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Case Study of Groundwater Management Issues at the Forefront of Large-scale Production from a Confined Aquifer: The Vista Ridge Project

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Abstract: Continuing population growth, increasing demands for water, and declining water availability are statewide water concerns in Texas. The development and movement of water from where it is located to where it is needed entails benefits to the receiving area and concerns for the area of origin. The Vista Ridge Project serves as an on-point example and case study of issues that will be revisited with future large water projects across Texas. Water level declines in existing wells caused by production from the Vista Ridge well field was a focus of significant public discussion in 2022, including Texas House and Senate interim session hearings. This paper spotlights groundwater management issues related to the Vista Ridge Project, including well mitigation; impacts from groundwater production across groundwater conservation district boundaries; meaningful consideration of nine factors in Texas Water Code § 36.108 (d); achieving the balance between groundwater production and conservation in Texas Water Code § 36.108 (d-2); protection of property rights; and the need for both good science and good science communication during the joint-planning process.

Keywords: Mitigation, property rights, fair share, modeled available groundwater, Groundwater Management Area 12, Post Oak Savannah GCD, Lost Pines GCD, Vista Ridge, socioeconomic impacts, desired future conditions

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Terms used in paper

Acronym/Initialism	Descriptive Name
af/yr	acre-feet per year
bgs	below ground surface
BVGCD	Brazos Valley Groundwater Conservation District
DFC(s)	desired future condition(s)
ft	feet
ft^2/day	square feet per day
GAM(s)	groundwater availability model(s)
GCD(s)	groundwater conservation district(s)
GMA(s)	groundwater management area(s)
GULF	Gulf Coast Land Subsidence and Groundwater-Flow
GWAP	Groundwater Assistance Program
HB	House Bill
LPGCD	Lost Pines Groundwater Conservation District
MAG(s)	modeled available groundwater(s)
PDL	protective drawdown limits
POSGCD	Post Oak Savannah Groundwater Conservation District
SAWS	San Antonio Water System
TCEQ	Texas Commission on Environmental Quality
TWC	Texas Water Code
TWDB	Texas Water Development Board
USC	United States Code

INTRODUCTION

The 2022 Texas state water plan predicts that Texas's population will increase 73% between 2020 and 2070 (Texas Water Development Board [TWDB], 2022). During this 50-year period, the demand for municipal water will increase 66%, or approximately 3.3 million acre-feet per year (af/yr). The existing supply of water is projected to decline by 18% over the same period, primarily due to statewide aquifer depletion (TWDB, 2022). More than 25% of the growth in water usage is projected to occur in four Texas regional water planning groups. The water demand for these four regional water planning groups, which encompass the cities of Dallas, Fort Worth, Houston, San Antonio, and Austin, is projected to increase 2.5 million af/yr from 2020 to 2070 (TWDB, 2022).

The complexity of moving water to where it is needed will be a key factor in meeting Texas's unprecedented economic and population growth. Projects that move water from where it is located to where it is needed have socioeconomic impacts to both the receiving area as well as the area of origin. Updated groundwater modeling and proper construction of these models are indispensable to properly consider the benefits and impacts from such projects.

This paper presents a case study of the Vista Ridge Project—a large groundwater export project in Burleson County—that illustrates the controversies, uncertainties, impacts, and expenses associated with moving large volumes of groundwater to where it is needed in Texas and spotlights issues that will likely be of concern related to other Texas groundwater development projects in the near future. These issues include:

- The potential importance of a fair share doctrine to the protection of property rights, the production of groundwater, and the conservation of groundwater in place (*see* section elaborating on this topic);
- Consideration of permitted production as a factor when developing desired future conditions (DFCs) (*see* section elaborating on this topic);
- Consideration of local socioeconomic impacts from the groundwater's area of origin when developing DFCs (*see* section elaborating on this topic);
- Potential benefits from presenting spatial and temporal distributions of drawdowns and water levels generated by groundwater availability model (GAM) simulations used to develop DFCs (*see* section elaborating on this topic);
- Recognition of uncertainty in GAM predictions of drawdown and DFCs (*see* section elaborating on this topic); and
- Understanding the limitations of modeled available groundwater (MAG) as an indicator for assessing the achievement of a DFC (*see* section elaborating on this topic).

Given that groundwater water supply projects like the Vista Ridge Project are being considered across Texas, groundwater decision makers would benefit from a familiarization with the groundwater issues, science, modeling, and mitigating factors associated with the Vista Ridge Project. Additionally, now that the 88th Texas Legislature has passed bills partly informed by the experiences and actions to mitigate impacts from groundwater production for transport—such as the Vista Ridge Project—this case study should assist GCDs with developing mitigation policies and accomplishing their groundwater management goals.

The case study is organized into five additional sections. Section II provides information on the hydrogeology and production associated with the Vista Ridge well field and on the Post Oak Savannah Groundwater Conservation District (POSGCD) management strategies most relevant to permitting and regulating Vista Ridge. Section III discusses several of the complex issues associated with the Vista Ridge Project from the perspectives associated with the responsibilities assigned to GCDs and groundwater management areas (GMAs). Section IV provides recommendations for improving the management of the joint planning process for adopting DFCs. Section V provides references, and Section VI provides the attachment.

GENERAL INFORMATION

Vista Ridge Project

The Vista Ridge Project is in western Burleson County within a few miles of the Lee County border. In 2020, the Vista Ridge Project began producing 50,000–55,000 af/yr from the Carrizo-Wilcox Aquifer and transporting it through a 142-mile pipeline to San Antonio. Because of impacts on the water levels in existing wells, the Vista Ridge Project was a focus of significant public discussion in 2022, including Texas House and Senate interim session hearings, front-page newspaper articles, GMA 12 meetings, and GCD meetings. These discussions and concerns led to consideration of several bills attempting to address the issues during the 88th Texas legislative session.

Hydrogeological Conditions

Vista Ridge production occurs from the deep confined portion of the Carrizo-Wilcox Aquifer. The Carrizo-Wilcox Aquifer is composed of four geologic units, which from youngest to oldest (or from shallowest to deepest) are the Carrizo, Calvert Bluff, Simsboro, and Hooper aquifers. The Vista Ridge wells are completed in the Carrizo and Simsboro aquifers.

Figure 1 shows the locations of the Vista Ridge well field and areas where the four geologic units outcrop at ground surface. Figure 2 shows a vertical cross section of the Carrizo-Wilcox Aquifer along a transect that begins in Milam County and

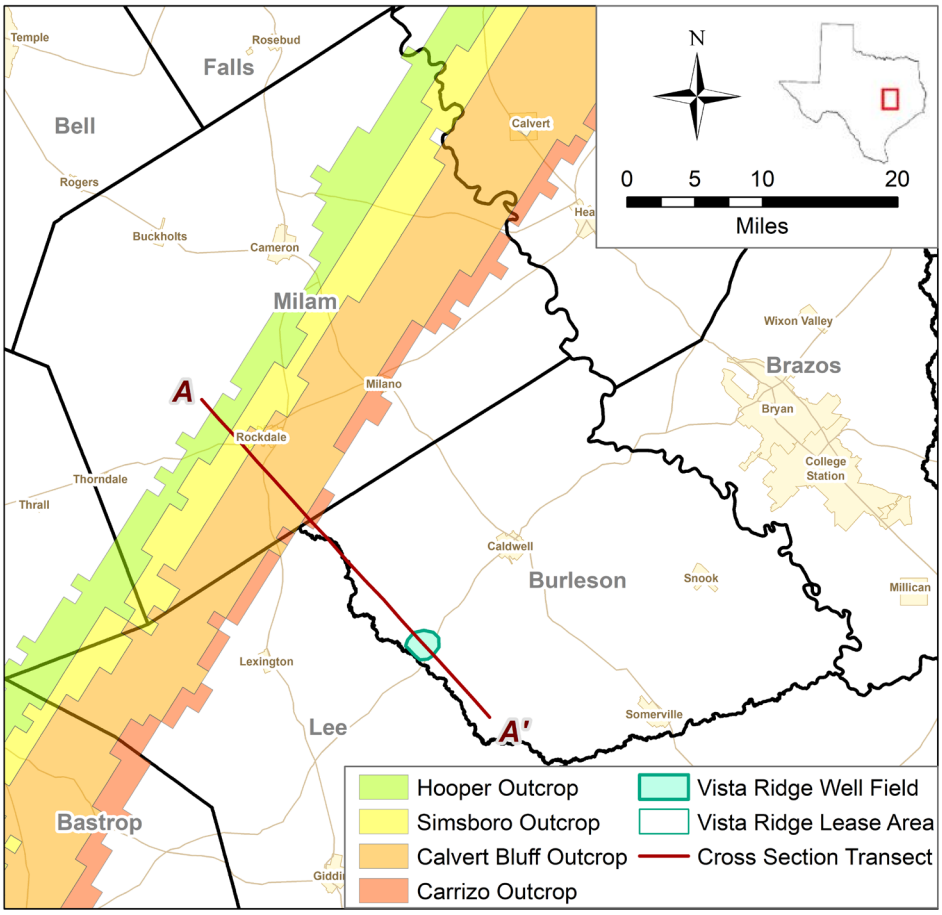

Figure 1. Location of the Vista Ridge well field and the outcrops of the four geologic units that comprise the Carrizo-Wilcox Aquifer (outcrop is where the aquifer intersects the ground surface).

