Groundwater Management Area 16 Joint Planning Cycle: 2019-2022 Hydrological Conditions

Falfurrias, TX
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Joint Planning Requirements

- Balancing Test
  - 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 in the management area*"

Joint Planning Requirements

- Consideration of 9 “factors” (paraphrased)
  - Aquifer uses or conditions
  - Water supply needs and management strategies
  - ***Hydrological conditions***
  - Other environmental impacts
  - Impact on subsidence
  - Socioeconomic impacts
  - Impact on private property rights
  - Feasibility of achieving the DFC
  - Any other relevant information

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Consideration of Hydrological Conditions

- Describe the hydrological conditions, including for each aquifer in the management area the total estimated recoverable storage as provided by the executive administrator, and the average annual recharge, inflows, and discharge

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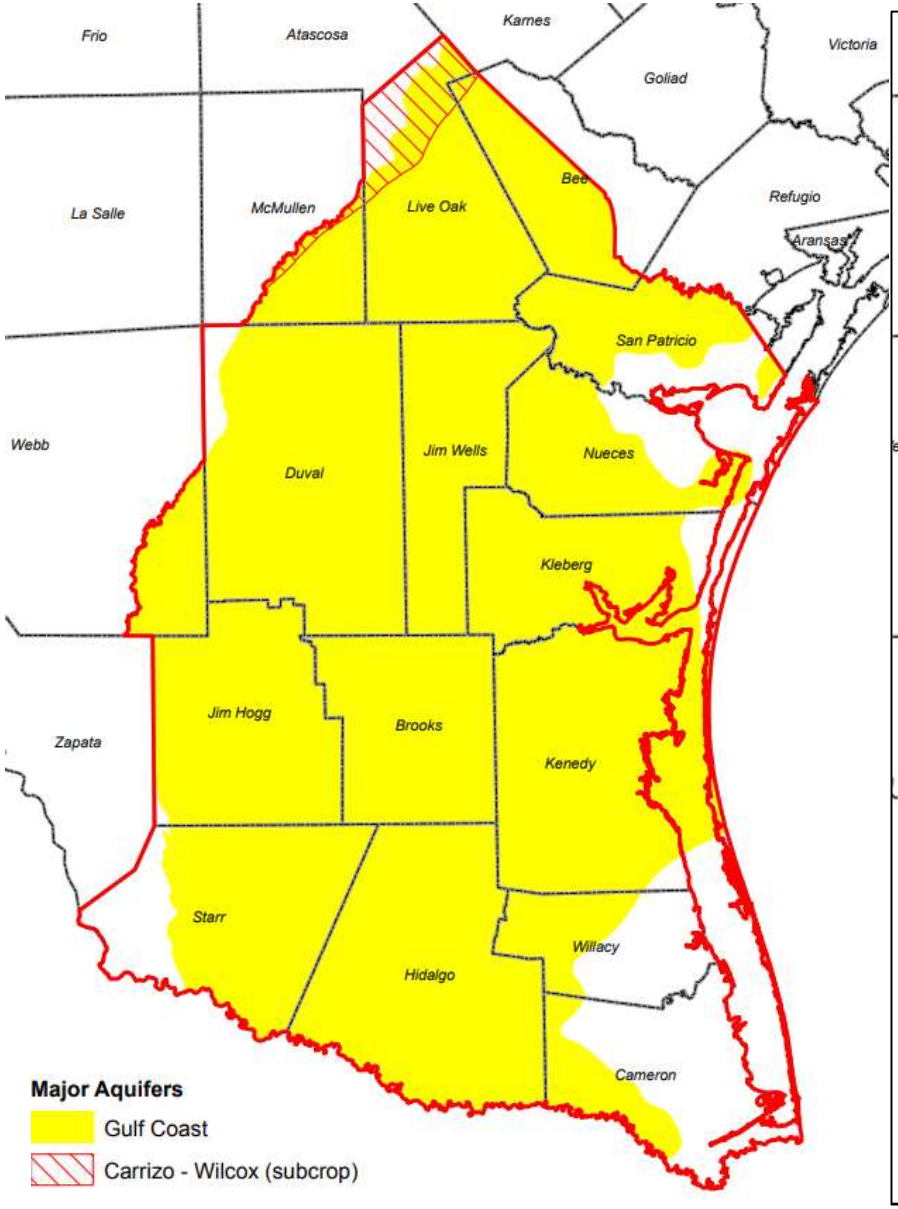
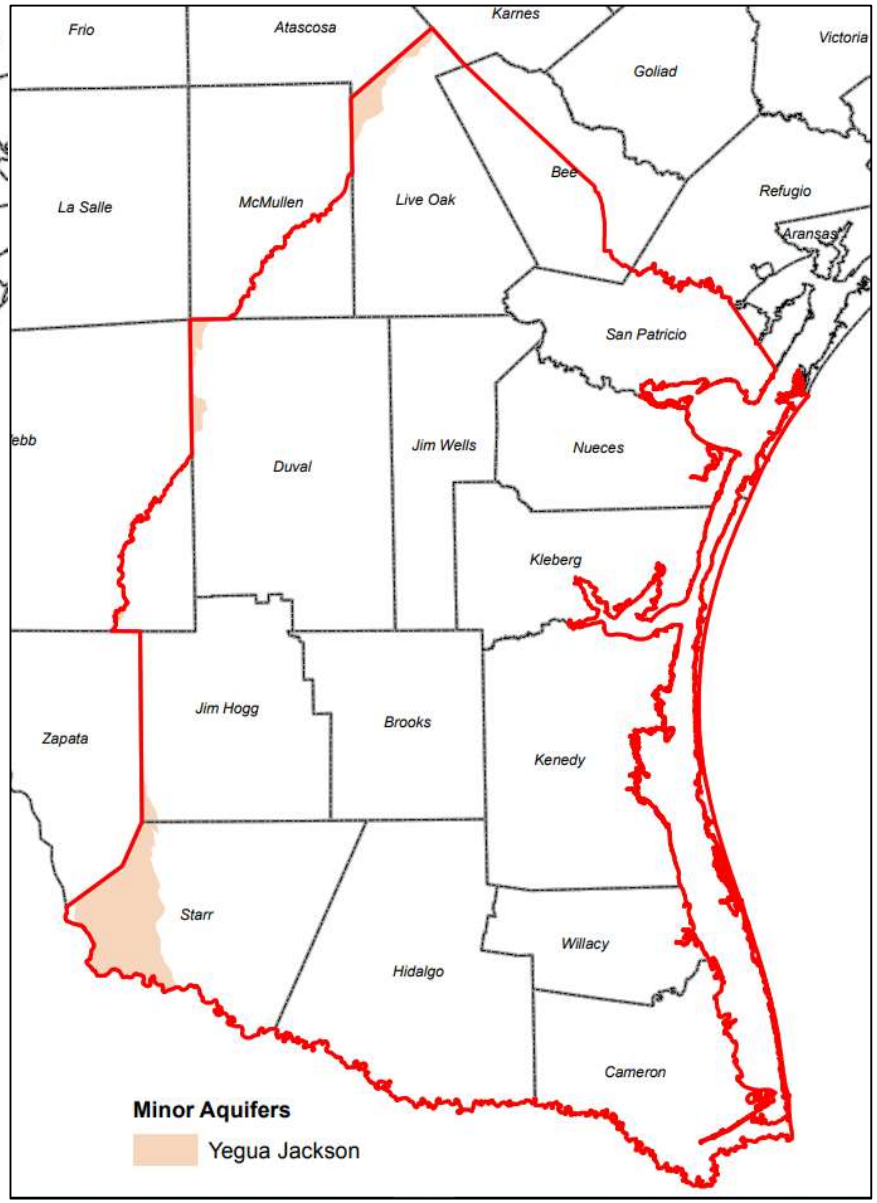
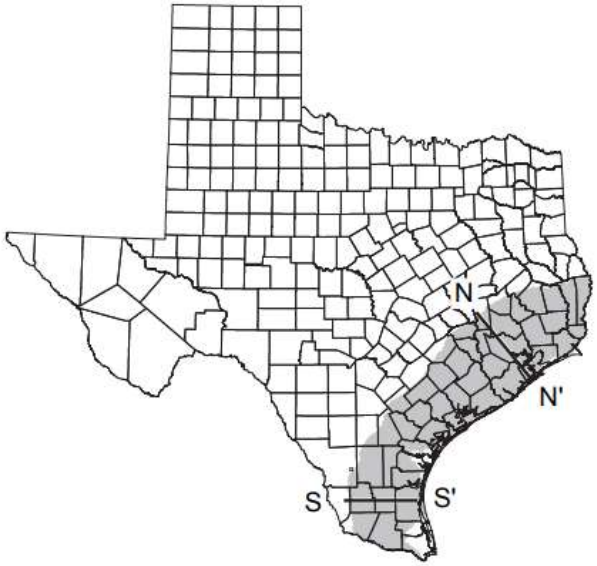
Non-Relevant Aquifers

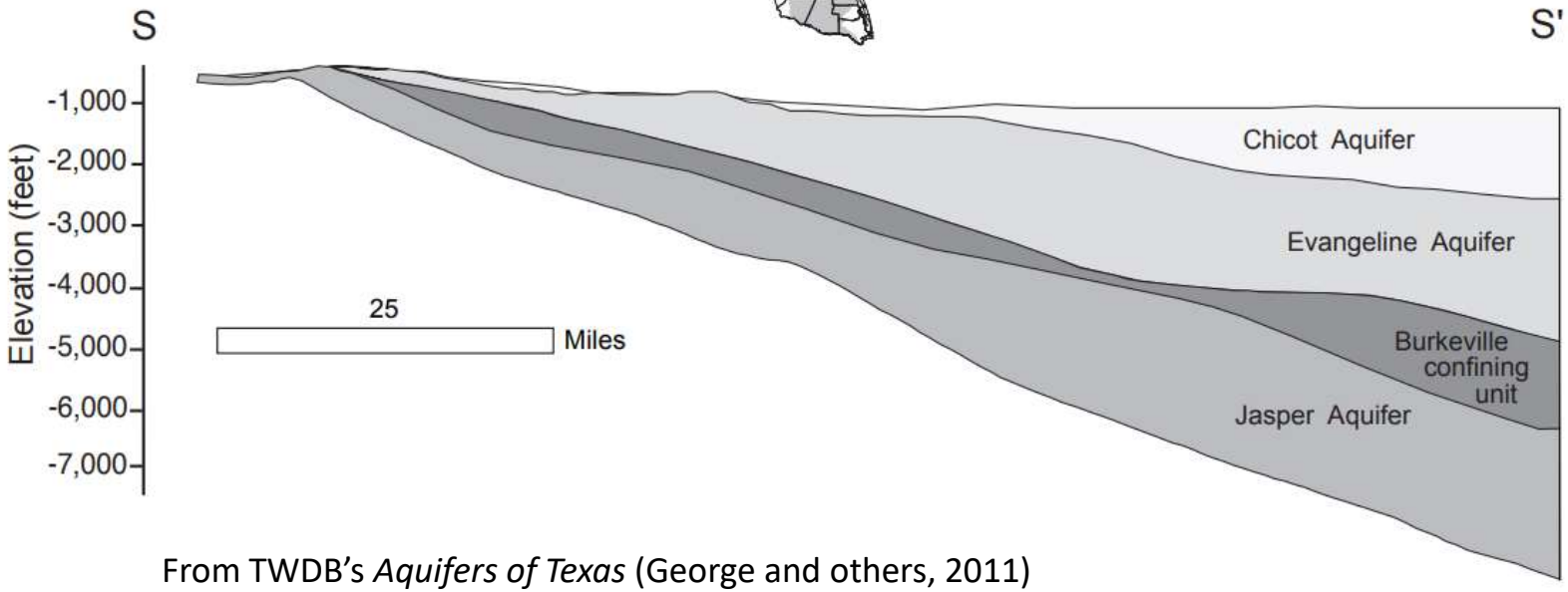




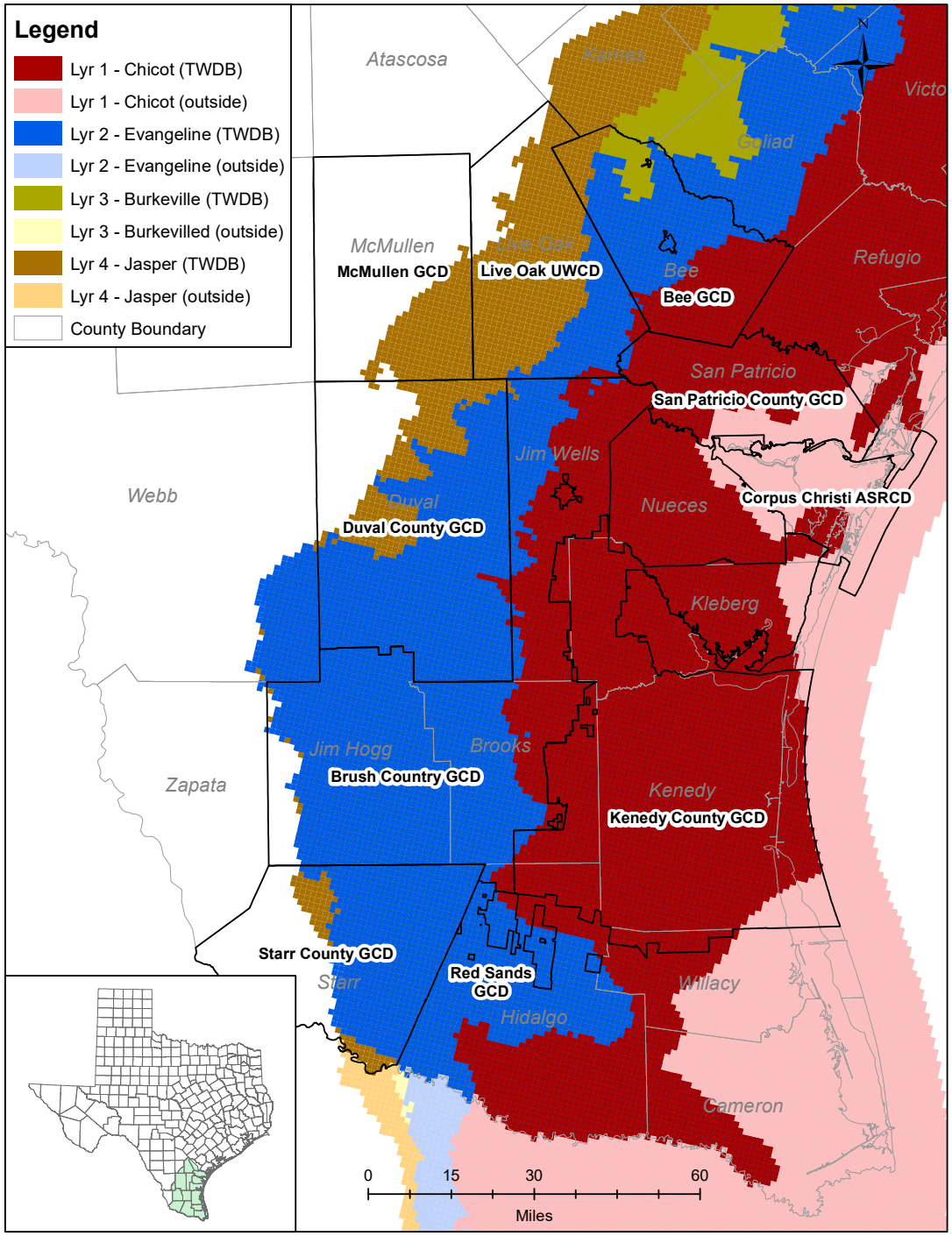
Gulf Coast Aquifer System

- Aquifers outcrop from East to West
- All layers dip towards the coast
- Unconfined in outcrop
- Confined downdip





