to decline below the elevation of the pump setting as a result of regional groundwater production in GMA 12 within the next 10 years. A well is designated as a high-priority well is water well in 2029 as predicted by the GAM is below the elevation of its pump setting recorded in the POSGCD database. Out of the forty-one (41) wells, 36 are completed in the Carrizo Aquifer.

Because most of the District wells do not have pump elevation data, the GANA also used several statistical analyses of the locations and depths of the high-priority wells to identify wells that are likely to have been classified as been high priority wells if pump elevation data were available. These wells are termed moderate priority wells. A total of fifty-six (56) moderate priority wells were identified. All of the fifty-six (56) moderate priority wells pump the Carrizo aquifer. Out of the 56 moderate-priority wells, thirty-three (33) of the wells were estimated to have problems with low water levels before the end of 2029.

The total number of high-priority and moderate-priority wells that the GANA estimated would have problems with low water levels before the end of 2029 is 74, of which sixty-nine (69) are Carrizo wells. Field investigations in 2020 have confirmed that the GANA predicted impacts to existing wells are reasonably accurate. The results of the 2020 GANA, ongoing GWAP investigations, and hydrogeologic studies provide a good basis for evaluating current aquifer conditions and the effectiveness of Management Strategies to identify and assess possible changes are needed in the District's management of groundwater in order to attain the District's management goals.

7.3 Management Issues Affecting the Monitoring and Enforcement of Production and Drawdown Thresholds

Because aquifer conditions are continually changing and the best science available is continually evolving, the District periodically reviews its Management Strategies and rules via the Board committees shown in Figure 4-1. Listed below are six management issues that are central to several of POSGCD Management Strategies that are key to POSGCD achieving its goals. These six issues are discussed in later subsections.

- Maximum Production Volumes Based on Permitted Acreage
- Operating & Transport Permit Fees
- Boundaries for Management Zones Associated with DFCs
- Time Intervals Associated with DFCs
- Compatibility Between DFCs and PDLs
- Enforcement of DFCs and PDLs by Curtailment of Production
- Unreasonable Impacts to Groundwater and Surface Water

7.3.1 Definition of Unreasonable Impacts to Groundwater and Surface Water Maximum Production Volumes Based on Permitted Acreage

The District currently uses an allocation of 2 acre-ft-year per acre (AFY/acre) to determine the maximum production volumes that can be allocated for the acreage associated with a permit. The allocation of 2 AFY/acre was established during the first several years after the creation of the District. During the last 15 years, POSGCD has periodically weighed the merits of the 2 AFY/acre allocation in response to the following: the District's improved understanding of its groundwater resources, the significant improvements in the GAMs, the increased demand for water in the District and the state, and significant changes in TWC statutes and administrative code.

On March 9, 2017, INTERA discussed options with the District DFC Committee for amending the current allocation rule in a presentation titled: "Investigation into Methods for Developing Fair Share." The presentation explained that a weakness with the current allocation approach is it does not account for the large differences in the amount of groundwater in-place and the large differences in the production capacity of the individual aquifers that underlies the District. The presentation provided a process for developing a correlative right that recognizes and accounts for significant difference in the availability of groundwater across the District. The process involved the following steps:

- Identify the aquifers or management zones that will be used for determining the correlative right
- Identify the range of maximum production rates that will be allowed for each management zone
- Identify the properties of each management zone that will be used to calculate the maximum production allocation
- Develop maps for individual management zones that show the spatial variability in maximum production allocation
- Develop maps that show the spatial variability for the maximum production allocation that includes all management zones.

Figures 7-1 and **7-2** provide maps that were discussed by the DFC committee associate the maximum pumping allocation to aquifer properties. Figure 7-1 provides an example map that accounts for the cumulative total of all of the aquifers whereas Figure 7-2 is an example map for just a single aquifer—the Carrizo Aquifer. In Figure 7-1, the correlative allocation across the District averages about 2 AFY/acre but ranges from about 0.6 AFY/acre to about 3 AFY/acre. Figure 7-2 shows correlative allocation for only the Carrizo aquifer that is based on aquifer thickness and ranges between 0 to 1.2 AFY/acre. If the District wishes to adopt a correlative policy that considers the difference among aquifers to produce groundwater availability, then the District should consider the following factors:

- Differences in water quality
- Aquifer cumulative thickness
- Aquifer information derived from the GAM and/or aquifer pumping tests
- Total Estimated Recoverable Storage
- DFCs and PDLs
- Impacts on current permits and production

7.3.2 Operating and Transport Permit Fees

The District currently uses the same schedule of fees for water use, production, transport, and permits for all groundwater regardless of aquifer. The decision of whether or not to vary the fee based on the aquifer pumped is an option that could be used by the District as a management to incentivize the pumping of one aquifer over another. The use of aquifer-based fee structure could be implemented District wide or within designated areas to managed groundwater depletion and drawdown within a specific management zone. A benefit of the aquifer-base fee structure is to help avoid the need for curtailment of pumping in a specific aquifer by charging a higher fee for pumping from that specific aquifer. The purpose of the aquifer-based fee schedule fee would be to provide sufficient financial incentive for current well owners to reduce their pumpage from one or more specific aquifer(s) and to increase pumpage from other aquifers and for new well owners to minimize pumpage from one or more specific aquifer(s) from the onset.

7.3.3 Boundaries for Management Zones Associated with Desired Future Conditions

TWC §36.001(30) defines Desired future condition as " a quantitative description, adopted in accordance with Section §36.108, of the desired condition of the groundwater resources in a management area at one or more specified future times." The District has previously set DFCs to represent the average drawdown for Total Management Areas. From the perspective of water resource planning, the Total Management Area may be an appropriate size because so that all of the available groundwater in a GCD is properly reported. However, the use of the Total Management area can be problematic from a regulatory perspective because of the lack of wells that can be used to evaluate compliance in the down dip portion of all of the District aquifers. The problem of inadequate well coverage is illustrated by the well locations in the Hooper Aquifer shown in **Figure 7-3**. In the Hooper Aquifer, approximately 70 percent of the down dip portion of the aquifer has no wells within.

