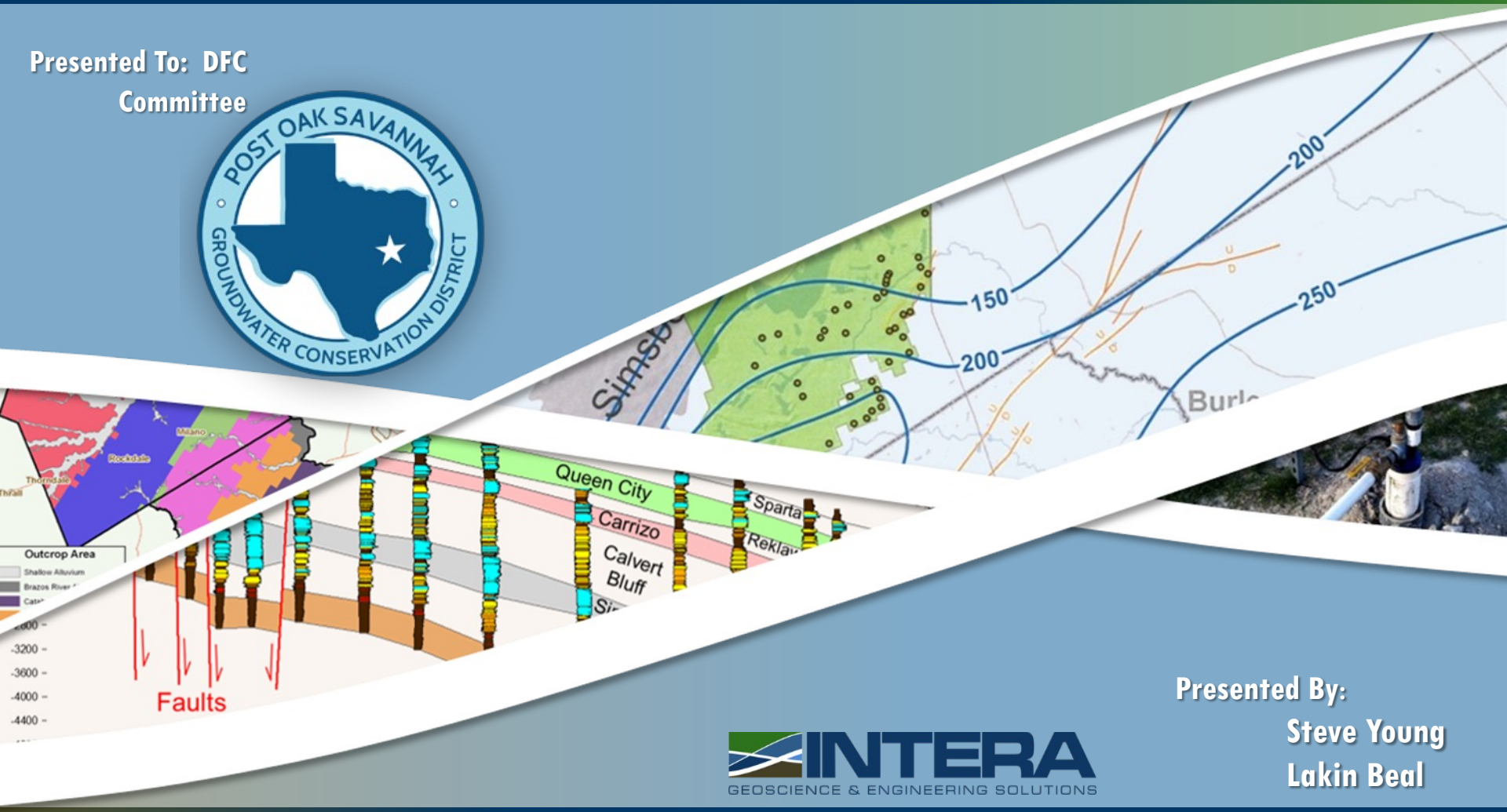
Desired Future Conditions Committee Update: Discussion of the Five-Year Renewal

Presented To: DFC Committee

POST OAK SAVANNAH GROUNDWATER CONSERVATION DISTRICT



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INTERA
GEOSCIENCE & ENGINEERING SOLUTIONS

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Disclaimer

INTERA prepared the presentation at request of the Post Oak Savannah Groundwater Conservation District (POSGCD) to support District's preparation for the five-year reviews that begin on January 1, 2025. The presentation may or may not be consistent with the POSGCD Board's current thinking.

Outline

- Objectives
- Rules
- Key Issues
  - DFC & PDL compliance
  - Fair share
  - Unreasonable Impacts
  - Sustainable production
- Schedule
- Considerations for Fair Share
- Potential Tasks to Conduct Prior to 5-year Review
- Status Report on Operational Model

Objectives

- Mission Statement

"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**."

- TWC § 36.0015

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.

Objectives (con't)

- TWC § 36.108 (d-2); Joint Planning Process

The desired future conditions proposed under Subsection (d) 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.

Rules

- Rule 7.1.9

9. The term of each operating permit issued by the District is set by the Board. The term will generally be for a period not to exceed forty (40) years from the date of issuance. All operating permits shall undergo review every five (5) years beginning January 1, 2025, and continue every five (5) years thereafter, as outlined in Rule 16.5. During any such review, operating permits may be modified to conform with intervening changes in the regulations, management plan or state law or to accommodate aquifer conditions. [Amended May 12, 2020]

- Rule 7.4

1. Each original application for a drilling permit, historic use permit, operating permit, transport permit, permit review or renewal, or permit amendment shall be on the form or forms required by the District. The forms will be furnished to the applicant upon request.