From TWDB's *Aquifers of Texas* (George and others, 2011)



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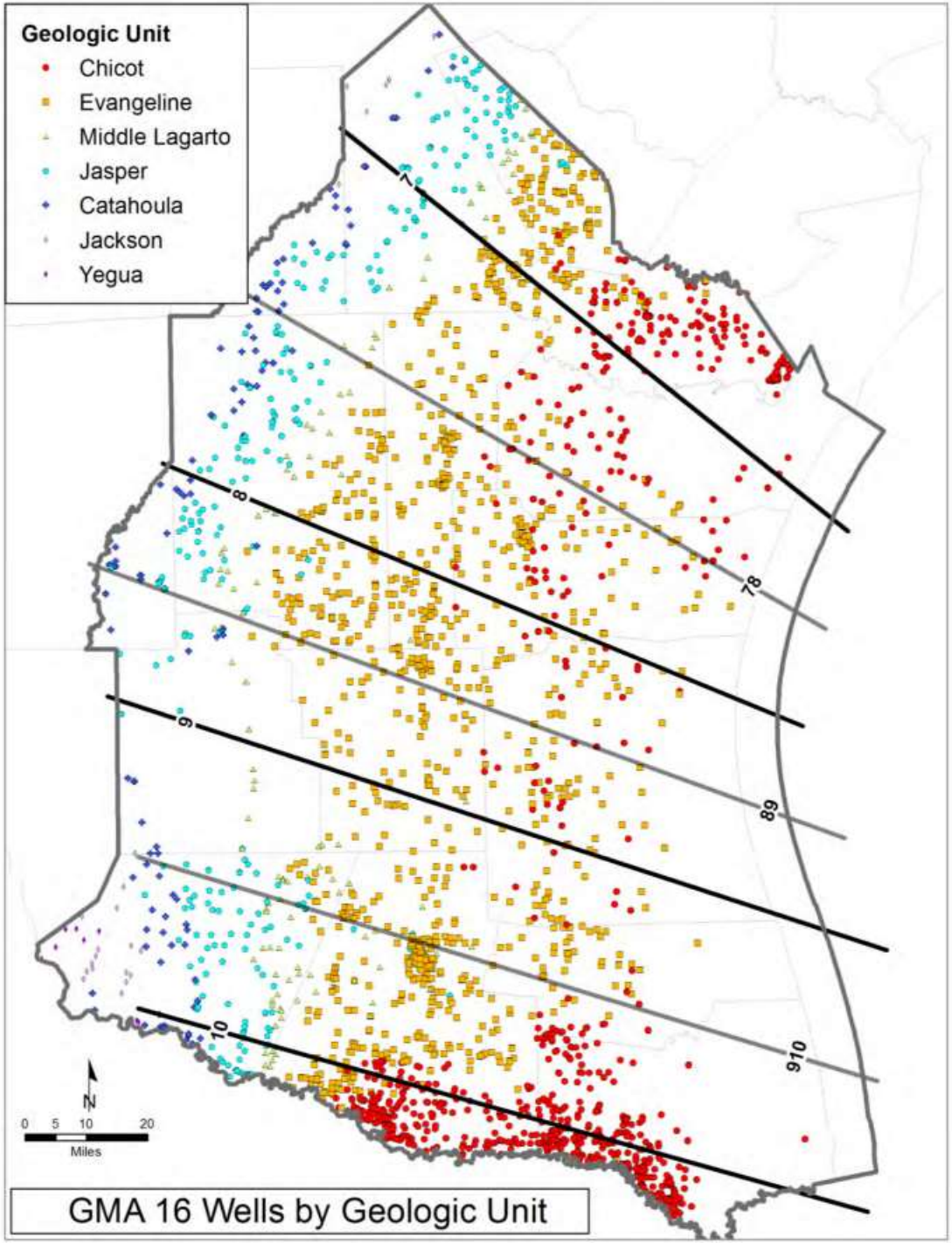
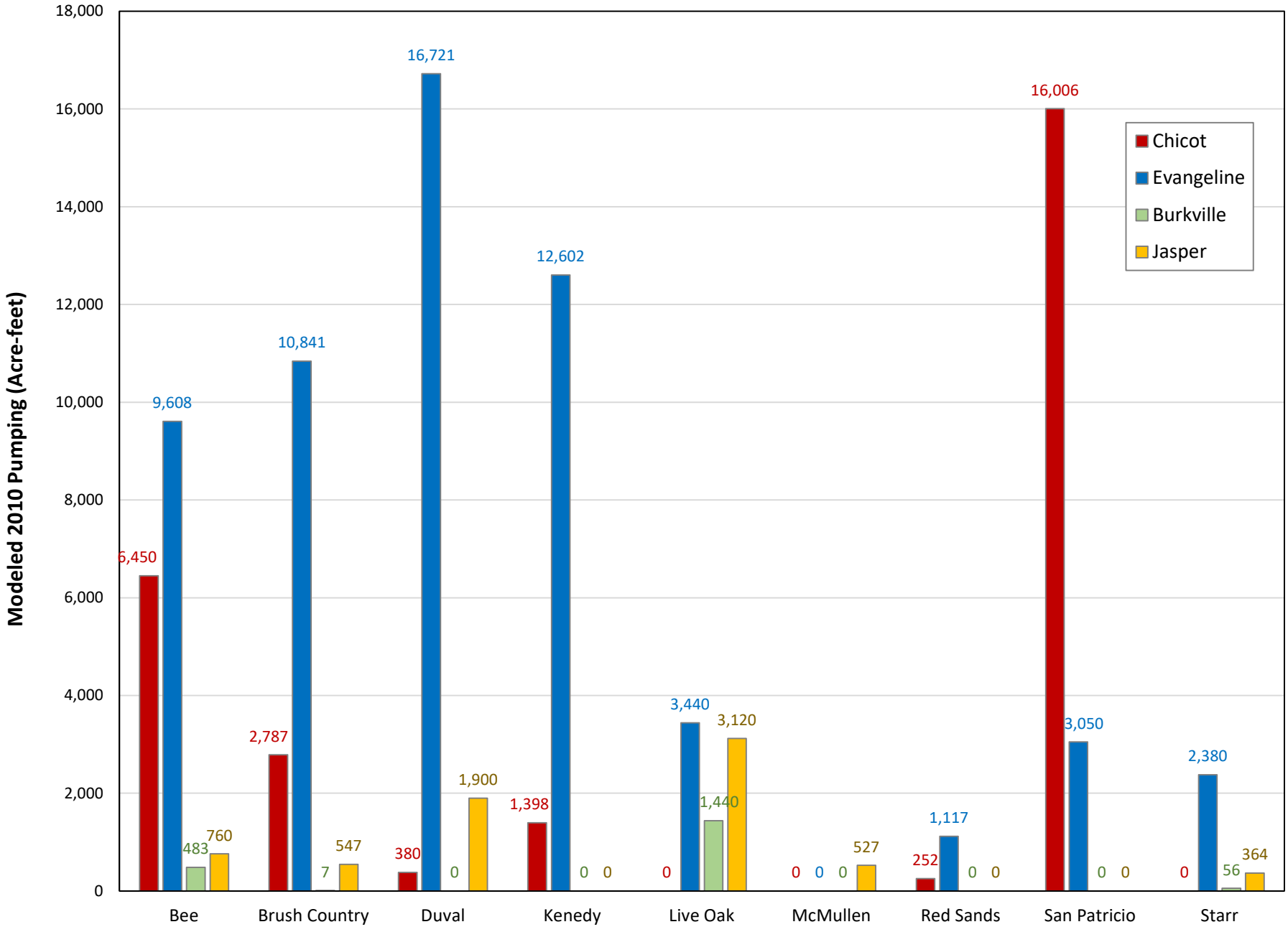
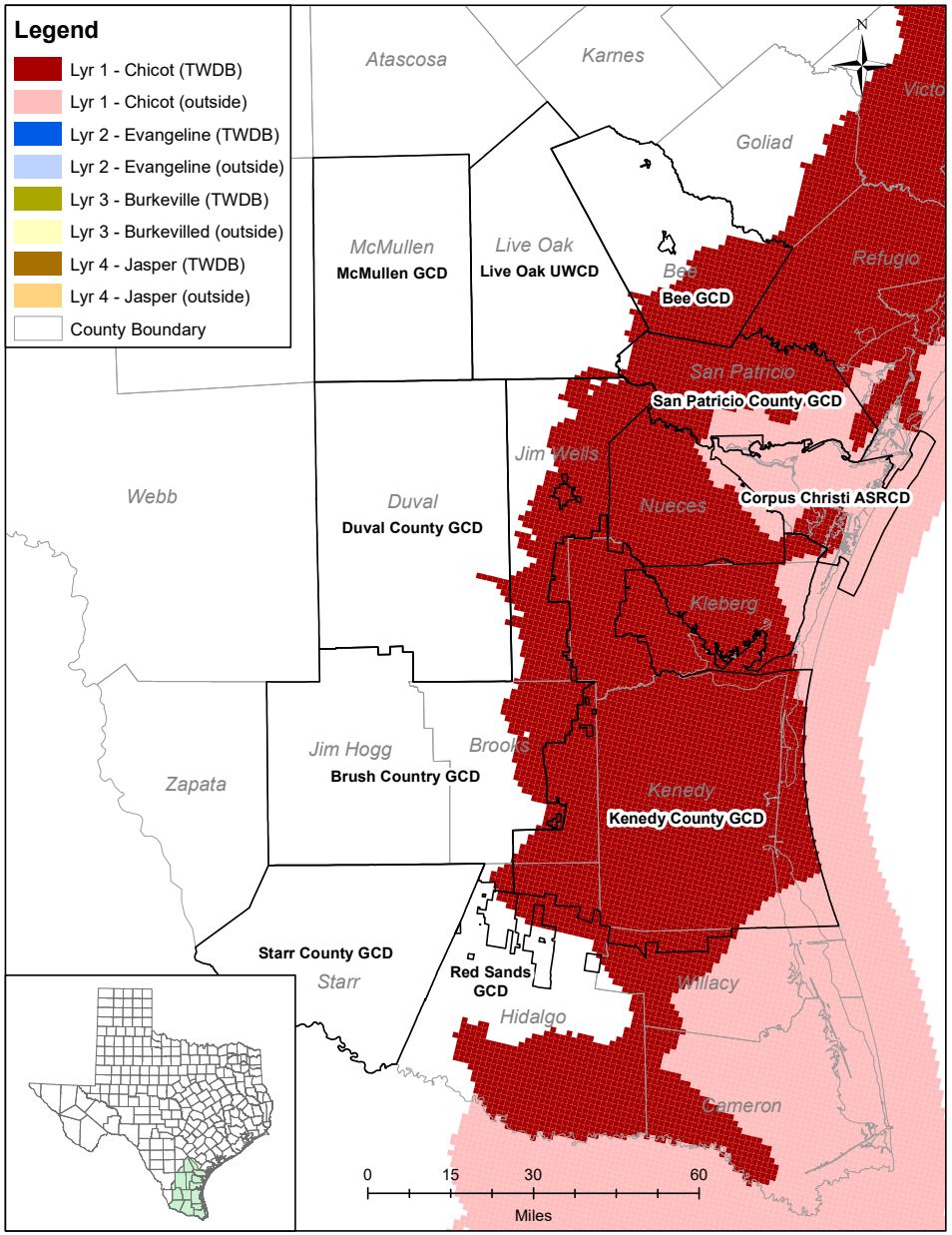


Hydrogeochemical Evaluation of the Texas Gulf Coast Aquifer System and Implications for Developing Groundwater Availability Models (Young & others, 2014)


Modeled 2010 Pumping (Acre-feet)
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
Chicot
Evangeline
Burkville
Jasper
6,450
9,608
483
760
2,787
10,841
7
547
380
16,721
0
1,900
1,398
12,602
0
0
0
3,440
1,440
3,120
0
0
0
527
252
1,117
0
0
16,006
3,050
0
0
0
2,380
56
364
Bee
Brush Country
Duval
Kenedy
Live Oak
McMullen
Red Sands
San Patricio
Starr

Chicot Aquifer

- Shallowest unit of the Gulf Coast Aquifer
- Sandy unit composed of Beaumont, Lissie & Willis Formations
- Most common source of water in San Patricio & near Rio Grande
- Also provides water to Bee, Brush Country, Duval, Kenedy & Red Sands
- Some wells in eastern section of GMA 16 but water quality degrades towards the coast



