GROUNDWATER MANAGEMENT AREA 9

JOINT PLANNING COMMITTEE MEETING

March 26, 2024

AGS
Advanced Groundwater Solutions, LLC

CLARIFICATION / DISCLAIMER

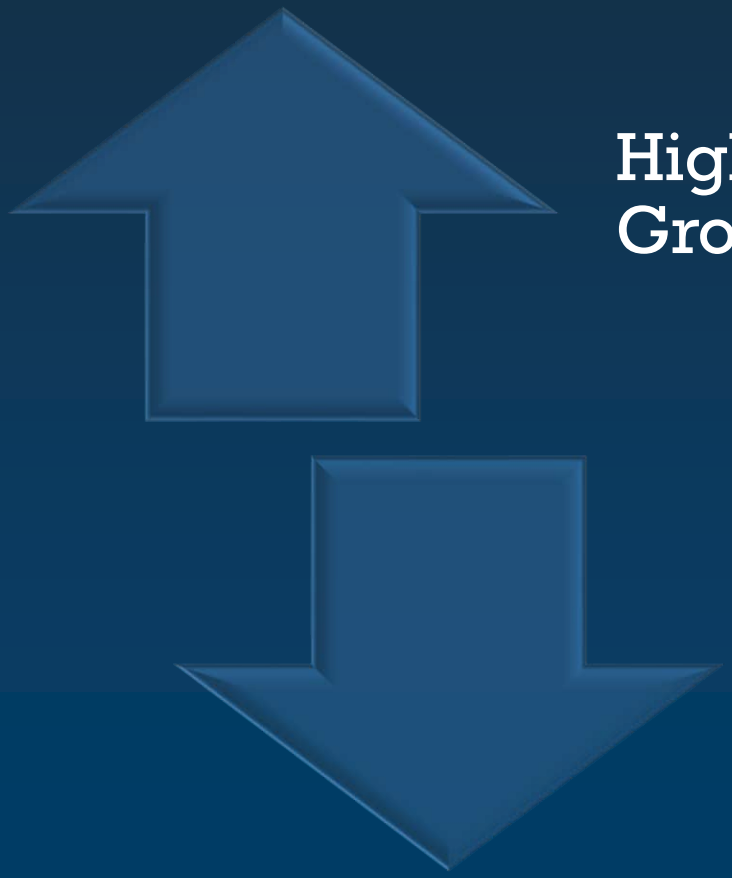
- GCDs in GMA 9 will determine DFCs, not the hydrogeologic consultant.
- Chapter 36 of the Texas Water Code contains concepts that blend legal and technical issues. AGS is not a law firm and we do not provide legal advice. Any statements relating to regulatory or legal issues shall not be considered legal advice.
- AGS may provide commentary based on our experience working with groundwater conservation districts, permitting, joint groundwater planning, GCD rules and management plans, water supply entities, and our general understanding of industry practices.

AGENDA ITEM 8

Presentation by AGS on three of the nine factors in accordance with TWC 36.108(d)

- the water supply needs and water management strategies included in the state water plan (Item 2)
- 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; (Item 3)
- the impact on subsidence; (Item 5)

BALANCE TEST FOR DESIRED FUTURE CONDITIONS



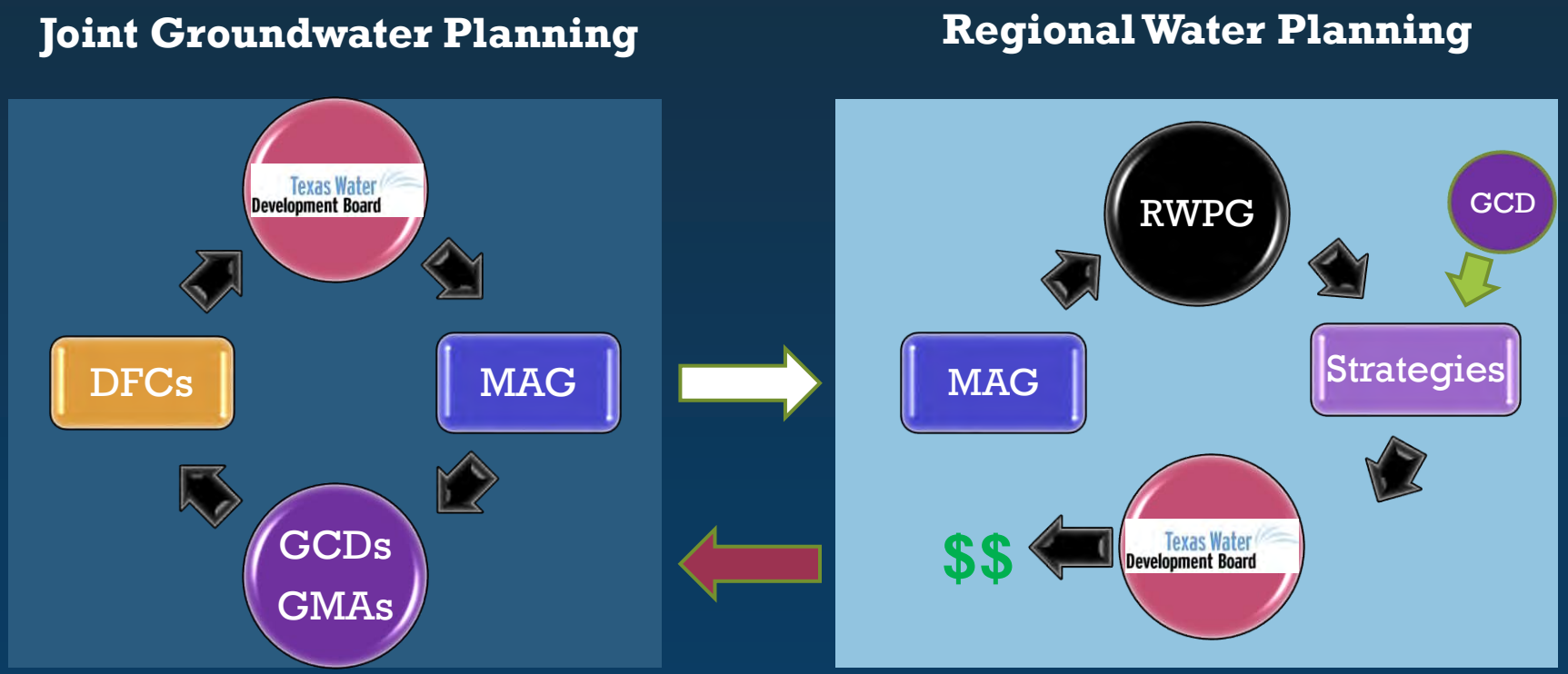
Highest Practicable Level of Groundwater Production

Conservation, Preservation, Protection, Recharging, and Prevention of Waste of Groundwater, and Control of Subsidence

FACTORS TO CONSIDER

Environmental Impacts	Subsidence Impacts	Hydrological Conditions
Aquifer Uses or Conditions	Supply Needs & Management Strategies	Private Property Rights
Socioeconomic Impacts	DFC Feasibility	Other Relevant Information

TEXAS GROUNDWATER PLANNING CYCLE



Discussion of Three of Nine Factors of TWC 36.108(d)

Presented to GMA 9 on March 26, 2024

AGS
Advanced Groundwater Solutions, LLC

2nd Factor (Section 36.108(d))- "Needs and Strategies"

- The districts shall consider:

  "The water supply needs and water management strategies included in the state water plan"

- This includes:
  - Demands
  - Supplies
  - Needs
  - Water Management Strategies

Notes on State Water Plan Data

- Data is from the 2022 State Water Plan
- More than half of the GMA 9 counties are only partially in GMA 9. Data summaries are for entire counties.

Demands

- Water Demand is the annual volume of water that a water user group would require during drought-of-record conditions.
- Demand is not specific to surface water or groundwater

Supplies

- Existing supplies are the amount of water that is physically and legally available to a water user group
- Existing supplies may be “MAG limited”
- For groundwater, it will be based on a number of factors including permits, wells and well capacities, etc.
- No specified methodology on how to calculate existing groundwater supplies. Each region may calculate these differently.

Needs

- Need is a potential water supply shortfall based on the difference between the projected water demands and existing water supplies
- Need/Surplus = Supply – Demand
  - If >0, then it is a surplus
  - If <0, then it is a need
- Demands vary by decade
- Needs vary by decade based on varying projected demands
- Needs are calculated for each water user group
- Needs are not addressed solely with groundwater and may not be met at all

Strategies

- A water management strategy is a plan or specific project to meet a water need for additional water by a water user group
- Strategies may include expanding the use of an existing supply or developing new supplies
- Strategies using groundwater from within an area (county, GMA, etc.) may not necessarily benefit a water user group located within that area
- Strategies discussed do not include ASR, brush control
- Strategies are not restricted to that county’s need

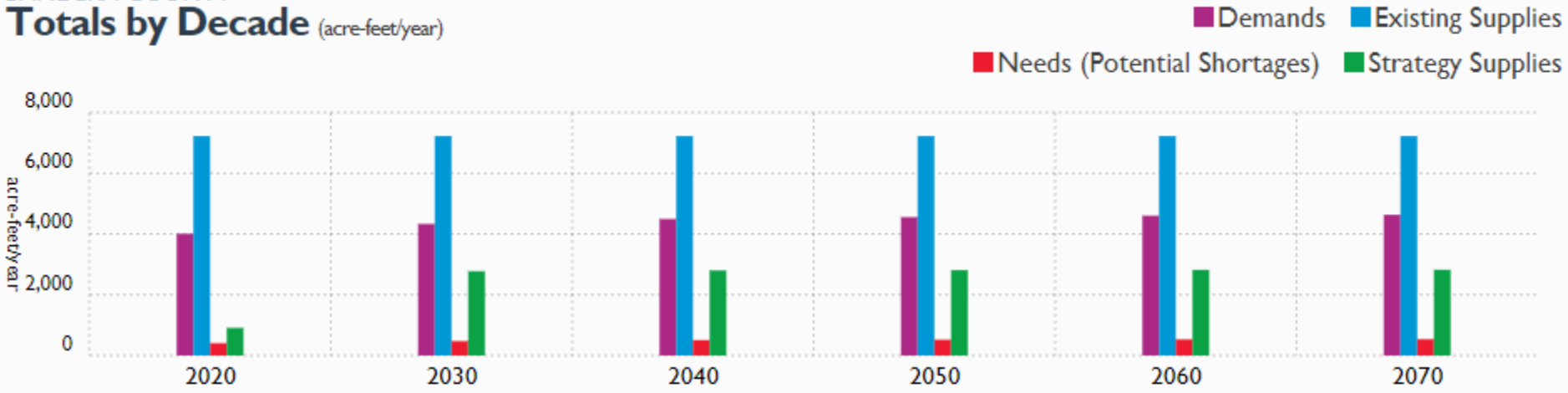
Bandera County

- Entire county is within GMA 9
- Population projected to grow from 24,991 (2020) to 32,357 (2070)
- Demand projected to increase to 4,629 ac-ft/yr in 2070

Bandera County

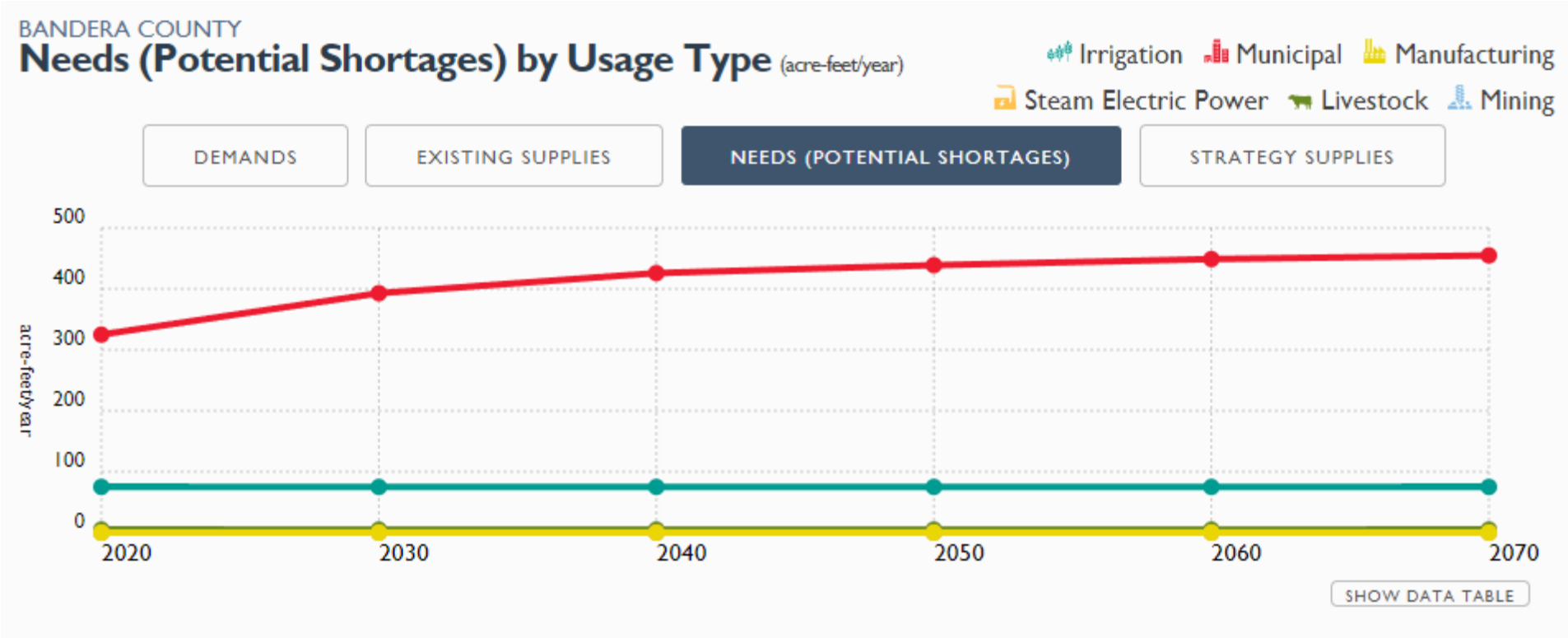
BANDERA COUNTY

Totals by Decade (acre-feet/year)



	2020	2030	2040	2050	2060	2070
Demands	4,007	4,330	4,493	4,553	4,601	4,629
Existing Supplies	7,219	7,219	7,219	7,219	7,219	7,219
Needs (Potential Shortages)	405	473	506	519	529	535
Strategy Supplies	909	2,773	2,799	2,809	2,817	2,821

Bandera County



Bandera County Strategies

- Six recommended groundwater water management strategies
- All in the Trinity Aquifer
- Benefitting: City of Bandera, Bandera FWSD 1, Medina WSC, Irrigation, and Livestock
- Total of 396 ac-ft/yr beginning in 2020
- Majority of benefit for PWS (316 ac-ft/yr)

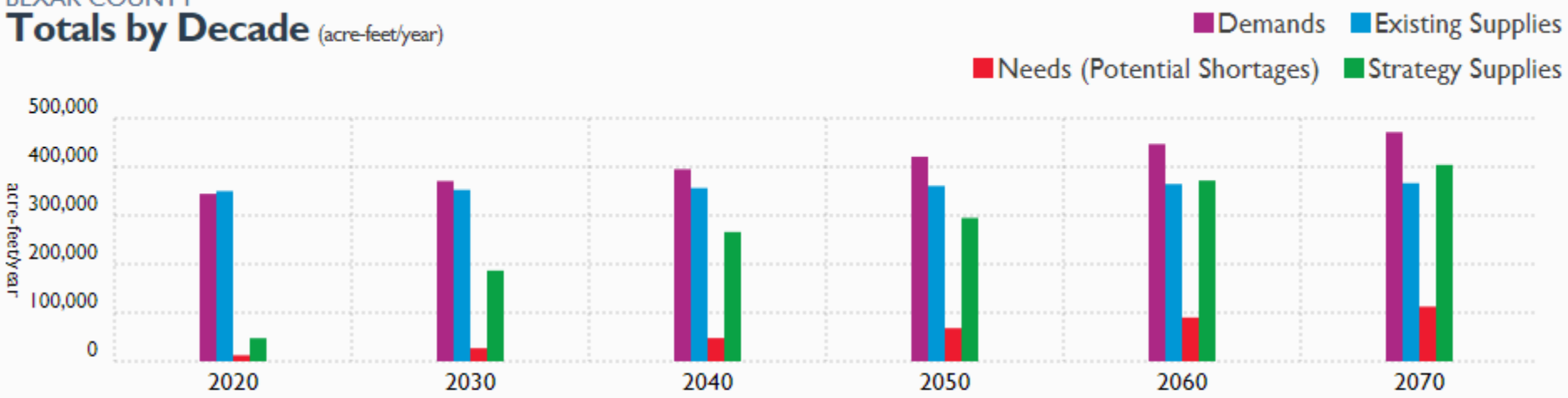
Bexar County

- Only the northern ~1/4 is in GMA 9
- Population projected to increase from 1,974,041 (2020) to 3,094,726 (2070) for the entire county
- Demand projected to increase to 471,297 ac-ft/yr in 2070 for the entire county