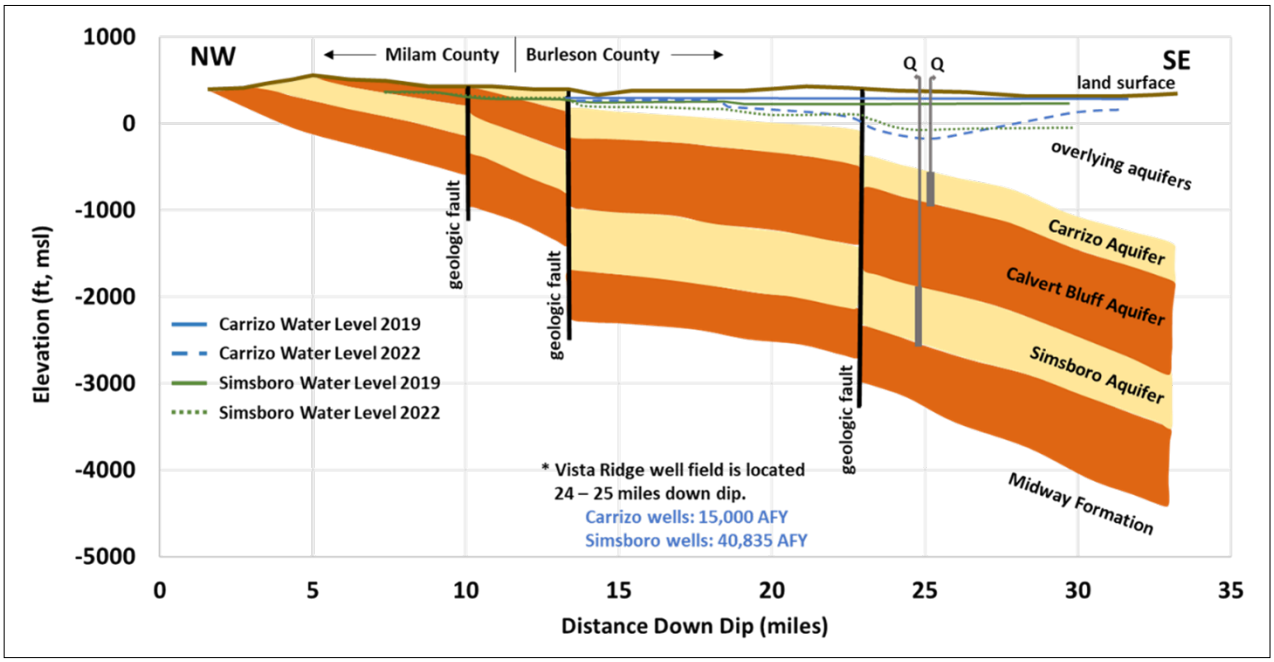

Figure 2. Vertical cross section along Transect A-A' in Figure 1 showing the four geological units that comprise the Carrizo-Wilcox Aquifer, the locations of several geologic faults, the Vista Ridge wells, and the Carrizo and Simsboro aquifer water levels in 2019 and 2022.

passes through the Vista Ridge well field in Burleson County. The cross section shows that the Carrizo-Wilcox Aquifer dips toward the southeast and occurs at increasingly deeper depths toward the Gulf Coast. At the Vista Ridge well field, the tops of the Carrizo and the Simsboro aquifers occur at approximately 800 and 2,000 feet (ft) below ground surface (bgs), respectively. Also shown in Figure 2 are 2019 and 2022 water level surfaces for the Carrizo and Simsboro aquifers. A water level surface represents the height that water will rise in a well as a result of the hydraulic pressure in the aquifer. Water level is recorded relative to sea level and has the units of feet above mean sea level.

Aquifer systems can be categorized as either unconfined or confined. Unconfined aquifer conditions exist where the water level in a well occurs below the top of the aquifer, typically at aquifer outcrops. Confined aquifer conditions exist where the water level in a well occurs above the top of the aquifer. In an unconfined aquifer, a decline in a well's water level represents a reduction in the saturated thickness of the aquifer caused by removal of water from the pore spaces between the aquifer sands and clays. In a confined aquifer, a decline in a well's water level represents a change in the hydraulic pressure of the groundwater in a fully-saturated aquifer. If sufficient drawdown occurs, a confined aquifer system will transition from a confined aquifer into an unconfined aquifer.

The water levels in Figure 2 show that despite drawdowns of hundreds of feet in both the Carrizo and Simsboro aquifers in 2022, both aquifers remain fully saturated with water levels in the production wells occurring several hundred feet above the top of their respective aquifer.

Operation Permits, Wells, and Groundwater Production

The Vista Ridge production permit is associated with 29,026 acres of leased water rights, which under POSGCD rules allow a maximum annual production of 58,052 af/yr. The Vista Ridge permit has an annual production cap of 55,835 af/yr, which consists of 15,000 af/yr from the Carrizo Aquifer and 40,835 af/yr from the Simsboro Aquifer.

Vista Ridge began testing the well field and transmission system in late 2019. Delivery of groundwater to the San Antonio Water System (SAWS) started in April 2020. Groundwater production occurs from 18 wells: nine wells pump the Carrizo Aquifer, and another nine wells pump the Simsboro Aquifer. The nine Carrizo Aquifer wells have screened intervals that span the interval from about 800 to 1,250 ft bgs. The nine Simsboro Aquifer wells have screened intervals that span the interval from about 2,200 to 2,700 ft bgs. Through the end of 2022, the maximum permitted pumping rates for the Carrizo Aquifer and Simsboro Aquifer wells were 1,200 and 3,000 gallons per minute, respectively.

Drawdowns Generated from 2 Years of Vista Ridge Production

Figures 3 and 4 show drawdowns for the first 2 years of Vista Ridge production in the Carrizo and Simsboro aquifers, respectively. The drawdown contours were generated by interpolating water level changes (drawdown) between water levels measured prior to Vista Ridge's 2020 production and in early 2022. Within the well field, the drawdowns are approximately 400 and 300 ft in the Carrizo and Simsboro aquifers, respectively. The cones of depression created by the Vista Ridge pumping in the Carrizo and Simsboro aquifers extend approximately 15 and 25 miles into Lee County, respectively.

Post Oak Savannah Groundwater Conservation District

Groundwater production from the Vista Ridge Project is permitted by the POSGCD. The POSGCD was created in Milam and Burleson counties by House Bill (HB) 1784 in 2001 and a local confirmation election in November 2002. The POSGCD is a member of GMA 12, which sets DFCs for the Carrizo and Simsboro aquifers. POSGCD is bordered by two other GCDs that are members of GMA 12: Lost Pines GCD (LPGCD) to the southwest and Brazos Valley GCD (BVGCD) to the northeast. This section discusses several POSGCD management strategies and programs relevant to addressing impacts from large production projects such as the Vista Ridge Project.

Management Strategy: Management Zones and Management Areas

The POSGCD allows production up to a total of 2 af/yr for each acre tied to the permit application. This maximum production is allowed until changes in aquifer conditions or groundwater levels mandate curtailment of permitted production. Allocations of water per acre are not uncommon in water management and permitting. For evaluating and managing groundwater resources, POSGCD has assigned each of its aquifers to a separate management zone and has subdivided the management zones into management areas. POSGCD has adopted DFCs for the Carrizo and Simsboro aquifers that are in Table 1. The DFCs represent the average predicted drawdown across the entire aquifer from January 2011 to January 2070. The protective drawdown limits (PDLs) in Table 1 were derived using the same methodology and GAM simulations used to determine DFCs, except the management areas cover only a portion of the aquifer instead of the entire aquifer. POSGCD created the PDLs to address concerns about potential problems with enforcing DFC compliance caused by the absence of monitoring wells across large areas of the aquifer.

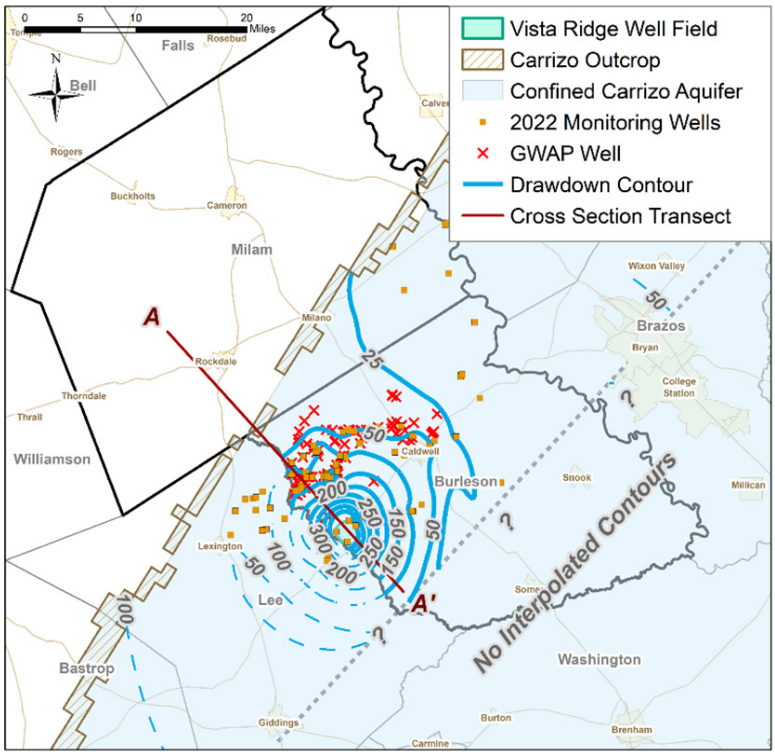

Figure 3. Contours of drawdown in the Carrizo Aquifer that occurred from 2019 to 2022 based on interpolation of measured water level data. Also shown are the location of 92 Carrizo Aquifer wells that Post Oak Savannah Groundwater Conservation District assisted through its Groundwater Assistance Program (GWAP).