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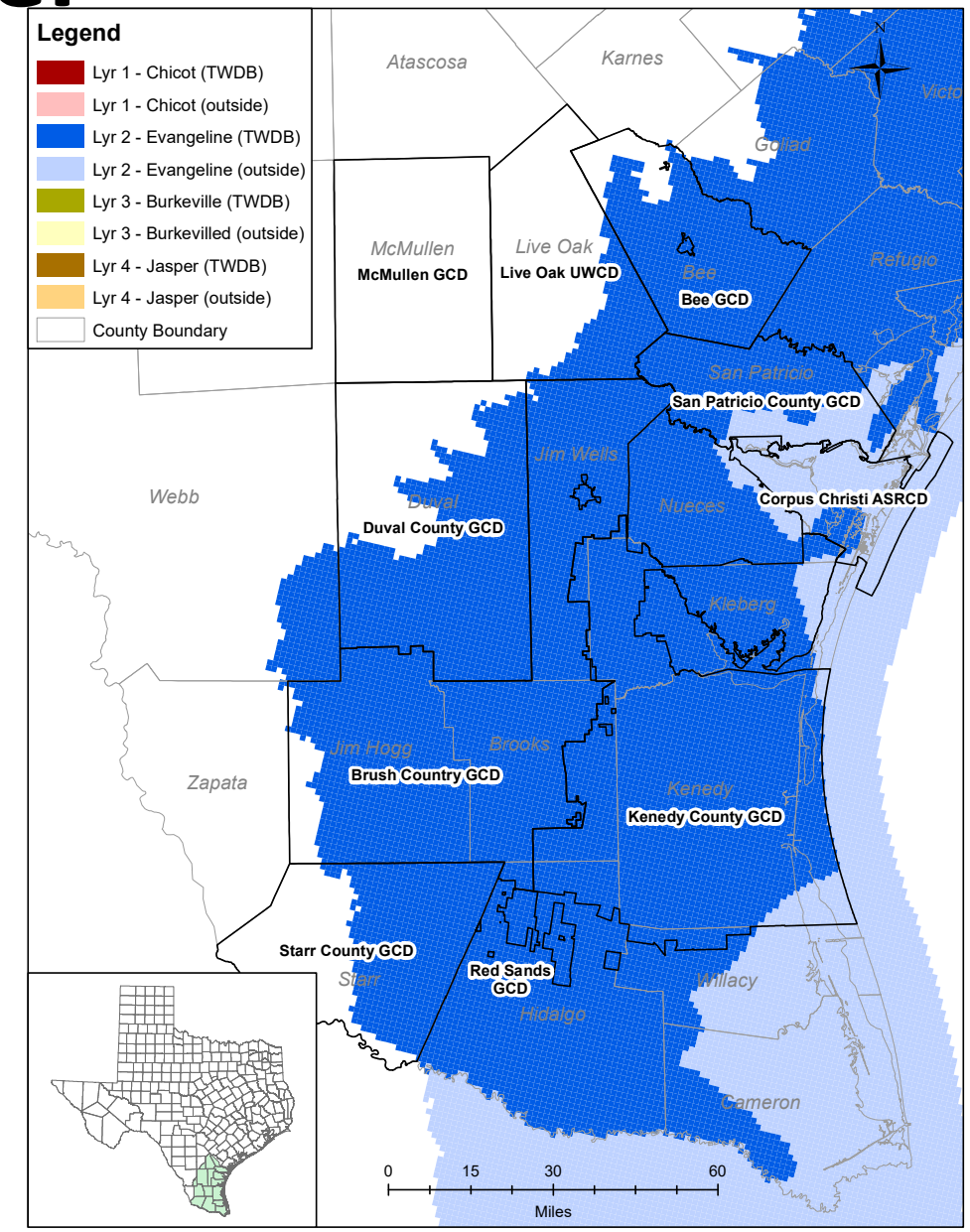
Evangeline Aquifer

- Unit of the Gulf Coast Aquifer below Chicot Aquifer
- Sandy unit comprised of the Goliad Formation
- Most common source of groundwater in GMA 16, except in McMullen and San Patricio



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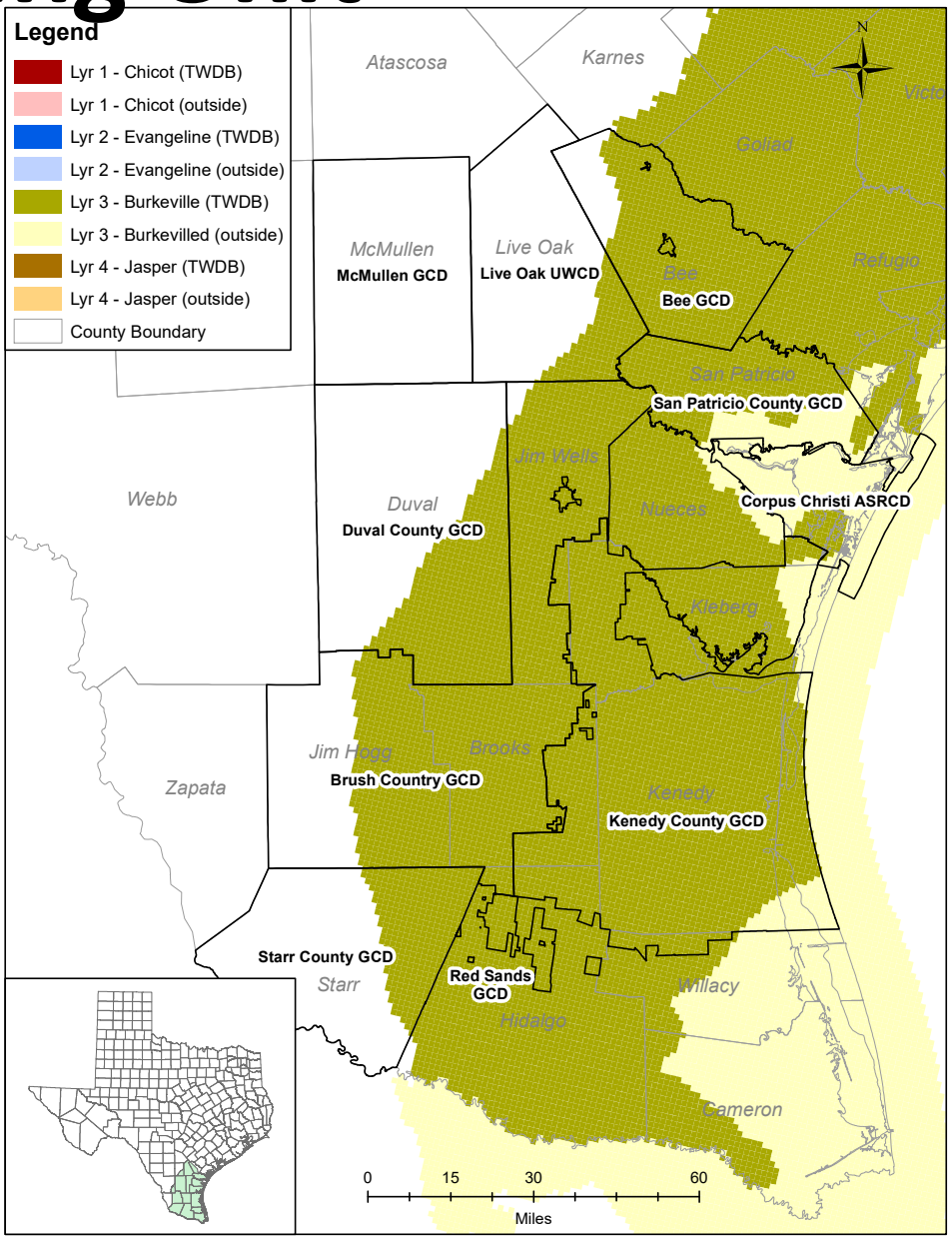
Burkeville Confining Unit

- Unit of the Gulf Coast Aquifer below Evangeline Aquifer
- It acts as a confining unit in some places but can produce water in others
- Composed of Lagarto Formation
- Wells generally clustered in shallow Burkeville in western section of GMA 16
- Provides a small % of water in Bee, Live Oak, Starr & Brush Country



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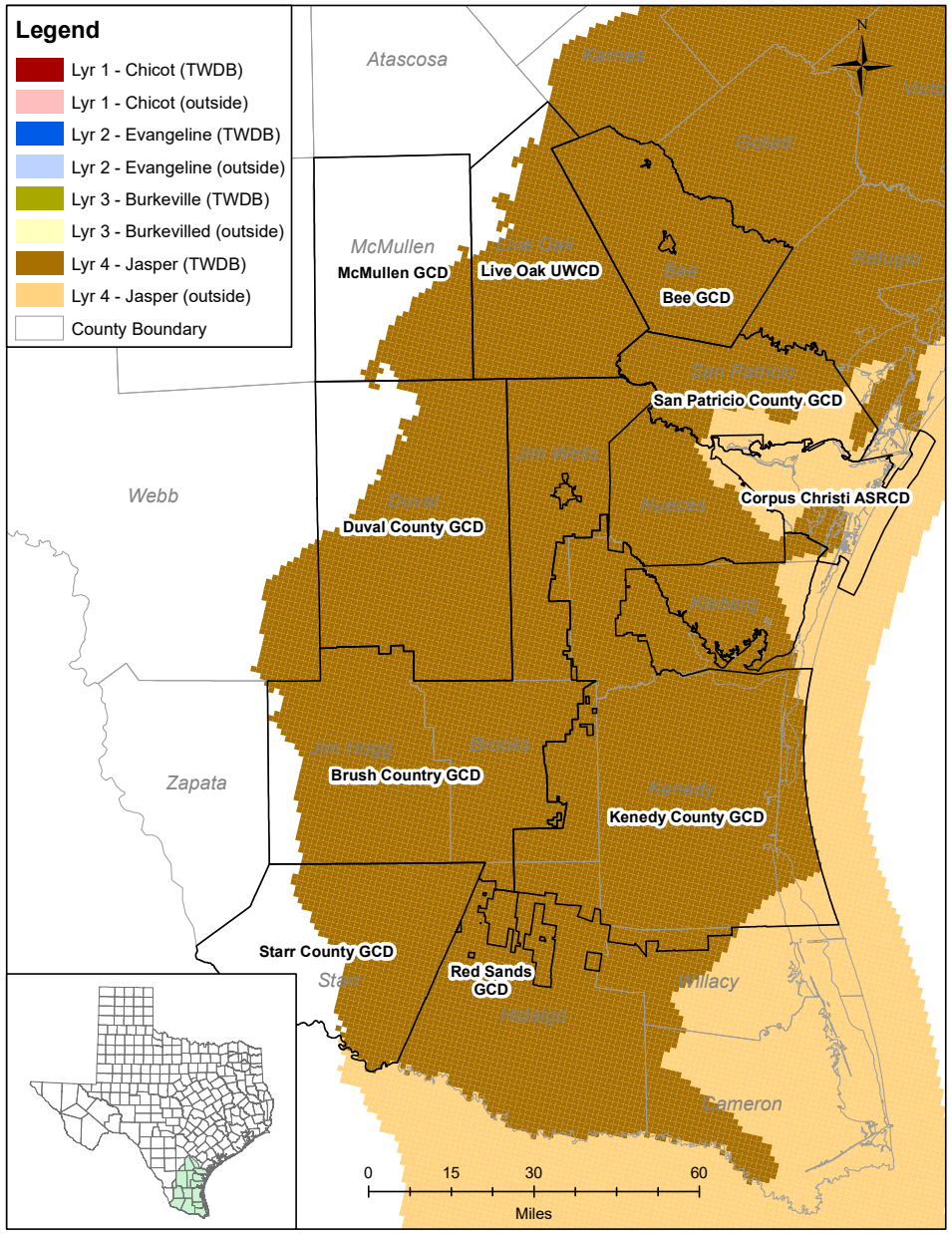
Jasper Aquifer

- Deepest unit of the Gulf Coast Aquifer
- Sandy unit comprised of Oakville Formation
- Wells generally found in shallower section in western/northwestern part of GMA 16
- Only source of Gulf Coast Aquifer water in McMullen
- Provides a large % of water in Live Oak and smaller % in Bee, Brush Country, Duval & Starr



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Total Estimated Recoverable Storage (TERS)

- **Total Estimated Recoverable Storage**—The estimated amount of groundwater within an aquifer that accounts for recovery scenarios that range between 25% and 75% of the porosity-adjusted aquifer volume

- TERS is a required consideration as part of the DFC process

- TERS is :
  - The amount of water physically present in the aquifer
  - NOT the amount of water available for production
  - NOT the amount of pumping that will prevent harm to the aquifer/users

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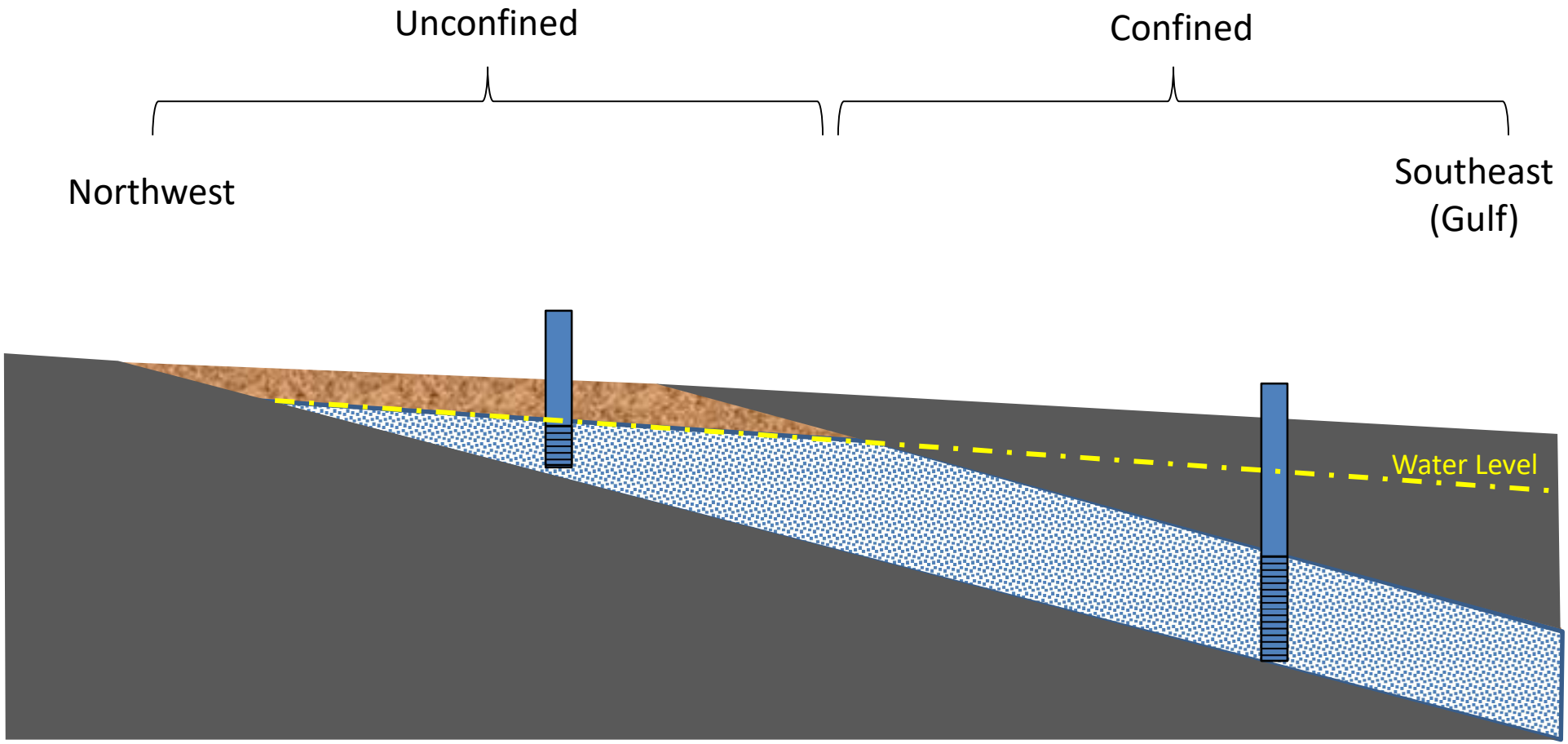
"Recoverable" is Aquifer Specific

- The range of 25% - 75% is not an appropriate range for all aquifers.
  - Could be 55 -75% or more for highly productive, unconfined aquifers at the surface such as the Ogallala and Seymour.
  - Likely no more than 3 - 15% for most dipping, confined aquifers in Texas (Trinity, Carrizo-Wilcox, Gulf Coast, etc.). Recovery of anywhere close to 75% is physically impossible given current well depths and impacts to water levels, quality, existing wells, well yields, surface water, and subsidence.
  - For karst aquifers, total storage is practically irrelevant to aquifer planning and management long term (Edwards). Total storage is relatively small and fluctuates significantly over time due to recharge events.