Bexar County

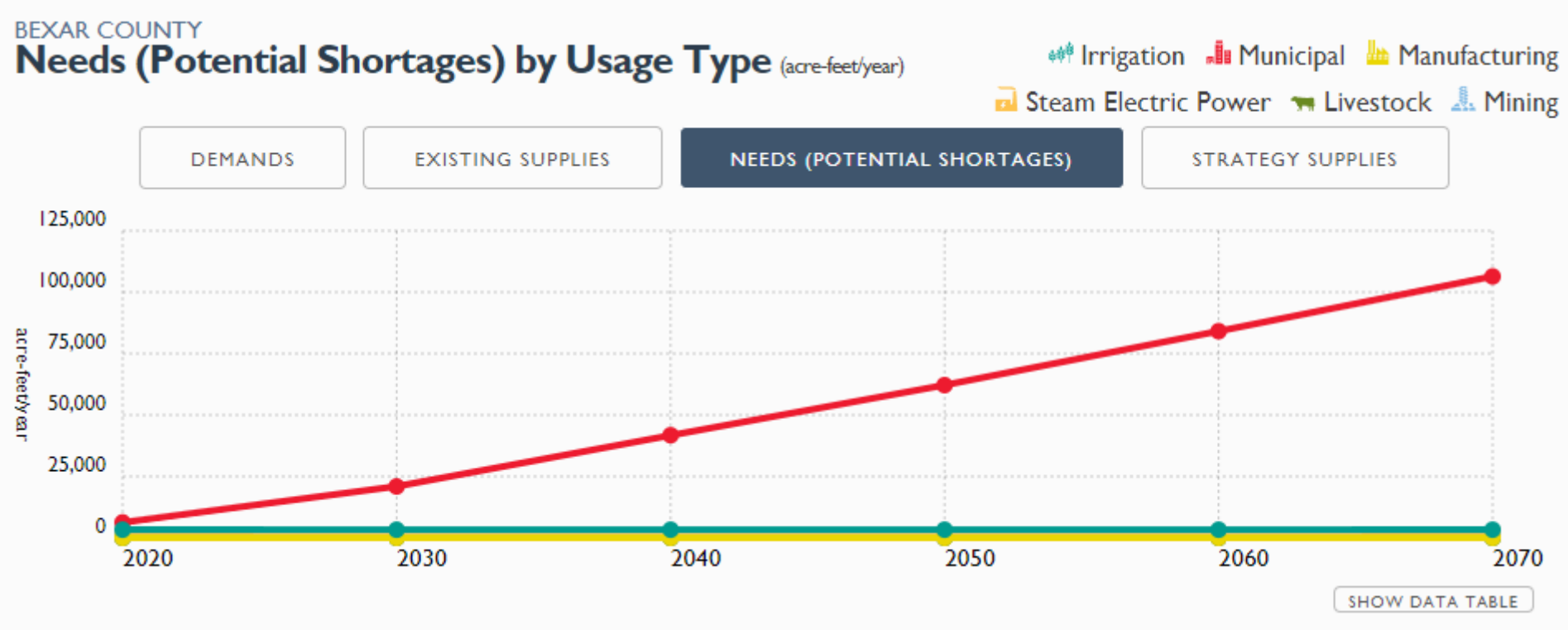
BEXAR COUNTY

Totals by Decade (acre-feet/year)



	2020	2030	2040	2050	2060	2070
Demands	344,503	370,868	395,122	420,879	446,877	471,297
Existing Supplies	350,128	352,726	356,461	360,814	364,601	366,478
Needs (Potential Shortages)	12,387	27,016	47,872	68,266	90,218	112,499
Strategy Supplies	47,631	186,674	265,999	294,951	371,856	404,066

Bexar County



Bexar County

- Only one recommended groundwater water management strategy
  (that isn't Edwards-BFZ or Carrizo-Wilcox)
- Local Trinity Aquifer development for Water Services
- 252 to 504 ac-ft/yr beginning in 2030

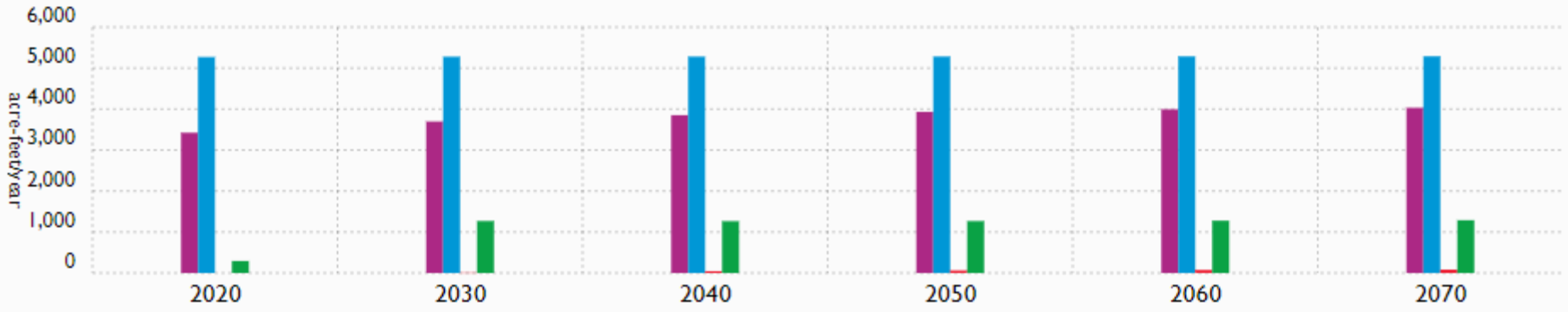
Blanco County

- Entire county is within GMA 9
- Population projected to increase from 13,105 (2020) to 18,472 (2070)
- Demand projected to increase to 4,032 ac-ft/yr in 2070

Blanco County

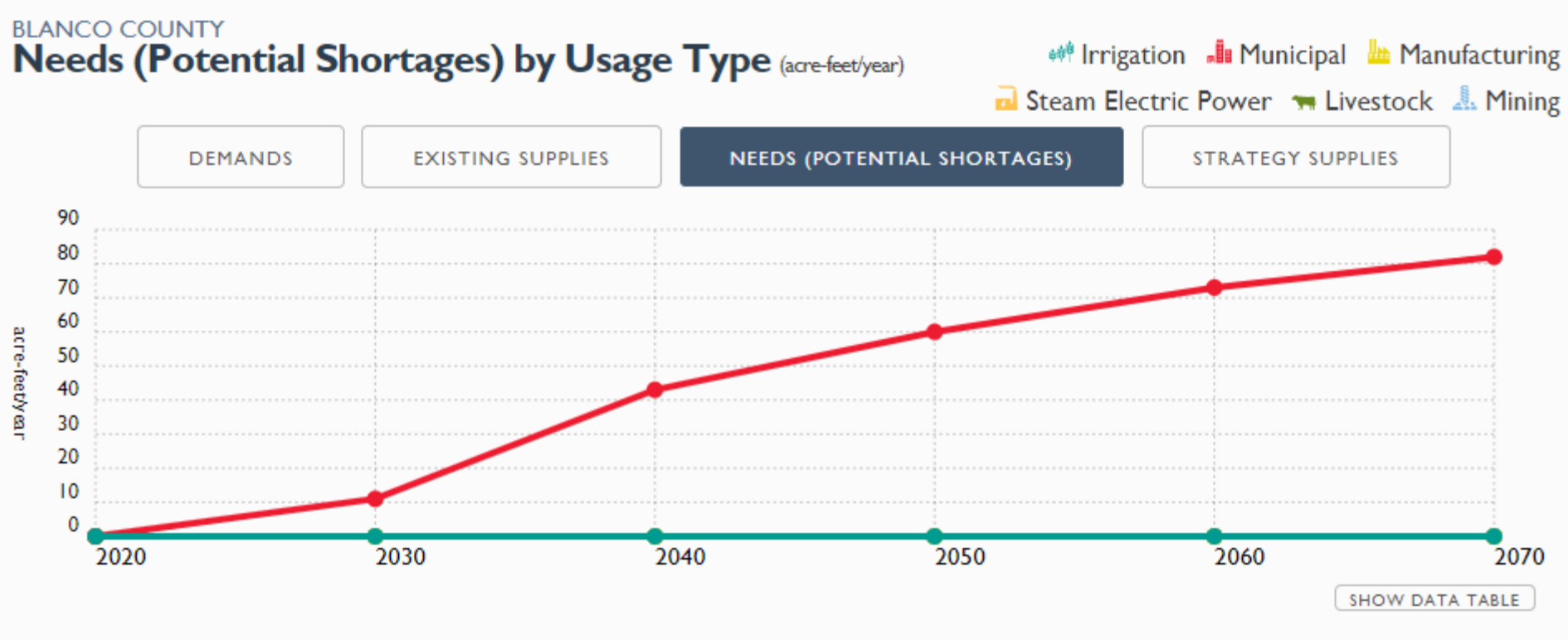
BLANCO COUNTY

Totals by Decade (acre-feet/year)



	2020	2030	2040	2050	2060	2070
Demands	3,423	3,697	3,851	3,932	3,994	4,032
Existing Supplies	5,270	5,279	5,281	5,283	5,286	5,288
Needs (Potential Shortages)	0	11	43	60	73	82
Strategy Supplies	292	1,269	1,265	1,267	1,277	1,288

Blanco County



Blanco County

- One groundwater water management strategy
- Groundwater well development in the Ellenburger-San Saba Aquifer for the City of Johnson City
- 100 ac-ft/yr beginning in 2030

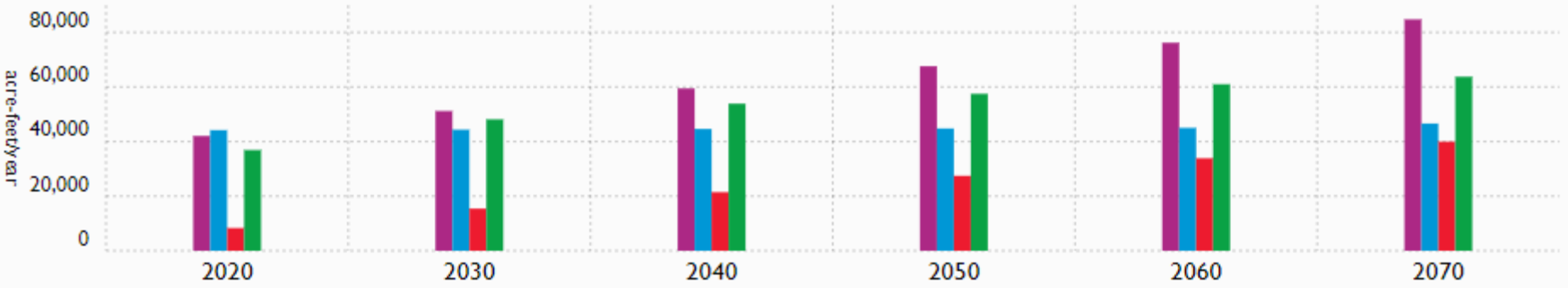
Comal County

- Approximately half of the county is within GMA 9
- Population projected to increase from 152,499 (2020) to 357,464 (2070)
- Demand projected to increase to 84,763 ac-ft/yr in 2070

Comal County

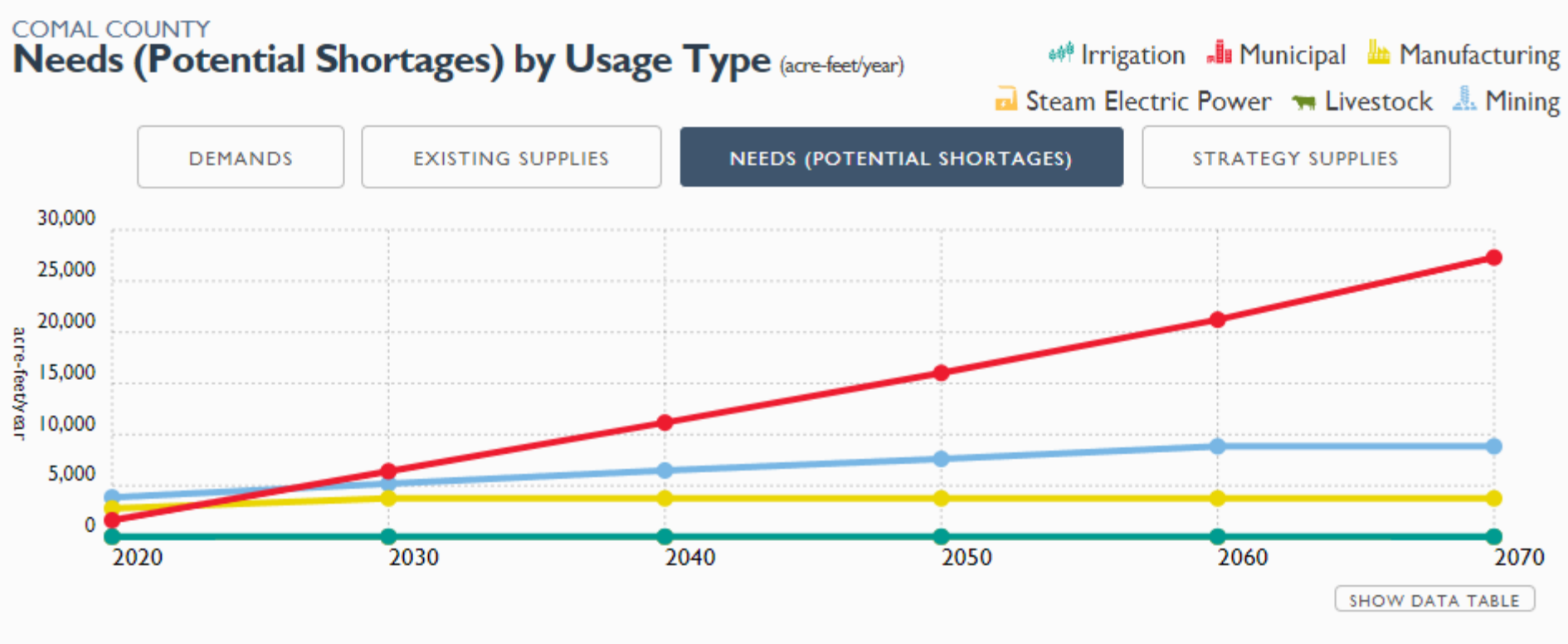
COMAL COUNTY

Totals by Decade (acre-feet/year)



	2020	2030	2040	2050	2060	2070
Demands	42,052	51,191	59,458	67,595	76,204	84,763
Existing Supplies	44,176	44,353	44,611	44,792	45,014	46,603
Needs (Potential Shortages)	8,307	15,421	21,459	27,434	33,874	39,952
Strategy Supplies	36,887	48,133	53,873	57,496	61,001	63,748

Comal County



Comal County

- Two recommended groundwater water management strategies
- Local Trinity Aquifer development for Clear Water Estates Water System, Garden Ridge, Wingert Water Systems, and mining for 5,957 to 13,574 ac-ft/yr beginning in 2020 *(majority of this is for mining)*
- Trinity Aquifer development for New Braunfels Utilities for 3,360 ac-ft/yr beginning in 2030