The absence of wells across most of the Hooper prevent the District from obtaining measured water levels so that credible estimates of actual drawdown can be determined. Without having field data or credible estimate of drawdown across large portions of a management zone would hinder the District's ability to enforce curtailment of groundwater production in that management zone. If the District is interested in using DFCs as a regulatory driver to justify curtailment in production in management zones, then the District should partition Total Management Zones into multiple management zones, whose areas are based on the following considerations:

- the location of available wells for monitoring the water levels in the management zones
- The wells in the District monitoring network that are located in the management zones
- Whether the DFC will be to use to regulate production and permitting
- The District's responsibility to set DFCs where there are no permitted wells
- The District's responsibility to set DFCs where there are no exempt wells

7.3.4 Time Intervals Associated with Desired Future Conditions

As previously stated, TWC §36.001(30) defines a desired future condition as " a quantitative description, adopted in accordance with Section §36.108, of the desired condition of the groundwater resources in a management area at one or more specified future times." For the last two joint planning session, POSGCD has adopted DFC values for only a single time, which has been at least 50 years into the future. Currently, GMA 12 has adopted DFCs only for only the year 2070 and for the third round to joint planning, the GMA 12 has proposed DFCs only for the year 2070.

From the perspective of planning, a DFC set 50 years into the future provides a useful endpoint for investigating the different future pumping scenario that can occur to achieve the DFC. Such an investigation would provide valuable information related to the amounts of groundwater production that are possible for the DFC. From the perspective of regulatory enforcement, however, a DFC set 50 years into the future may not be a useful endpoint because the data are beyond the renewal date for all of POSGCD permits, which are issued with 40-year terms. Among important regulatory questions associated with the using a 2070 DFC as a regulatory driver is whether or not the DFC can be exceeded prior to 2070 if the DFC will still be achieved 2070. Because a DFC only applies to a specific time, a well owner could argue that a 2070 DFC could be exceeded prior to 2070 as long as the DFC can be shown via groundwater modeling that the DFC will be achieved in 2070.

For the purposes of discussion, the POSGCD has several large permits that are up for renewal before 2055. Two of these large permits account for approximately 110,000 AFY of permitted pumping. Because POSGCD has the ability to significantly reduce pumping before 2070 by not reissuing permits at their current production limits at the end of the 40-year term of the permits, owners of the two large permits could argue that POSGCD cannot use a 2070 DFC as justification to adjust their permitted pumping before 2055 because if the owners can demonstrate through groundwater modeling that the Carrizo-Wilcox Aquifer will have sufficient recovery with a reduced pumpage after 2055 to meet a 2070 DFC.

Besides evaluating whether POSGCD should adopt a single year for a DFC, POSGCD may also consider the merits of GMA 12's historical practice of performing DFC simulations based on the presumption that all current permits stay in effect through the duration of the entire DFC GAM simulation. In 2021, GMA 12 has voted to use pumping scenarios that have pumping associated with large production permits in POSGCD throughout 2070 even though the permit's 40-year renewal date for the permit occurs before 2070. The presumption that the permits will be renewed at their current production values introduces a bias toward higher drawdowns in 2070, which is an obstacle for the District's ability to curtail production in order to set and manage to an acceptable amount of drawdown. **Figure 7-4** shows that a significant amount of drawdown occurs after 2050, which is the end date for the 40-year term for the Vista Ridge and I-130 permits. From 2050 to 2070, the average drawdown increases approximately 60, 50, 30, and 25 ft for the Simsboro, Hooper, Calvert Bluff, and Carrizo aquifers, respectively.

If POSGCD desires to use DFCs as a regulatory driver to justify curtailment, the District should consider the benefit of selecting a DFC for multiple times and not just for the time corresponding to the end of the 50-year planning cycle. Among the considerations for selection of other time periods are:

- The end dates for the permit associated with large production amounts in aquifers of concern
- The nature and extent of permits for large production in adjacent GCDs

7.3.5 Compatibility of DFCs and PDLs

The District has assigned a Shallow Management Zone and a Total Management Zone to each aquifer. The Shallow Management Zone for each aquifer includes only the portion of the aquifer that extends to depth of 400 feet, whereas the entire aquifer is contained within a Total Management Zone. A concern with setting a PDL and a DFC for the same aquifer is that the two may not be compatible. If DFCs and a PDL are not compatible in an aquifer, the PDL may prevent the DFC from being achieved, which means that the DFC is not feasible. This situation would be in violation of TWC §36.108(8), which requires that groundwater management areas shall consider the feasibility of achieving the DFC.

One of the obstacles with checking the compatibility between the District's PDLs and DFCs is developing a credible method for evaluating whether or not they are compatible. Whereas the GAMs simulated water levels can be used to directly calculate a DFC, these same water levels cannot also be used to directly calculate a PDL. The reason why water levels from the GAMs can be directly used to check DFCs for aquifers is that the model layers have been constructed to align and to represent aquifers. Because the GAMs model layers are not structured to represent a boundary associated with the 400-foot depth associated with the Shallow Management Zone associated with the PDLs, the simulated water levels from the GAM must be interpolated to calculate a PDL based on simulated water levels. **Figure 7-5** shows the simulated values for PDLs over time based on the pumping in GMA 12 Pumping Scenario S-7. These simulated PDLs are significantly higher than 20 ft in 2070 for four aquifers, which suggests that the PDL of 20 ft is incompatible with the DFCs for those four aquifers.