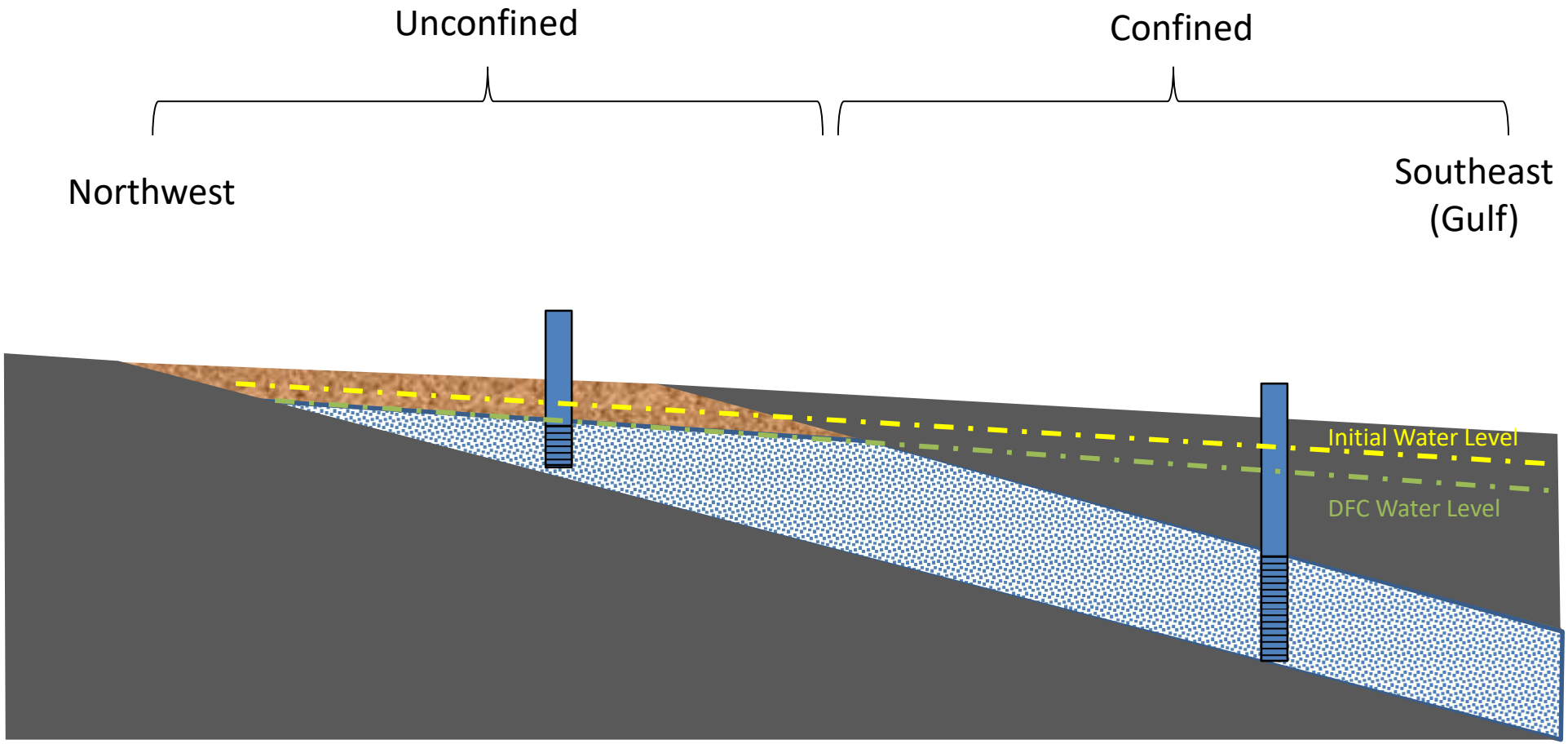
- Wade Oliver (INTERA), Feb 2014 TAGD Quarterly Meeting

Typical Dipping Aquifer in South/Southeast Texas



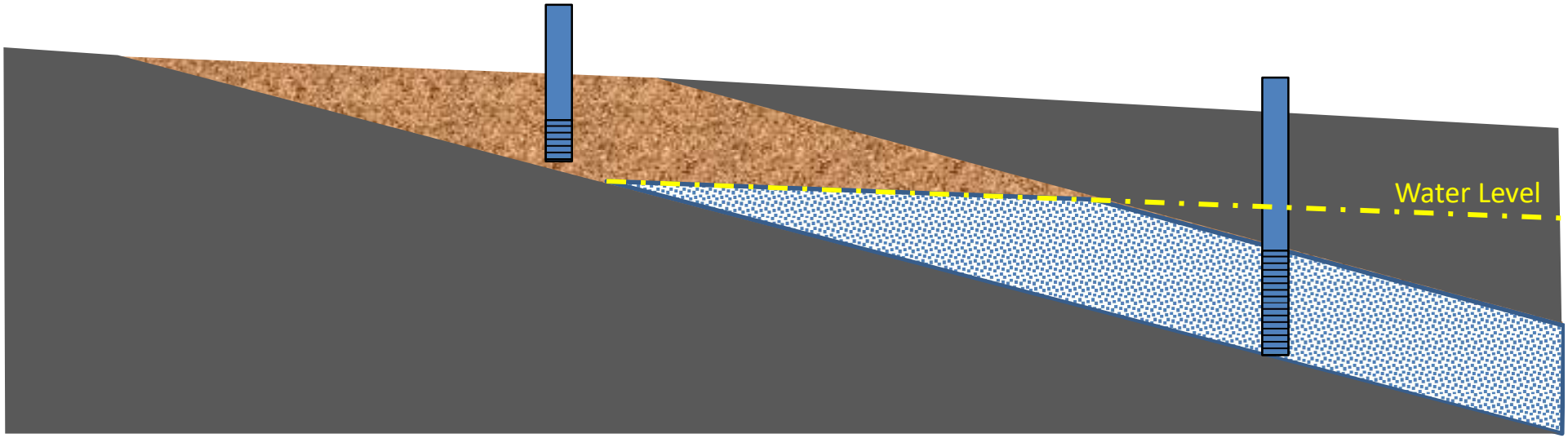
Approximate illustration – not to scale

Typical DFC Water Level Change in South/Southeast Texas

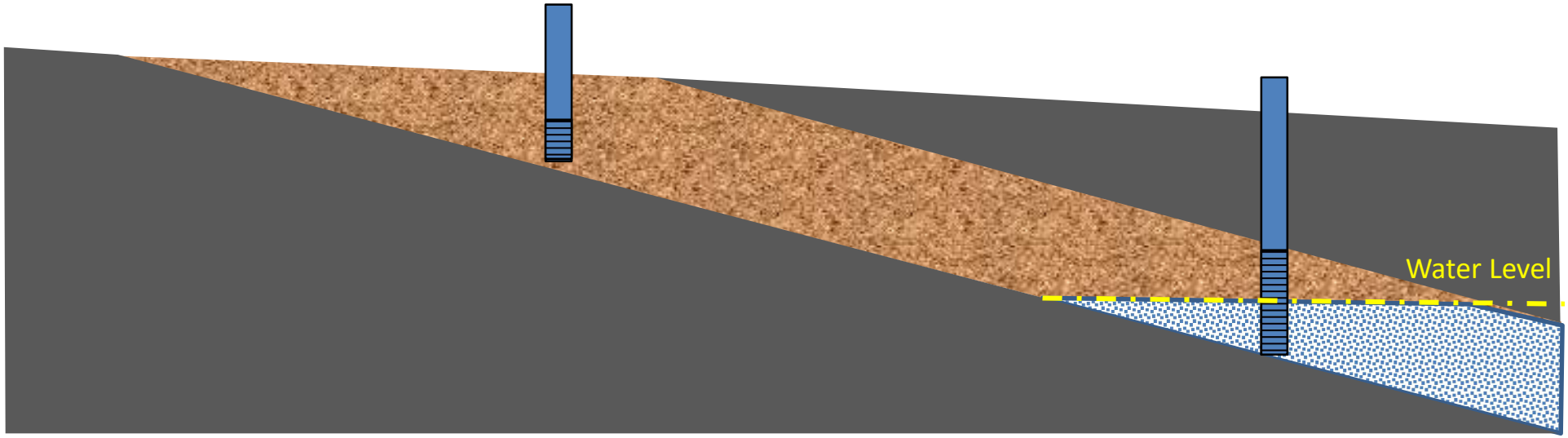


Approximate illustration – not to scale

~25% Storage removed (Low End of TERS)



~75% Storage removed (High End of TERS)

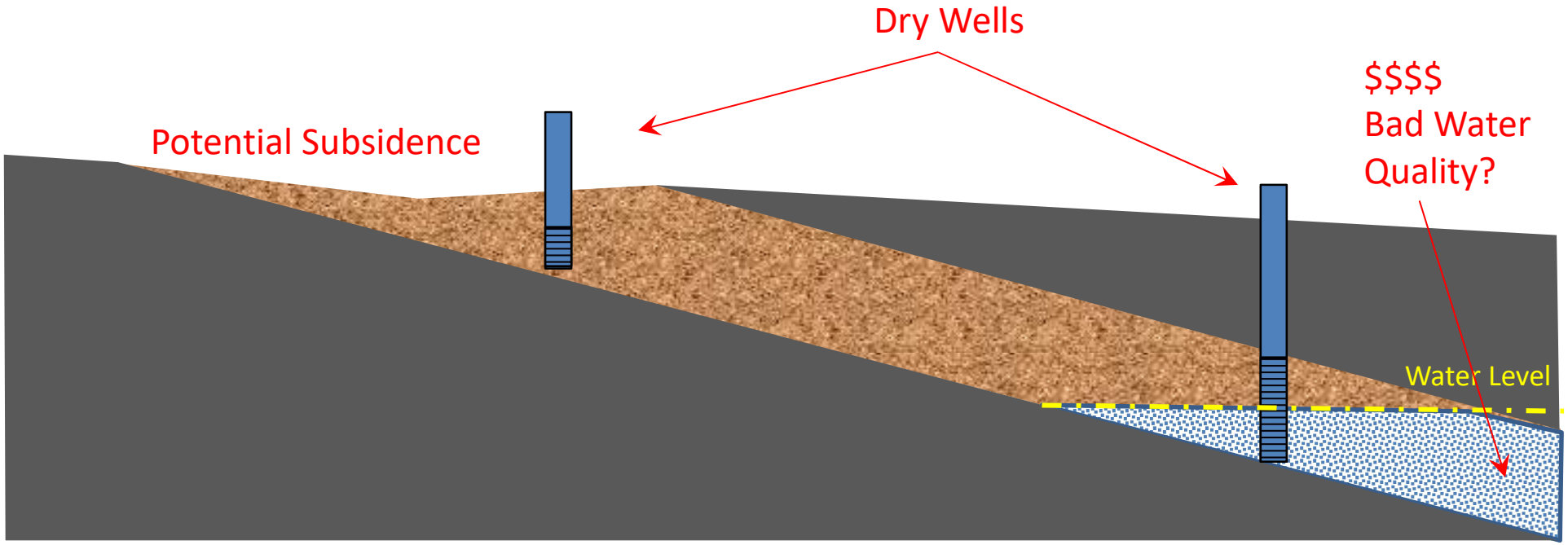


Approximate illustration – not to scale

Total Estimated Recoverable Storage (TERS)

TERS does not account for :

– Aquifer water quality
– Water levels dropping below pumps
– Land surface subsidence
– Degradation of water quality
– Changes to surface water-groundwater interaction
– Practicality/economics of development



Approximate illustration – not to scale

Total Estimated Recoverable Storage (TERS)

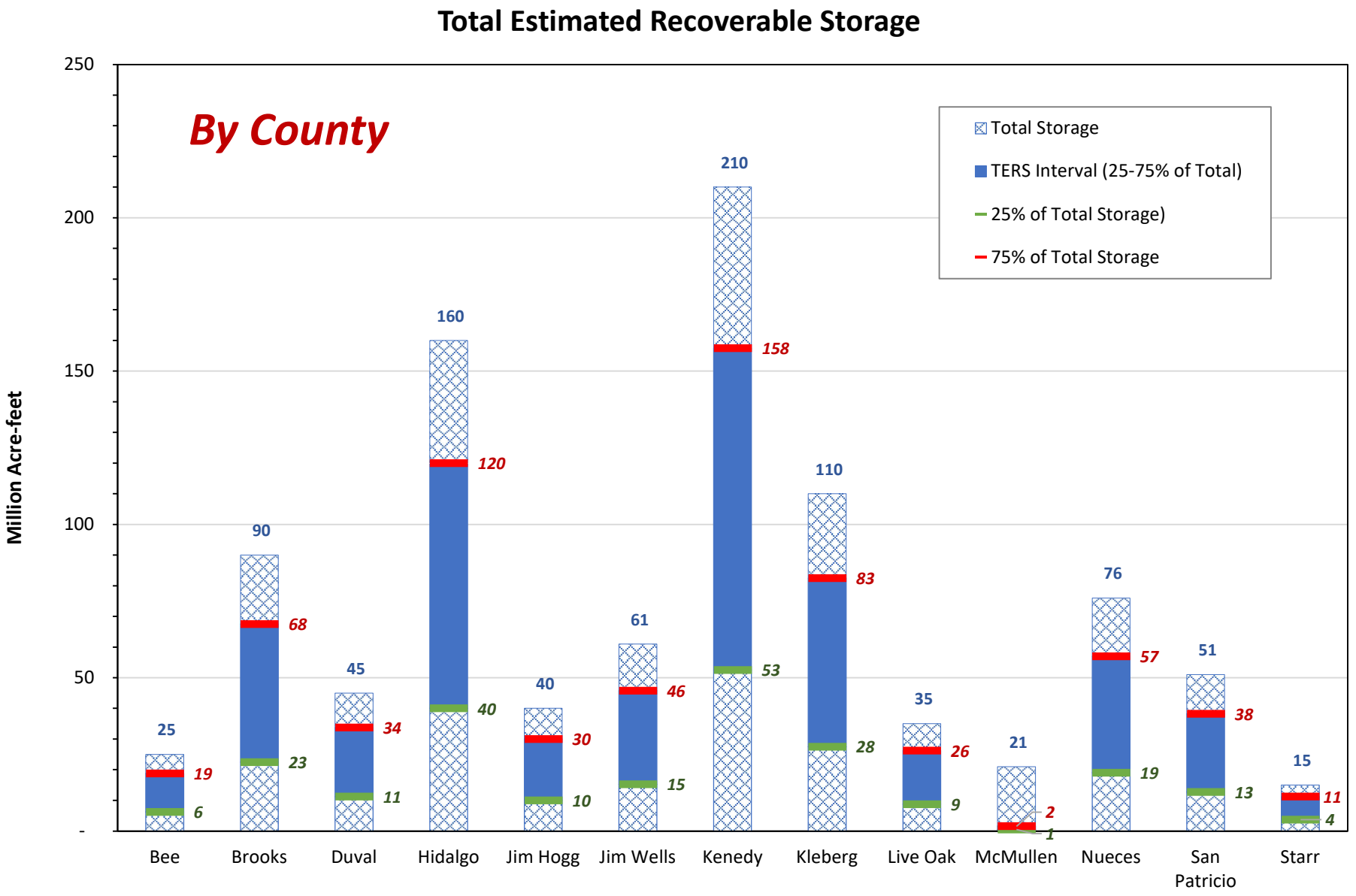
*Note: TWDB only provides TERS values for entire Gulf Coast Aquifer, not the individual 4 units