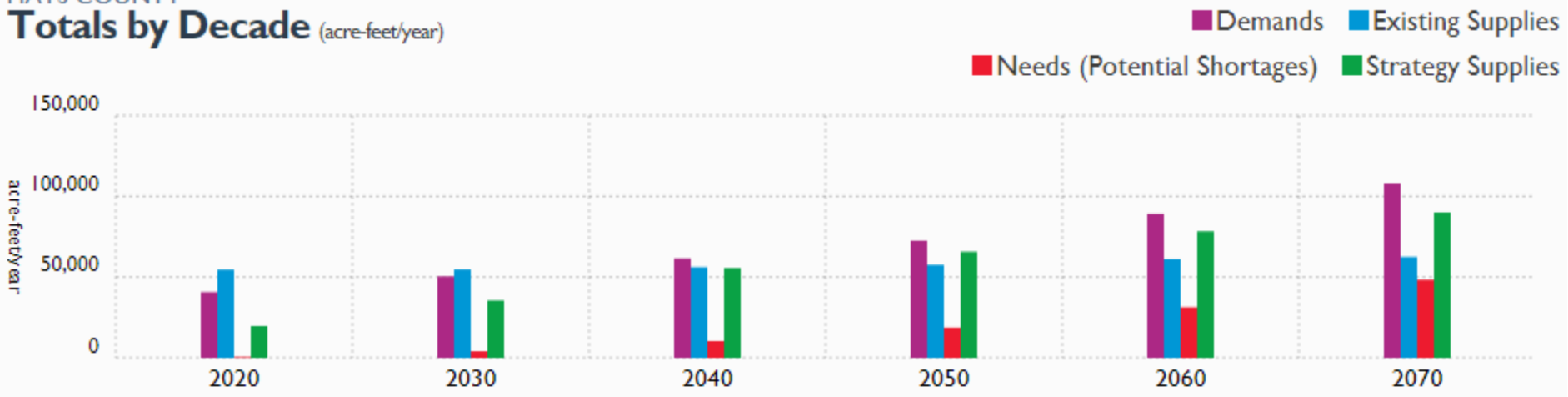
Hays County

- Approximately half of the county is within GMA 9
- Population projected to increase from 238,862 (2020) to 728,344 (2070)
- Demand projected to increase to 107,760 ac-ft/yr in 2070

Hays County

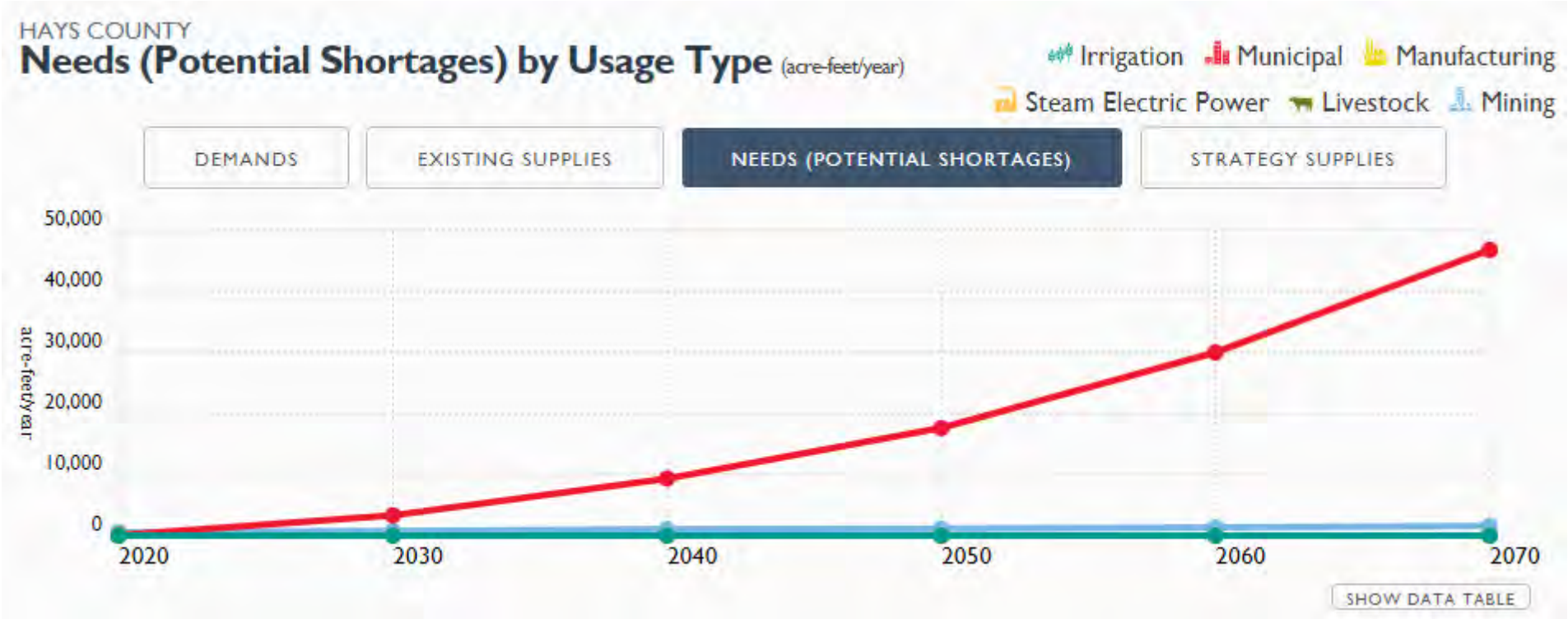
HAYS COUNTY

Totals by Decade (acre-feet/year)



	2020	2030	2040	2050	2060	2070
Demands	40,729	50,453	61,476	72,555	89,124	107,760
Existing Supplies	54,630	54,727	56,157	57,587	61,082	62,497
Needs (Potential Shortages)	626	4,079	10,390	18,751	31,337	48,349
Strategy Supplies	19,698	35,543	55,564	65,714	78,368	90,058

Hays County


HAYS COUNTY
Needs (Potential Shortages) by Usage Type (acre-feet/year)
Irrigation
Municipal
Manufacturing
Steam Electric Power
Livestock
Mining
DEMANDS
EXISTING SUPPLIES
NEEDS (POTENTIAL SHORTAGES)
STRATEGY SUPPLIES
50,000
40,000
30,000
20,000
10,000
0
acre-feet/year
2020
2030
2040
2050
2060
2070
SHOW DATA TABLE

Hays County

- Three recommended groundwater water management strategies
- Trinity Aquifer well field for County Line SUD for 500 to 740 ac-ft/yr beginning in 2050
- Trinity Aquifer well field for Maxwell WSC for 230 ac-ft/yr beginning in 2040
- Expansion of Trinity Aquifer supplies for Dripping Springs WSC, county-other, and mining for 267 to 767 ac-ft/yr beginning in 2020

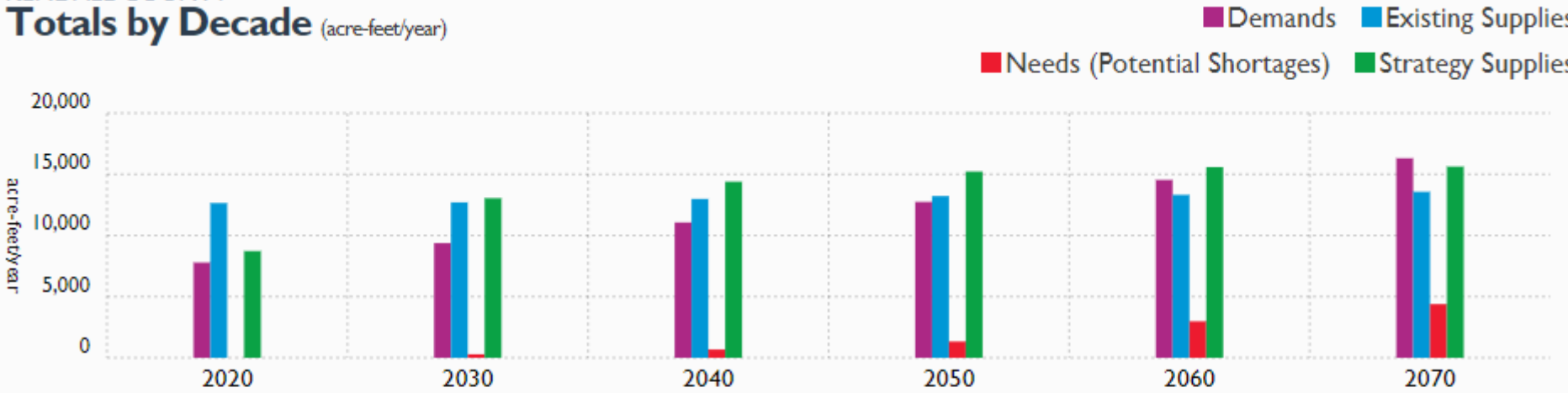
Kendall County

- Entire county is within GMA 9
- Population projected to increase from 42,185 (2020) to 94,549 (2070)
- Demand projected to increase to 16,310 ac-ft/yr in 2070

Kendall County

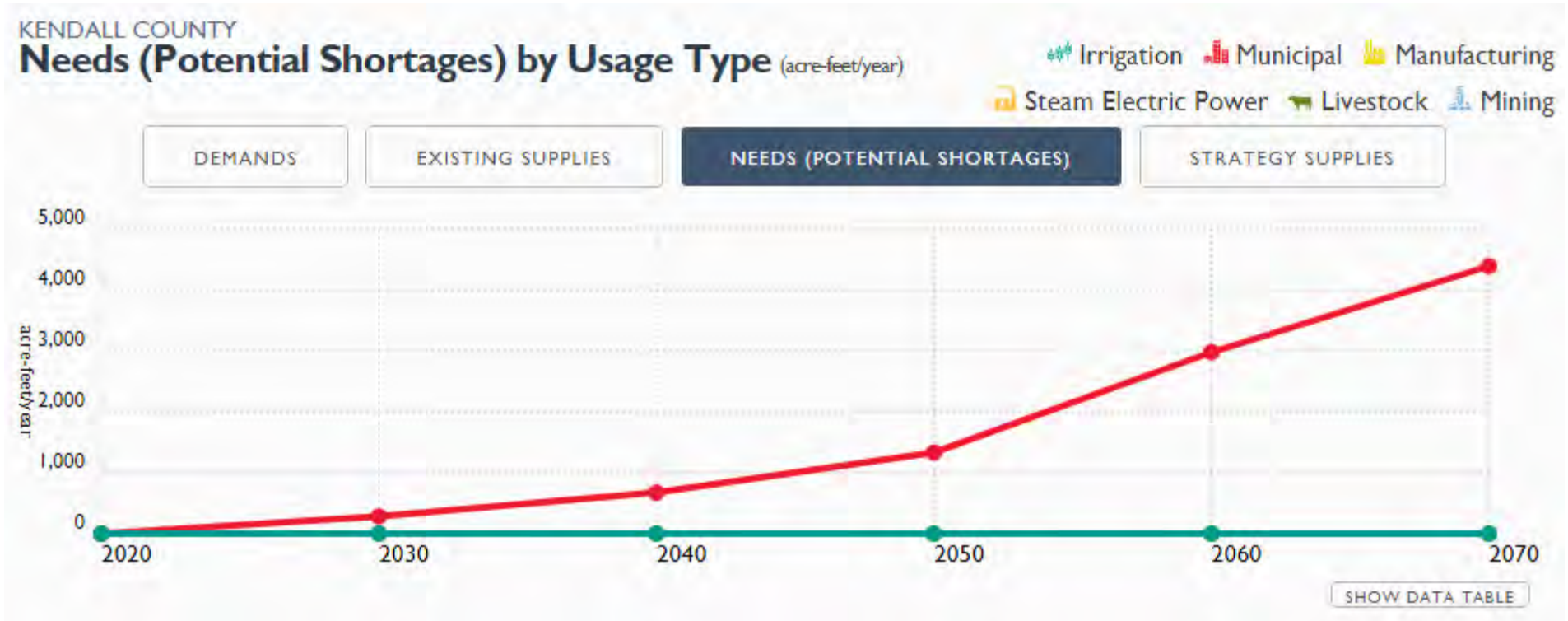
KENDALL COUNTY

Totals by Decade (acre-feet/year)



	2020	2030	2040	2050	2060	2070
Demands	7,784	9,371	11,062	12,743	14,540	16,310
Existing Supplies	12,649	12,707	12,982	13,216	13,318	13,568
Needs (Potential Shortages)	1	283	674	1,332	2,980	4,390
Strategy Supplies	8,722	13,046	14,395	15,223	15,588	15,628

Kendall County



Kendall County

- One groundwater water management strategy
- Groundwater well development in the Trinity Aquifer for Kendall West Utility
- 282 to 1,596 ac-ft/yr beginning in 2030

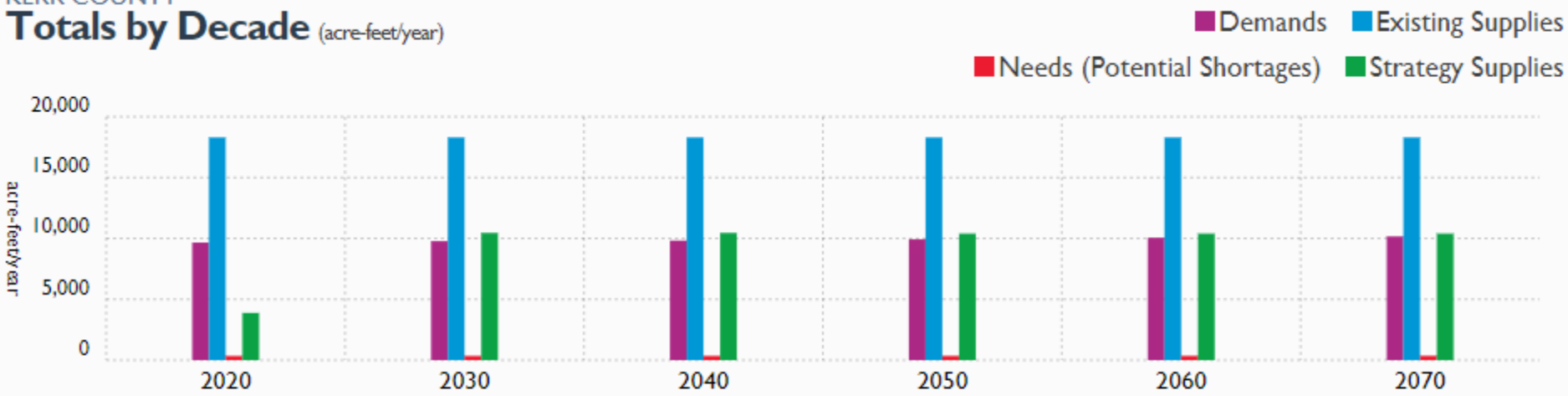
Kerr County

- Entire county is within GMA 9
- Population projected to increase from 52,644 (2020) to 60,725 (2070)
- Demand projected to increase to 10,166 ac-ft/yr in 2070

Kerr County

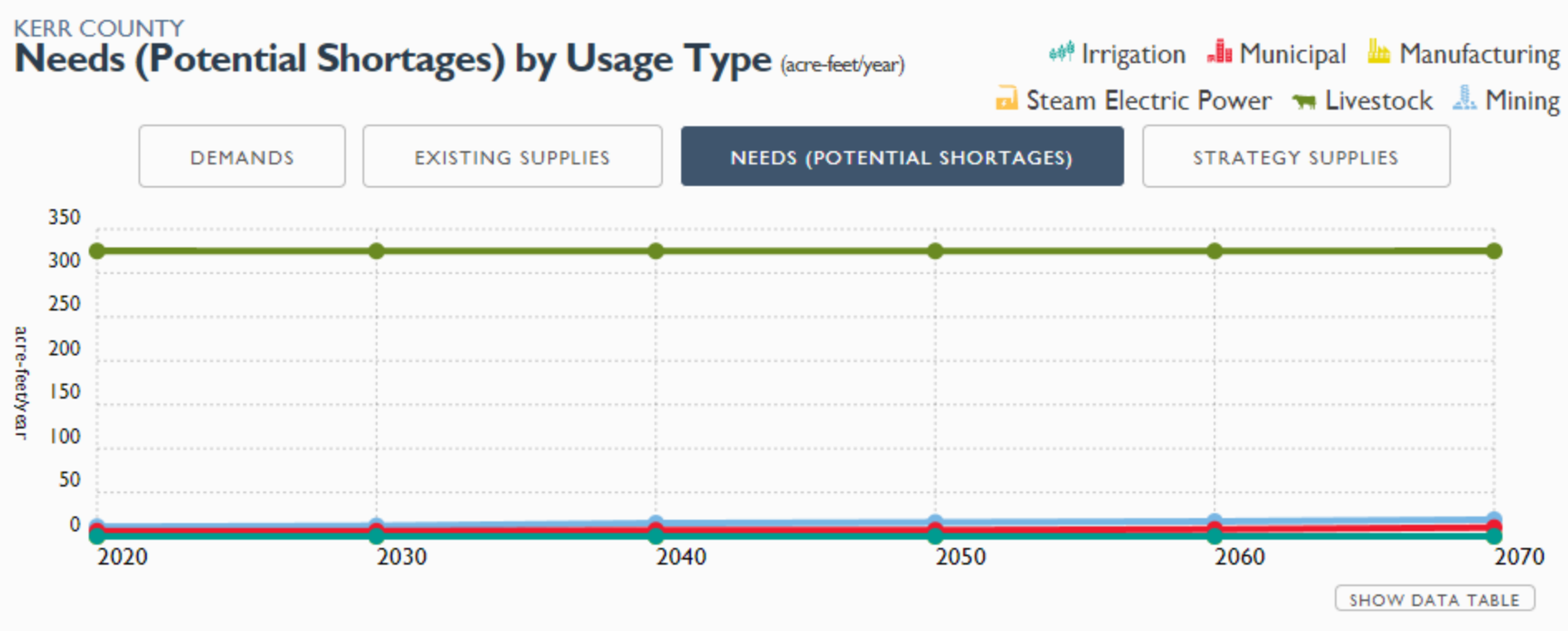
KERR COUNTY

Totals by Decade (acre-feet/year)