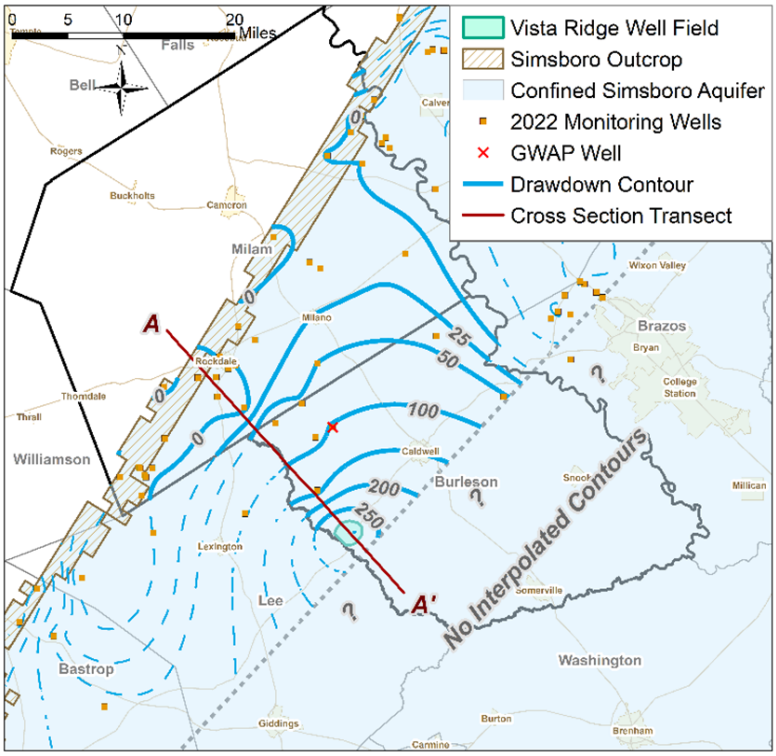

Figure 4. Contours of drawdown in the Simsboro Aquifer that occurred from 2019 to 2022 based on interpolation of measured water level data.

Table 1. Post Oak Savannah Groundwater Conservation District desired future conditions (DFCs) and protective drawdown limits (PDLs) for the Carrizo and Simsboro aquifers.

Aquifer management zone	Average drawdown January 2011–December 2069		
	DFC for entire aquifer	PDL for Management Area 1	PDL for Management Area 2
Carrizo	146	75	175
Simsboro	278	91	335

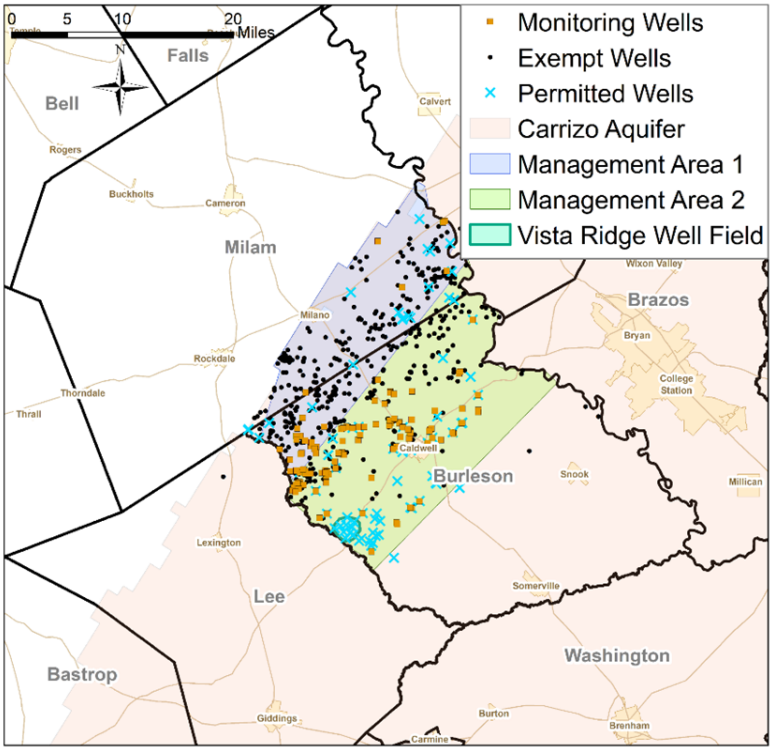

Figure 5. Areal extend of the Carrizo Aquifer and two management areas associated with Post Oak Savannah Groundwater Conservation District desired future conditions and protective drawdown limits.

Figure 5 shows the management areas associated with the two PDLs for the Carrizo Aquifer. Both management areas have monitoring wells spatially distributed throughout the entire area.

Management Strategy: Curtailment of Production

POSGCD rules that govern reductions in permitted production are summarized as follows:

- *Preventing DFCs or PDLs exceedances:* POSGCD has three threshold levels (1, 2, and 3) to gage compliance to DFCs and PDLs. Each increasing threshold level provides for an increased level of response. POSGCD has rules to authorize the development of plans for reducing permitted production when threshold level 3 has been exceeded. Threshold level 3 is reached when 75% of a DFC or a PDL has been achieved.
- *Restoration of aquifer conditions after an unreasonable impact:* Before granting or denying a permit, Texas Water Code (TWC) § 36.113 (d) (2) requires GCDs to consider if the permitted production would unreasonably affect existing groundwater and surface water resources or existing permit holders. POSGCD defines unreasonable impacts in their Rule 16.4.6 (POSGCD, 2023a). POSGCD considers the impacts from an aggregate of wells associated with one or more permits to be unreasonable if pumping from the aggregated wells by themselves and not part of the aggregate of permitted wells caused by any one of several conditions. For the confined aquifer conditions occurring at the Vista Ridge

Project, POSGCD Rule 16.4.6 states unreasonable impacts to groundwater are defined as more than a 100-foot reduction and more than a 40% reduction in water level above the top of the aquifer being pumped along any part of the boundary of the permit's property.

Groundwater Assistance Program

POSGCD began developing its Groundwater Assistance Program (GWAP) in early 2016, received public comment throughout 2017, and adopted the program on January 9, 2018. The primary objective of GWAP is to predict and provide corrective action for landowners whose wells experience water level declines below the pump due to regional pumping in GMA 12. Corrective actions provided by GWAP include, but are not limited to, lowering a pump in a well, modifying the construction of an existing well, or drilling a new well. In most cases, these actions result in the pump being set at a depth that is below the anticipated 30-year water level decline. To be eligible for funding under GWAP, a well must be a low capacity non-exempt well or an exempt well. Another eligibility requirement for GWAP assistance is that the landowner commits to the well becoming a part of the POSGCD monitoring program. As of December 2022, GWAP had addressed 100 wells. Out of these 100 wells, 92 are Carrizo Aquifer wells, the locations of which are shown in Figure 3.

TEXAS WATER CODE § 36.0015 (b) REQUIREMENTS OF GROUNDWATER CONSERVATION DISTRICTS

Per TWC § 36.0015 (b), GCDs have the responsibility "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" (TWC § 36, 2023, § 36.0015 (b)). Per TWC § 36.108 (d-2), within a GMA, GCDs are required to adopt DFCs that "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 management area" (TWC § 36, 2023, § 36.0018 (d-2)).

Protect Property Rights

TWC § 36.002 recognizes that landowners own the groundwater below the surface of their land as real property. The TWC also authorizes GCDs to regulate the drilling and operation of wells within their jurisdiction. Despite assigning the GCD responsibilities to protect property rights, the TWC does not clearly articulate what that protection entails, much less how it should be implemented. Relevant to any discussion of property rights is the evolution of case law regarding groundwater as a property right. For that reason, this paper includes Attachment A, which provides a historical account of case law on the ownership of groundwater in Texas.

Property Right Issues Raised by Well Owners Affected by Vista Ridge Production

The Vista Ridge Project gained increased statewide attention with an August 2021 Texas Tribune article entitled *Central Texas Landowners Blame SAWS Vista Ridge Pipeline for Dry Wells* (Douglas, 2021). The article states that dozens of landowners in LPGCD have lowered their water pumps because of declines in water levels attributed to the Vista Ridge Project. Public hearings were conducted by the Texas House Committee on Natural Resources on August 24, 2022, and by the Texas Senate Committee on Water, Agriculture & Rural Affairs on November 16, 2022. During both hearings, rural landowners from LPGCD voiced complaints over the Vista Ridge Project. The complaints included a loss of property rights caused by lower water levels, the financial burden of lowering pumps, no access to a well assistance program similar to POSGCD's GWAP, no evaluation of local socioeconomic impacts of Vista Ridge permits as part of the DFC process, and the injustice of water marketers profiting at the expense of rural landowners.

During the 2022 House interim session hearing, the LPGCD president's concern regarding the impacts of the Vista Ridge Project on Lee County was conveyed in the testimony: "One option is for us [i.e., LPGCD] to file a petition with TCEQ asserting that Post Oak is not properly managing their groundwater, not considering unreasonable impacts, nor balancing groundwater production with conservation as required by statute. Though Chapter 36 is a great tool to assist districts in managing their groundwater resources in a fair and equitable manner, much is open to interpretation" (Texas House Committee on Natural Resources, 2022, 4:34:42).