To help to avoid the potential problems that could arise if a PDL and a DFC are not compatible, the District should consider the compatibility of between its PDLs and DFCs prior to their acceptance. As part of this assessment, the District should review the definition of a PDL. The District rules state that PDLs are intended to represent the water level conditions in the unconfined portions of the aquifer. However, water levels in some of the wells that terminate at depths near 400 feet below ground surface may not be representative of water levels in the unconfined portions of the aquifer. In order to improve the technical and legal defensibility of adopting and enforcing DFCs and PDLs , then the District should consider the following:

- Review the definition of PDLs to determine whether there is sufficient cause to warrant a change it is definition or in the measured water levels used to calculate it
- Adjust the which water levels are used to calculate a PDL so that a PDL represent drawdown in the unconfined portion of an aquifer
- Develop a process for evaluating the compatibility between the PDL and the DFC for a given aquifer
- Change the definition of the management zones associated with the DFCs and PDLs so that to demonstrate the PDL will not impact the feasibility of achieving the DFC
- Adjust the model layers in the Sparta/Queen City/Carrizo Wilcox GAM so it will be better suited for calculating an average drawdown for the Shallow Management Zone.
- Adjust the definition of the PDLs so that the current Sparta/Queen City/Carrizo Wilcox GAM can be used to simulate an average drawdown for the Shallow Management Zone.

7.3.6 Enforcement of DFCs and PDLs by Curtailment of Production

The enforcement of DFCs and PDLs may be require considerably more effort than any previous enforcement actions for two reasons. One reason is the lack of statutory guidance from state agencies regarding the monitoring and analysis of water levels for DFC compliance. The second reason is that there is a general lack of case law in Texas regarding enforcement actions by GCDs to curtail production and permits. For these two reasons, there is no roadmap for the District to follow avoid the lengthy hearing regarding the appropriateness of the District's enforcement action.

As part of its preparation for determining how and when to enforce DFCs, PDLs, or similar limits on groundwater depletion, the District should consider performing a comprehensive review of all its entire set of management strategies and rules related to enforcement of production and drawdown thresholds because the aquifer conditions are continually changing and best science available is continually evolving. Among the objectives of such a comprehensive review would be to identify rules that: (1) may not be adequately supported by best available science and thus need to be updated; (2) may not be sufficiently articulated to serve their intended purpose: (3) may contain words that are not sufficiently defined; for (4) are in conflict with other rules or management strategies. Such a review could begin with mapping the relationships shown in **Table 7-4**. Table 7-4 shows the interconnected relationships among the management strategies, TWC statutes, District Rules, and science. The mapping of these interconnections among management strategies helps to identify the critical components and potential gaps in science and in policy for managing groundwater.

Table 7-4 Interconnection among scientific analysis & techniques, hydrogeological applications, and Management Strategies

Management Strategy	Regulation/Guidance	Dependence on Science	Overlap with Other MS
1. Education and Public Outreach	MP Sec 16,	T-1 D-1	All
2. Regional Planning	TWC Chapter 36,	T-1 D-1, D-2, D-3, D-4	4, 5
3. Compliance Evaluations for DFC and PDLs	Rules Sec 16/ MP Sec 7,	T-1, T-2, T-4 D-1, D-3, D-4	4, 5
4. Management Zones	Rules Sec 16/ MP Sec 5	T-1, T-4 D-4	2
5. Well Monitoring Program	Rules Sec 4, 11 / MP Sec-10/ Compliance Monitoring Document	T-1, T-4 D-1, D-2, D-4	2, 3, 4, 5, 7, 8, 9
6. District Action Triggered by Exceeding Threshold Levels	Rules Sec 16 /MP 11	T-1, T-4 D-1, D-2, D-4	2, 3, 4, 5
7. Well Permitting Requirements	Rules Sec 5, 12	T-1, T-2, T-3 D-2, D-3, D-4	4, 5, 8, 9
8. Production Limitations	Rules Sec 5	T-1	2, 3, 4, 5, 7, 9
9. Curtailment of Permitted Production	Rules Sec 16 /MP 11	T-1, T-2, T-4 D-1, D-2, D-3	2, 3, 4, 5, 6, 7
10. Conservation Programs	Rules Sec 8, 13; MP Sec 16,		3, 4, 8
Science: Analysis & Techniques		**Science: Quantitative Data**	
T-1. Groundwater Availability Models		D-1. Monitored WL Data	
T-2 Modified Groundwater Availability Models		D-2. Reported Pumping Rates	
T-3. Analytical Models for Groundwater Flow		D-3. Aquifer Pumping Tests	
T-4 Software to Interpolate Monitoring Data		D-4. Driller and Geophysical Logs	

Another objective of the comprehensive review is to provide the information to help develop an approach for implementing curtailment. This workplan would include one or more of the following:

- Technical analyses and data to demonstrate that DFC or PDL has been exceeded or that unreasonable impacts have occurred. These analyses would be expected to be similar in nature to those presented in the INTERA's compliance report (2021b)
- Justification for the technical analysis used to demonstrate that curtailment
- Technical analyses to determine the amount of reduction required at each permitted well in POSGCD to achieve compliance; These analyses would be expected to be similar in nature to those presented in **Figure 7-6**.
- Justification for the technical analysis used to determine the amount and location of reduced production.
- Rationale to support the curtailment of production reductions are necessary and appropriate based on District rules and goals.