	2020	2030	2040	2050	2060	2070
Demands	9,659	9,780	9,827	9,926	10,054	10,166
Existing Supplies	18,303	18,303	18,303	18,303	18,303	18,303
Needs (Potential Shortages)	342	343	347	348	350	354
Strategy Supplies	3,881	10,451	10,451	10,397	10,397	10,397

Kerr County


KERR COUNTY
Needs (Potential Shortages) by Usage Type (acre-feet/year)
Irrigation
Municipal
Manufacturing
Steam Electric Power
Livestock
Mining
DEMANDS
EXISTING SUPPLIES
NEEDS (POTENTIAL SHORTAGES)
STRATEGY SUPPLIES
350
300
250
200
150
100
50
0
acre-feet/year
2020
2030
2040
2050
2060
2070
SHOW DATA TABLE

Kerr County

- Four groundwater water management strategies
- Groundwater desalination in the Trinity Aquifer for county-other; 860 to 806 ac-ft/yr beginning in 2030
- Ellenburger Aquifer development for Center Point, Center Point Taylor System, and county-other; 108 ac-ft/yr beginning in 2030
- Ellenburger Aquifer development for City of Kerrville; 1,156 ac-ft/yr beginning in 2020
- Edwards-Trinity (Plateau) groundwater for mining; 19 ac-ft/yr beginning in 2020

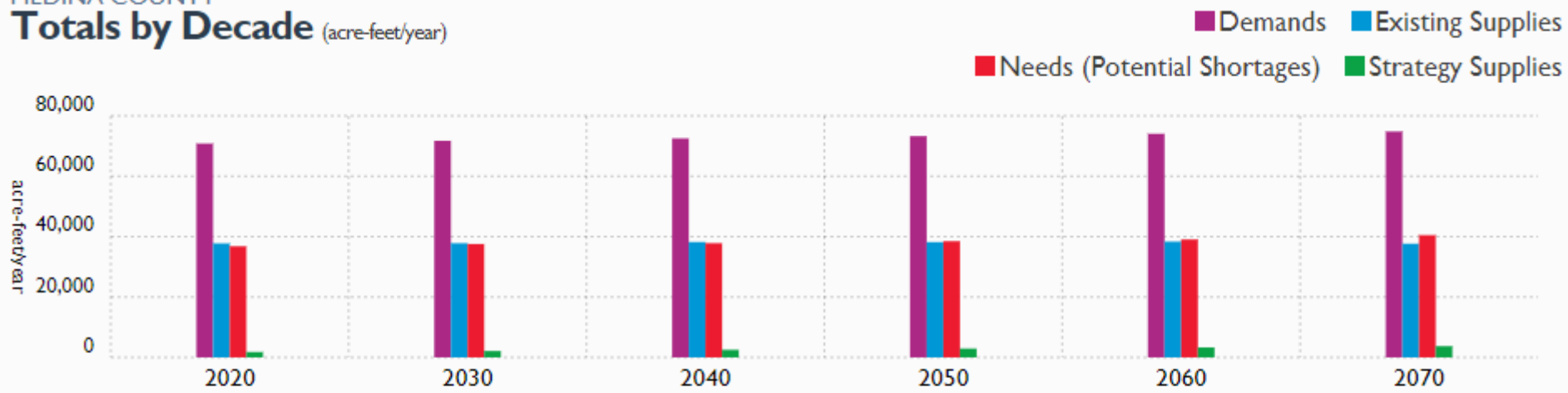
Medina County

- Only a small portion of the county is within GMA 9
- Population projected to increase from 52,653 (2020) to 79,700 (2070)
- Demand projected to increase to 74,822 ac-ft/yr in 2070

Medina County

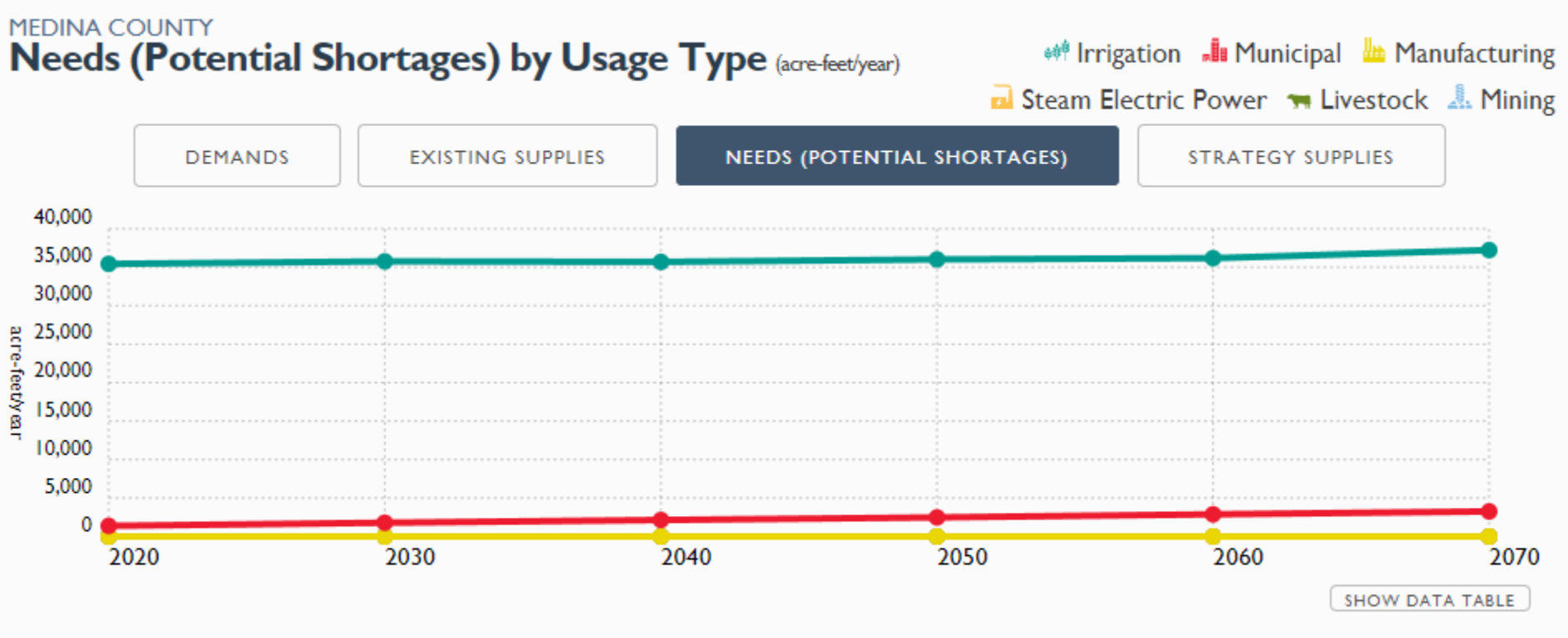
MEDINA COUNTY

Totals by Decade (acre-feet/year)



	2020	2030	2040	2050	2060	2070
Demands	70,826	71,745	72,527	73,276	74,069	74,822
Existing Supplies	37,751	37,814	38,202	38,181	38,353	37,643
Needs (Potential Shortages)	36,808	37,544	37,831	38,489	39,053	40,481
Strategy Supplies	1,779	2,126	2,519	2,918	3,293	3,726

Medina County



Medina County

- No strategies identified

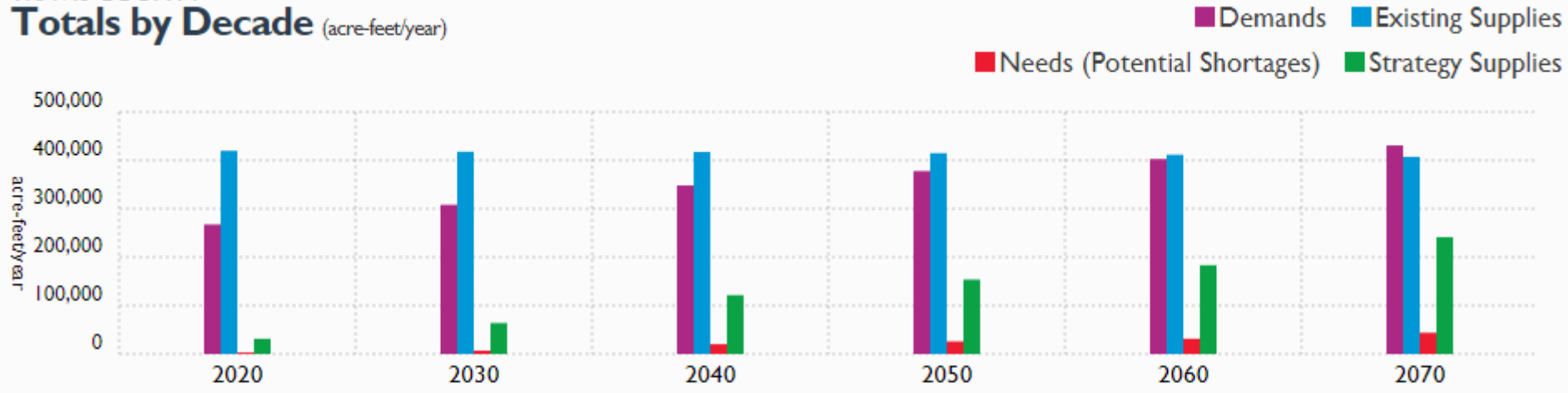
Travis County

- Approximately ¼ of the county is within GMA 9
- Population projected to increase from 1,298,624 (2020) to 2,233,259 (2070)
- Demand projected to increase to 430,760 ac-ft/yr in 2070

Travis County

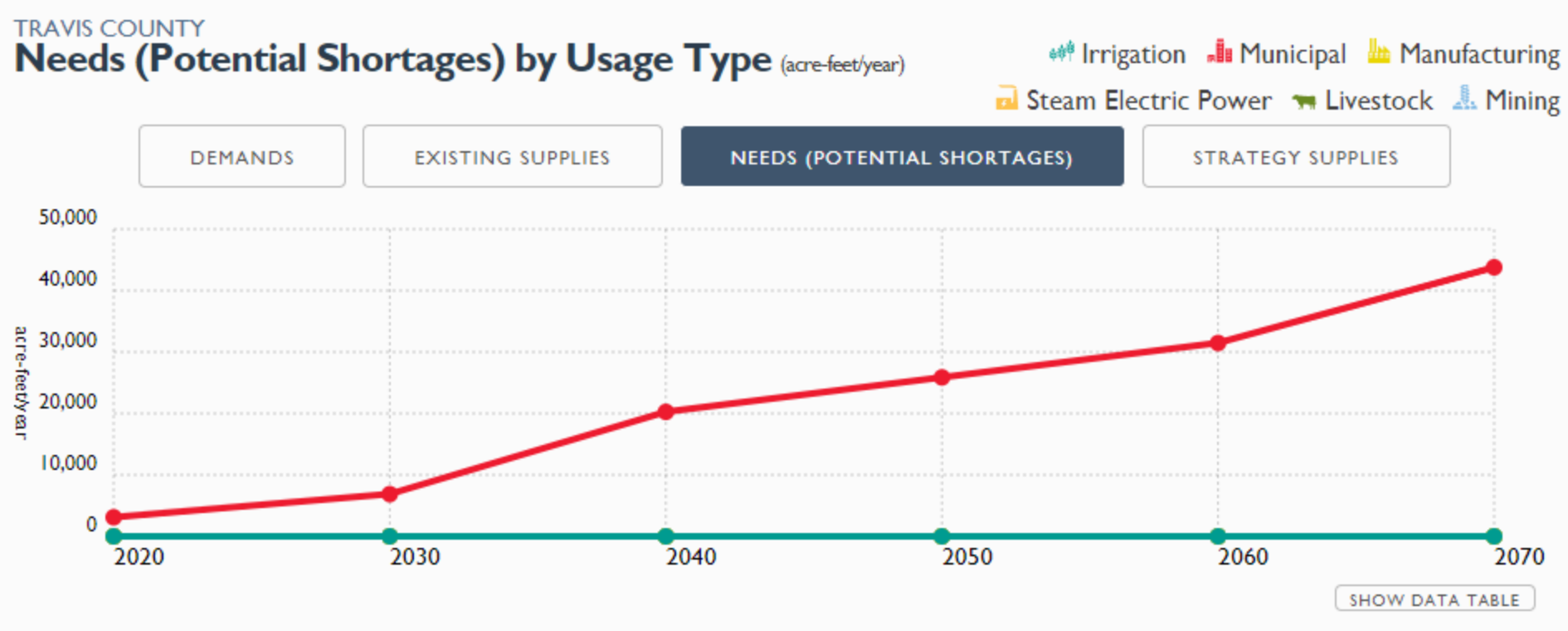
TRAVIS COUNTY

Totals by Decade (acre-feet/year)



	2020	2030	2040	2050	2060	2070
Demands	267,501	308,104	348,116	377,848	402,586	430,760
Existing Supplies	419,733	417,640	417,290	414,772	411,540	407,170
Needs (Potential Shortages)	3,102	6,867	20,254	25,866	31,463	43,787
Strategy Supplies	31,385	63,916	121,452	153,681	183,330	241,184

Travis County



Travis County

- One groundwater water management strategy
- New groundwater development in the Trinity Aquifer for Elgin, Sunset Valley, Travis County MUD 10; 100 to 1,175 ac-ft/yr beginning in 2030

3rd Factor (Section 36.108(d))- "Hydrological Conditions"

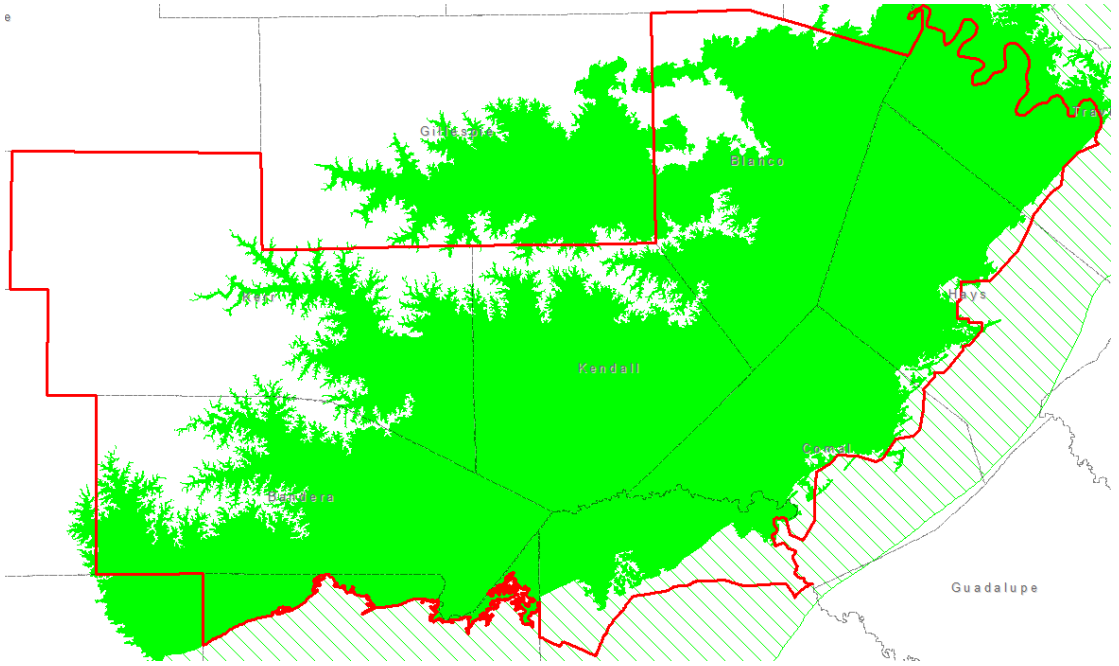
- The districts shall consider:

  "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."