Source for GMA 16: TWDB report GAM RUN 12-025 (March 28, 2013)

By County

County	*Total Storage (acre-feet)*	*25% of Total Storage (acre-feet)*	*75% of Total Storage (acre-feet)*
Bee	25,000,000	6,250,000	18,750,000
Brooks	90,000,000	22,500,000	67,500,000
Cameron	49,000,000	12,250,000	36,750,000
Duval	45,000,000	11,250,000	33,750,000
Hidalgo	160,000,000	40,000,000	120,000,000
Jim Hogg	40,000,000	10,000,000	30,000,000
Jim Wells	61,000,000	15,250,000	45,750,000
Kenedy	210,000,000	52,500,000	157,500,000
Kleberg	110,000,000	27,500,000	82,500,000
Live Oak	35,000,000	8,750,000	26,250,000
McMullen	2,100,000	525,000	1,575,000
Nueces	76,000,000	19,000,000	57,000,000
San Patricio	51,000,000	12,750,000	38,250,000
Starr	15,000,000	3,750,000	11,250,000
Webb	250,000	62,500	187,500
Willacy	45,000,000	11,250,000	33,750,000
Total	**1,014,350,000**	**253,587,500**	**760,762,500**

Total Estimated Recoverable Storage (TERS)



Total Estimated Recoverable Storage (TERS)

*Note: TWDB only provides TERS values for entire Gulf Coast Aquifer, not the individual 4 units

Source for GMA 16: TWDB report GAM RUN 12-025 (March 28, 2013)

By GCD

Groundwater Conservation District	*Total Storage (acre-feet)*	*25% of Total Storage (acre-feet)*	*75% of Total Storage (acre-feet)*
Bee	25,000,000	6,250,000	18,750,000
Brush Country	150,000,000	37,500,000	112,500,000
Corpus Christi ASRCD	6,000,000	1,500,000	4,500,000
Duval County	45,000,000	11,250,000	33,750,000
Kenedy County	360,000,000	90,000,000	270,000,000
Live Oak	35,000,000	8,750,000	26,250,000
McMullen	2,100,000	525,000	1,575,000
Red Sands	3,100,000	775,000	2,325,000
San Patricio County	51,000,000	12,750,000	38,250,000
Starr County	15,000,000	3,750,000	11,250,000
No District	310,000,000	77,500,000	232,500,000
Total	**1,002,200,000**	**250,550,000**	**751,650,000**

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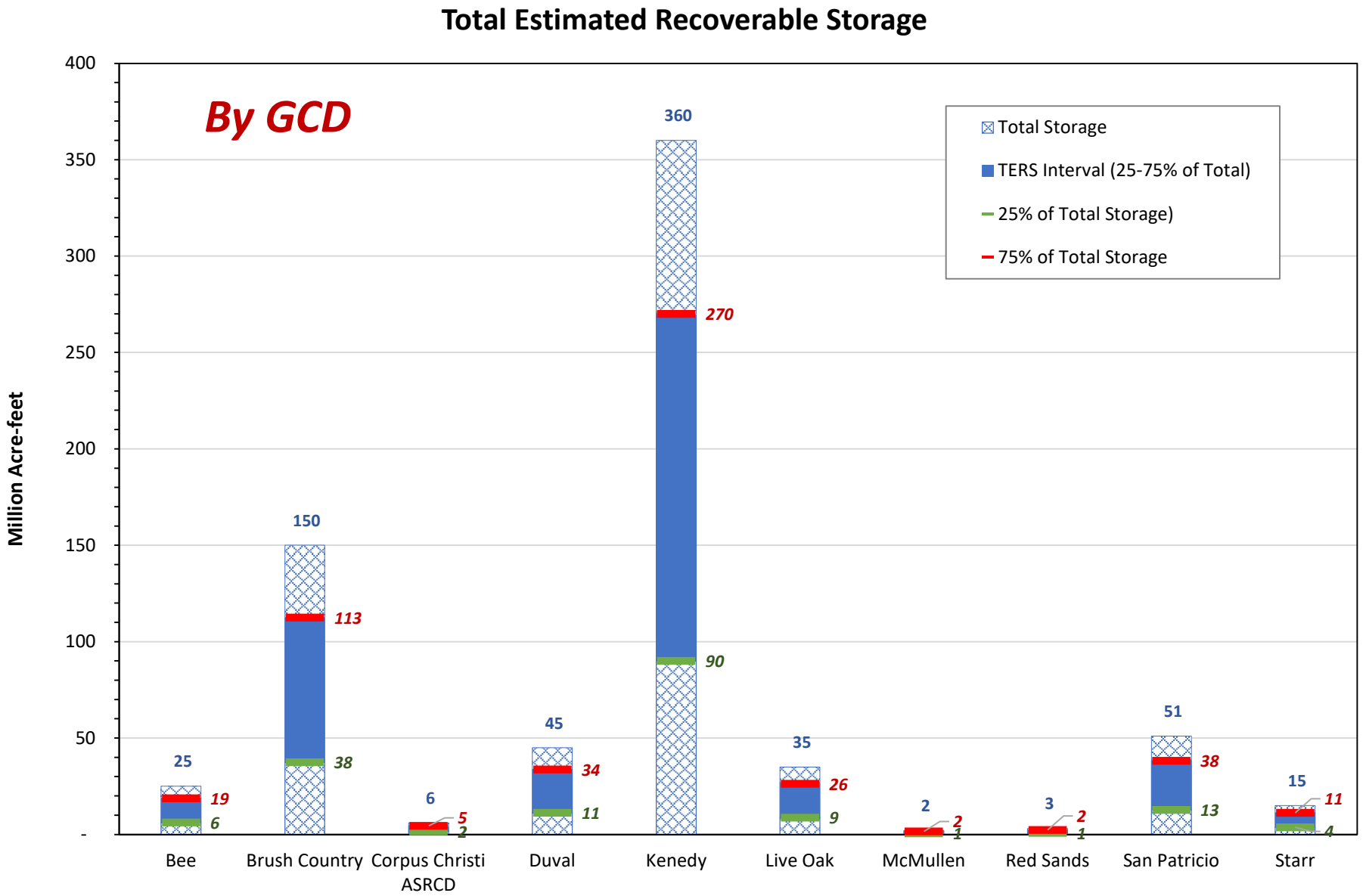
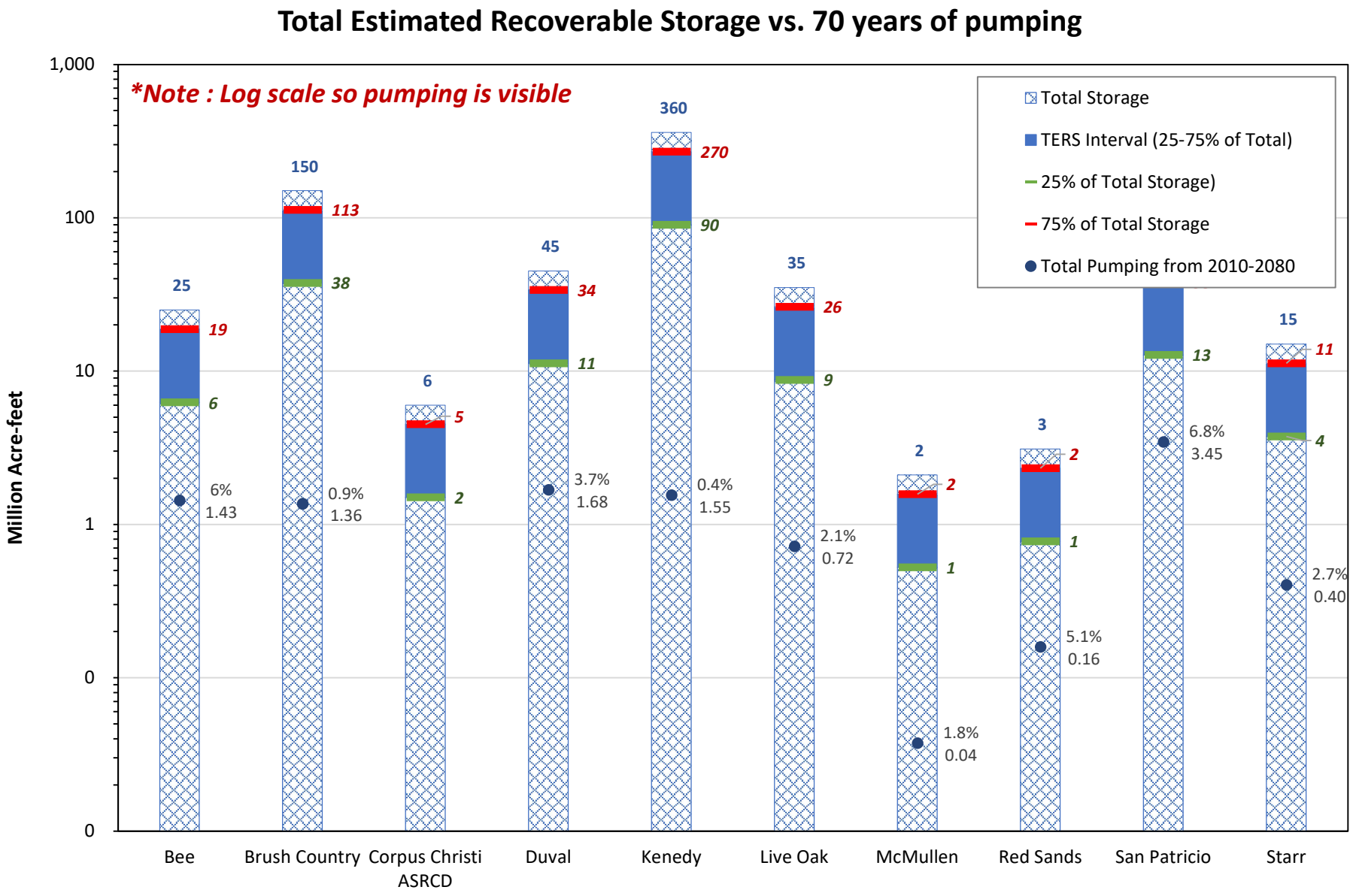
Total Estimated Recoverable Storage (TERS)



Total Estimated Recoverable Storage (TERS)



Annual Recharge, Inflows & Discharge

- Annual Recharge, Inflow & Discharges are required consideration as part of the DFC process
- TWDB provides GAM Run reports in support of management plan development

*Note: TWDB only provides annual values for entire Gulf Coast Aquifer, not the individual 4 units

GCD	Report Name	Report Date
Bee	GAM Run 17-015	1/31/2018
Brush Country	GAM Run 17-001	10/4/2017
Corpus Christi ASRCD	GAM Run 18-012	6/27/2018
Duval County	GAM Run 16-011	10/21/2016
Kenedy County	GAM Run 16-009	3/18/2016
Live Oak	GAM Run 14-014	12/12/2014
McMullen	GAM Run 17-011	11/20/2017
Red Sands	GAM Run 16-008	5/16/2016
San Patricio County	GAM Run 16-003	8/4/2016
Starr County	GAM Run 18-016	2/28/2019

Annual Recharge, Inflows & Discharge – Bee GCD

Management Plan requirement	Aquifer or confining unit	Results
Estimated annual amount of recharge from precipitation to the district	Gulf Coast Aquifer System	21,081
Estimated annual volume of water that discharges from the aquifer to springs and any surface-water body including lakes, streams, and rivers	Gulf Coast Aquifer System	13,055
Estimated annual volume of flow into the district within each aquifer in the district	Gulf Coast Aquifer System	4,000
Estimated annual volume of flow out of the district within each aquifer in the district	Gulf Coast Aquifer System	17,080
Estimated net annual volume of flow between each aquifer in the district	Flow from the Catahoula Formation into the Jasper Aquifer[1]	332
	Flow to the Catahoula Formation from the Upper Jackson Formation subcrop[1]	46