7.3.7 Unreasonable Impacts To Groundwater and Surface Water

Before granting or denying a permit, or a permit amendment issued in accordance TWC §36.1146, requires that the district shall consider whether the proposed use of water unreasonably affects existing groundwater and surface water resources or existing permit holders. The District rules do not explicitly define what represents an unreasonable impact to groundwater or surface water. Unreasonable impact allows the District to account for site specific conditions that cannot be adequately accounted or in the well spacing rules. Site specific conditions that could be of importance if a proposed well field is in close proximity to a spring or surface water body, a sensitive ecosystem, a relatively low productive area of the aquifer, or historical pumping. In order have the rules address the issue of unreasonable impact, the District should consider defining unreasonable impacts of groundwater and surface water as part of their rules.

Two options that POSGCD could consider for monitoring for unreasonable impacts is to define zones for preventing an undesirable depletion of either groundwater depletion or surface water. Among the reasons for creating a groundwater depletion zone would be to prevent pumping from causing undesirable impacts to existing wells or undesirable declines in aquifer water levels. Among the reasons for creating a surface water depletion zone would be to prevent pumping from causing undesirable impacts to surface water-groundwater interactions.

7.4 Additional Management Issues

In addition to the six issues identified and discussed in Section 7.3 that are central to POSGCD Management Strategies, the District Board has also identified three additional issues or management goals for that integrate in the District strategy for managing the groundwater resources within the District. These are:

- Incentivize Conjunctive Use of Groundwater and Surface Water
- Incentivize Aquifer Storage and Recovery
- Promote Water Conservation

Both conjunctive use and conservation currently are included in the District-approved Management Plan as Management Goals. The Management Plan also includes a brief introduction to Aquifer Storage and Recovery (ASR) with acknowledgement that ASR could be a strategy to improve groundwater management in GMA-12 . Each of these management issues will be briefly discussed below.

7.4.1 Incentivize Conjunctive Use of Groundwater and Surface Water

Conjunctive use in water resources is generally defined as the use of groundwater and surface water resources in a conjunctive, or integrated method, to increase the overall reliability and availability of water in the long-term. An example of conjunctive management in Texas is the management plan for the Harris-Galveston Subsidence District. In their jurisdiction, they have moved to a regional water resource portfolio that conjunctively relies limiting use of groundwater and increased reliance on surface water and other sources to mitigate land subsidence in the region.

In most cases, groundwater and surface water management strategies are developed separately. This has especially been true in Texas where regulatory authorities and the water law generally treat these two water sources as separate. The benefits of groundwater as a source is that it is generally considered a drought-proof source of supply. The benefits of surface water are that it has historically been plentiful in the central and eastern portions of the state. Surface water is subject to drought and as a result surface water reservoirs have been constructed to store surface water when river flows are constrained. In recent history, the development of new reservoirs has been limited because of several issues related to their siting, environment and permitting.

If one has access to surface water and groundwater, it has long been recognized that through conjunctively using these two resources one can increase supply and maximize availability. In some cases, the addition of a little groundwater to a surface water project can significantly increase the project firm yield. It may be of interest to the District to development a management approach that recognizes that all groundwater production does not have the same impact on the region. If groundwater is a key component to a conjunctive project greatly increasing supplies within the District, this may be a practice that could be incentivized through permitting in some manner which recognizes the increase in firm yield supply a given project brings to the region. Among the options to incentivize conjunctive projects is a reduction in production fees or an increase term of the permit

Among the conjunctive project s that are in the state water plan for central Texas are ASR projects that use surface water to recharge the aquifers for recovery during times of low surface water availability.

7.4.2 Incentivize Aquifer Storage and Recovery

ASR is a proven technology and is used as a water supply strategy to increase the availability of either groundwater or surface water. Most water resource engineers are familiar with the concept of using water supply reservoirs to store surface water in times of high availability for use in times of limited availability. Similarly, ASR increases storage by using the subsurface as a reservoir. ASR uses the aquifer to store excess water during times of plenty and recovers that water from the aquifer when it is needed.

Water that is stored will later be recovered through the pumping of the well through which the water was injected or through the pumping a well located near the injection well. Like a surface reservoir, a properly designed ASR project will define a yield (storage volume) that the ASR project will supply over some time horizon. Experience dictates that the initial ASR project recharge volume, termed the target storage volume (TSV), should be approximately two times the project storage volume. This creates a buffer zone between the recharge water and the native groundwater and provides stability in terms of produced water quality and aquifer performance. Because aquifers have ambient groundwater flow and geochemical considerations, a recharge project will not recover 100% of the water recharged while maintaining the same water quality. The percent of recharge water that is recoverable is called the recoverability of the ASR project. This means that one will always initially recharge more water in an ASR project than one expects to recover.

In 2015, Legislation clarifying the statutes governing ASR in Texas was enacted through the passage of House Bill-655 (HB-655). This legislation was significant in that it established the Texas Commission on Environmental Quality (TCEQ) as the sole regulatory authority for ASR in Texas. However, the legislation recognized that GCDs have authority over registration and permitting of wells within their jurisdiction and if an ASR project produces more water than authorized by their TCEQ permit, all GCD rules come into play. This doesn't mean that a GCD doesn't have a role in supporting ASR as a way to increase supplies within their region.

As we stated above, a typical ASR project recharges up to twice the volume of water that they recover. From a groundwater management perspective, that increases the aquifer water volume over what existed prior to the project. The District could incentivize ASR by allowing the ASR Project to recover some percent of their recharge water volume either through limited ASR over-production or through groundwater production from another well owned by the operator near the project location and in the same aquifer. The District could also look at reduced production fees for the additional production associated with a recharge credit.

7.4.3 Promote Water Conservation

The District currently has a management objective in the Management Plan for Conservation of groundwater through several means within the District. Some of these methods include rainwater harvesting, brush control, conjunctive management and recharge enhancement projects (which could include ASR). A key premise of conservation of groundwater in the District is that the more efficiently all the water resources are used within the District, the more groundwater will be conserved. Current conservation performance standards are based upon education and grant programs. These programs could be expanded to include additional consideration for conjunctive and regional water resource strategies that conserve groundwater within the District while improving the availability of water and best practices for reducing water usage for common home and irrigation practices. In addition, the District could modify their rules to provide the District with additional authority to identify and prevent waste associated with the production, transmission, and use of groundwater.