Aquifers

- Trinity
- Edwards-Trinity (Plateau)
- Hickory
- Ellenburger-San Saba
- Marble Falls

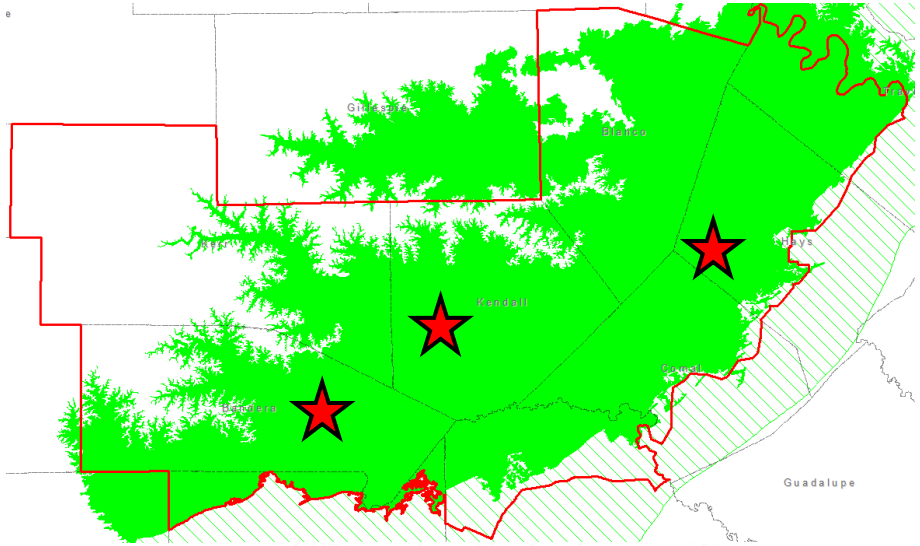
Trinity Aquifer

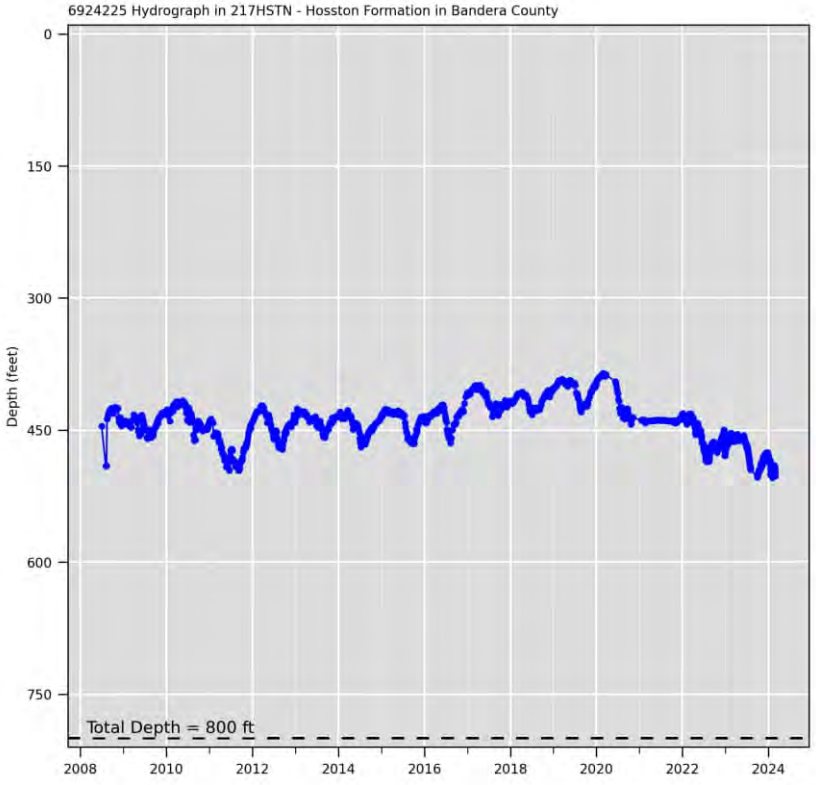


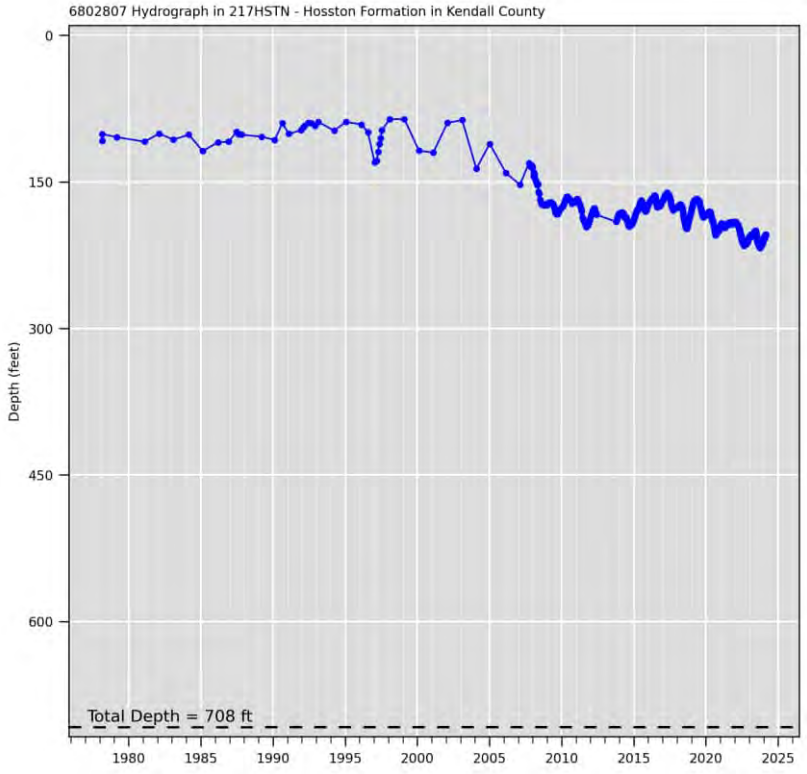
- Major aquifer
- Primary aquifer in most of GMA 9
- Yields small to large quantities of water
- Groundwater is produced from different units within the Trinity in different parts of the GMA
  - Lower Trinity- Hosston, Sligo
  - Middle Trinity- Cow Creek, Hensell, lower Glen Rose
  - Upper Trinity- Upper Glen Rose