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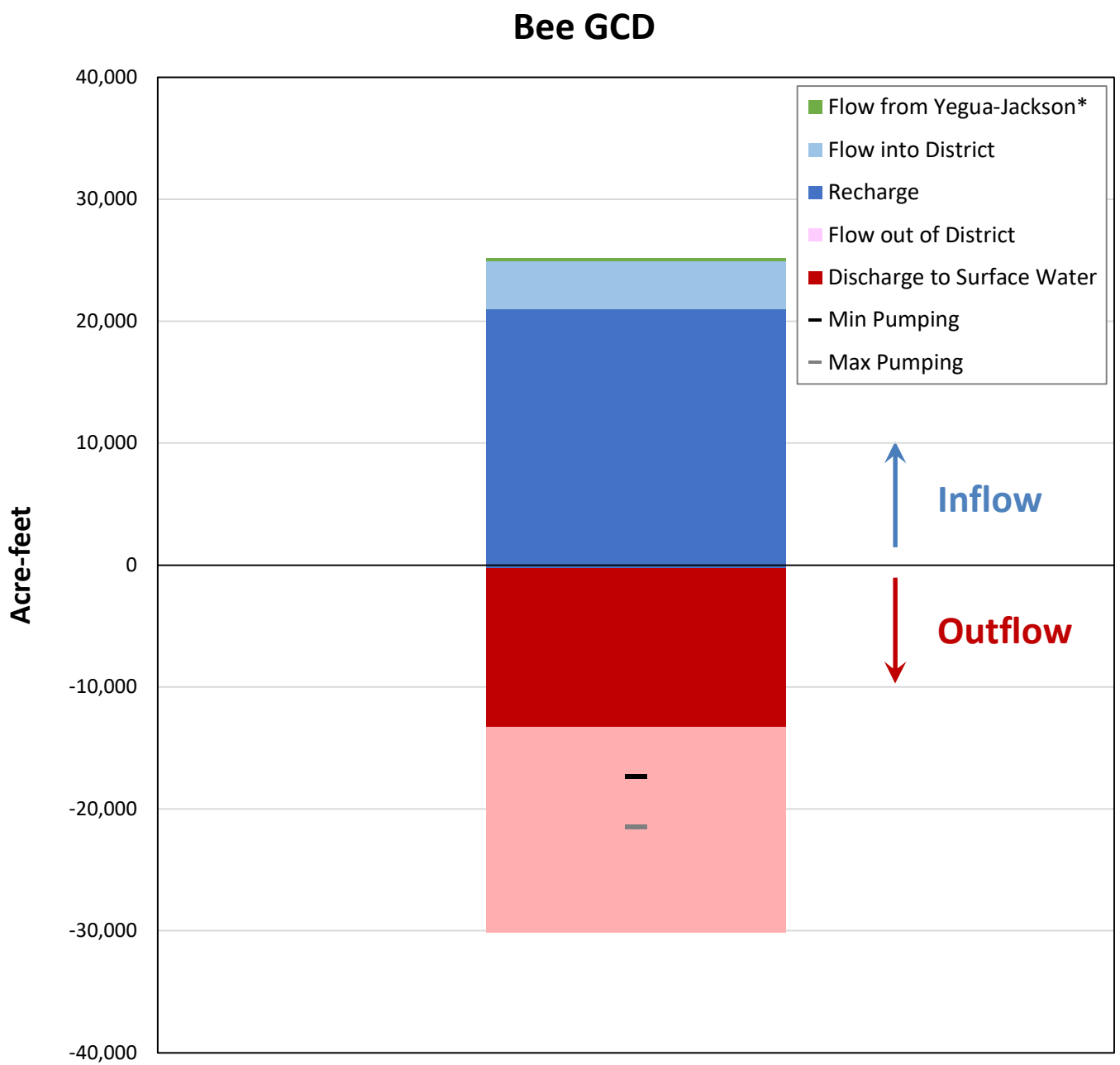

**refers to Catahoula Formation in Yegua-Jackson GAM*

Annual Recharge, Inflows & Discharge – Brush Country GCD

Management Plan requirement	Aquifer or confining unit	Results
Estimated annual amount of recharge from precipitation to the district	Gulf Coast Aquifer	8,291
Estimated annual volume of water that discharges from the aquifer to springs and any surface-water body including lakes, streams, and rivers	Gulf Coast Aquifer	2,633
Estimated annual volume of flow into the district within each aquifer in the district	Gulf Coast Aquifer	26,724
Estimated annual volume of flow out of the district within each aquifer in the district	Gulf Coast Aquifer	43,886
Estimated net annual volume of flow between each aquifer in the district	From the Gulf Coast Aquifer into the underlying Yegua-Jackson Aquifer	401

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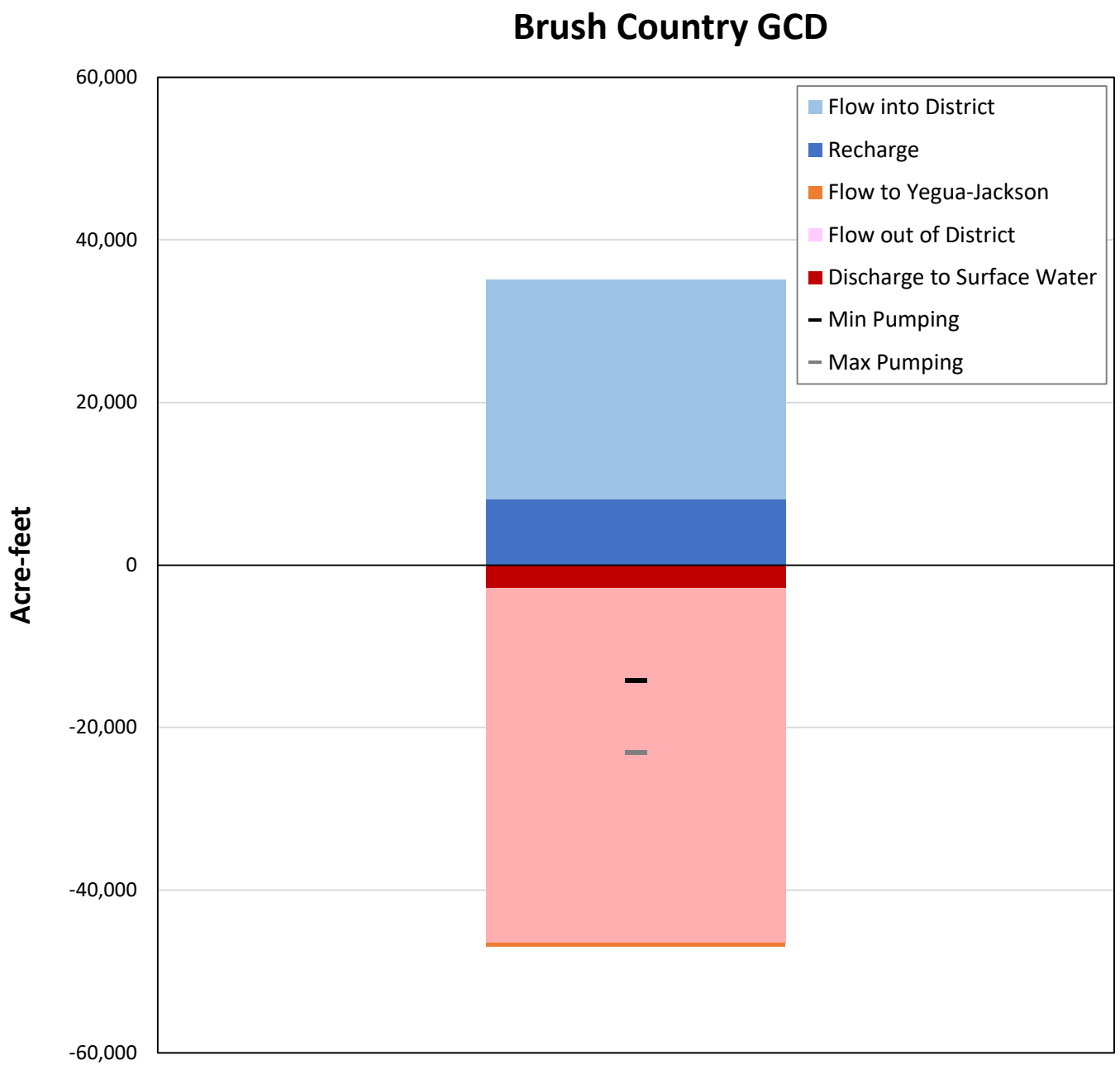
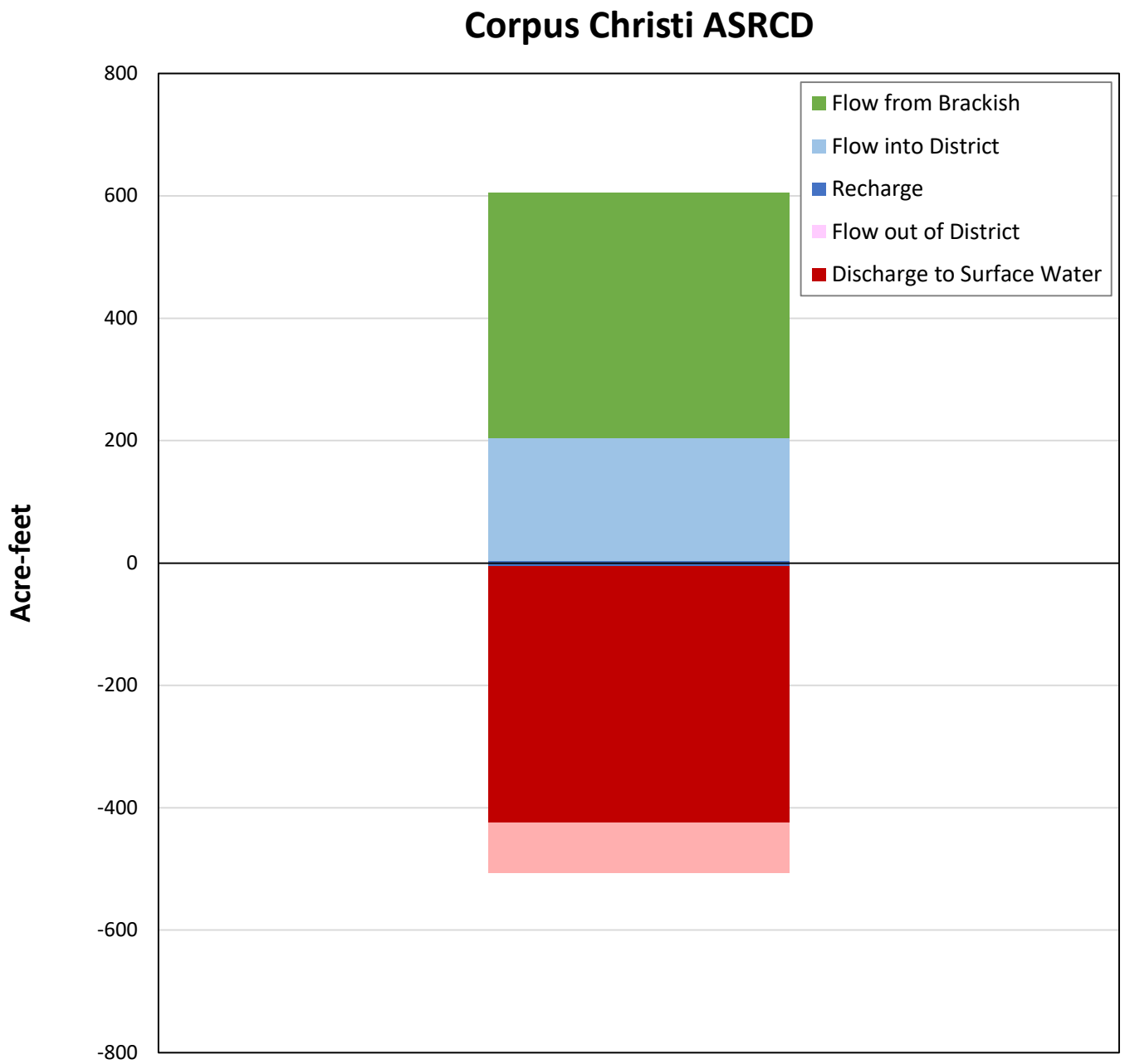

Brush Country GCD
Acre-feet
60,000
40,000
20,000
0
-20,000
-40,000
-60,000
Flow into District
Recharge
Flow to Yegua-Jackson
Flow out of District
Discharge to Surface Water
Min Pumping
Max Pumping

Annual Recharge, Inflows & Discharge – Corpus Christi ASRCD

Management Plan requirement	Aquifer or confining unit	Results
Estimated annual amount of recharge from precipitation to the district	Gulf Coast Aquifer System	7
Estimated annual volume of water that discharges from the aquifer to springs and any surface-water body including lakes, streams, and rivers	Gulf Coast Aquifer System	417[1]
Estimated annual volume of flow into the district within each aquifer in the district	Gulf Coast Aquifer System	202
Estimated annual volume of flow out of the district within each aquifer in the district	Gulf Coast Aquifer System	89
Estimated net annual volume of flow between each aquifer in the district	Flow from brackish units into the Gulf Coast Aquifer System	396


Corpus Christi ASRCD
Acre-feet
800
600
400
200
0
-200
-400
-600
-800
Flow from Brackish
Flow into District
Recharge
Flow out of District
Discharge to Surface Water

Annual Recharge, Inflows & Discharge – Duval County GCD

Management Plan requirement	*Aquifer or confining unit*	*Results*
Estimated annual amount of recharge from precipitation to the district	Gulf Coast Aquifer System	18,509
Estimated annual volume of water that discharges from the aquifer to springs and any surface-water body including lakes, streams, and rivers	Gulf Coast Aquifer System	11,537
Estimated annual volume of flow into the district within each aquifer in the district	Gulf Coast Aquifer System	3,830
Estimated annual volume of flow out of the district within each aquifer in the district	Gulf Coast Aquifer System	10,341
Estimated net annual volume of flow between each aquifer in the district[1]	Not applicable	Not applicable