Because conjunctive use of groundwater and ASR can conserve groundwater while increasing supply, it would be appropriate for the District to investigate regulatory methods to incentivize conservation and conjunctive use which includes ASR. As stated in the Management Plan, the District’s objective is to benefit the existing and future users of groundwater in the District by providing for the more efficient use of water, increasing recharge to aquifers, reducing waste, limiting groundwater level declines, and maintaining or increasing the amount of groundwater available.

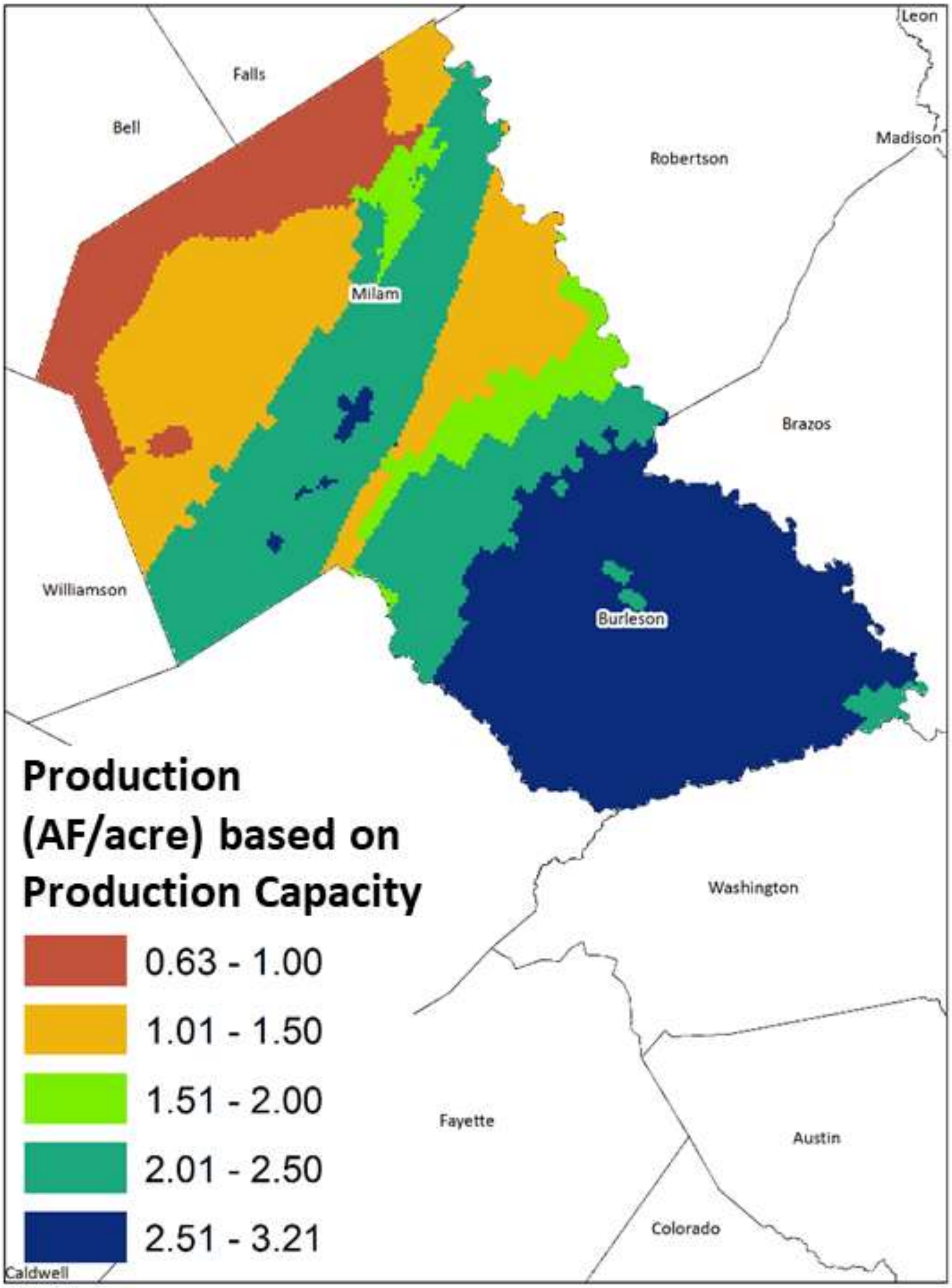


Figure 7-1 Example of the of a correlative right for allocation of a maximum production rate per acre that is based on of the aquifers and the attributes of the aquifers that underlie a property (presented to District DFC committee in March 2017)