Potential Importance of a Fair Share Doctrine to the Protection of Property Rights, the Production of Groundwater, and the Conservation of Groundwater in Place

Fair share is relevant to the discussion of the protection of property rights since the opinion in *Edwards Aquifer Authority v. Day* (2012). Case law has established that groundwater is a vested right and regulation cannot unreasonably deprive landowners of their vested groundwater rights without just compensation. However, because fair share has not been explicitly applied in evaluating GCD regulations and is not defined in TWC § 36, the application of fair share to permit decisions remains unexplained by the courts. Consequently, a landowner's property right to preserve, protect, and produce ground-

water is for all practical purposes determined by the rules of capture or the groundwater rules of a GCD or of a conservation district.

Per TWC § 36.0015, GCDs are required to use the best available science to develop rules associated with conservation and development of groundwater (TWC § 36, 2023). A sensible assumption for TWC § 36.0015 is to promote similar and reasonable groundwater rules and by extension similar protection of property rights for landowners sharing the same aquifer but located in adjacent GCDs. Yet the rules developed by POSGCD and LPGCD to regulate production from the Carrizo-Wilcox Aquifer in Burleson and Lee counties have substantial differences. The differences in LPGCD and POSGCD rules and policies concerning the protection of property and a fair share doctrine would seemingly be the basis for the concerns raised by the LPGCD president during the 2022 Legislature interim hearings (Texas House Committee on Natural Resources, 2022, 4:34:42).

The decisions of the courts discussed in Attachment A suggest that the fair share doctrine applicable to mineral ownership and development, if applied to groundwater, will need to be modified to account for how groundwater differs from oil/gas in both its source and uses. Policies regarding a fair share doctrine for groundwater property rights should therefore consider, among other factors, the following: (1) historic use; (2) provisions for future use because unlike oil and gas, it is replenished; (3) consequences caused by the use of groundwater, such as environmental impacts or land subsidence; (4) prevention of waste; (5) considerations for groundwater's many uses from irrigation and industry to drinking and recreation; and (6) just compensation for a possible taking. Both POSGCD and LPGCD have comparable rules that address several of these items, including well spacing, achievement of the DFCs, the prevention of waste, consideration of environmental impact, and land subsidence. For this paper, we have focused on noticeable differences between the POSGCD and LPGCD rules as related to protection and production of groundwater. The comparison is based on GCD rules that were in existence at the time of the legislative interim hearings in 2022. Since that time, LPGCD, POSGCD and BVGCD have adopted and are considering additional rule changes (BVGCD, 2023; LPGCD, 2023; POSGCD, 2023a).

1. *Historical use:* POSGCD rules recognize historical production and provide greater protection than do the rules for non-historical production permitted since the creation of POSGCD. LPGCD rules do not provide for permitting of historic use.
2. *Fair opportunity to extract groundwater:* POSGCD rules recognize a correlative right of 2 af/yr per acre assigned to the permit to as the maximum annual production associated with a permit. The 2 af/yr/ac production rate was adopted by POSGCD primarily to accommodate irrigation needs for agricultural use but extends to all types of permitted use to provide the same property right regardless of usage. LPGCD does not use a correlative right approach in its rules or permitting decisions. LPGCD requires the applicant to prove the amount needed for the intended use. The applicant then negotiates with district staff to agree on a permit amount. If accepted, the application is then sent to the LPGCD board for approval, or the applicant, if unsatisfied, can request a contested case hearing.
3. *Reductions in authorized production to prevent unreasonable impacts:* POSGCD adopted rules regarding unreasonable impacts to help protect and protect the groundwater levels at the property boundary near large capacity well fields. These rules augment POSGCD well spacing rules and are intended to discourage a permittee from disproportionately concentrating production within a small portion of the permitted acreage near the property boundary.
4. *Well assistance/mitigation:* Throughout Texas, some permit applicants have voluntarily created mitigation programs to address impacts to existing wells. In POSGCD, mitigation programs with a specifically targeted set of landowners were created and executed by the permittees for the Vista Ridge, Blue Water 130, and Sandow Lakes Properties Projects. As previously discussed, POSGCD began using these funds to establish GWAP in 2018. In LPGCD, Recharge Water LP agreed that the issued permits would require funding a well mitigation program that can be accessed after Recharge Water LP begins production. During the House testimony, the LPGCD president explained that LPGCD had started a program to reimburse well owners for their mitigation efforts but had terminated it after being threatened with litigation by an attorney. At the time of the hearing, LPGCD had no mitigation program similar to POSGCD's GWAP (Texas House Committee on Natural Resources, 2022, 4:29:46).

The comparison of the two sets of GCD rules illustrates the significant differences in how POSGCD and LPGCD were managing and regulating groundwater resources in 2022. The differences occurred despite the two GCDs overlying the same aquifers and the TWC requirements to use best available science in rulemaking and to protect property rights. The notable differences in rules between the two GCDs likely causes landowners in both GCDs to question whether their GCD is appropriately protecting their property rights when a large well field is permitted near their well(s). In the case of the Vista Ridge well field, a disproportionate number of LPGCD landowners as compared to POSGCD landowners vocalized their discontentment with the Vista Ridge Project. Based on testimonies, the LPGCD president's and LPGCD landowners' concerns go

beyond the lack of a well assistance program like POSGCD and includes several of the components of a fair share doctrine for groundwater that have been previously discussed.

Emerging Issues

As the demand for groundwater in central Texas increases, the question of how to balance property rights and manage groundwater production and protection will grow increasingly more contentious. The evolution of statutes and rules related to protecting property rights could address a number of issues, including the following:

- Whether the courts will apply the fair share doctrine to their evaluations of production authorizations and permits;
- What role the Legislature will play in outlining the authority of groundwater districts to regulate; and
- How GCD rules will evolve to strike an appropriate balance between producing and protecting the groundwater with appropriate consideration for the protection of historical use, current use, and future use, while recognizing the vested property rights of the landowners and a responsibility to meet the needs of the state.

Balance the Conservation and Development of Groundwater to Meet the Needs of the State

TWC § 36.0015 (b) tasks GCDs with the responsibility to balance the conservation and development of groundwater to meet the needs of the state of Texas. This responsibility overlaps with responsibilities in TWC § 36.108 (d-2), which requires GMAs to adopt DFCs that "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 management area" (TWC § 36, 2023, § 36.108 (d-2)). This section discusses some of the challenges faced by GMAs and GCDs when achieving these balancing requirements.

Overview of the Joint Planning Process

The joint planning process requires GMAs to adopt DFCs every 5 years. TWC § 36.001 defines DFCs 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" (TWC § 36, 2023, § 36.001 (30)). TWDB equates a DFC as a representation of "a management goal that captures the philosophy and policies addressing how an aquifer will be managed" (Mace et al., 2006, p. 3; Mace et al., 2008, p. 3). After a GMA adopts its DFCs, TWC § 36.1084 (b) requires TWDB to determine a MAG for each management area that the districts have adopted a DFC (TWC § 36, 2023). A MAG is defined as "the amount of water that may be produced on an average annual basis to achieve a desired future condition established under Section 36.108" (TWC § 36, 2023, § 36.001 (25)). The MAGs are then incorporated into regional water plans and used to determine future available water and as part of the evaluation to determine if a water project is eligible for financial assistance from the State Water Implementation Fund for Texas (SWIFT).

Consideration of Permitted Production as a Factor When Developing DFCs

Like many other GMAs, GMA 12 used GAM simulations to predict drawdown impacts caused by different future pumping scenarios to help evaluate DFCs. After 20 GAM simulations, GMA 12 selected Run S-19 in November 2021 for developing and justifying DFCs (Daniel B. Stephens & Associates et al., 2022; POSGCD, 2023b). Most of the GMA 12 future pumping scenarios, including Run S-19, were based on a combination of permitted and anticipated pumping.

Prior to adopting GAM Run S-19, POSGCD discovered that GAM simulations that incorporated Vista Ridge's full permitted production of 15,000 af/yr from the Carrizo Aquifer predicted what POSGCD deemed as an undesirable amount of drawdown in about 140 Carrizo Aquifer wells in Burleson County (INTERA Incorporated, 2020; INTERA Incorporated, 2021a, 2021b; POSGCD, 2021b, 2021c; Wise, 2021). To reduce the Vista Ridge pumping to a level that would achieve a balance between development and conservation, POSGCD proposed to GMA 12 that Vista Ridge reduce Vista Ridge maximum production in the Carrizo Aquifer from 15,000 af/yr to about 9,000 af/yr, in the GAM, so that the maximum total Carrizo Aquifer production in POSGCD would be reduced from 18,200 af/yr to about 12,000 af/yr (INTERA Incorporated, 2021a). During their meeting on January 15, 2021, GMA 12 voted 4–1 (with POSGCD opposing) to not only to maintain Carrizo Aquifer pumping rate in the GAM simulations at 15,000 af/yr for the Vista Ridge Project but to keep that pumping rate until 2070, which is 18 years beyond when the 40-year Vista Ridge permit expires (GMA 12, 2021).

To justify their request to represent Vista Ridge Carrizo Aquifer production as 9,000 af/yr in the GAM simulations instead of the permitted production of 15,000 af/yr, POSGCD (2021a, 2021b) argued that: (1) there are no requirements in the TWC to include all permitted production in the GAM DFC simulations; (2) POSGCD had developed DFCs for the Carrizo-Wilcox Aquifer primarily using spreadsheet calculations with minimal reliance on GAM simulations and permitted production amounts in previous joint planning cycles; (3) the GAM simulations predicted that Vista Ridge's production of 15,000 af/yr from the Carrizo Aquifer would lower water

levels below pump elevations in an objectionable number of exempt wells; and (4) a reduction in the drawdowns simulated from a Vista Ridge production amount of 15,000 af/yr from the Carrizo Aquifer is warranted in order to achieve the balance required in TWC § 36.108 (d-2) (POSGCD, 2021b, 2021c; Wise, 2021).