5. Applications for permits for wells that will have a maximum pumping rate that equals or exceeds 500 gpm shall include:

    requires model simulations

Issues

- Compliance with Desired Future Conditions and Protective Drawdown Limits
- Fair Share
- Unreasonable Impacts
- Sustainability of Groundwater Resources

Compliance to Desired Future Conditions(DFCs) and Protective Drawdown Limits (PDLs)

Rule 16.4 Actions Based on Monitoring Results

Criteria	THRESHOLD		
	1	2	3
Drawdown (DFC or PDL)	Average drawdown calculated from measured water levels is >50% of DFC or PDL	Average drawdown calculated from measured water levels is >60% of DFC or PDL	Average drawdown calculated from measured water levels is >75% of DFC or PDL
MAG	Annual Production is > 50% than MAG	Annual Production is > 70% than MAG	NA
Model Prediction	Model predicts DFC or PDL will be exceeded in 15 years	NA	NA

* Management Zone or Management Area

Rule 16.4. Actions Based on Monitoring Results

Threshold 1	1. Perform studies to improve quantification of pumping effects, characterization of aquifer, and prediction of changes in future water levels 2. Evaluate options for possible curtailment to achieve management goals
Threshold 2	1. Evaluate the Management Plan and rules regarding management zones, collection and analysis of monitoring data, and DFCs. 2. May notify well owners if Board decides to develop plans for curtailing groundwater production
Threshold 3	1. Conduct public hearing to discuss aquifer conditions. Develop a Response Action Work Plan to achieve DFCs and PDLs. 2. May reduce the water production permitted per acre for the Management Zone/Area and the water authorized to be produced under any permit issued by the District for that zone/area

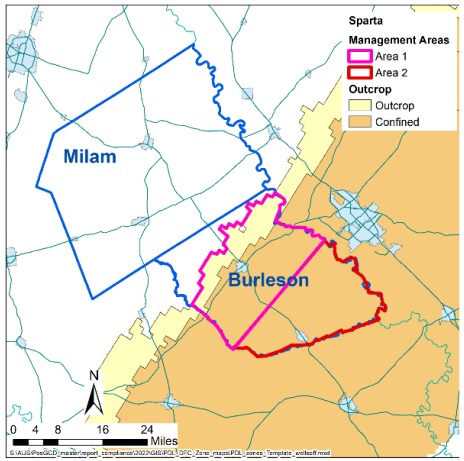
Threshold 3

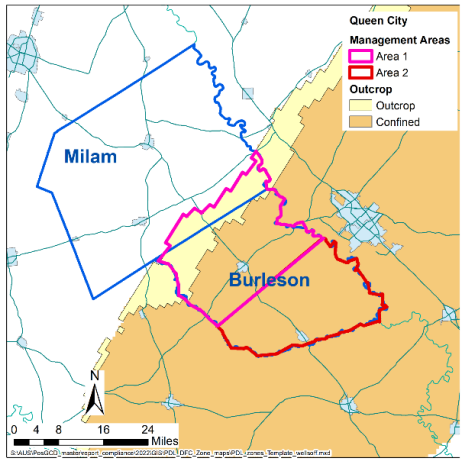
- Rule 16.4.3 Threshold Level 3

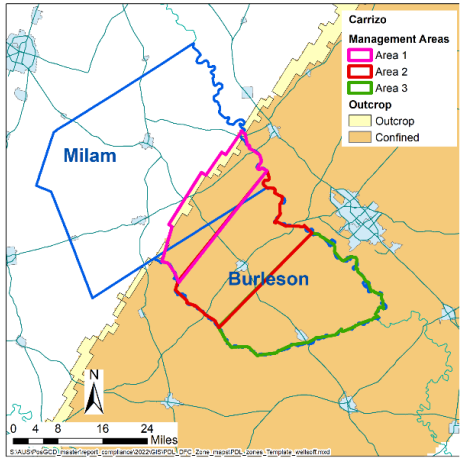
Threshold Level 3 will be reached, and the Board will consider and adopt amendments to the management plan, rules and regulations at such time as the average groundwater drawdown, calculated from monitored water levels, for an aquifer is greater than **75%** of an average groundwater drawdown listed in Section 7 of the management plan as a **DFC** or as a **PDL** for that aquifer

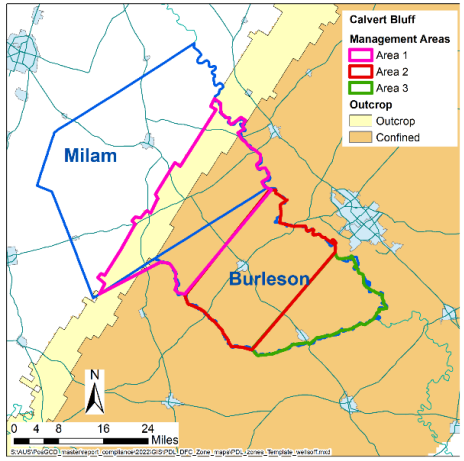
Management Area		2070 Drawdown
Sparta	Area 1	28
Queen City	Area 1	75
Carrizo	Area 1	75
	Area 2	175
Calvert Bluff (Upper Wilcox)	Area 1	88
	Area 2	223
Simsboro (Middle Wilcox)	Area 1	91
	Area 2	335
Hooper (Lower Wilcox)	Area 1	210