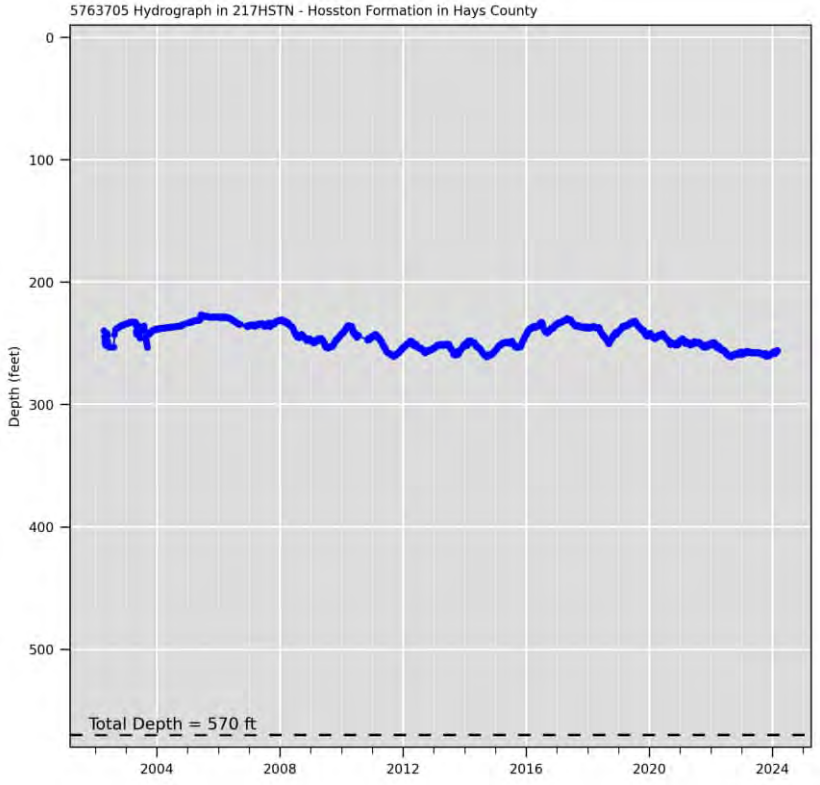
Trinity Aquifer

Lower Trinity Hydrographs



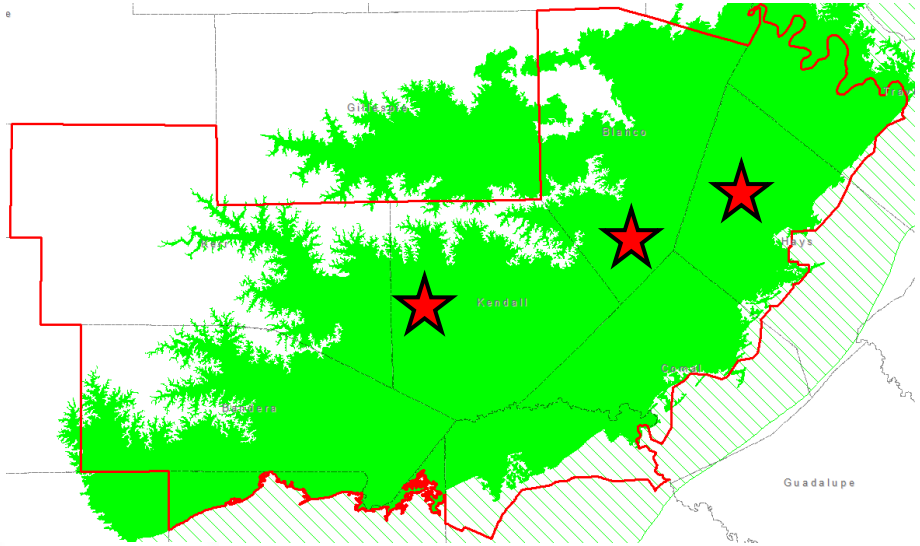


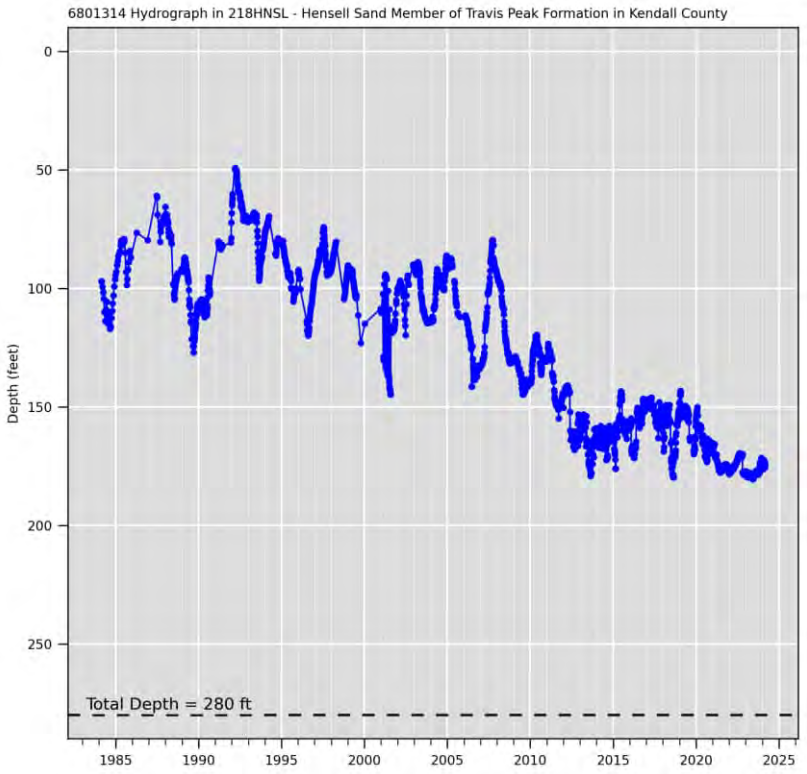


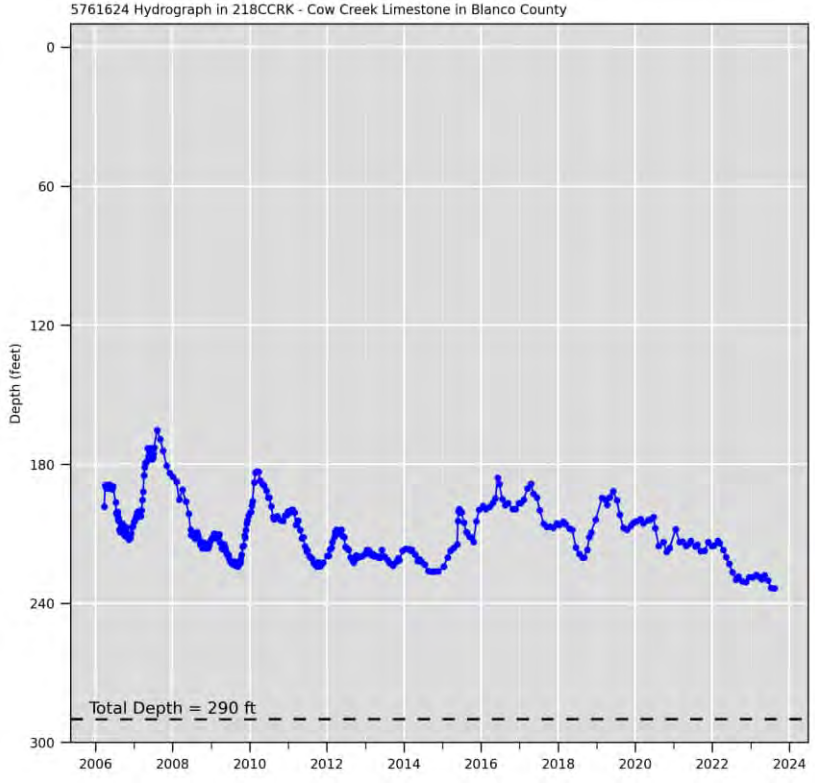


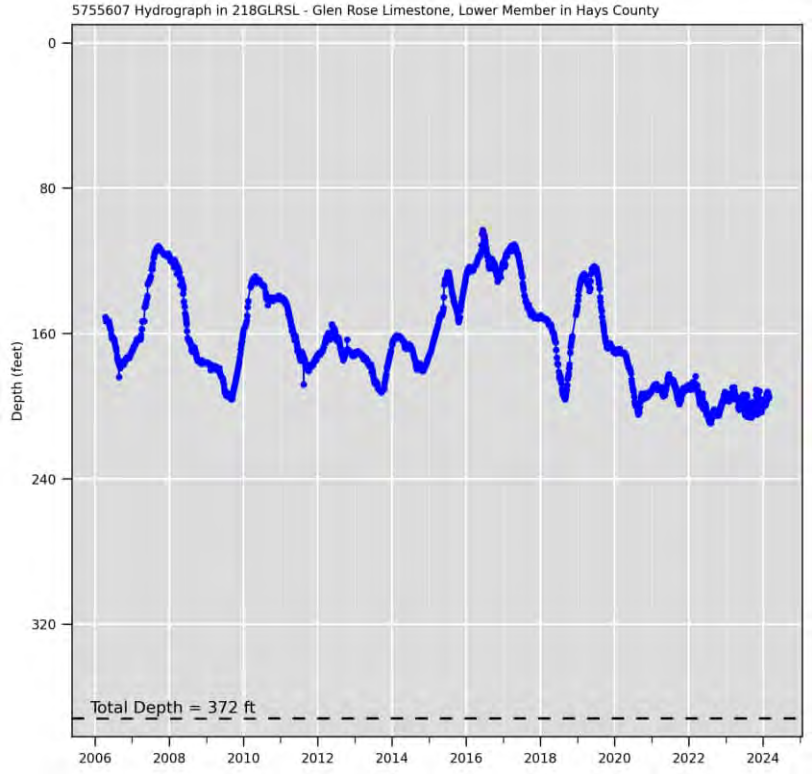
Trinity Aquifer

Middle Trinity Hydrographs



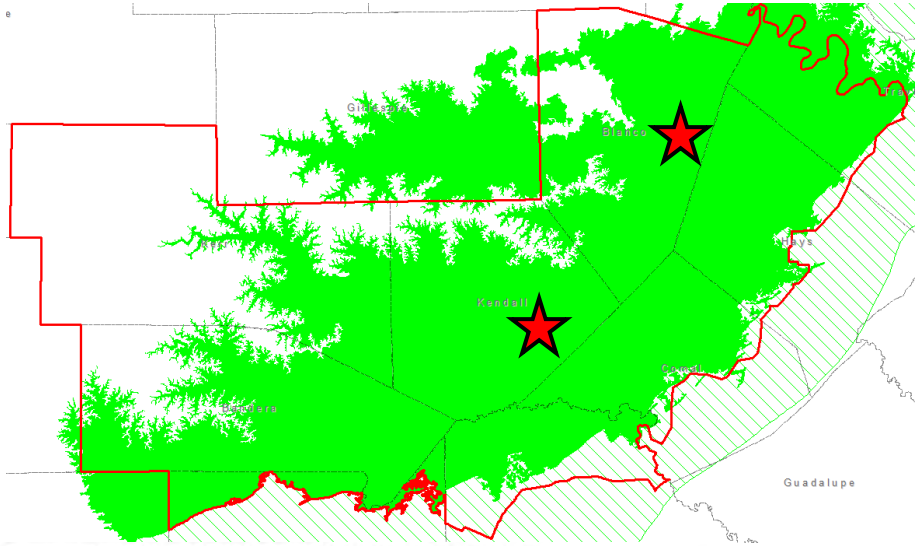


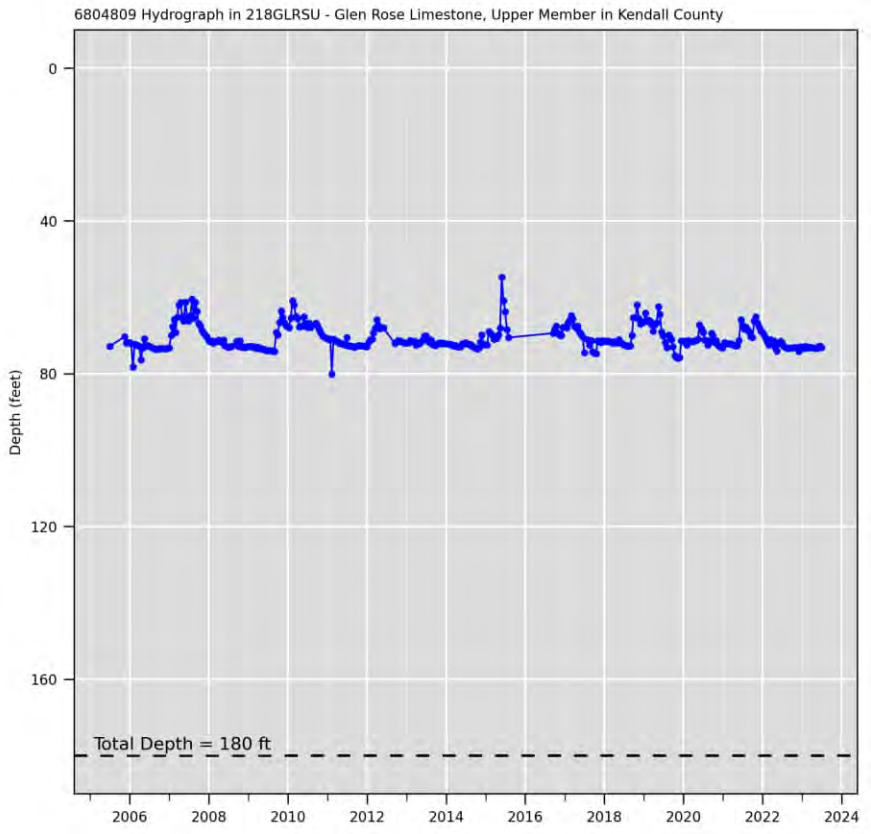


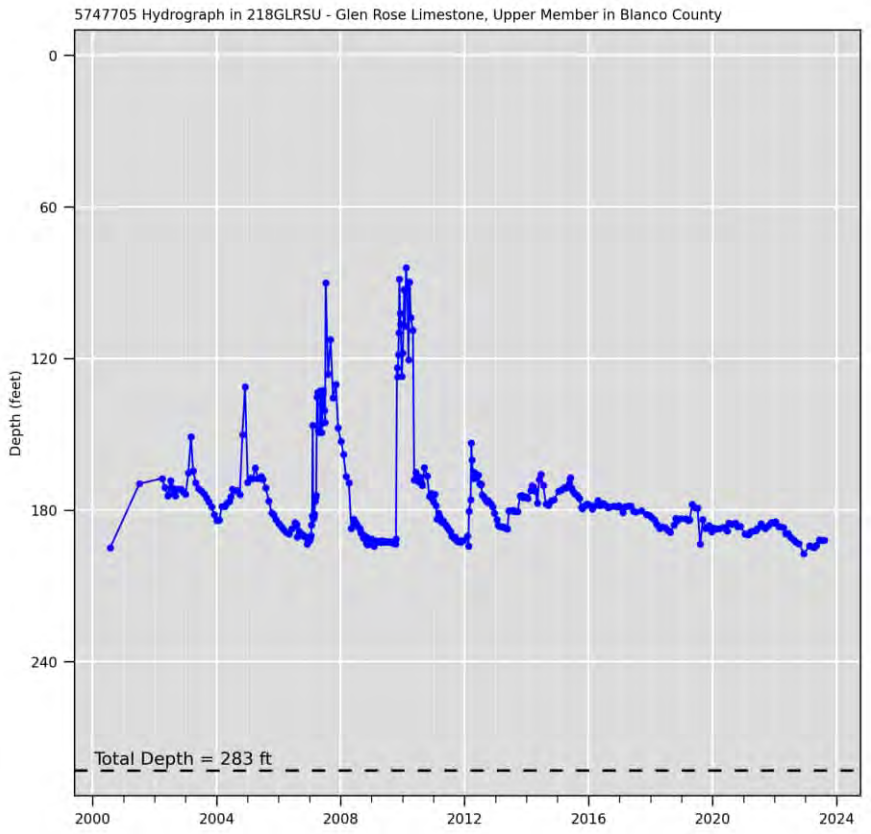


Trinity Aquifer

Upper Trinity Hydrographs

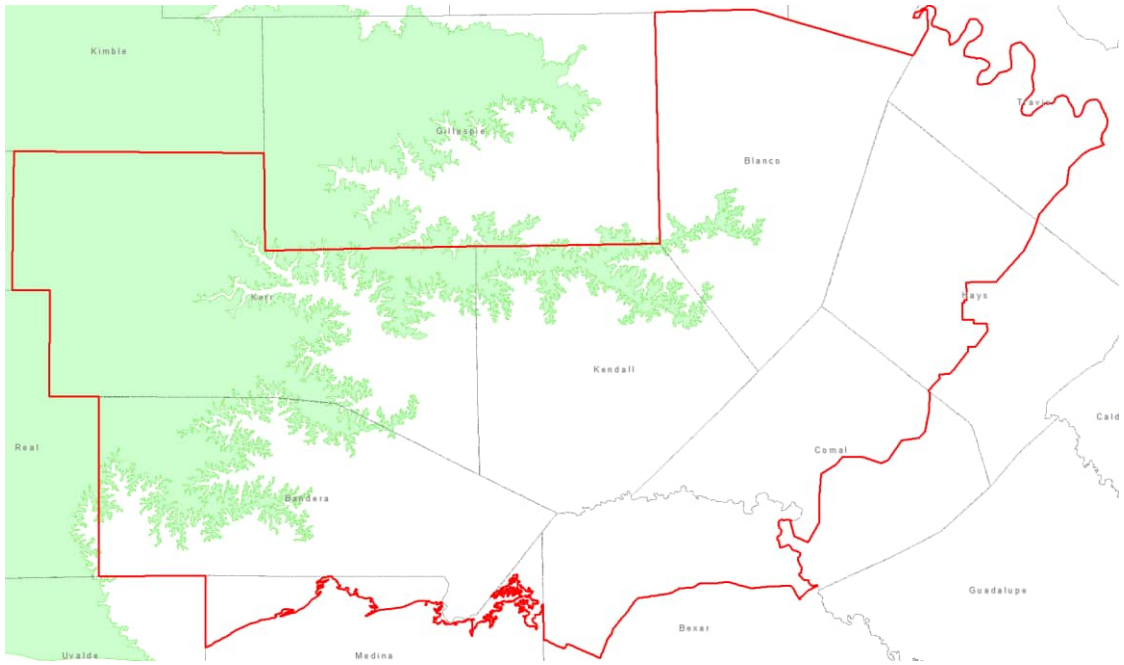




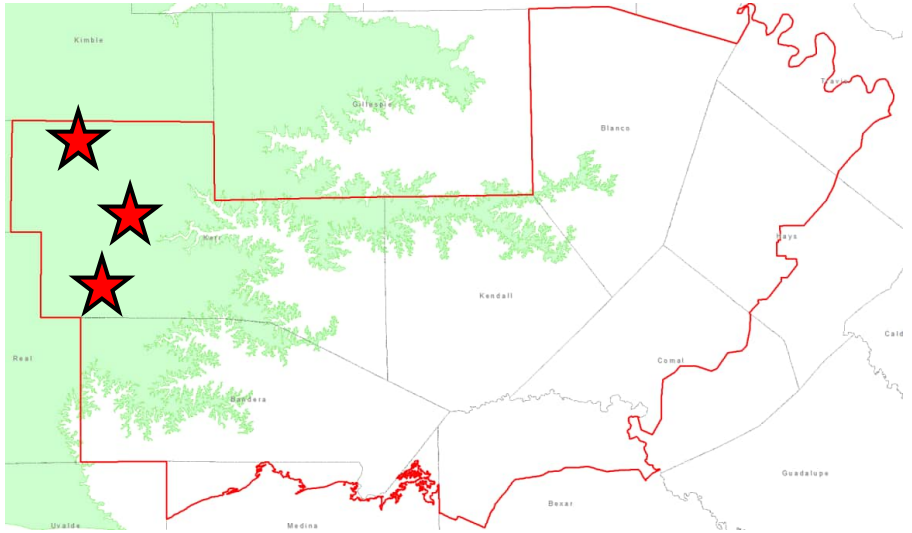


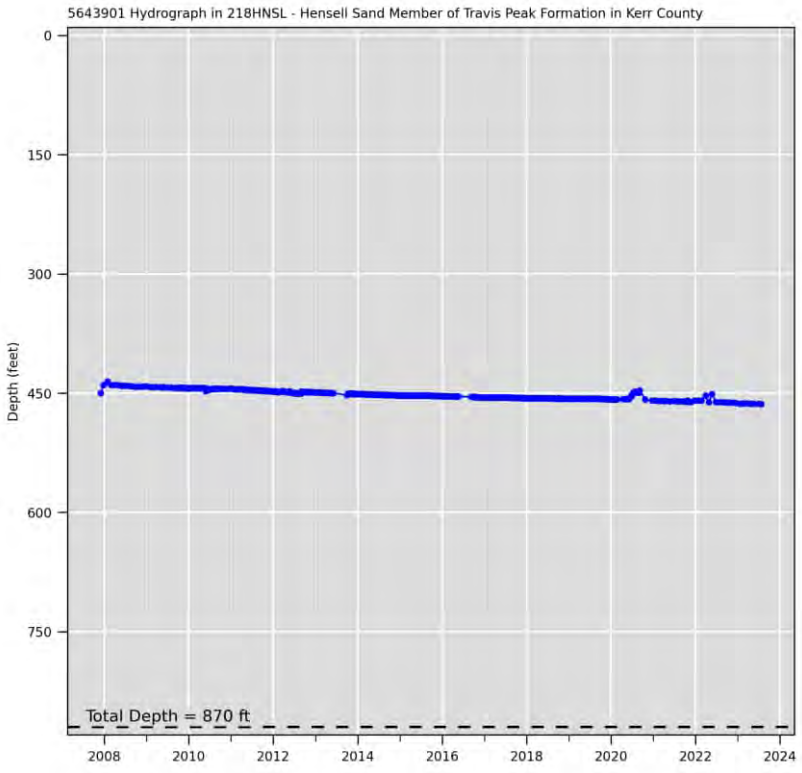
Edwards-Trinity (Plateau) Aquifer

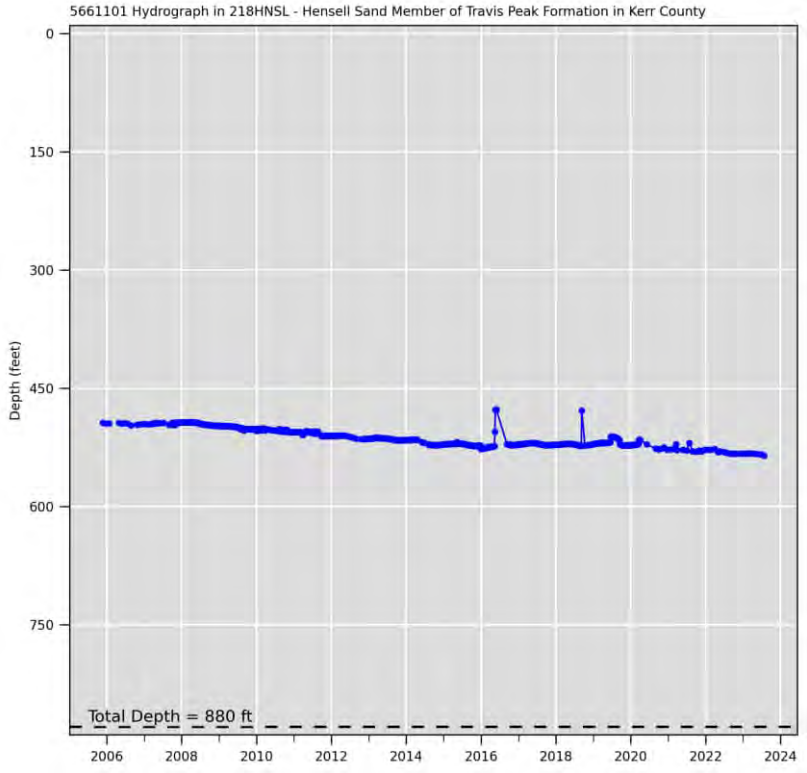
- Major aquifer
- Primarily occurs in the western part of GMA 9
- Consists of the Edwards and associated limestones and the underlying Trinity sands