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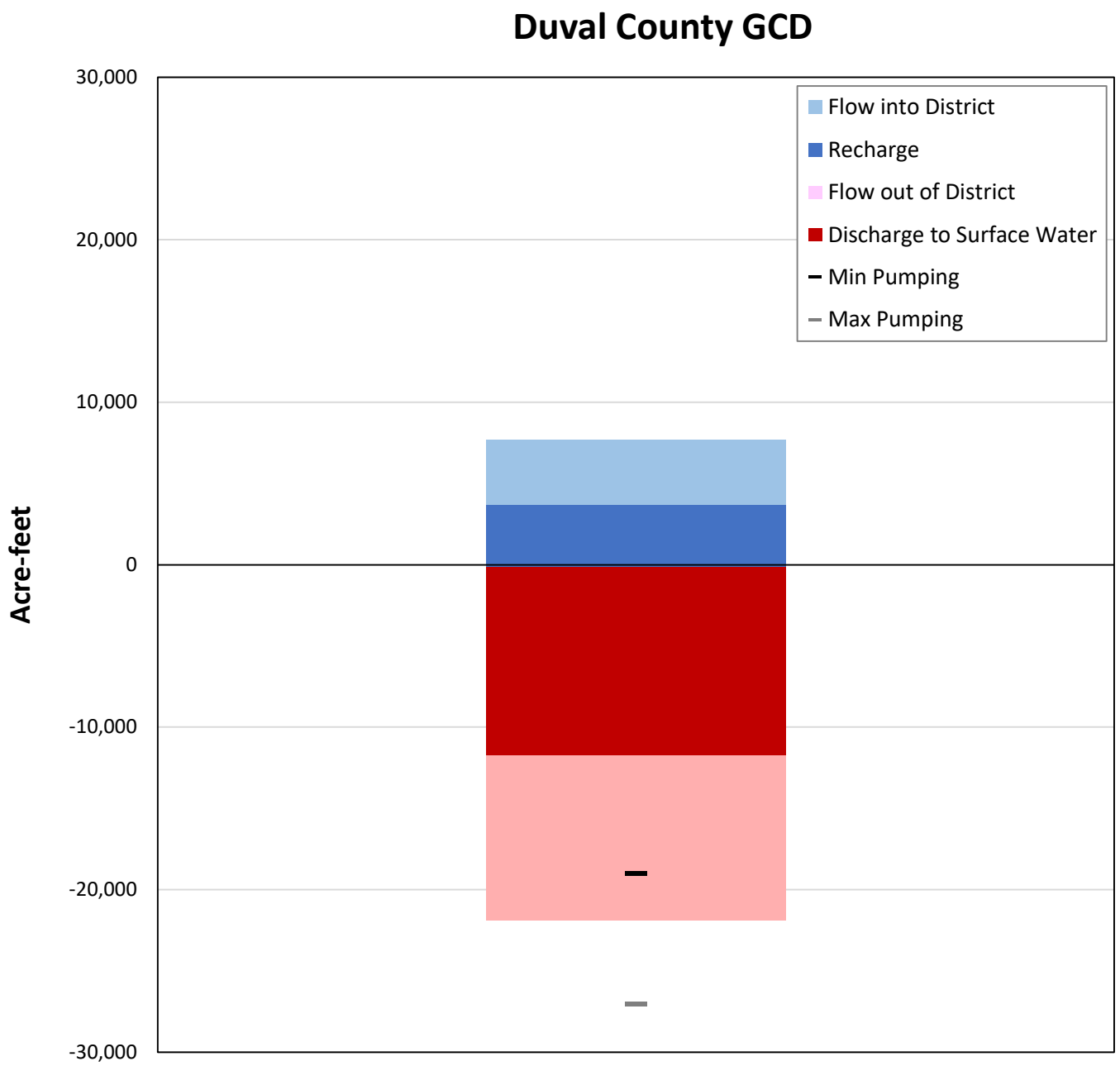
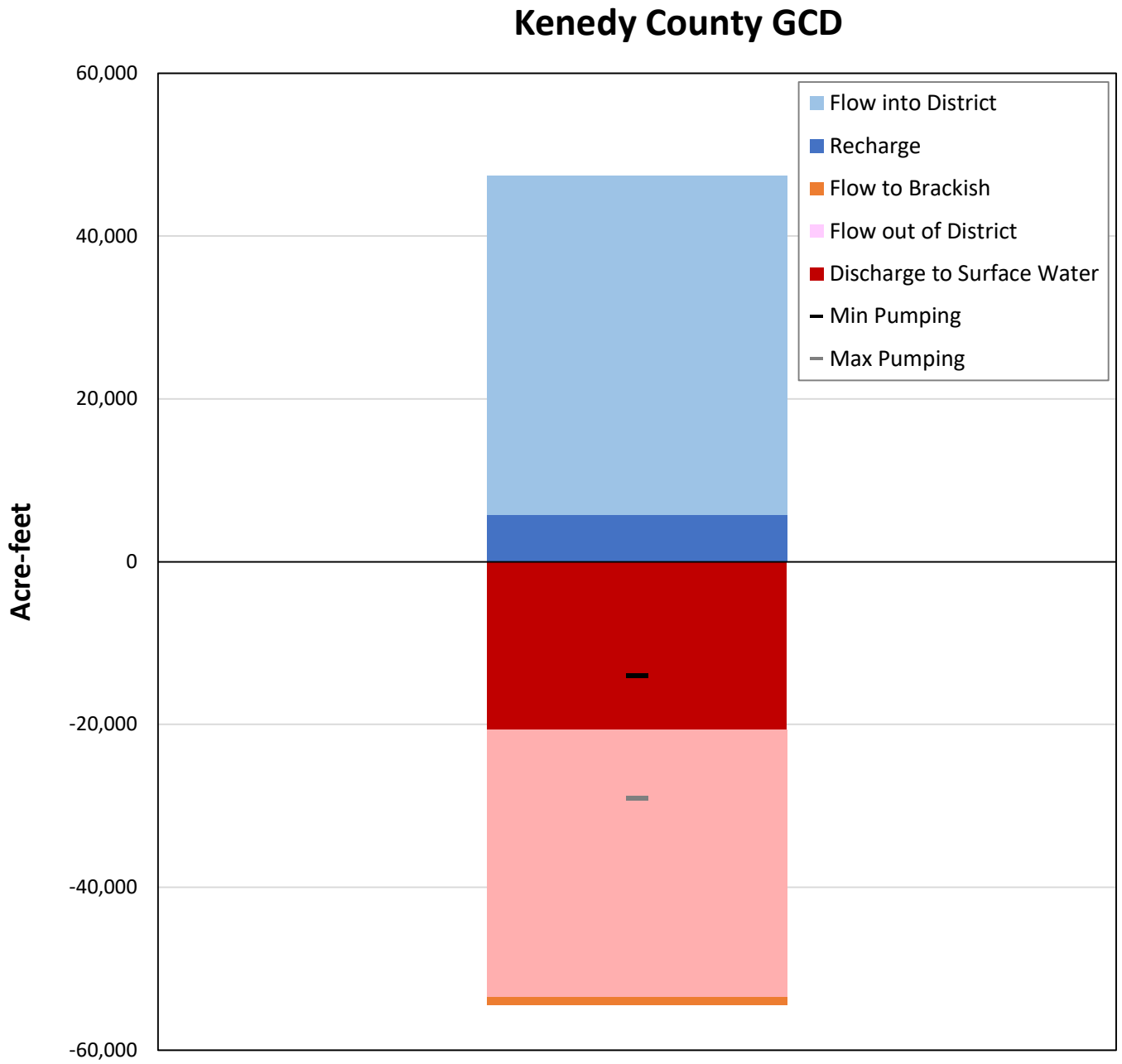

Duval County GCD
30,000
20,000
10,000
0
-10,000
-20,000
-30,000
Acre-feet
Flow into District
Recharge
Flow out of District
Discharge to Surface Water
Min Pumping
Max Pumping

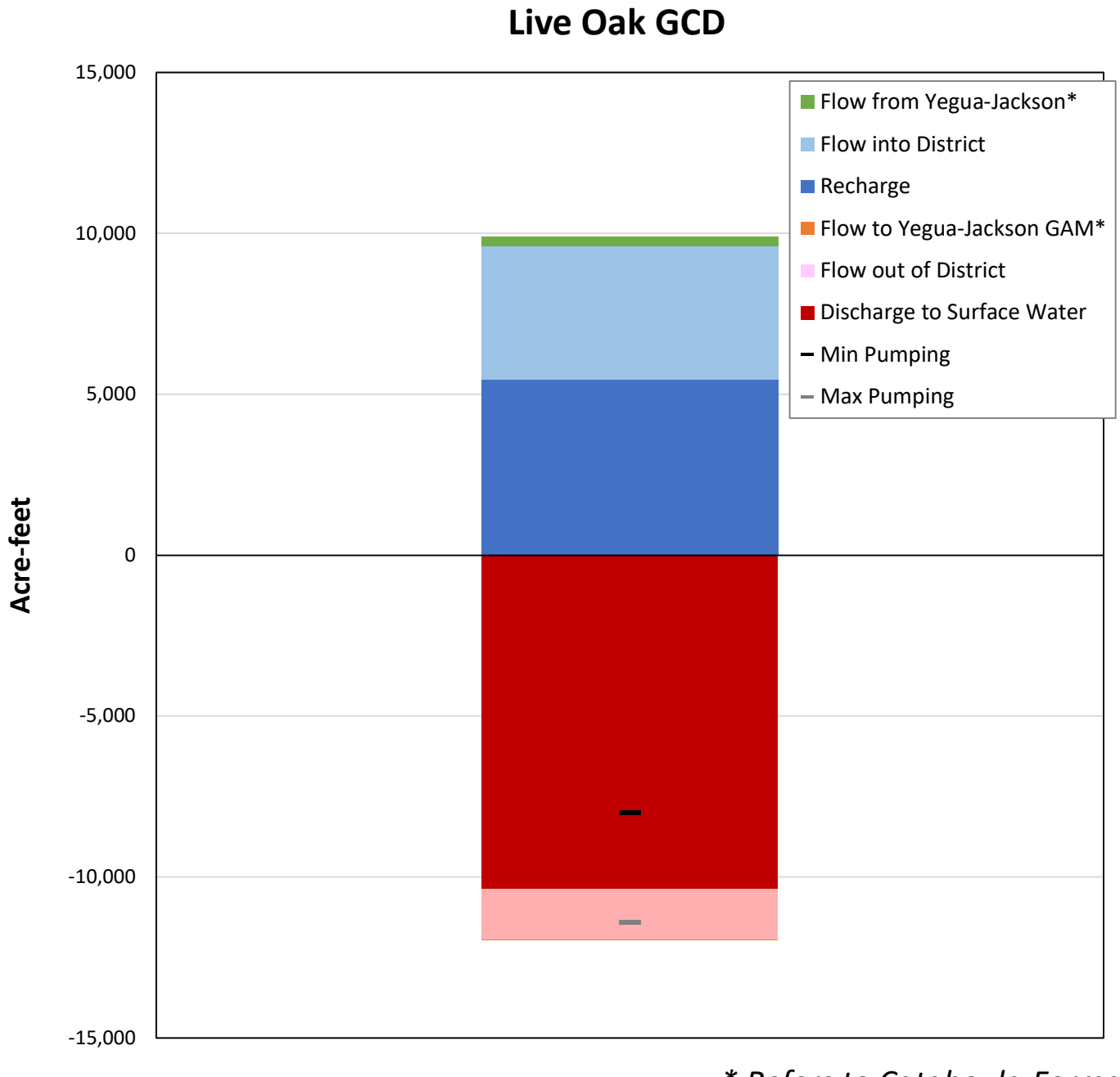
Annual Recharge, Inflows & Discharge – Kenedy County GCD

Management Plan requirement	Aquifer or confining unit	Results
Estimated annual amount of recharge from precipitation to the district	Gulf Coast Aquifer System	5,998
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Gulf Coast Aquifer System	20,643
Estimated annual volume of flow into the district within each aquifer in the district	Gulf Coast Aquifer System	41,396
Estimated annual volume of flow out of the district within each aquifer in the district	Gulf Coast Aquifer System	32,644
Estimated net annual volume of flow between each aquifer in the district *	From Gulf Coast Aquifer System to brackish water containing formations	1,216


Kenedy County GCD
60,000
40,000
20,000
0
-20,000
-40,000
-60,000
Acre-feet
Flow into District
Recharge
Flow to Brackish
Flow out of District
Discharge to Surface Water
Min Pumping
Max Pumping

Annual Recharge, Inflows & Discharge – Live Oak GCD

Management Plan requirement	Aquifer or confining unit	Results
Estimated annual amount of recharge from precipitation to the district	Gulf Coast Aquifer System	5,487
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Gulf Coast Aquifer System	10,378
Estimated annual volume of flow into the district within each aquifer in the district	Gulf Coast Aquifer System	4,124
Estimated annual volume of flow out of the district within each aquifer in the district	Gulf Coast Aquifer System	1,572
Estimated net annual volume of flow between each aquifer in the district	From the Catahoula Formation into Yegua-Jackson Aquifer[1]	7
	From the confined Yegua-Jackson units into the Catahoula Formation[2]	273



** Refers to Catahoula Formation in Yegua-Jackson GAM*

Annual Recharge, Inflows & Discharge – McMullen GCD

Management Plan requirement	*Aquifer or confining unit*	*Results*
Estimated annual amount of recharge from precipitation to the district	Gulf Coast Aquifer System	244
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Gulf Coast Aquifer System	809
Estimated annual volume of flow into the district within each aquifer in the district	Gulf Coast Aquifer System	242
Estimated annual volume of flow out of the district within each aquifer in the district	Gulf Coast Aquifer System	594
Estimated net annual volume of flow between each aquifer in the district	Not Applicable*	Not Applicable*

*Model assumes no-flow conditions at the base

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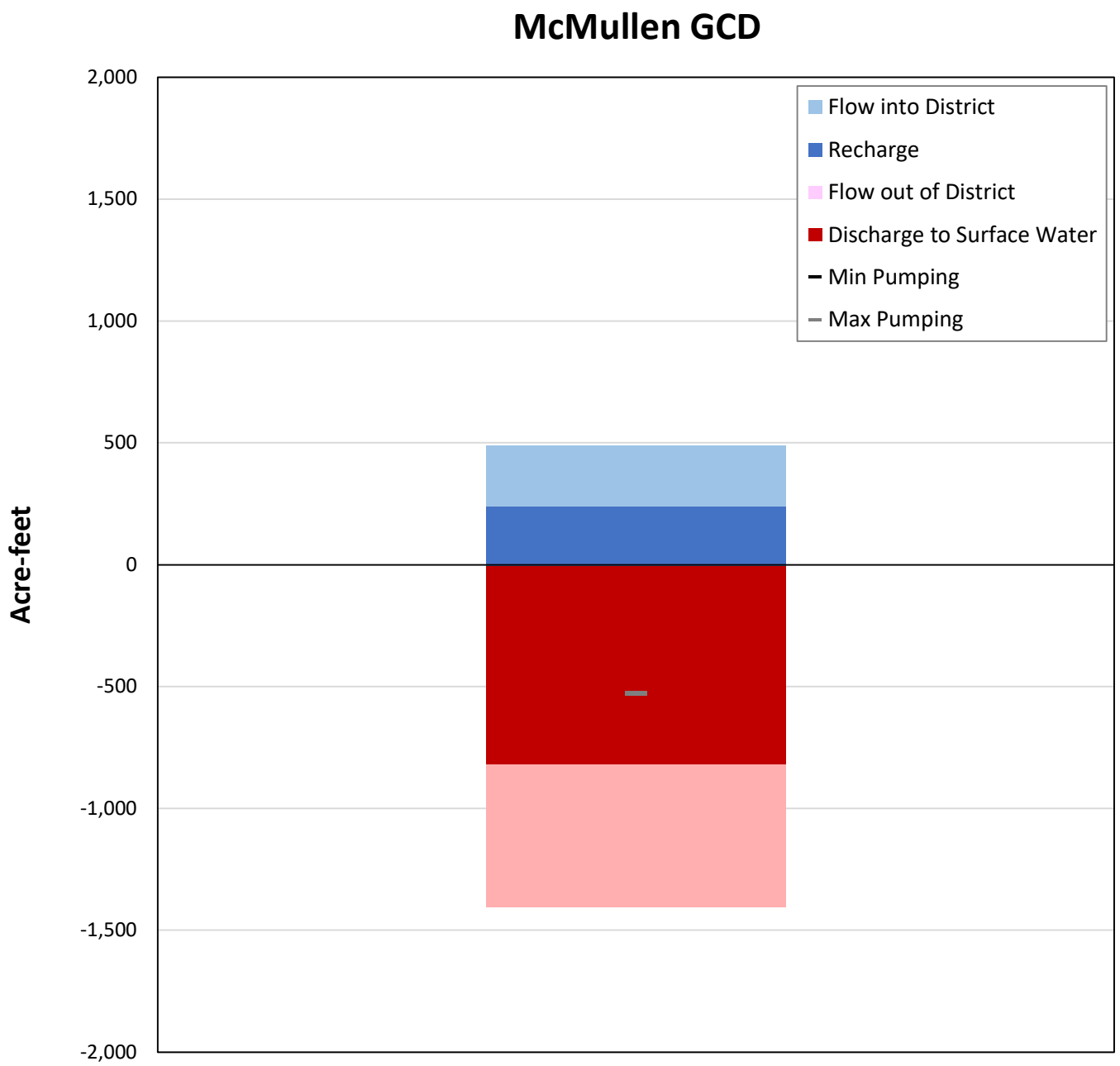
McMullen GCD
Acre-feet
2,000
1,500
1,000
500
0
-500
-1,000
-1,500
-2,000
Flow into District
Recharge
Flow out of District
Discharge to Surface Water
Min Pumping
Max Pumping