During 2020 and 2021, GMA 12 had multiple discussions about whether all of Vista Ridge Project permitted production in the Carrizo Aquifer should be included in GAM DFC simulations. Several GCDs voiced concerns about legal action from Vista Ridge if GMA 12 did not include the full Vista Ridge production. Both BVGCD (2021) and Vista Ridge Blue Water (Terrill & Waldrop, 2020) sent letters to POSGCD to explain the rationale for keeping the Vista Ridge Carrizo Aquifer production at 15,000 af/yr in the GAM simulations. Below are excerpts from their letters:

> "To that end, it is essential that the 15,000 acre-feet of known, permitted Carrizo Aquifer production for the Vista Ridge Project be included in the model input in this DFC/MAG planning cycle to comply with the legal requirements of Chapter 36" (Terrill & Waldrop, 2020).
>
> "The desired future conditions ('DFCs') adopted under Section 36.108 of the Texas Water Code, are a joint planning tool of the management area that must include in its planning numbers the groundwater permits issued by each groundwater district that are currently in effect, as well as known production. … The request of Post Oak Groundwater Conservation District (POSGCD) to use a Groundwater Availability Model ("GAM") run that does not include all known permitting and production in all districts is not only troubling for transparency and accuracy issues, but also for the precedence that it sets in the GMA of not acknowledging each district's local permitting. Although POSGCD this time is voluntarily asking GMA 12 to disregard permits that it has issued, it is concerning that the precedent would be set for the permits issued by the constituent districts to be involuntarily disregarded by the GMA in the future" (BVGCD, 2021).

Consideration of Local Socioeconomic Impacts from the Groundwater's Area of Origin When Developing DFCs

The TWC lists two key requirements for developing DFCs. TWC § 36.108 (d) states that the districts shall consider nine factors when developing the DFCs, and TWC § 36.108 (d-2) states that DFCs "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" (TWC § 36, 2023, § 36.108 (d-2)).

During the House and Senate public hearings concerning Vista Ridge and during GMA 12 meetings, LPGCD landowners expressed concerns that GMA 12 was not adequately considering the nine factors. A specific concern was an alleged inadequate consideration of the socioeconomic impact to existing exempt wells and specifically those wells near Vista Ridge. As discussed in a recent Environment Defense Fund report (Rubinstein & Puig-Williams, 2023), GMA 12 and most other GMAs met the TWC requirement for considering the socioeconomic impacts by presenting the TWDB socioeconomic impacts for regional water planning groups, which focuses on the impacts of not meeting the identified water needs in their regional water plans.

A criticism of using the TWDB socioeconomic analysis is that it does not address the socioeconomic impacts associated with declining aquifer levels from increased groundwater pumping and drought, which can result in local socioeconomic consequences, such as impacts to groundwater wells or aquifer interactions with surface water. As a result, the TWDB analysis is not directly applicable for evaluating the differences in socioeconomic impacts associated with different DFCs, including impacts to existing wells. An alternative or supplement to using the TWDB socioeconomic analysis is one that considers local-scale impacts resulting from the water level changes predicted by the DFC GAM simulation. One such approach is discussed by Thompson et al. (2020), who describe a methodology that includes evaluating the increased costs associated with lowering pumps, replacing pumps, and operating pumps as water levels in existing wells decline over time because of regional pumping. When POSGCD (POSGCD, 2021b, 2021c) presented their case to GMA 12 to reduce the Vista Ridge Carrizo Aquifer pumping in the GAM simulations, their evaluation was similar to that of Thompson et al. (2020). POSGCD predicted drawdowns at existing wells and identified wells where pumps would require lowering to maintain the productivity of the well. The approaches used by Thompson et al. (2020) and POSGCD for assessing local-scale drawdown-related socioeconomic impacts at individual wells is straightforward and provides the type of information that well owners can understand.

Put another way, the socioeconomic impact analysis currently undertaken by GMA 12 and other GMAs thus far is a one-way consideration of how insufficient additional water supply development impacts the area of need. As reflected in this paper, and certainly a central consideration, the impacts to the area of the groundwater origin must be recognized and quantified as part of a proper assessment of overall socioeconomic impacts. Although not comprehensive, the evaluations conducted by POSGCD and Thompson et al. (2020) provide a mechanism to help recognize local-scale impacts that have been largely ignored by GMA 12 and other GMAs.

Emerging Issues

Among the emerging questions at the forefront of groundwater management issues with TWC § 36.108 (d-2) are:

- What are reasonable criteria for defining a "highest practicable level of groundwater production"?
- What are reasonable criteria for evaluating whether DFCs provide a balance between the opposing objectives of production and protection of groundwater?
- Should the evaluation of the balance requirement be determined piecemeal by each GCD or globally by the GMA?

Possible drivers in evaluating balance requirements in TWC § 36.108 (d-2) are considerations for the nine factors per TWC § 36.108 (d), a fair share doctrine applicable to groundwater, and mitigation programs. The last issue may be fast approaching some GMAs, including GMA 12. Within 5–10 years, GMA 12 may have at least three additional well fields besides the Vista Ridge's well field that are within a few miles of a GCD boundary, exporting groundwater outside of GMA 12. These three known projects will export groundwater to a Samsung plant in Taylor, Texas, and to the cities of Georgetown, Hutto, and Manor. The transport permits for all four water supply projects will likely exceed 110,000 af/yr—thus, the fees associated with the passage of HB 3059 during the 88th legislative session could be substantial. HB 3059 authorizes a GCD to use fees collected from the export of water to maintain the operability of wells significantly affected by groundwater development, develop and distribute alternative water supplies, or conduct aquifer monitoring, data collection, or science (Kirkle et al., 2023). An emerging issue that will impact the functionality among GCDs in a GMA is how the GCDs decide to share fees authorized by HB 3059 with their neighboring GCDs and whether well owners believe that their GCDs are adequately funding the mitigation of impacted wells.

During the third joint planning cycle that was completed in January 2022, subtle but significant changes occurred in how GMA 12 developed its GAM simulation for DFC evaluations compared to previous joint planning cycles. One change was a greater emphasis on representing permitted production in the GAM simulation for evaluating and developing DFCs. Another change was to not allow POSGCD to determine how to represent its permitted production in the GAM simulations. During the first two joint planning cycles, GMA 12 allowed all GCDs to unilaterally determine how to represent their permitted production in the GAM simulations. Although we can only speculate why these two changes occurred, the GMA 12 meetings provide ample evidence that a motivation for these two changes were concerns of a takings claim by the Vista Ridge Project and other water supply projects if their permitted production were not adequately accounted for in the MAG values determined by TWDB. The use of GAM Run S-19 to develop DFCs for GMA 12 raises several questions about the joint planning process, which include:

- Is there a point where the DFC process can become over-reliant on GAM simulations given the inherent limitations and deficiencies of GAMs?
- Under what circumstances, if any, should individual production permits be treated differently in generating future pumping scenarios used in GAM simulations to develop DFCs?
- Was GMA 12's veto of POSGCD's request to underrepresent the Vista Ridge Carrizo Aquifer production in the GAM simulations appropriate given the requirements in TWC § 36.108 (d) and TWC § 36.108 (d-2)?

Communicating the Use of Best Available Science

During the 2022 Senate and House interim hearings, there were several inferences that bad science may have contributed to some well owners being caught off guard by the large drawdowns associated with Vista Ridge production. This section discusses the science relevant to DFCs, MAGs, impacts caused by Vista Ridge production in GMA 12, uncertainty associated with the GAM predictions, and the importance of good communication of the science to policy makers and the public.

Potential Benefits from Presenting the Spatial and Temporal Distributions of Simulated Drawdowns and Water Levels Associated with GAM Simulations Used to Develop DFCs

In GMA 12, as in some other GMAs, creating DFCs has evolved into a process where the pumping rates used in GAM simulation for DFC evaluations are based on existing and anticipated operational permits. Because they incorporate numerous permits across a GMA, the output from these simulations, if analyzed and visualized properly, could provide valuable information for areas with the greatest adverse impacts to groundwater levels and surface water flows. The Vista Ridge Project is included in most of GMA 12 GAM simulations, including Run S-19. Run S-19 therefore contains information about the spatial and temporal distributions of simulated drawdowns that is potentially useful for planning and anticipating future impacts to existing wells.