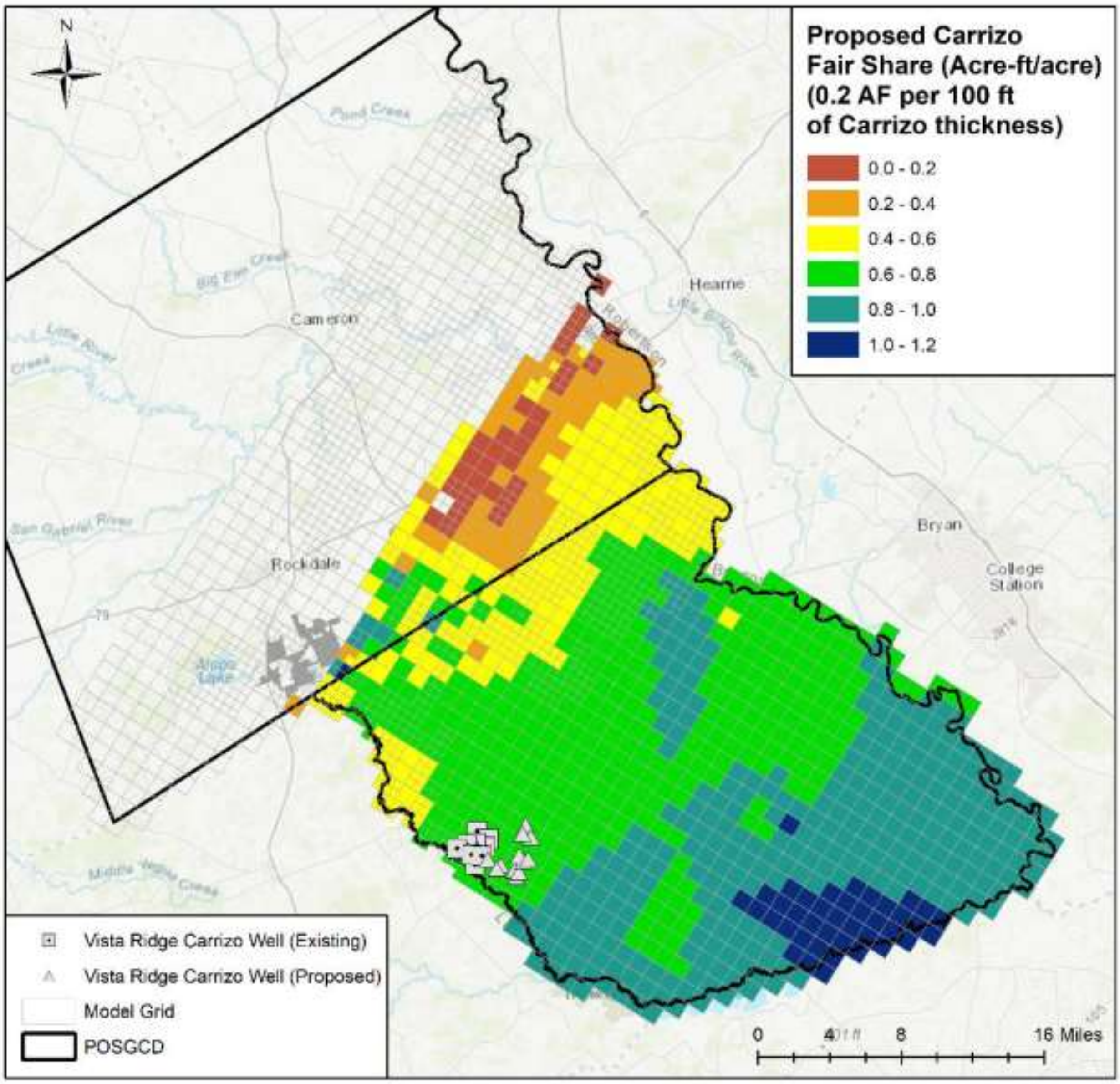


Figure 7-2 Example of a correlative right for a maximum production rate per acre for the Carrizo Aquifer that is based on aquifer thickness. (presented to District DFC committee in May 2020)