Annual Recharge, Inflows & Discharge – Red Sands GCD

Management Plan requirement	Aquifer or confining unit	Results
Estimated annual amount of recharge from precipitation to the district	Gulf Coast Aquifer System	675
Estimated annual volume of water that discharges from the aquifer to springs and any surface-water body including lakes, streams, rivers, springs, and flowing wells	Gulf Coast Aquifer System	0
Estimated annual volume of flow into the district within each aquifer in the district	Gulf Coast Aquifer System	6,324
Estimated annual volume of flow out of the district within each aquifer in the district	Gulf Coast Aquifer System	6,548
Estimated net annual volume of flow between each aquifer in the district	Not applicable*	Not applicable

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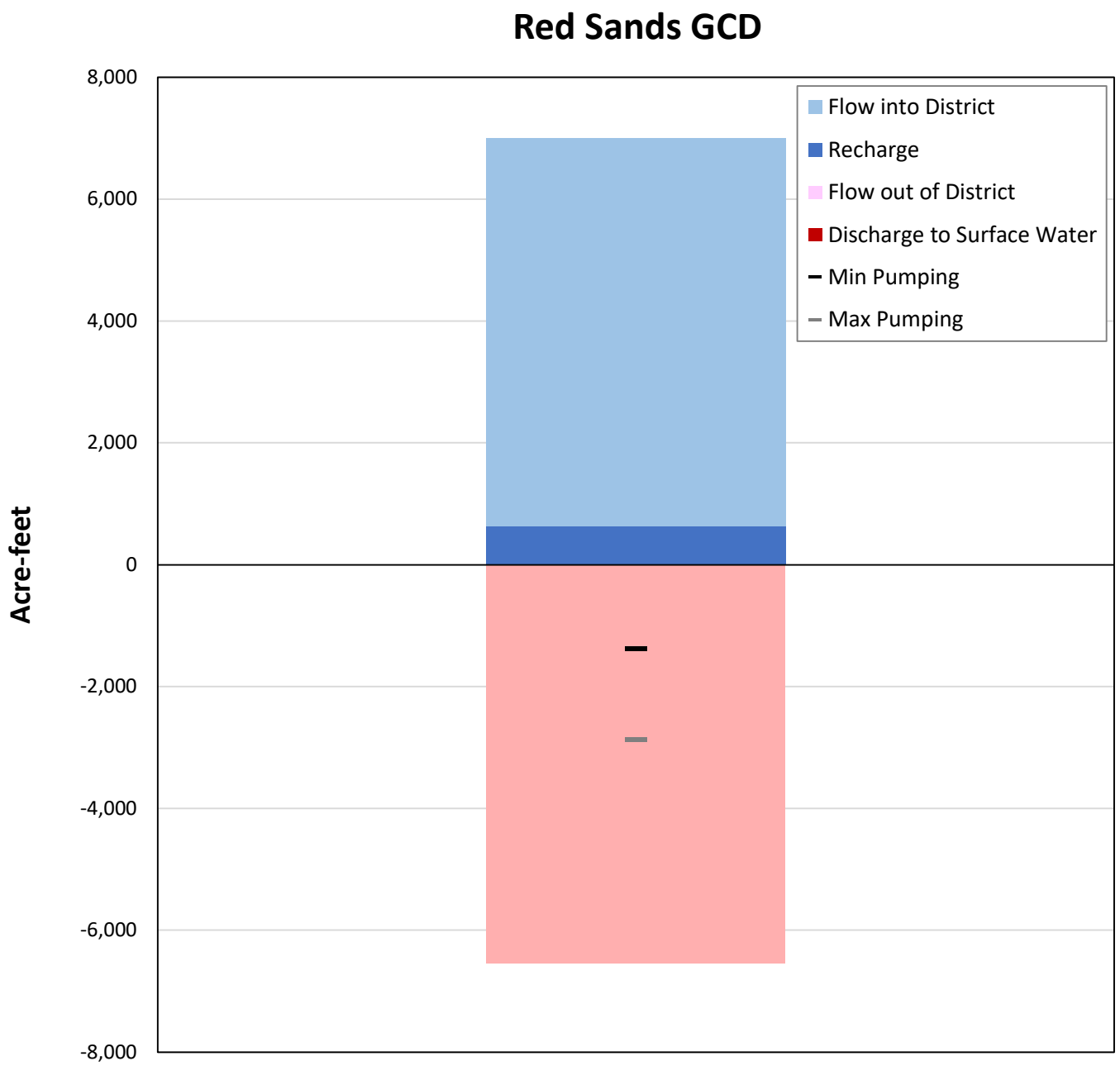
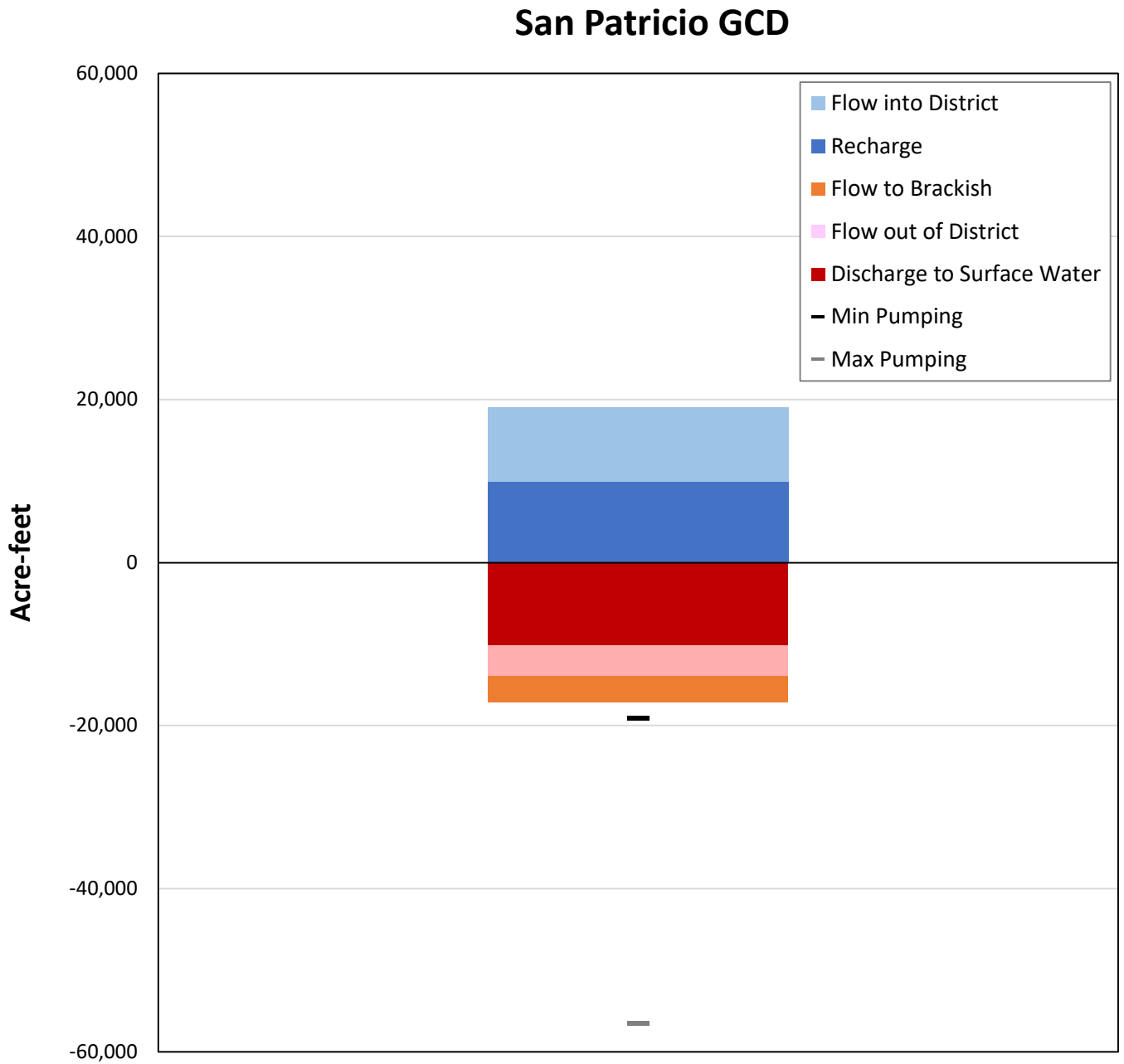

Red Sands GCD
8,000
6,000
4,000
2,000
0
-2,000
-4,000
-6,000
-8,000
Acre-feet
Flow into District
Recharge
Flow out of District
Discharge to Surface Water
Min Pumping
Max Pumping

Annual Recharge, Inflows & Discharge – San Patricio GCD

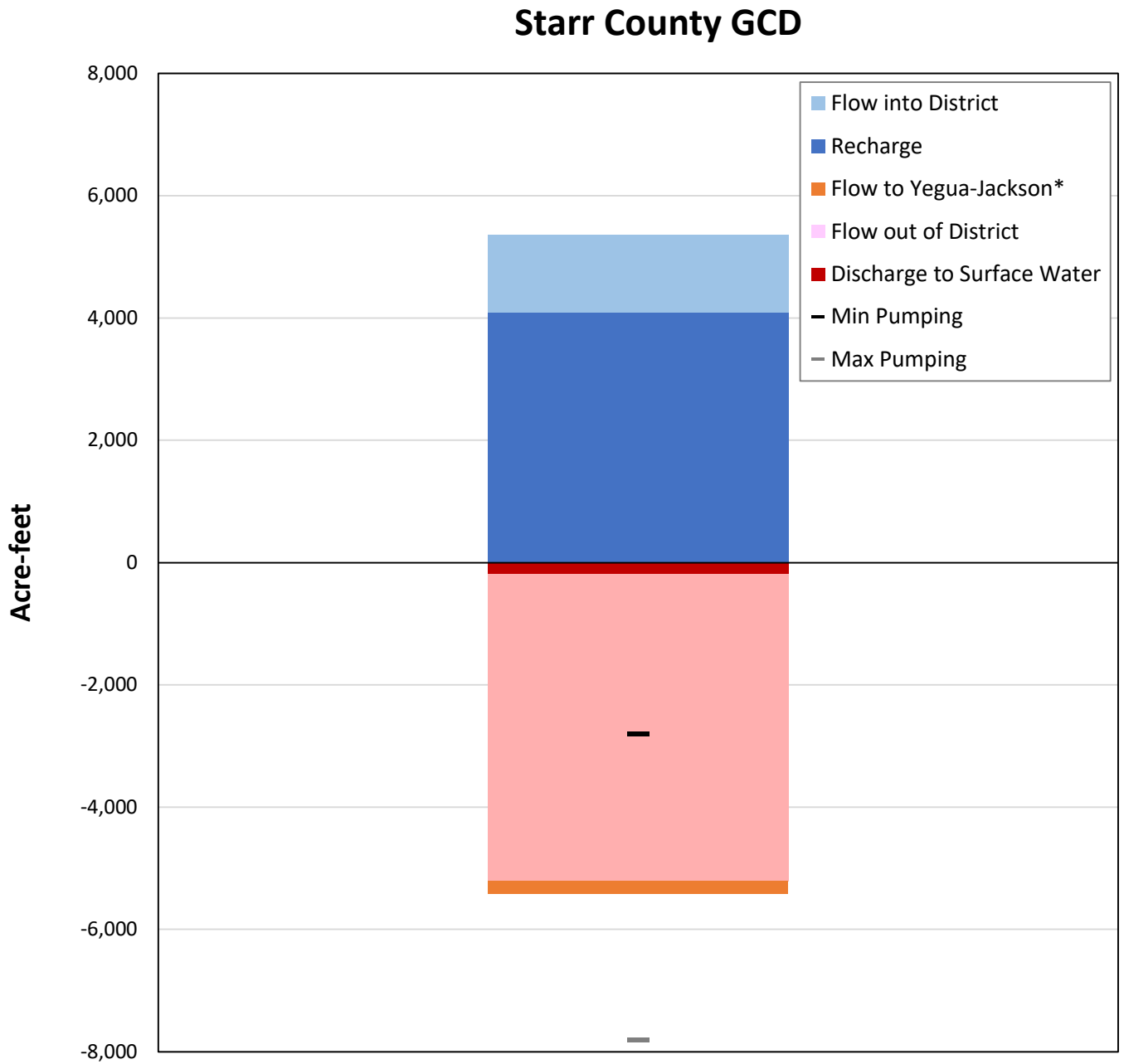
Management Plan requirement	*Aquifer or confining unit*	*Results*
Estimated annual amount of recharge from precipitation to the district	Gulf Coast Aquifer System	9,977
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Gulf Coast Aquifer System	10,100
Estimated annual volume of flow into the district within each aquifer in the district	Gulf Coast Aquifer System	9,013
Estimated annual volume of flow out of the district within each aquifer in the district	Gulf Coast Aquifer System	3,807
Estimated net annual volume of flow between each aquifer in the district[1]	From Gulf Coast Aquifer System to formations containing brackish water	3,216


San Patricio GCD
60,000
40,000
20,000
0
-20,000
-40,000
-60,000
Acre-feet
Flow into District
Recharge
Flow to Brackish
Flow out of District
Discharge to Surface Water
Min Pumping
Max Pumping

Annual Recharge, Inflows & Discharge – Starr County GCD

Management Plan requirement	Aquifer or confining unit	Results
Estimated annual amount of recharge from precipitation to the district	Gulf Coast Aquifer System	4,119
Estimated annual volume of water that discharges from the aquifer to springs and any surface-water body including lakes, streams, and rivers	Gulf Coast Aquifer System	167
Estimated annual volume of flow into the district within each aquifer in the district	Gulf Coast Aquifer System	1,241
Estimated annual volume of flow out of the district within each aquifer in the district	Gulf Coast Aquifer System	5,046
Estimated net annual volume of flow between each aquifer in the district	From Gulf Coast Aquifer System (Catahoula Formation) to Yegua-Jackson Aquifer	210*

*: Flow calculated from the groundwater availability model for the Yegua-Jackson Aquifer.



** Refers to Catahoula Formation in Yegua-Jackson GAM*

Explanatory Report

- Previous report (O'Rourke, 2017) will be used as template
- Explanatory report will briefly summarize this presentation & provide a copy as appendix
- Any District can provide INTERA with more District-specific information or details regarding this topic, if they feel it is necessary
- Deadline for addl District-specific information: next GMA meeting

Questions?

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