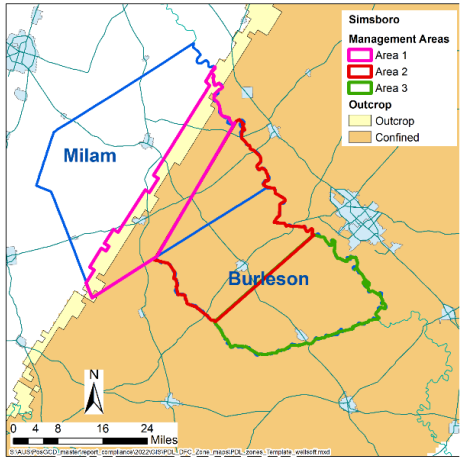
*2011 – 2070 Drawdown

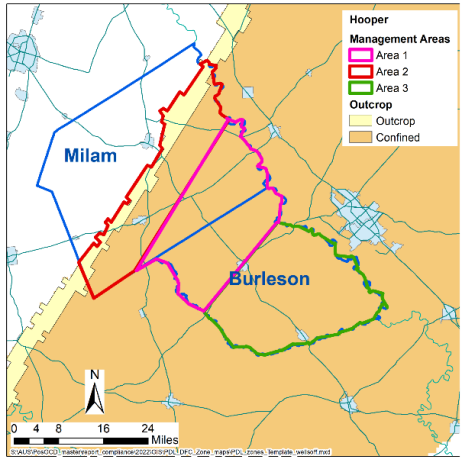








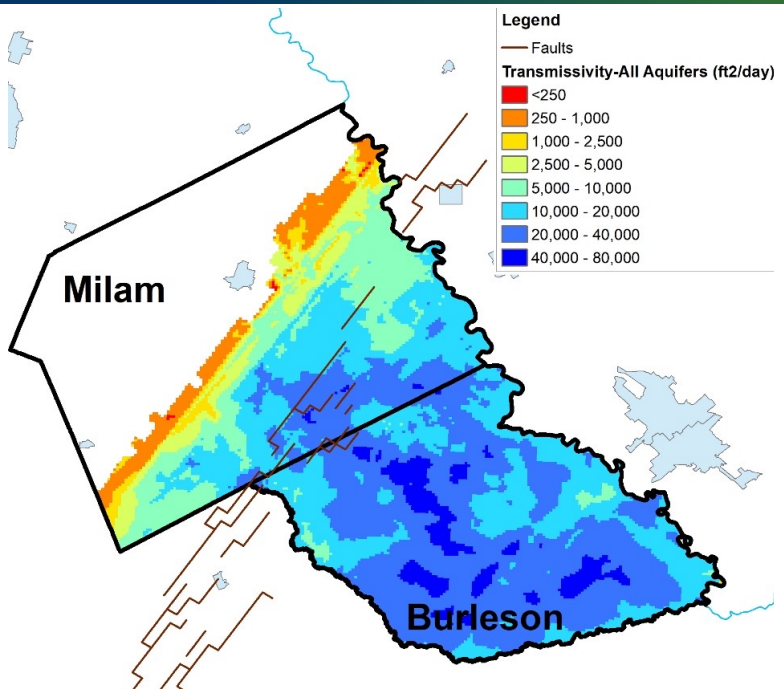




Fair Share Considerations

Aquifers	Production Capacity		Aquifer Property	
	Amount*	Percent	Area (mi^2)	Average Transmissivity (ft^2/day)
Upper Trinity	17	1	807	211
Lower Trinity	14	1	807	591
Sparta	62	3	577	1,066
Queen City	97	4	753	1,286
Carrizo	181	8	832	2,178
Calvert Bluff	179	8	1,025	1,747
Simsboro	1,583	68	1,128	14,035
Hooper	109	5	1,234	885
Yegua Jackson	90	4	368	2,440

* area x average transmissivity



Key Observations

- Average production capacity among aquifers varies by a factor of 10
- Within each aquifer the production capacity can vary by a factor of 5
- A 2 acre-ft/ac production allotment is not physical possible for some aquifer regions
- **Prudent aquifer management includes adjusting the production allotment to the aquifer different hydrogeologic conditions**
- Besides transmissivity, other hydrogeologic conditions

Adjustments to Maximum Production Allotment

- Rule 16.6.1 Adjusting Maximum Production Permitted
  - If the water drawdown level within a Management Zone*, or in any zone within the District in which the water drawdown level is impacted by production in such Management Zone, exceeds the water drawdown **Threshold Level 3** in Rule 16.4, 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 for that zone will be reduced.
  - The maximum allowable production of 2 acre feet of groundwater per acre of land, provided in Rule 5.1.2, may be reduced,
  - A new permit may require the maximum allowable production authorized under all permits issued by the District for that Management Zone to be further reduced to be consistent with the DFCs and/or PDLs in such Management Zone.

* Management Zone or Management Area

Unreasonable Impacts

- Rule 16.4.6 Unreasonable Impacts

  In order to help achieve a balance between production and conservation of groundwater resources, the District will consider the impacts from an aggregate of wells associated with one or more operating permits to be unreasonable if pumping from the aggregate wells, by themselves and without contribution of pumping from wells not part of the aggregate of permitted wells, cause any of the following:

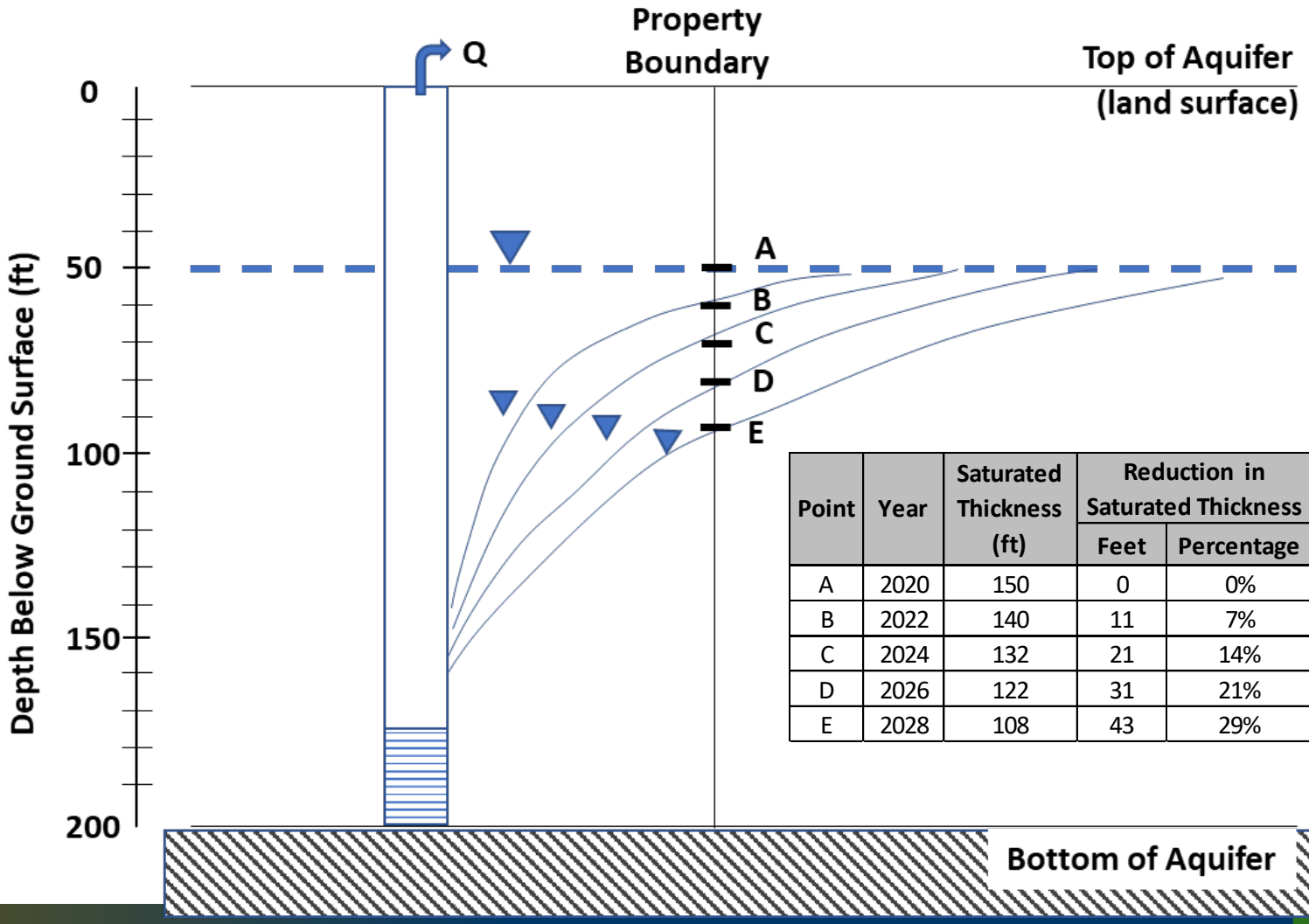
  c) More than a 30-foot reduction and more than a 25% reduction in the saturated thickness of the aquifer being pumped by the aggregate wells at any well location outside of one or more operating permits' property or along any part of the boundary of the operating permits' property;

  d) More than a 100-foot reduction and more than a 40% reduction in the pressure head above the top of the aquifer at any well location outside of one or more operating permits' property or along any part of the boundary of the operating permits' property;

  e) The District has the authority to set the baseline value for a saturated thickness and an artesian pressure on a case by case basis for a baseline year that is not before 2010

Unreasonable Impacts: Unsaturated Thickness

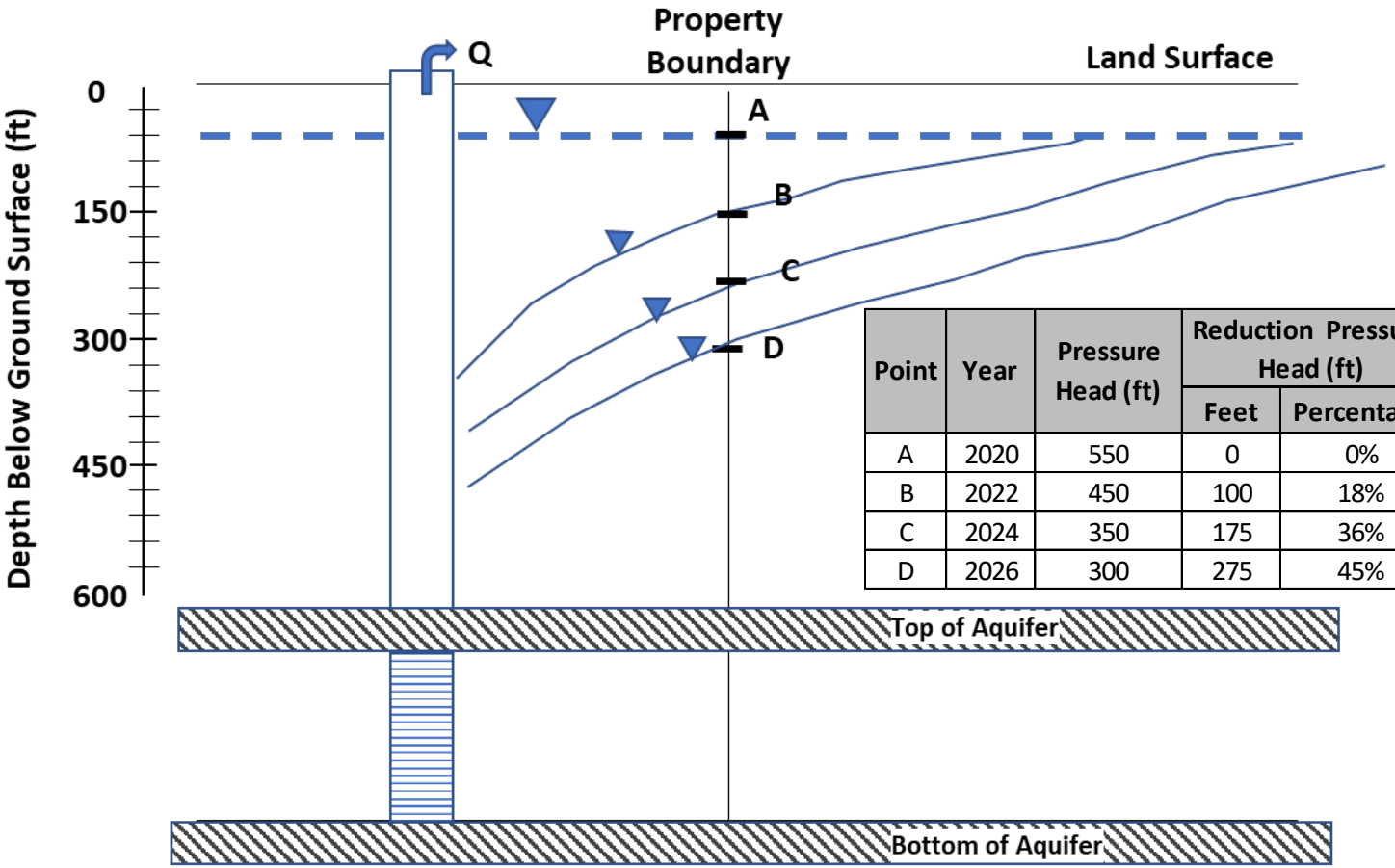
> 30-foot reduction and >25% reduction in the saturated aquifer thickness