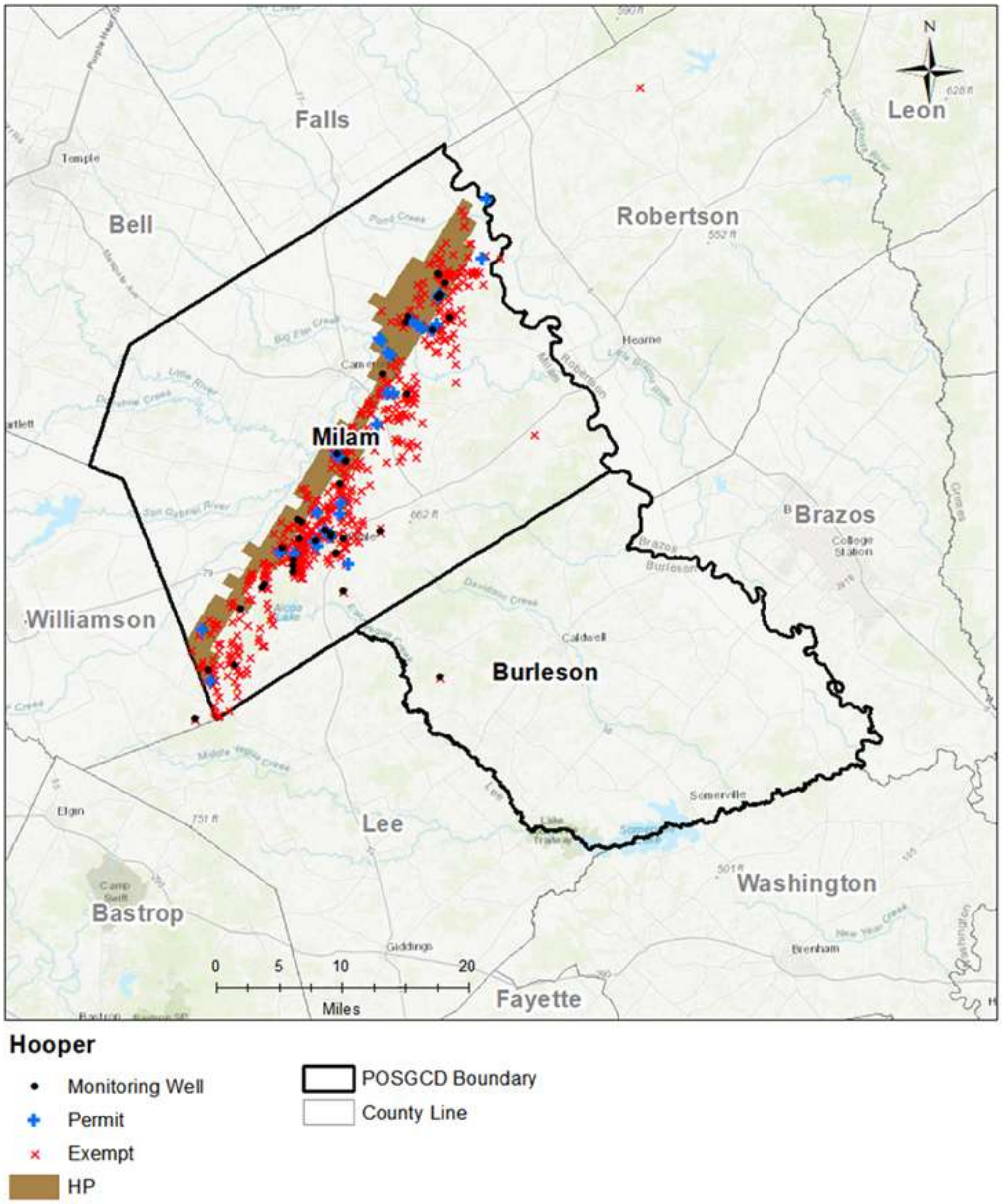
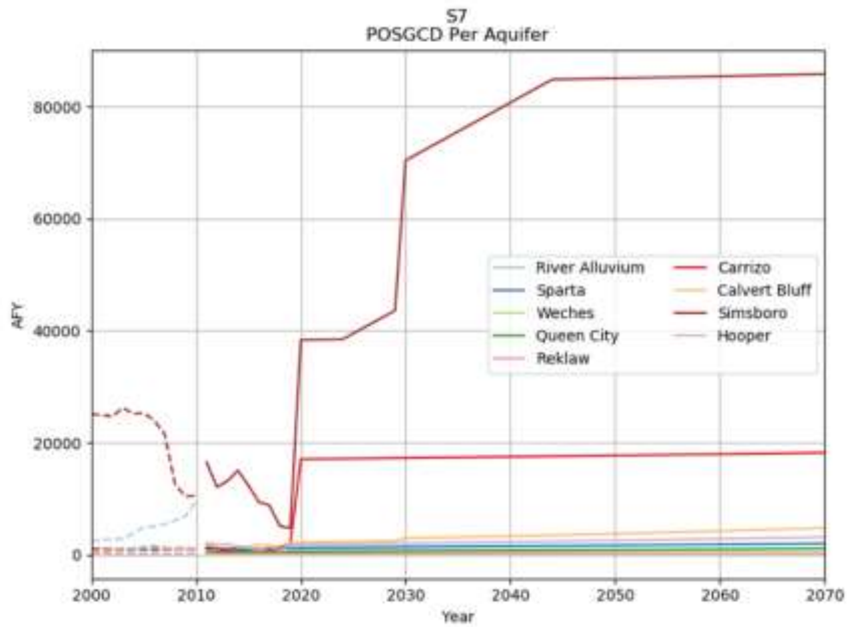


Figure 7-3 Location of registered wells in the Hooper Aquifer. The most up-dip extend of the aquifer is designated by the brown shaded area. (presented to District DFC committee in January 2021)

a)



b)

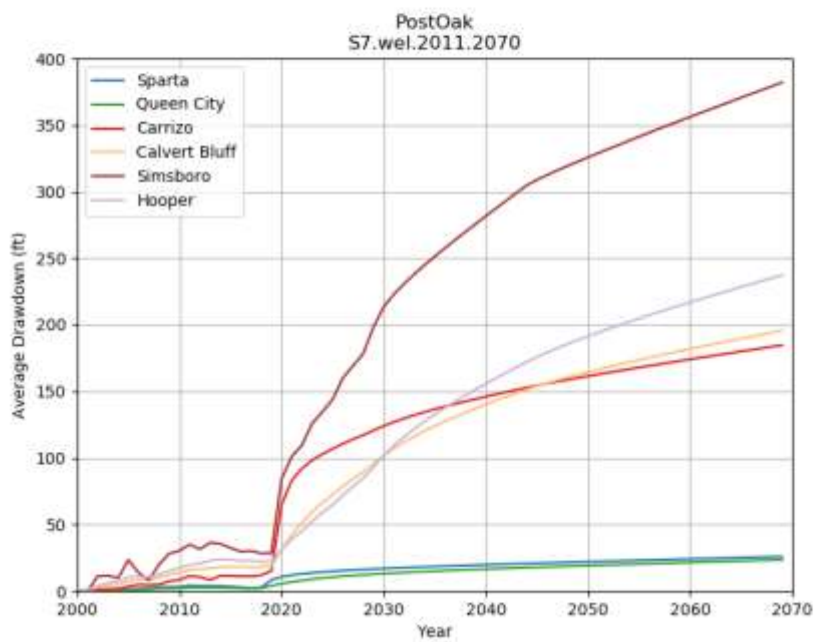


Figure 7-4 GMA 12 Pumping Scenario 7 for POSGCD, (a) annual pumping rates by aquifer (pre 2010 values are from the calibrated model) (b) average drawdown by aquifer measured relative to the year 2000