Figures 6–9 have been generated to show how much greater and quicker drawdowns can occur in the localized area around the Vista Ridge Project compared to the timing and magnitude of a DFC at a regional scale. Figure 6 shows the contours of drawdowns that are predicted to occur in 2011–2070 in the Carrizo and Simsboro aquifers within about 35 miles of the

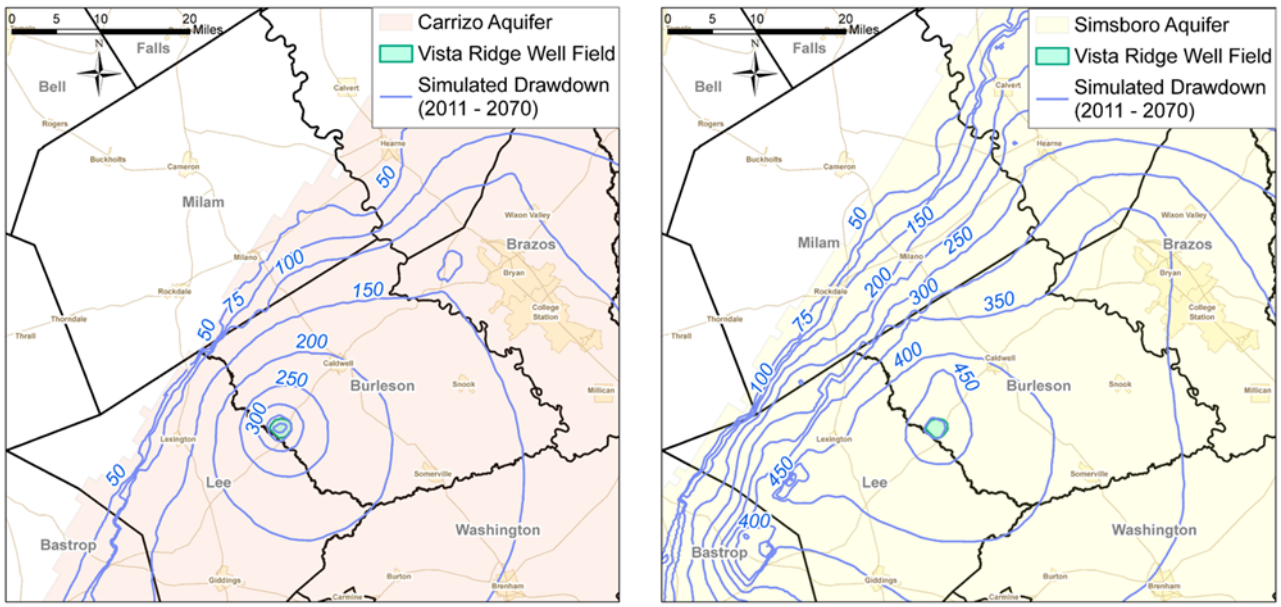

Figure 6. Contours of simulated drawdown from January 2011 to January 2070 for the Carrizo and Simsboro aquifers based on Groundwater Availability Model Run S-19.

Vista Ridge well field. The contours indicate that drawdowns greater than 300 and 450 ft occur in the Carrizo and Simsboro aquifers, respectively. Figure 7 displays charts of the Simsboro Aquifer spatial distribution of drawdown as a function of aquifer area distributions for POSGCD and LPGCD. For both POSGCD and LPGCD, charts show: (1) only 15% of the Simsboro Aquifer area has predicted drawdowns within 50 ft of the DFCs; (2) more than 33% of the Simsboro Aquifer area has drawdowns greater than 100 ft than the DFCs; and (3) drawdowns greater than 500 ft occur in both POSGCD and LPGCD. Figure 8 shows that after 4 years of Vista Ridge production, more than one-third (33%) of the Simsboro and Carrizo aquifers' DFCs would be "achieved" in Lee and Burleson counties. This means that 33% of the average drawdown that was planned to occur in 59 years would occur in only 4 years, 2020–2023. Figure 9 shows that approximately 180 Carrizo Aquifer wells and 30 Simsboro Aquifer wells would experience more than 100 ft of drawdown after 3 years of Vista Ridge pumping.

If these types of figures were regularly discussed in GMA 12, landowners in Lee County would have known that the large drawdowns they experienced in 2021 and 2022 were predicted by the GAM simulations. Besides providing information that could help attract well owners to the DFC process, illustrations of spatial and temporal distributions of predicted drawdown could provide information to better assist general managers and board members of GCDs to manage, plan, and regulate the groundwater production and mitigate well impacts.

Recognition of Uncertainty in GAM Predictions of Drawdowns and DFCs

Because of the large size of many GAMs (for instance, the GAM for the central portion of the Carrizo-Wilcox Aquifer covers more than 26,000 square miles), GAMs often have a wide variation in the types, quality, and amount of data used to develop and calibrate different modeled areas. As a result, a GAM's predictions of water level change will often contain different degrees of uncertainty and error for different areas of interest.

The GAM currently being used by GMA 12 for the Carrizo-Wilcox Aquifer was developed in 2020 (Young et al., 2020). This GAM was developed in response to concerns by GMA 12 about the suitability of using a GAM (Young et al., 2018) that was developed in 2018 prior to any data regarding the impacts that the large production from Vista Ridge would have on groundwater resources. These concerns included: (1) historical water levels from only one Simsboro Aquifer well in Burleson County was used in calibrating the model; (2) the maximum annual production from the Simsboro Aquifer in Burleson County during the GAM calibration period was only 140 af/yr, which is too low a production rate to validate the GAM's capability to predict drawdown caused by production of 35,000 af/yr; and (3) the GAM calibration did not incorporate the simulation of the nine Simsboro Aquifer pumping tests conducted by Vista Ridge. As a result of these concerns, GMA 12 performed a recalibration of the 2018 GAM to create

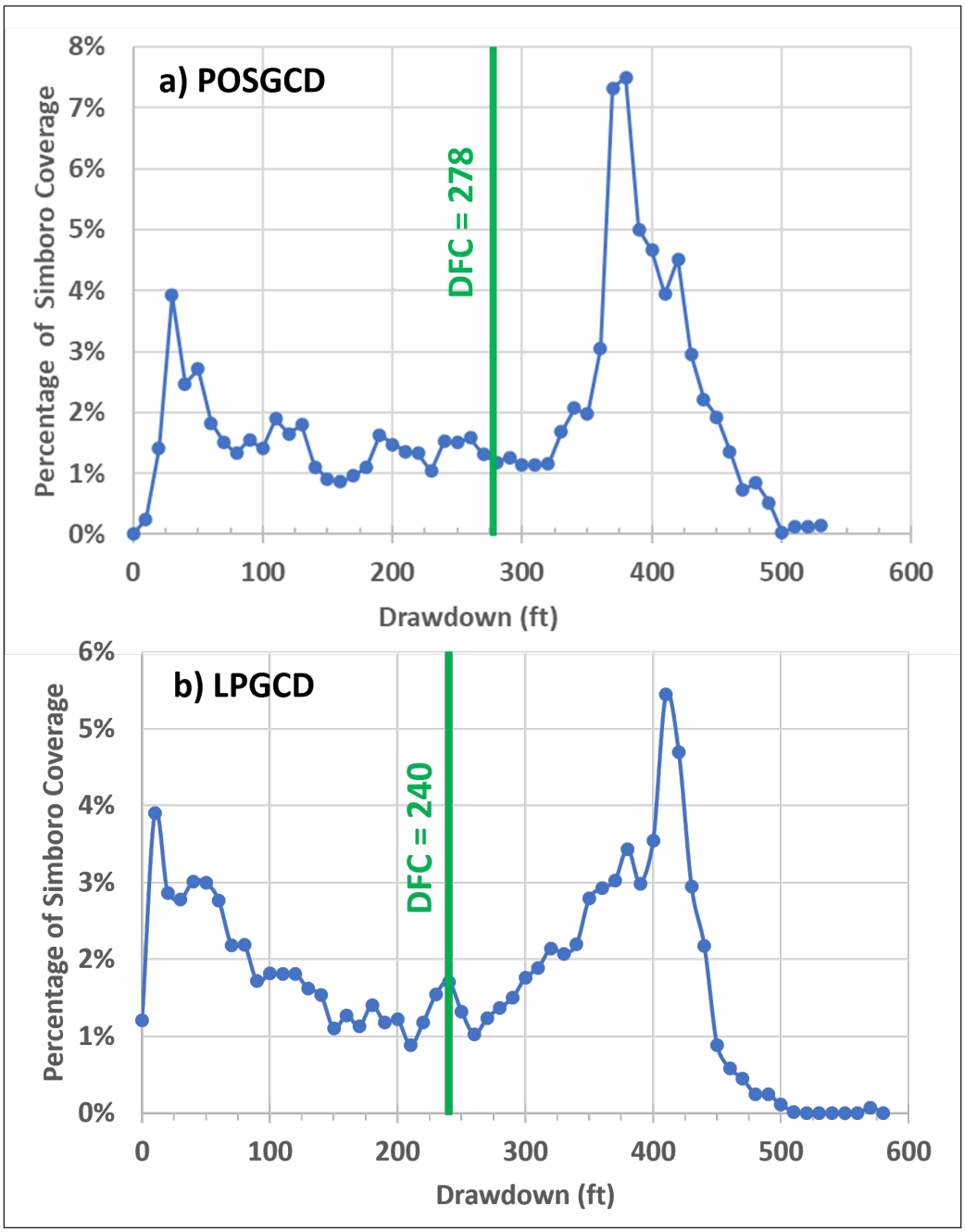

Figure 7. Distributions of the Simsboro Aquifer drawdowns simulated by Run S-19 that are used to determine the desired future conditions for Post Oak Savannah Groundwater Conservation District (POSGCD) and Lost Pines Groundwater Conservation District (LPGCD). Note the bin size for the x-axis is 10 feet (ft).