Point	Year	Saturated Thickness (ft)	Reduction in Saturated Thickness		Unreasonable Impact Reductions	
			Feet	Percentage	>30-ft	>25%
A	2020	150	0	0%	No	No
B	2022	140	11	7%	No	No
C	2024	132	21	14%	No	No
D	2026	122	31	21%	Yes	No
E	2028	108	43	29%	Yes	Yes

Unreasonable Impacts: Pressure Head

>100-foot reduction and >40% reduction in the pressure head above the top of the aquifer



Point	Year	Pressure Head (ft)	Reduction Pressure Head (ft)		Unreasonable Impact Reductions	
			Feet	Percentage	>100-ft	>40%
A	2020	550	0	0%	No	No
B	2022	450	100	18%	Yes	No
C	2024	350	175	36%	Yes	No
D	2026	300	275	45%	Yes	Yes

Sustainability of Groundwater Resources

17.11 Sustainability of the Groundwater Resource

- Management Objective:
  Beginning in 2023, the District will evaluate the long-term sustainability of its groundwater supply relative to current production and permitted production. The District will describe the conditions that define sustainability and develop and apply a set of criteria for evaluating the sustainability of the District's aquifers.

- Performance Standards:
  At least once every three years, the general manager will report to the board on the sustainability of the groundwater resources. The report will include a definition of groundwater sustainability and the methodology for assessing the sustainability of each relevant aquifer based on current production and projected production. Projected water demands

TWDB Estimated Sustainable Production: Carrizo-Wilcox

County	Modeled Available Groundwater (2060)	2007 State Water Plan Groundwater Availability (2060)	2011 Regional Water Plan (2060)	Recharge	Storage - In Place	Maximum Sustainable Pumping Level
BASTROP	28,498	28,000	28,000	21,783	98,429,578	5,951
BRAZOS	57,169	53,000	57,156	0	136.726.259	9.591
BURLESON	38,701	44,000	35,482	142	153,184,778	1,283
FALLS	895	1,000	910	2,390	822,161	83
FAYETTE	1,000	400	400	0	104,383,421	342
FREESTONE	5,259	6,653	6,653	41,502	45,870,392	2,811
LEE	27,380	45,000	27,533	7,604	129,532,459	8,326
LEON	15,196	5,558	5,558	5,933	178,933,891	4,129
LIMESTONE	11,918	20,000	12,162	21,061	11,692,040	856
MADISON	2,542	1,518	1,518	0	121,343,009	219
MILAM	22,319	45,000	20,090	25,691	46,350,226	4,737
NAVARRO	15	180	180	1,883	1,046,211	1
ROBERTSON	46,583	38,000	46,016	27,043	108,094,335	6,377
WILLIAMSON	7	0	0	2,146	500,081	0
Total	257,482	288,309	241,658	157,178	1,136,908,838	44,707

Units are acre-ft/year except for Storage (acre-ft)

Preliminary Schedule

Activity		2024				2025											
#	Description	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
1	POSGCD Operational Model																
2	Compliance Evaluation of DFCs and PDLs (2023)																
3	Permit Renewal Letter & Workshop																
4	Permittee Submits Renewal Application																
5	District Evaluation of Administrative Complete																
6	Permit Evaluations																
	DFCs and PDL Complaince Evaluation (2024)																
	Unreasonable Impacts																
7	Evaluation of 2 af/acre (Fair Share allocations)																
8	Determination of Curtailment by Permit																
9	Public Hearings for Permits																

Considerations for Evaluation of Fair Share/Maximum Production Allotment

- Property rights litigation has been weighted towards development
- Long-term sustainability of production is not well understood
- Significant information about aquifers have been developed since POSGCD first set of rules in 2004 when 2 af/acre was established
- Large-scale development of Carrizo-Wilcox is occurring