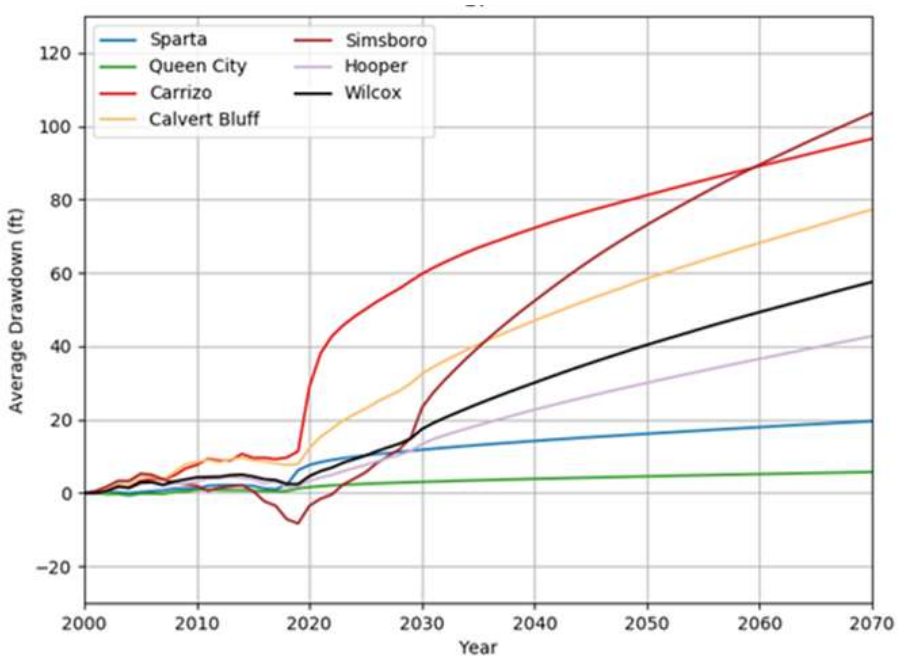


Figure 7-5 Example of simulation a GMA 12 DFC Run that suggests that the Districts PDLs are not compatible with GMA 12 DFC pumping scenarios (presented to District DFC committee in April 2020)

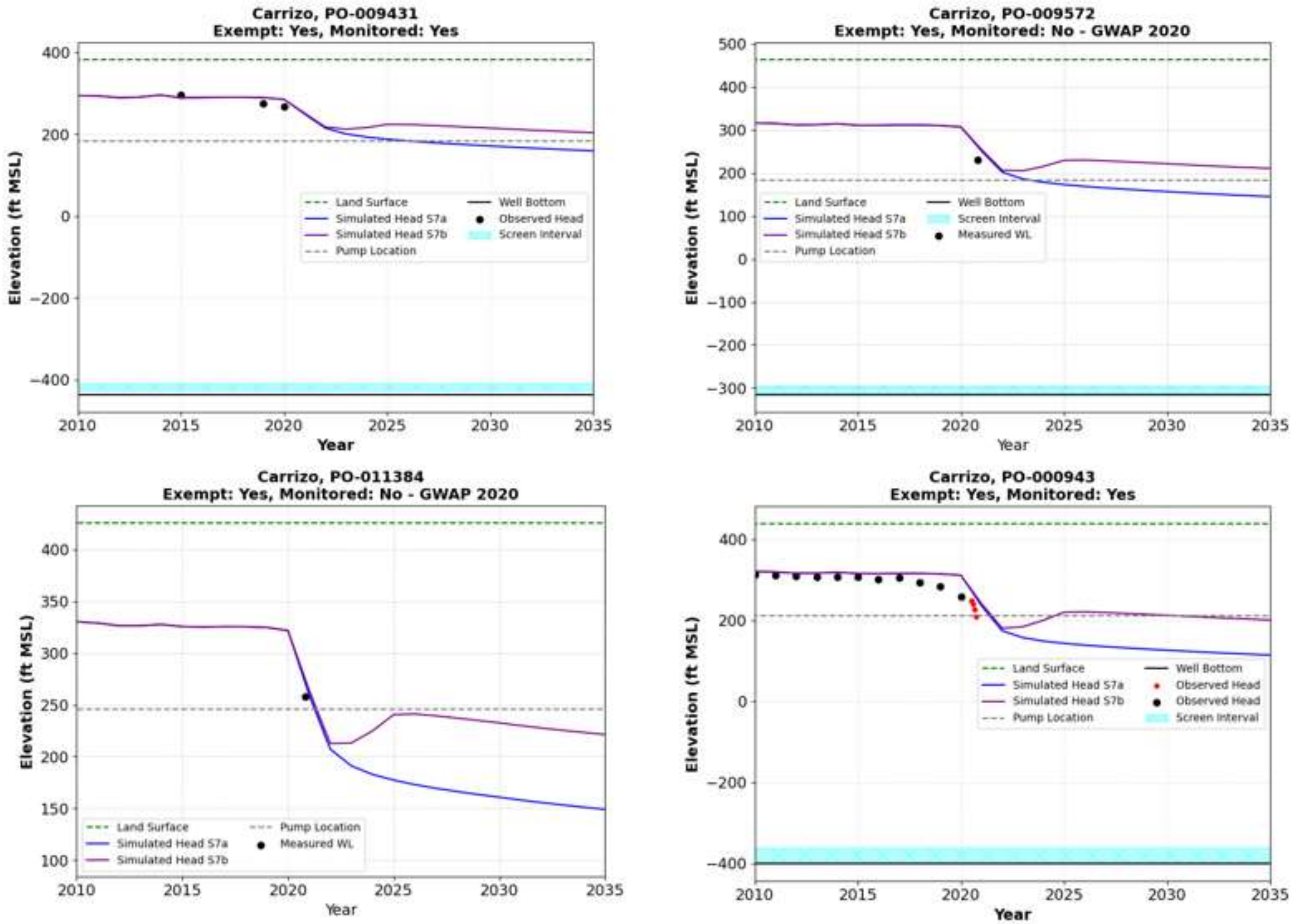


Figure 7-6 Result showing the impacts of reduction of Carrizo pumping on wells located near Vista Ridge well field (presented to District DFC committee in December 2020)

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