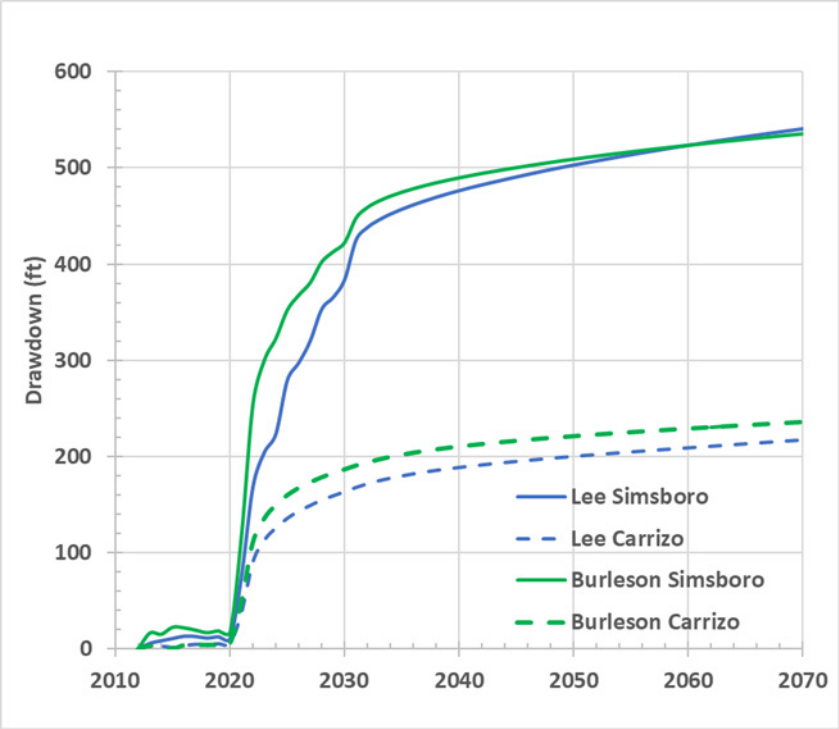

Figure 8. Evolution of the average drawdown calculated from Run S-19 for the Simsboro and Carrizo aquifers in Burleson and Lee counties.

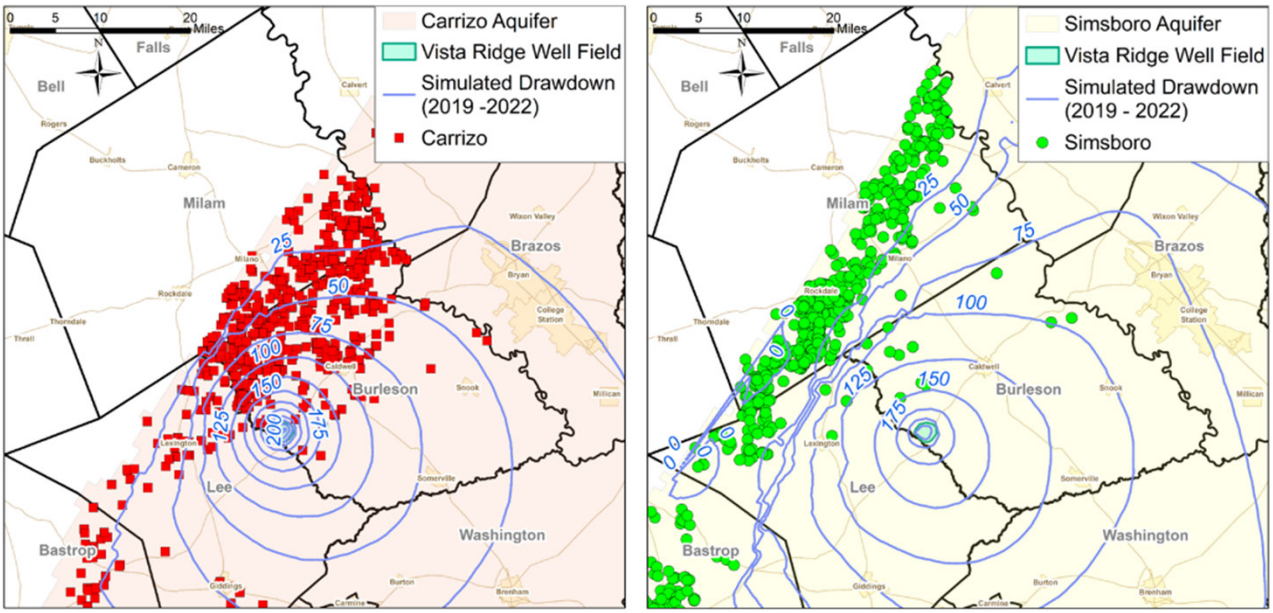

Figure 9. Contours of drawdowns simulated from Run S-19 from December 2019 to December 2022 superimposed on the locations of exempt wells in the Lost Pines and Post Oak groundwater conservation districts database for the Carrizo and Simsboro aquifers.

Table 2. Comparison of the average drawdown predicted in Lost Pines Groundwater Conservation District (LPGCD) and Post Oak Savannah Groundwater Conservation District (POSGCD) from 2011 to 2070 based on Groundwater Availability Model (GAM) Run S-19 and on a GAM simulation with the same annual pumping equally distributed across the groundwater conservation districts (GCDs) by aquifer.

GCD	Aquifer	MAG[1] (acre-feet per year)	Average drawdown (feet) 2011–2070 based on pumping distribution	
			Based on Run S-19	Based on distributing pumping from Run S-19 across the entire aquifer by county
LPGCD	Carrizo	12,980	134	49
	Simsboro	79,945	238	61
POSGCD	Carrizo	18,206	146	56
	Simsboro	79,422	236	87

the 2020 GAM. The 2020 GAM was developed using both a regional-scale calibration using historical water levels from 1930 to 2010 across the entire model domain and a series of local-scale calibrations using 36-hour pumping tests performed at each of the nine Simsboro Aquifer wells. A major change effected by the recalibration was doubling the Simsboro Aquifer transmissivity values from about 7,000 square feet per day (ft^2/day) to about 15,000 ft^2/day in the vicinity of the well field for the Vista Ridge Project (Daniel B. Stephens & Associates et al., 2020).

Realizing the importance of calibrating GAMs at both local and regional scales for improved GAM predictions, POSGCD has an ongoing program to improve the calibration for the central portion of the Carrizo-Aquifer GAM by using the calibration software called PEST++ (White et al., 2020), which helps quantify uncertainty in predictions of drawdowns. Figure 10 shows the uncertainty in the prediction of the POSGCD DFCs for the Simsboro Aquifer using GMA Run S-12, which preceded Run S-19 after the GAM recalibration had been expanded to include simulating the evolution of the drawdown cone case by Vista Ridge production from 2020 to 2021. The drawdown results in Figure 10 were generated from the statistics of 100 runs and average 292 ft with standard deviation of about 11 ft (Young et al., 2021). The prudent application of PEST++ offers considerable promise in helping GCDs understand predictive uncertainty and how to reduce it. An example of applying PEST++ to quantify predictive uncertainty is provided by Ellis et al. (2023), who document the development and application of the *Gulf Coast Land Subsidence and Groundwater-Flow* (GULF) groundwater model for GMA 14.

Understanding the Limitations of Modeled Available Groundwater as an Indicator for Assessing the Achievement of Desired Future Conditions

After the Vista Ridge Project began pumping in 2020, several landowners in POSGCD became concerned that the permitted production and the actual production volumes from the Carrizo and Simsboro aquifers in POSGCD were greater than the respective MAG for each aquifer. These concerns were expressed during GMA 12 meetings and were part of an inquiry submitted to the Texas Commission on Environmental Quality (TCEQ).

Table 2 shows the importance of pumping location to achieving a DFC. This demonstration involves performing a variation of Run S-19 by reallocating the annual pumping so that the total annual pumping in each GCD is distributed evenly across the entire GCD by aquifer. The reallocation was achieved by determining the annual amount of pumping per square mile per aquifer for each GCD then applying the rate for each respective GCD to each aquifer grid. This reallocation will cause the MAG to be spread uniformly across each aquifer in each GCD. The model results in Table 2 show that changing the location of the pumping while maintaining the MAG can reduce the value of a calculated DFC by about 60% for both the Carrizo and Simsboro aquifers. The results in Table 2, along with the understandings that GAMs are not perfect predictors of an aquifer drawdown and that the future hydrogeological conditions are unknown, are substantial reasons why a MAG may not be a reliable indicator of whether a DFC will be achieved if the MAG is pumped on an annual basis.

Emerging Issues

Because of HB 3059 becoming law and the potential importance of GAMs to GCDs' management decisions, an emerging issue will be the emphasis placed on developing GAMs for the purpose of improving their capabilities to support predictions of localized impact from pumping; evaluation of permit applications for production; development of mitigation strategies; evaluation of DFCs; and implementing curtailment of permitted production. A relatively recent advancement with constructing models that will greatly enhance the utility of GMA is using a groundwater code called MODFLOW 6 (Langevin et al., 2021). MODFLOW 6 allows submodels, which cover small areas of interest, to be built into a much larger regional model. GAMs built using MODFLOW 6 will allow GCD consultants to straightforwardly refine and recalibrate GAMs in one or more well fields of interest.

An emerging issue with groundwater management is improved coordination among GCDs in a GMA to coordinate and integrate their design monitoring of well networks, measurement of water levels, and evaluation of compliance with DFCs. Ideally, the GCDs in the same GMA should have similar, if not identical, methods for collecting data and evaluating DFC compliance. The inconsistency in how GCDs in a GMA collect and evaluate water level data for DFC compliance can only work against a GCD trying to demonstrate a DFC violation and the need for curtailment of production.