Adjacent GCDs: Maximum Production Allotment

- Lost Pines GCD
  - currently determined by well spacing
  - Recently proposed allotments in draft rules
    - Sparta Aquifer = 0.3 AF/acre
    - Queen City Aquifer = 0.2 AF/acre
    - Carrizo Aquifer = 0.8 AF/acre
    - Calvert Bluff Aquifer = 0.5 AF/acre
    - Simsboro Aquifer 1.6 AF/acre
    - Hooper Aquifer = 0.5 AF/acre
- Brazos Valley GCD
  - currently determined by well spacing (acres * 0.62 gpm)
  - Recent UW Brazos Farm Permit
    - 5.5 AF/acre - operational permit
    - 6.5 AF/acre - operational + historical

$$\frac{\left(\text{Average Annual Production Rate in Gallons/Minute} \times \text{District Spacing Requirement Between Wells}\right)^2 \times \pi}{43{,}560} = \text{Total number of contiguous acres required to be assigned to the well site}$$

Example: $\frac{(620\text{gpm} \times 1\ \text{ft/gpm})^2 \times \pi}{43{,}560} = 28\ \text{acres}$

Results from 2022 Fair Share Analysis :

Maximum Production Allocation for any parcel is 2.5 acre-ft/acre

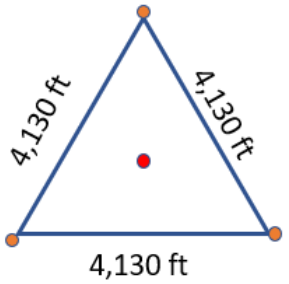
Maximum production allocation can vary among aquifers and can vary spatially within an Aquifer

- Production Allocations for Carrizo-Wilcox Aquifers
  - Outcrop and less than 250 feet thickness: minimum rate
  - Increase allocations based on aquifer depth and aquifer thickness
  - Include a threshold production rate
  - Perform additional evaluations with different productions other than 10,000 AFY

Aquifer	Production Allocation (ac-ft/acre)	
	Minimum	Maximum
Yegua Jackson	0.25	0.25
Sparta	0.25	0.25
Queen City	0.25	0.25
Carrizo	0.25	0.75
Calvert Bluff	0.25	0.5
Simsboro	0.5	2
Hooper	0.25	0.5

Fair Share Evaluation

- Hypothesize a well field of 5,000 acres
  - 2 ac-ft/ac = 10,000 AFY (6,195 gpm)
  - Three wells pumping 2,065 gpm spaced 2 ft/gpm



- Extract Aquifer Properties from Operational Model (August 2021)
- Simulate Drawdown Impact for the Hypothetical Well Field using a Theis-based Groundwater Model
- Compare Simulated Drawdown obtain from Model Simulation to Estimated Water Column Above Top of Aquifer

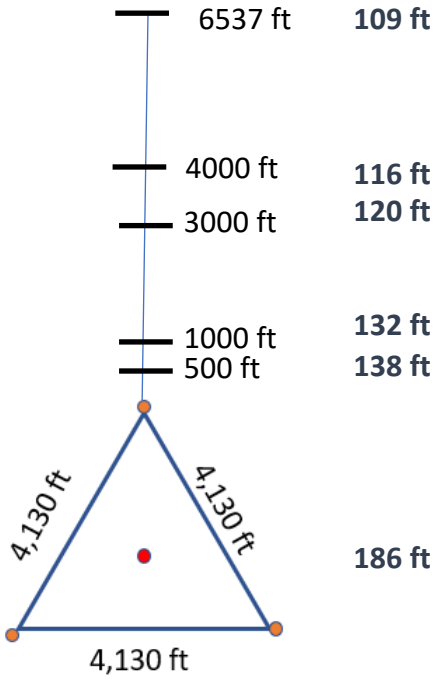
$$\text{Ratio} = \frac{\text{Drawdown}}{\text{Available Drawdown}}$$

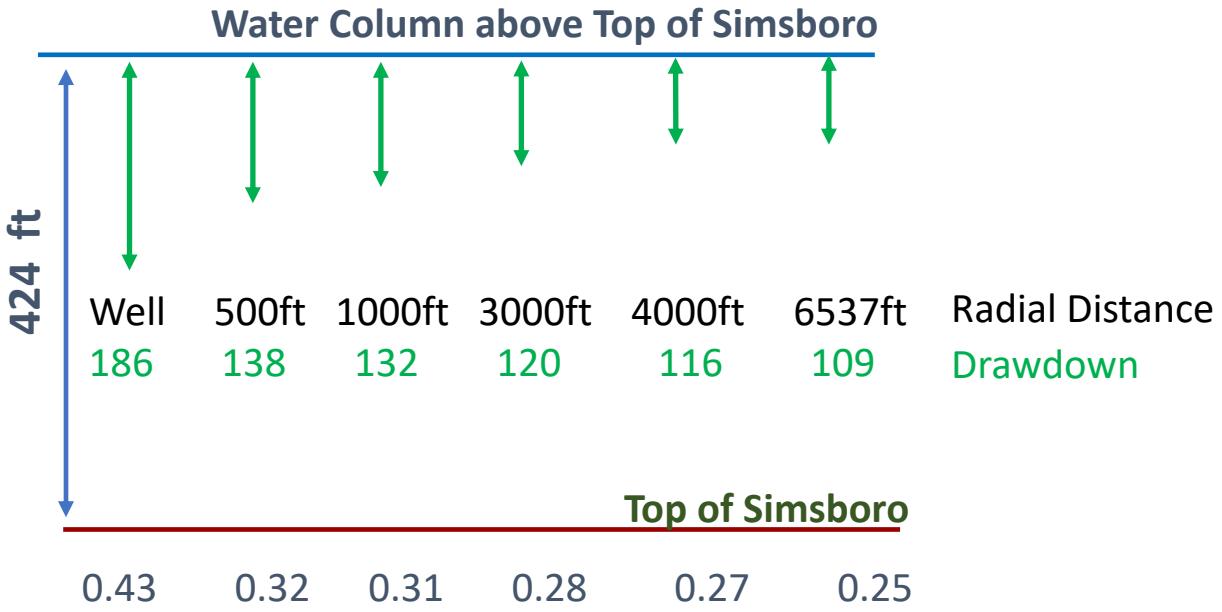
Ratio << 1 Well field is viable
Ratio >> 1 Well field is not viable