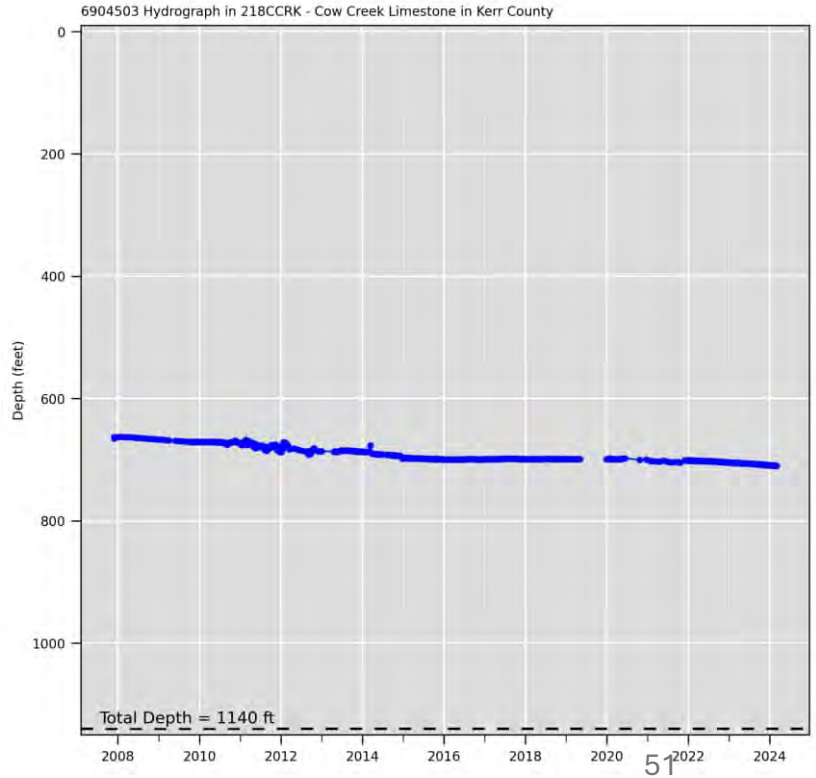


Edwards-Trinity (Plateau)
Hydrographs



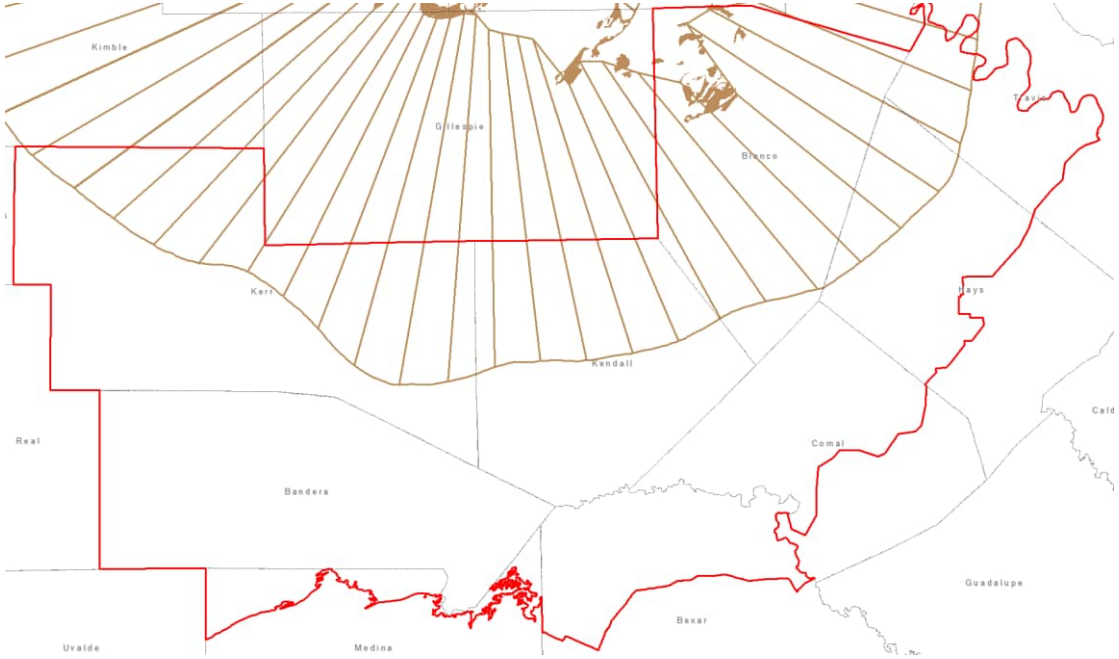




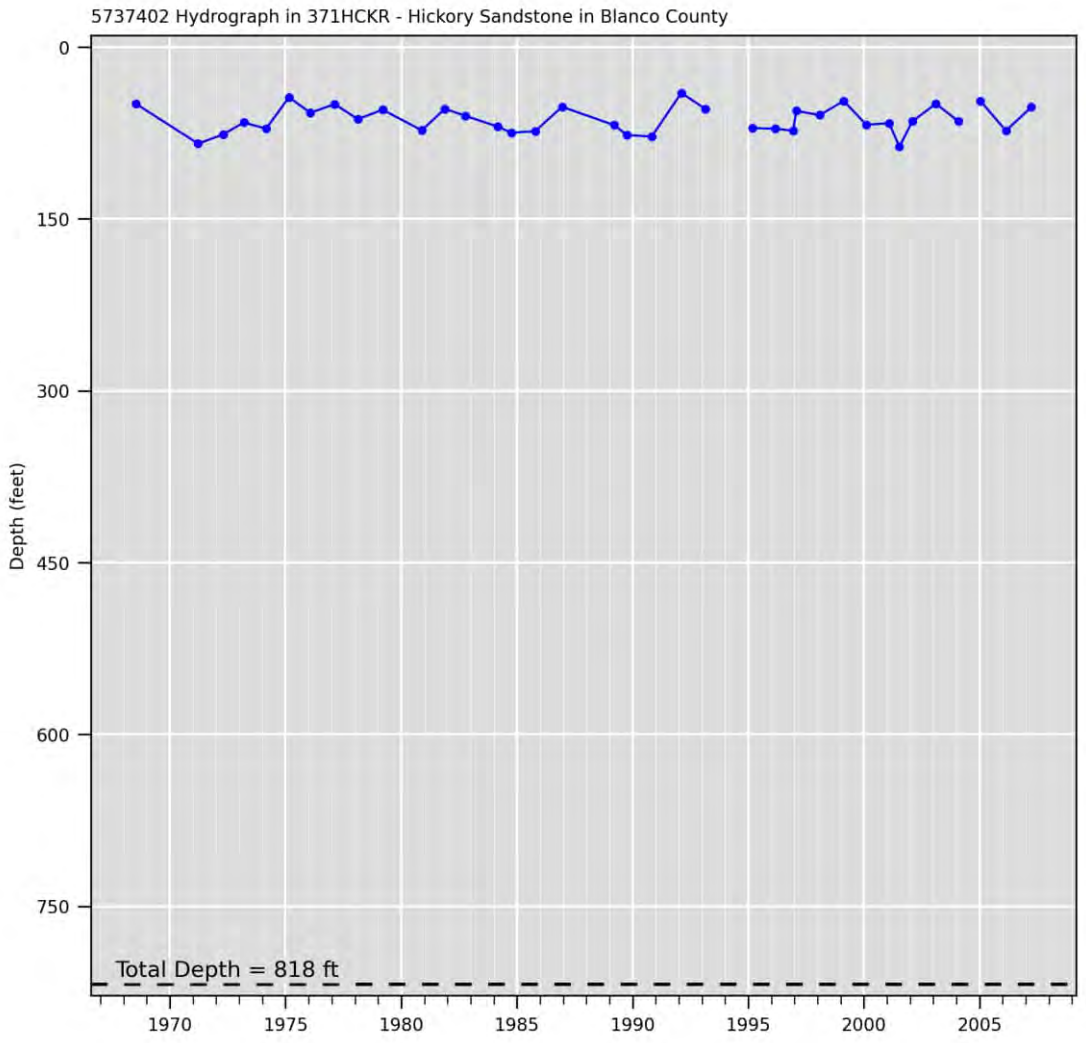


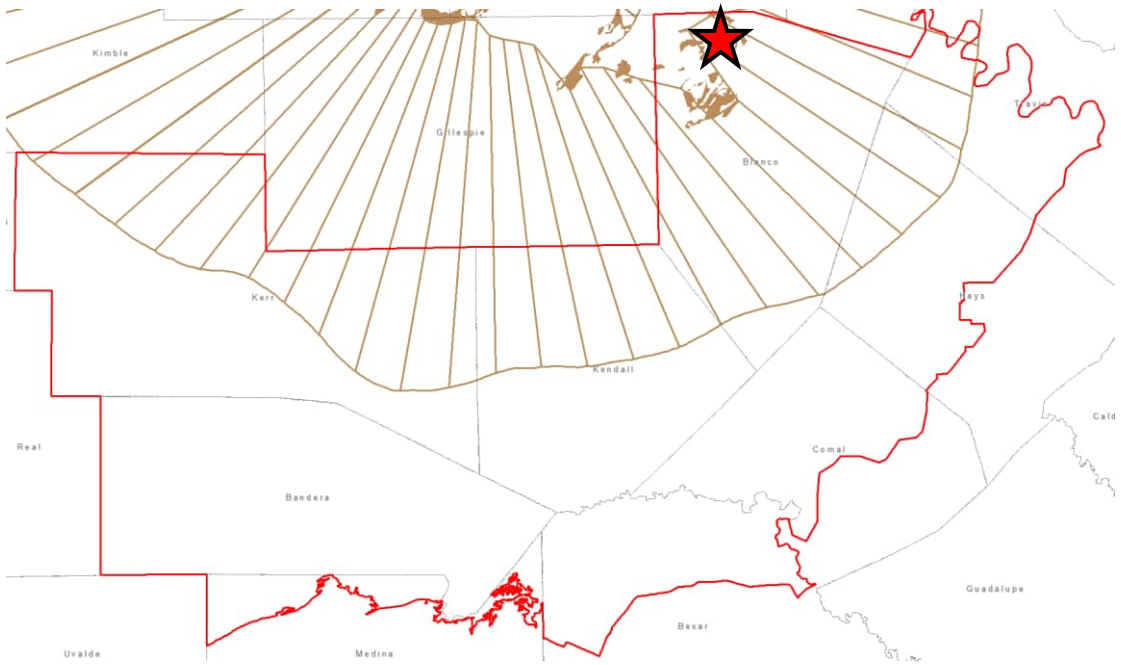
Hickory Aquifer

- Llano Uplift aquifer
- Mostly downdip; some outcrop in Blanco County
- Consists of the Hickory Sandstone, which outcrops around the Llano Uplift and dips radially away from the center
- Up to 480 feet thick
- Fresh water but may have high iron and naturally occurring radioactivity (gross alpha, radium, radon)



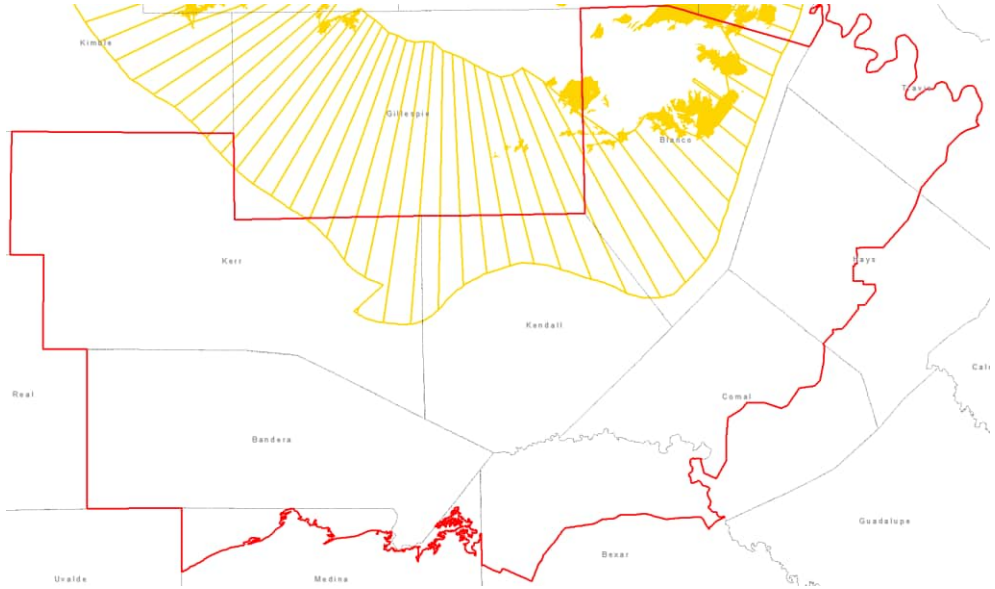
Hickory Sandstone



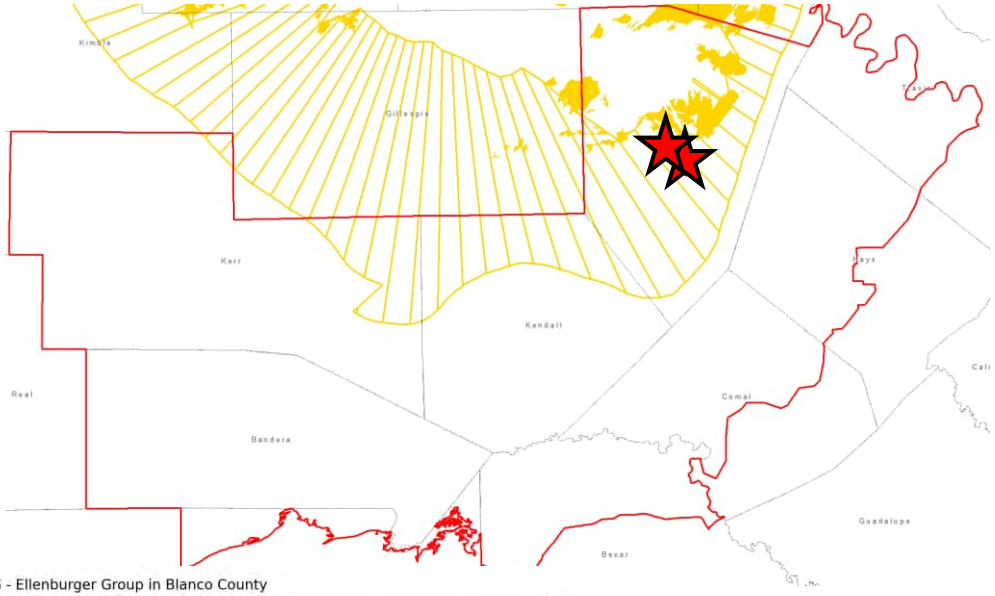


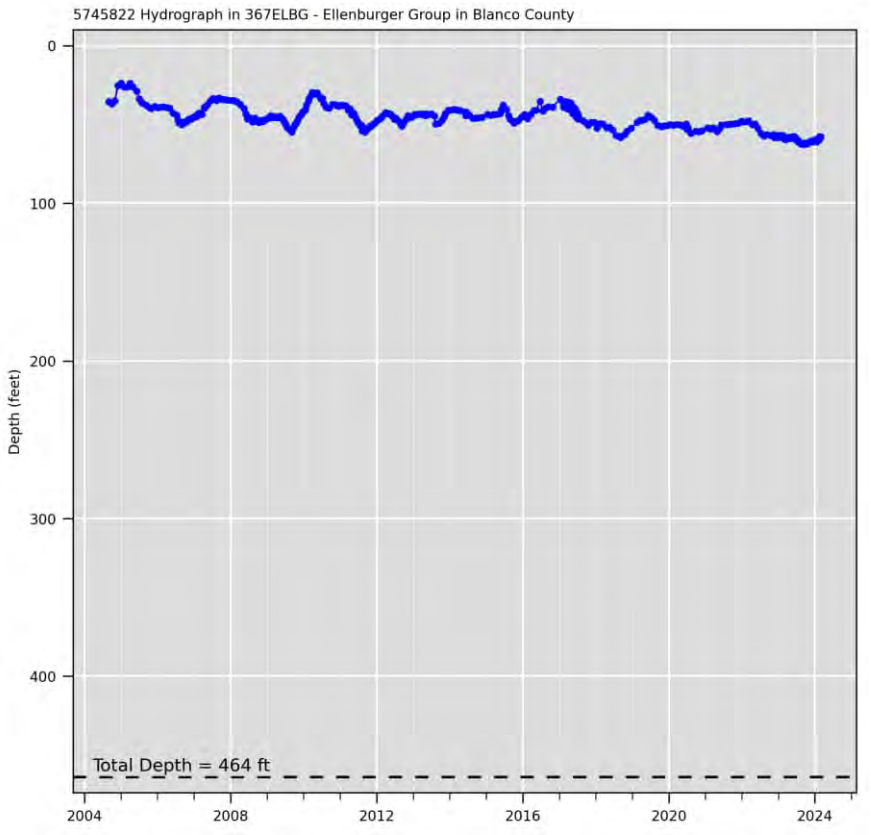
Ellenburger-San Saba Aquifer

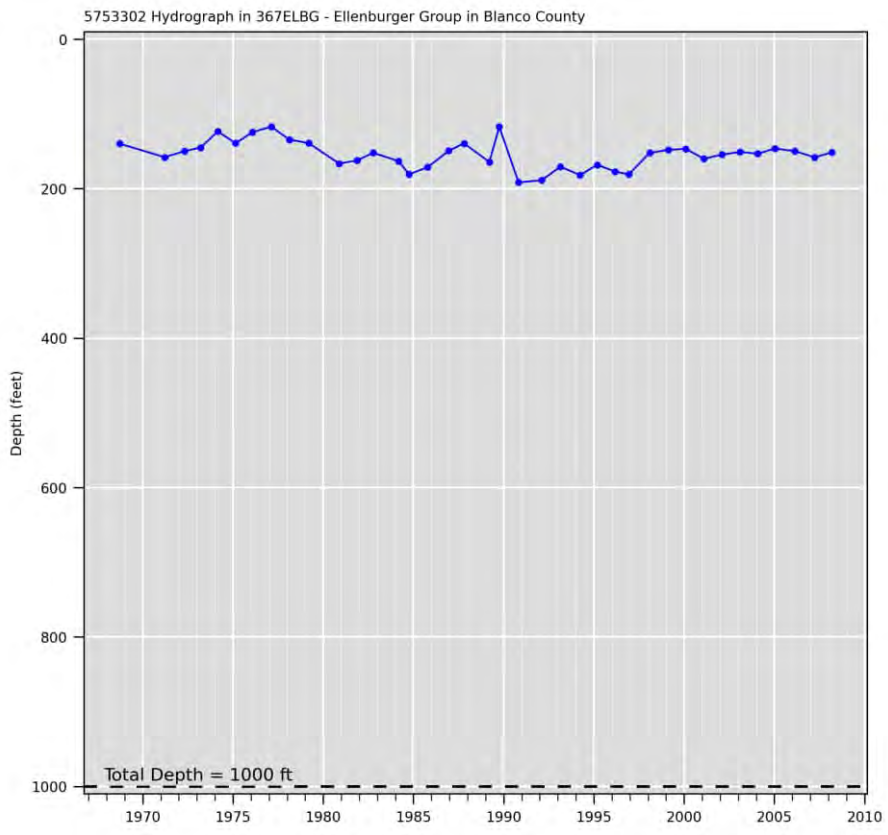
- Llano Uplift aquifer
- Mostly downdip; some outcrop in Blanco County
- Consists of a sequence of limestone and dolomite that outcrop around the Llano Uplift and dip radially away from the center
- Maximum thickness is about 2,700 feet
- Groundwater commonly under confined conditions
- Highly permeable in some areas