As the discussion continues regarding the need to improve the GAMs, it is necessary to acknowledge that, despite the known limitations with the current set of GAMs, the GAMs remain our best available science for developing DFCs and MAGs. Even with those limitations, GAMs may be reasonably good predictors of pumping impacts for some areas of interest. To better understand GAMs' potential limitations and how these limitations may be GMA- and problem-dependent, the issue of predictive uncertainty will likely become increasingly important. The importance of uncertainty is recognized by the U.S. Code (USC), which is the codification of the statutory laws of the United States. The USC Title 33 § 1321 (a) (27) (c) definition of "best available science" includes the requirement that it "clearly documents and communicates risks and uncertainties in the scientific basis for such projects" (USC 33 § 1321, 2023, § 1321 (a) (27) (C)). The importance of communicating risks and uncertainties is an important and emerging issue for GCDs to address soon as they adopt DFCs.

RECOMMENDATIONS

We, the authors, recognize that we each represent different groundwater-related points of view and skill sets. Among these are legal, hydrogeologic, and policy considerations. The purpose of writing this case study was, in our view, to review and learn from what has taken place in GMA 12 related to large-scale water transfers, current joint planning and modeling limitations, real world impacts, and mitigation efforts. As noted in this paper, the 88th Legislature has recognized some of these limitations and impacts and has taken action to address some of these concerns. We welcome the recent legislative action including the enactment of HB 3059. In the spirit of continued improvement, informed by a retrospective review of what has taken place, and in this case, the lessons learned from the Vista Ridge Project, we offer recommendations that we feel could, in total or in part, assist in consideration of additional large-scale water transfers in other similarly situated parts of the state. We recognize that site- and case-specific considerations may differ. Thus, based on our review of the impacts of the Vista Ridge Project on groundwater management in GMA 12, we recommend that the following topics be considered for future discussions:

1. Explore options for clarifying the language in TWC § 36 regarding the balance requirements in TWC § 36.108 (d-2) and TWC § 36.0015 (b) to help guide GMAs and GCDs with accomplishing the intent of the statute;
2. Expand TWDB's role to authorize—only upon petition by an affected landowner within a GCD—for TWDB to undertake a limited review of the explanatory report beyond an administrative review. An expanded review could include determining whether the GMA and the explanatory report have, in fact, (1) undertaken substantial review and applicability of the nine factors outlined in TWC § 36.108; (2) meaningfully and appropriately evaluated the "balance test" in TWC § 36.108 (d-2); and (3) adequately addressed the concerns and questions submitted to a GMA during the public comment period on the proposed DFCs. This recommendation recognizes the increased transparency requirements of GCDs in the development, consideration, and adoption of a DFC as enacted by the Legislature during the 88th legislative session as HB 3278. The review would not authorize TWDB to determine the appropriateness of the DFC, but rather to recommend additional data and analysis that should be considered by the GCD in developing a DFC under a process that has been, upon TWDB review, found to have not meaningfully considered the nine elements under the TWC;
3. Provide TWDB with appropriate funding to support the development and improvement of the data and capability of GAMs to evaluate the environmental and localized socioeconomic impacts of proposed DFCs; and
4. Provide GMAs with funding to improve communication of the science, improve public participation, and prepare explanatory reports that document a meaningful consideration of the nine factors in TWC § 36.108 (d).

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ATTACHMENT A: GROUNDWATER OWNERSHIP IN TEXAS

Although the rule of capture has been the law in Texas since 1904 and has been consistently described as a property right incident to ownership, the courts were never required to define the exact nature of the right until regulation of these rights became authorized through groundwater conservation districts. Beginning with *Houston & T.C. Ry. Co. v. East* (1904). the courts described the rule of capture as a right but never clearly defined when or if the right is a vested real property right protected by the constitutional prohibition against a governmental taking without compensation. In *Houston & T.C. Ry. Co. v. East* (1904), the Texas Supreme Court, citing New York law, stated: "So the owner of land is the absolute owner of the soil and of percolating water, which is a part of, and not different from, the soil" *(Houston & T.C. Ry. Co. v. East* (1904), p. 4). Similarly, in Pecos County, the El Paso Court of Appeals stated:

> "It seems clear to us that percolating or diffused and percolating waters belong to the landowner, and may be used by him at his will . . . . These cases seem to hold that the landowner owns the percolating water under his land and that he can make a non-wasteful use thereof, and such is based on a concept of property ownership" *(Pecos County Water Control & Improvement District No. 1 v. Williams*, 1954, p. 1).

The nature of the groundwater right and whether it was vested remained hotly debated yet unresolved until the Supreme Court's decision in *Edwards Aquifer Authority v. Day* (2012). On February 24, 2012, the Supreme Court issued a 50-page, unanimous opinion confronting and answering for the first time the question of whether a landowner's groundwater rights are a vested real property right protected by the Texas and U.S. Constitutions' prohibitions against uncompensated taking. The opinion begins with a succinct summary of the issue presented in the decision:

> "We decide in this case whether landownership includes an interest in groundwater in place that cannot be taken for public use without adequate compensation guaranteed by Article 1, § 17(a) of the Texas Constitution. We hold that it does" *(Edwards Aquifer Authority v. Day*, 2012, p. 2).

The court noted that while it had never addressed the issue regarding groundwater, it had done so long ago with respect to oil and gas, to which the rule of capture also applies. The court, quoting its previous decisions, noted that the right to the oil and gas beneath a landowner's property is an exclusive and private property right inherent in landownership, which may not be deprived without a taking of private property.

The Supreme Court found that there was no basis in the differences cited between groundwater and oil and gas to conclude that the common law recognized a vested ownership of oil and gas in place but not groundwater. Specifically, the court explained:

> "In our state the landowner is regarded as having absolute title and severalty to the oil and gas in place beneath his land. The only qualification of that rule of ownership is that it must be considered in connection with the law of capture and is subject to police regulations. The oil and gas beneath the soil are considered a part of the realty. Each owner of land owns separately, distinctly and exclusively all the oil and gas under his land and is accorded the usual remedies against trespassers who appropriate the minerals or destroy their market value.
>
> We now hold that this correctly states the common law regarding the ownership of groundwater in place" *(Edwards Aquifer. v. Day*, 2012, p. 2).

The court cited the legislative revisions to TWC § 36.002 demonstrating the Legislature's understanding of the interplay between groundwater ownership and groundwater regulation.

The opinion in *Edwards Aquifer Authority v. Day* resolved decades of conflict concerning the nature of the ownership right held by landowners in groundwater in Texas. By applying the case law applicable to oil and gas, the Supreme Court has determined that groundwater is "owned in place" in *Edwards Aquifer v. Day* (2012, p. 9) by the landowner and that this ownership right can support a claim for uncompensated taking under the state and federal constitutions.

The Supreme Court further signaled that it would rely on its over 100 years of decisions applying the absolute ownership rule to oil and gas disputes in resolving groundwater issues in its decision in *Coyote Lake Ranch LLC v. City of Lubbock* (2016). The City of Lubbock had purchased and held the groundwater rights under the Coyote Lake Ranch for years. New owners of the property objected to plans announced by the city to drill 60+ wells on the ranch to produce and transport groundwater to the city. On review of a judgment favorable to the landowner, the Supreme Court determined that the severed groundwater right was, like a severed mineral interest, the dominant estate, with the right to use the surface to access the groundwater. However, the court ruled that, like in oil and gas law, the Accommodation Doctrine applied to the exercise of this right. In summary, this means the groundwater estate, in exercising it rights, must act with due regard for the surface owner's use.

This decision indicates that the courts will likely consider its decisions in disputes involving minerals on issues arising in groundwater disputes involving permitting. The ownership rights must be considered and addressed by groundwater districts in striking the appropriate balance between conserving and protecting the groundwater resources within their jurisdic-

tion while recognizing the vested property rights of the landowners subject to regulation.

The courts' decisions make clear two fundamental principles: (1) that groundwater rights are a vested property right protected from governmental action that constitutes a taking of that right without just compensation; and (2) that the courts will consider case law in disputes involving oil and gas in deciding conflicts regarding groundwater.

Groundwater districts need to be mindful of the judicial precedents established in evaluating oil and gas regulatory programs and impacts on landowners' vested rights in the minerals below ground. One important and likely relevant concept is that regulation cannot unreasonably deprive the landowner of their fair share of the managed resource *(Atlantic Refining Co. v. Railroad Commission*, 1961). While the goals and consequences of groundwater management are distinctly different than in mineral development, the courts will consider oil and gas precedents in deciding whether regulatory decisions made by groundwater districts limit the landowners' groundwater ownership rights to the extent that a constitutionally prohibited taking has occurred.

This tension is particularly acute when districts protect existing use by limiting or preventing future use. The Rule of Capture, as a legal principle, provides no protection for historic use. Landowners who have conserved the resource by not producing from it can have their rights limited to protect the resource and historic use, but the courts will consider oil and gas decisions in determining if limiting those rights rises to the level of a taking. At the same time, they must consider how the goals of groundwater regulation differ from the goals of regulation of oil and gas. As the Supreme Court noted in *Edwards Aquifer Auth. v. Day* (2012):

> "The principal concerns in regulating oil and gas production are to prevent waste and to provide a landowner a fair opportunity to extract and market the oil and gas beneath the surface of the property. Groundwater is different in both its source and uses. Unlike oil and gas, groundwater in an aquifer is often being replenished from the surface, and while it may be sold as a commodity, its uses vary widely, from irrigation, to industry, to drinking, to recreation. Groundwater regulation must take into account not only historical usage but future needs, including the relative importance of various uses, as well as concerns unrelated to use, such as environmental impacts and subsidence" *(Edwards Aquifer Auth. v. Day*, 2012, p. 18).

How this balance will be struck will be the subject of future court decisions.