Simulate Drawdown After 5-years of Pumping: Simsboro Example @ 2 Acre-ft/Acre

Aquifer	Depth of Aquifer	Available Drawdown (ft)	Simulated Drawdown					
			Pumping Well	Radial Distance from Well				
				500 ft	1000 ft	3000 ft	4000 ft	6537 ft
Simsboro	0 to 250	-61	223	145	135	116	110	99
	250 to 500	67	154	111	105	95	91	85
	500 to 1000	424	186	138	132	120	116	109
	1000 to 2000	1089	125	95	91	84	82	78
	2000 to 3000	2026	105	81	78	72	71	67

Simulated Drawdown for Simsboro (depth= 500 to 1000 ft)





$$\text{Ratio} = \frac{\text{Drawdown}}{\text{Available Drawdown}}$$

Impact Matrix for 5-years of Pumping based on Different Maximum Production Allocations

Aquifer	Depth (ft)	2 af/ac			1 af/ac			0.5 af/ac			0.25 af/ac			0.125 af/ac		
		Well	3000 ft	6537 ft	Well	3000 ft	6537 ft	Well	3000 ft	6537 ft	Well	3000 ft	6537 ft	Well	3000 ft	6537 ft
Sparta	0 to 250	8.1	3.9	***3.2***	4.1	1.9	***1.6***	2.0	1.0	0.8	1.0	0.5	0.4	0.5	0.2	0.2
	250 to 500	25.1	13.6	***11.7***	12.6	6.8	***5.9***	6.3	3.4	***2.9***	3.1	1.7	***1.5***	1.6	0.9	0.7
	500 to 1000	6.4	3.7	***3.3***	3.2	1.9	***1.6***	1.6	0.9	***0.8***	0.8	0.5	***0.4***	0.4	0.2	0.2
	1000 to 2000	2.2	1.3	***1.2***	1.1	0.7	***0.6***	0.5	0.3	0.3	0.3	0.2	0.1	0.1	0.1	0.1
	2000 to 3000	2.3	1.4	***1.3***	1.2	0.7	***0.6***	0.6	0.4	0.3	0.3	0.2	0.2	0.1	0.1	0.1
Queen City	0 to 250	8.4	4.0	***3.3***	4.2	2.0	***1.7***	2.1	1.0	0.8	1.1	0.5	0.4	0.5	0.3	0.2
	250 to 500	12.8	7.1	***6.2***	6.4	3.6	***3.1***	3.2	1.8	***1.6***	1.6	0.9	0.8	0.8	0.4	0.4
	500 to 1000	2.9	1.8	***1.6***	1.5	0.9	***0.8***	0.7	0.4	0.4	0.4	0.2	0.2	0.2	0.1	0.1
	1000 to 2000	1.7	1.1	***0.9***	0.9	0.5	***0.5***	0.4	0.3	0.2	0.2	0.1	0.1	0.1	0.1	0.1
	2000 to 3000	1.5	0.9	***0.9***	0.8	0.5	***0.4***	0.4	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1
Carrizo	0 to 250	8.9	4.2	***3.4***	4.4	2.1	***1.7***	2.2	1.1	0.9	1.1	0.5	0.4	0.6	0.3	0.2
	250 to 500	4.5	2.6	***2.2***	2.2	1.3	***1.1***	1.1	0.6	0.6	0.6	0.3	0.3	0.3	0.2	0.1
	500 to 1000	1.7	1.1	***0.9***	0.9	0.5	***0.5***	0.4	0.3	0.2	0.2	0.1	0.1	0.1	0.1	0.1
	1000 to 2000	0.6	0.4	0.4	0.3	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0
	2000 to 3000	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Calvert Bluff	0 to 250	7.9	3.8	***3.1***	3.9	1.9	***1.6***	2.0	0.9	0.8	1.0	0.5	0.4	0.5	0.2	0.2
	250 to 500	8.1	4.7	***4.1***	4.1	2.3	***2.1***	2.0	1.2	1.0	1.0	0.6	0.5	0.5	0.3	0.3
	500 to 1000	2.3	1.4	***1.3***	1.2	0.7	***0.7***	0.6	0.4	0.3	0.3	0.2	0.2	0.1	0.1	0.1
	1000 to 2000	1.1	0.7	***0.6***	0.6	0.3	0.3	0.3	0.2	0.2	0.1	0.1	0.1	0.1	0.0	0.0
	2000 to 3000	1.5	0.9	***0.8***	0.7	0.5	***0.4***	0.4	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1
Simsboro	0 to 250	3.0	1.5	1.3	1.5	0.8	***0.7***	0.7	0.4	0.3	0.4	0.2	0.2	0.2	0.1	0.1
	250 to 500	2.1	1.3	1.1	1.0	0.6	***0.6***	0.5	0.3	0.3	0.3	0.2	0.1	0.1	0.1	0.1
	500 to 1000	0.4	0.3	0.3	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0
	1000 to 2000	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2000 to 3000	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hooper	0 to 250	12.3	5.7	***4.6***	6.2	2.8	***2.3***	3.1	1.4	1.1	1.5	0.7	0.6	0.8	0.4	0.3
	250 to 500	17.3	9.5	***8.2***	8.6	4.8	***4.1***	4.3	2.4	***2.1***	2.2	1.2	1.0	1.1	0.6	0.5
	500 to 1000	4.0	2.4	***2.1***	2.0	1.2	***1.1***	1.0	0.6	***0.5***	0.5	0.3	0.3	0.2	0.1	0.1
	1000 to 2000	1.6	1.0	***0.9***	0.8	0.5	***0.4***	0.4	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1
	2000 to 3000	1.0	0.6	***0.6***	0.5	0.3	0.3	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.0	0.0

$$\text{Ratio} = \frac{\text{Drawdown}}{\text{Available Drawdown}}$$

Color								
Ratio	0 - 0.25	0.25 - 0.5	0.5 - 0.75	0.75 - 1	1.0 - 2.0	2.0 - 4.0	4.0 - 8.0	8.0 - 16.0	16.0 - 32.0

Potential Tasks to Prepare for 5-year Review

- Guidance Document for 5-year Renewal Process
- 5-year Renewal Application
- Revisit Action Items for Threshold Limits
- Additional Fair Share Evaluations
- Update to Guidance Document for Evaluating Compliance DFCs and PDLs
- Enhanced methods for Analysis of Measured Water Levels
- Develop Guidance Document for Implementing and Monitoring Curtailment
  - for achieving DFCs and PDLs
  - for preventing unreasonable impacts

Potential Tasks to Prepare for 5-year Review

- Revised Aquifer Tops and Bottoms
- Coordinate with TWDB on Aquifer assignments for wells
- Evaluations of Sustainable Groundwater Production
- Perform Quality checks on HALFF Well Database

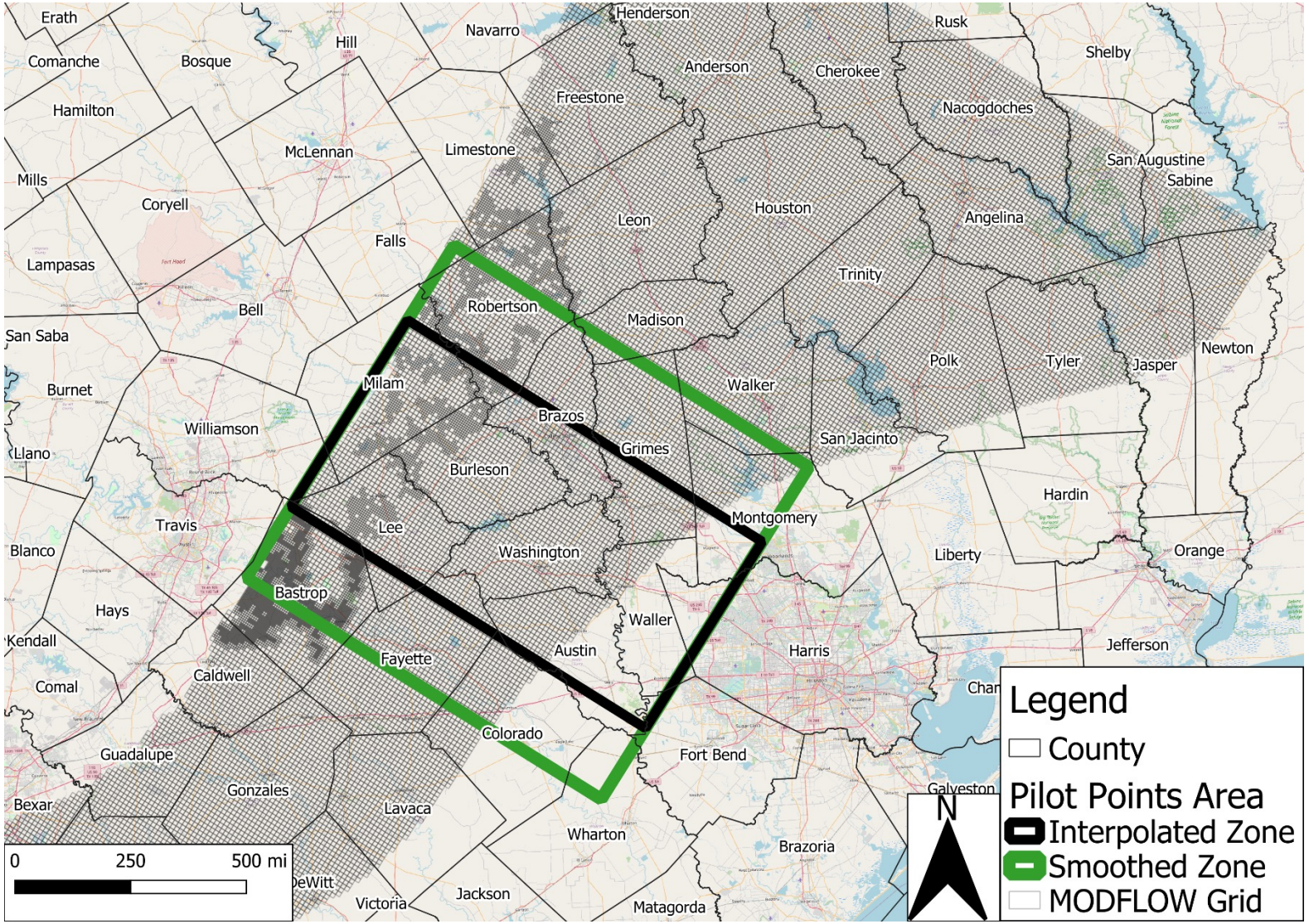
POSGCD Operational Model

POSGCD Operational Model

Generate a Technical Defensible GW Model to Support District Decisions Related to:

- Permit Renewals
- Long-term aquifer sustainability
- Improved climate resiliency
- Desired Future Conditions
- Curtailment of production
- Fair share allocations
- Drought management

GAM Recalibration Area for Aquifer Hydraulic Properties



Progress Report

- Began expanding data from 2010 to 2022
  - Assemble data from LSGCD, BVGCD, FCGCD, METGCD
  - Production
  - Water Levels
  - Well Construction Specification
- Incorporated End Lakes into Model
- Transfer Model to New Computer Cluster