Ellenburger Group

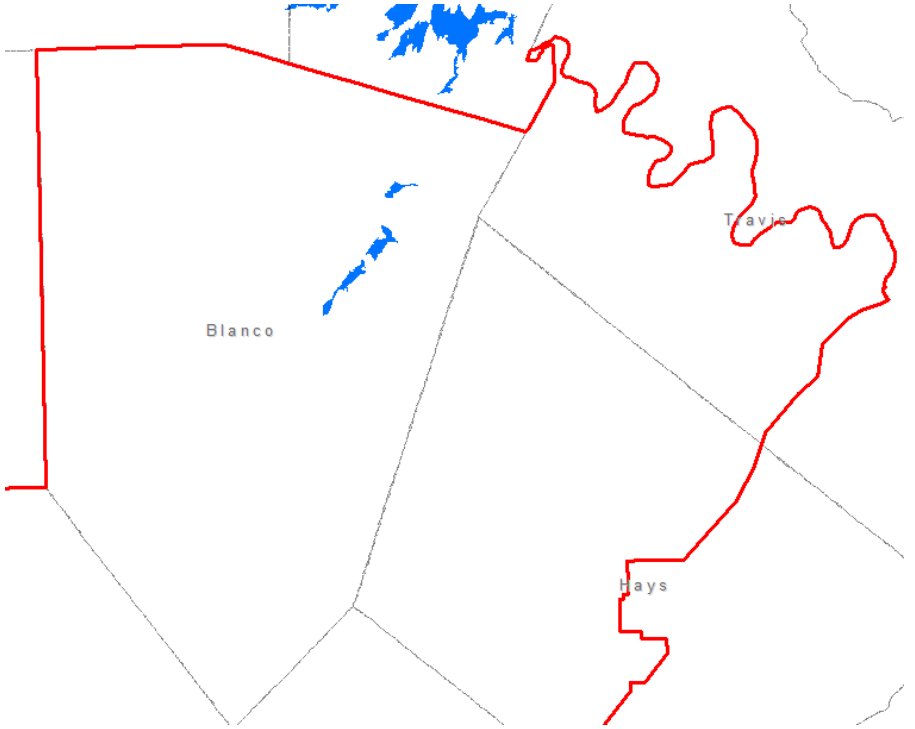






Marble Falls Aquifer

- Outcrop area in Blanco County
- Downdip extent unknown
- Occurs in the limestones of the Marble Falls Formation
- May be hydraulically connected to the underlying Ellenburger-San Saba
- Up to 600 feet thick



Total Estimated Recoverable Storage (TERS)

- Required to be evaluated as part of the DFC process
- Provided by the TWDB in GAM Task 13-032 report dated October 2, 2013
- “Recoverable” is defined as the estimated amount of groundwater that accounts for recovery scenarios that range from 25% to 75% of the total storage
- Total storage = L x W x H x Storage coefficient

Total Estimated Recoverable Storage (TERS)

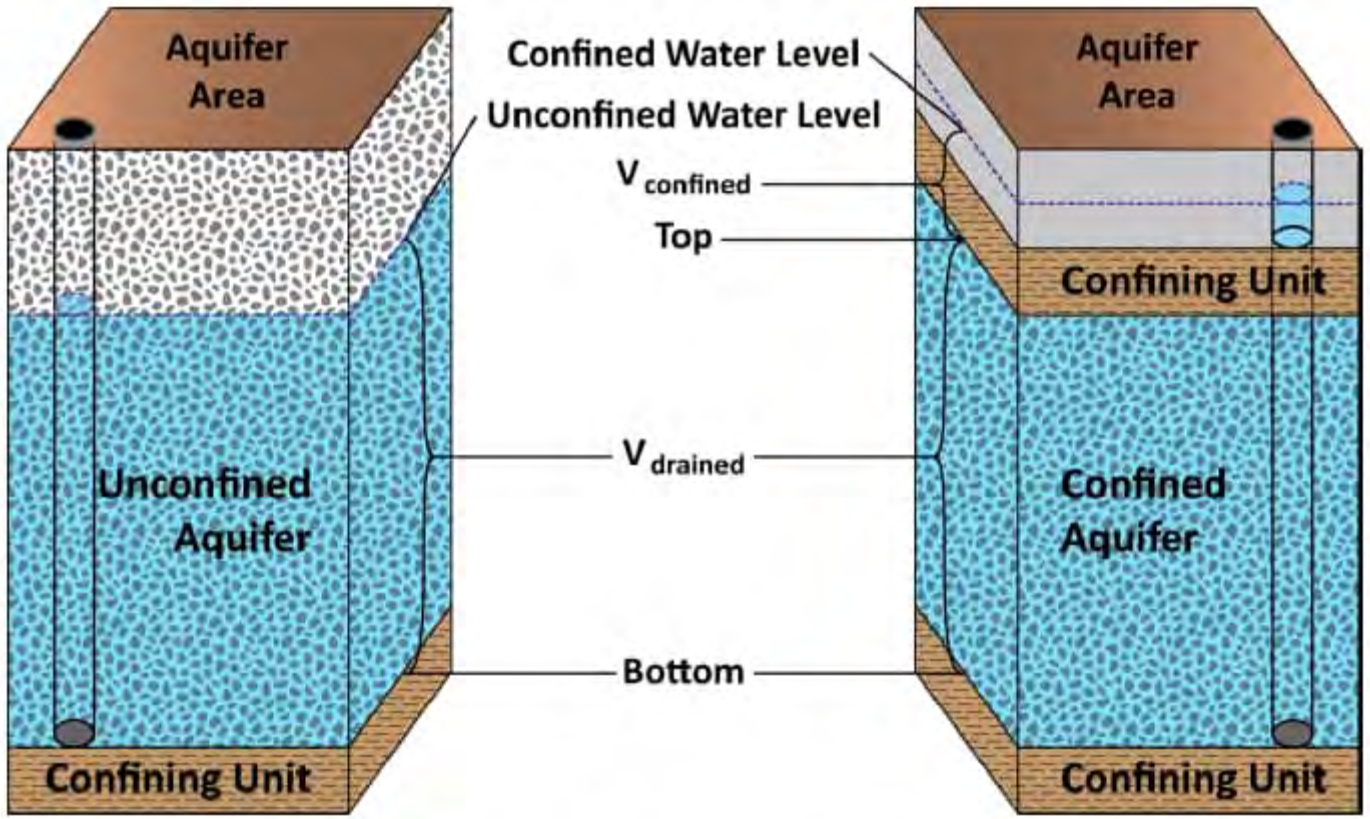


FIGURE 1. SCHEMATIC GRAPH SHOWING THE DIFFERENCE BETWEEN UNCONFINED AND CONFINED AQUIFERS.

Total Estimated Recoverable Storage (TERS)

- Estimates have been restricted based on the “official” aquifer extents per the TWDB
- Does not account for subsidence potential
- Does not account for impact on surface water
- Does not account for water quality variations

Total Estimated Recoverable Storage (TERS)

- Solely based on how much water is present and how much might be pumped out based on TWDB definition of 25% to 75%
- One-size-fits-all definition of “recoverable”. How much is actually recoverable may vary based on aquifer type

Hickory Aquifer TERS

County	*Total Storage (acre-feet)*	*25 percent of Total Storage (acre-feet)*	*75 percent of Total Storage (acre-feet)*
Blanco	4,700,000	1,175,000	3,525,000
Hays	58,000	14,500	43,500
Kendall	2,100,000	525,000	1,575,000
Kerr	4,700,000	1,175,000	3,525,000
Travis	24,000	6,000	18,000
Total	11,582,000	2,895,500	8,686,500

Groundwater Conservation District (GCD)	*Total Storage (acre-feet)*	*25 percent of Total Storage (acre-feet)*	*75 percent of Total Storage (acre-feet)*
No District	24,000	6,000	18,000
Blanco-Pedernales GCD	4,700,000	1,175,000	3,525,000
Cow Creek GCD	2,100,000	525,000	1,575,000
Hays Trinity GCD	58,000	14,500	43,500
Headwaters GCD	4,700,000	1,175,000	3,525,000
Total	11,582,000	2,895,500	8,686,500

Ellenburger-San Saba Aquifer TERS

County	*Total Storage (acre-feet)*	*25 percent of Total Storage (acre-feet)*	*75 percent of Total Storage (acre-feet)*
Blanco	8,300,000	2,075,000	6,225,000
Kendall	3,500,000	875,000	2,625,000
Kerr	2,100,000	525,000	1,575,000
Total	13,900,000	3,475,000	10,425,000

Groundwater Conservation District (GCD)	*Total Storage (acre-feet)*	*25 percent of Total Storage (acre-feet)*	*75 percent of Total Storage (acre-feet)*
Blanco-Pedernales GCD	8,300,000	2,075,000	6,225,000
Cow Creek GCD	3,500,000	875,000	2,625,000
Headwaters GCD	2,100,000	525,000	1,575,000
Total	13,900,000	3,475,000	10,425,000

Marble Falls Aquifer TERS

County	*Total Storage (acre-feet)*	*25 percent of Total Storage (acre-feet)*	*75 percent of Total Storage (acre-feet)*
Blanco	1,300	325	975
Total	1,300	325	975

Groundwater Conservation District (GCD)	*Total Storage (acre-feet)*	*25 percent of Total Storage (acre-feet)*	*75 percent of Total Storage (acre-feet)*
Blanco-Pedernales GCD	1,300	325	975
Total	1,300	325	975

Trinity Aquifer TERS by County

County	*Total Storage (acre-feet)*	*25 percent of Total Storage (acre-feet)*	*75 percent of Total Storage (acre-feet)*
Bandera	1,200,000	300,000	900,000
Bexar	680,000	170,000	510,000
Blanco	420,000	105,000	315,000
Comal	620,000	155,000	465,000
Hays	550,000	137,500	412,500
Kendall	770,000	192,500	577,500
Kerr	340,000	85,000	255,000
Medina	370,000	92,500	277,500
Travis	330,000	82,500	247,500
Total	5,280,000	1,320,000	3,960,000

Trinity Aquifer TERS by GCD

Groundwater Conservation District (GCD)	*Total Storage (acre-feet)*	*25 percent of Total Storage (acre-feet)*	*75 percent of Total Storage (acre-feet)*
No District	910,000	227,500	682,500
Bandera County River Authority & Ground Water District	1,200,000	300,000	900,000
Barton Springs/Edwards Aquifer Conservation District	2,200	550	1,650
Blanco-Pedernales GCD	420,000	105,000	315,000
Cow Creek GCD	760,000	190,000	570,000
Edwards Aquifer Authority	37,000	9,250	27,750
Hays Trinity GCD	550,000	137,500	412,500
Headwaters GCD	340,000	85,000	255,000
Medina County GCD	370,000	92,500	277,500
Trinity Glen Rose GCD	680,000	170,000	510,000
Total	5,269,200	1,317,300	3,951,900

Edwards-Trinity (Plateau) Aquifer TERS

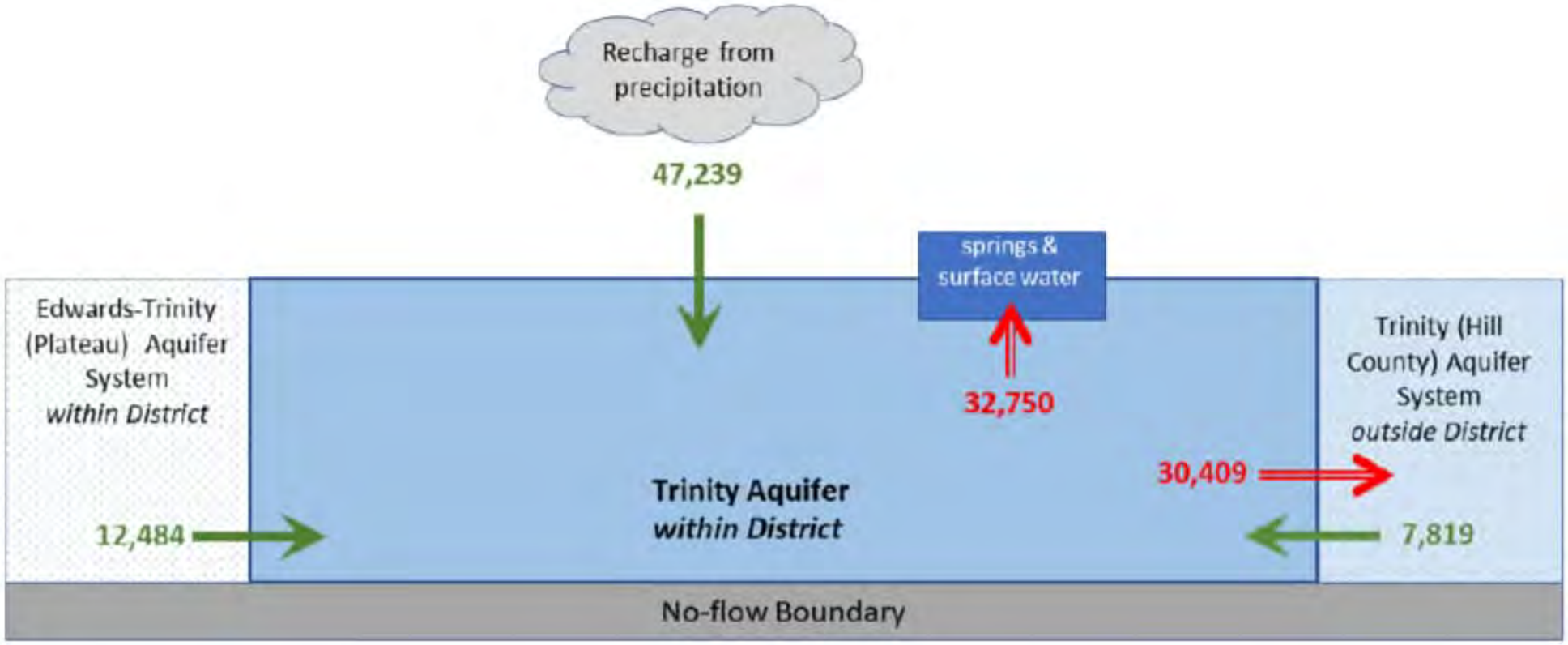
County	Total Storage (acre-feet)	25 percent of Total Storage (acre-feet)	75 percent of Total Storage (acre-feet)
Bandera	450,000	112,500	337,500
Blanco	12,000	3,000	9,000
Kendall	96,000	24,000	72,000
Kerr	1,800,000	450,000	1,350,000
Total	2,358,000	589,500	1,768,500

Groundwater Conservation District (GCD)	Total Storage (acre-feet)	25 percent of Total Storage (acre-feet)	75 percent of Total Storage (acre-feet)
Bandera County River Authority & Ground Water District	450,000	112,500	337,500
Blanco-Pedernales GCD	12,000	3,000	9,000
Cow Creek GCD	96,000	24,000	72,000
Headwaters GCD	1,800,000	450,000	1,350,000
Total	2,358,000	589,500	1,768,500

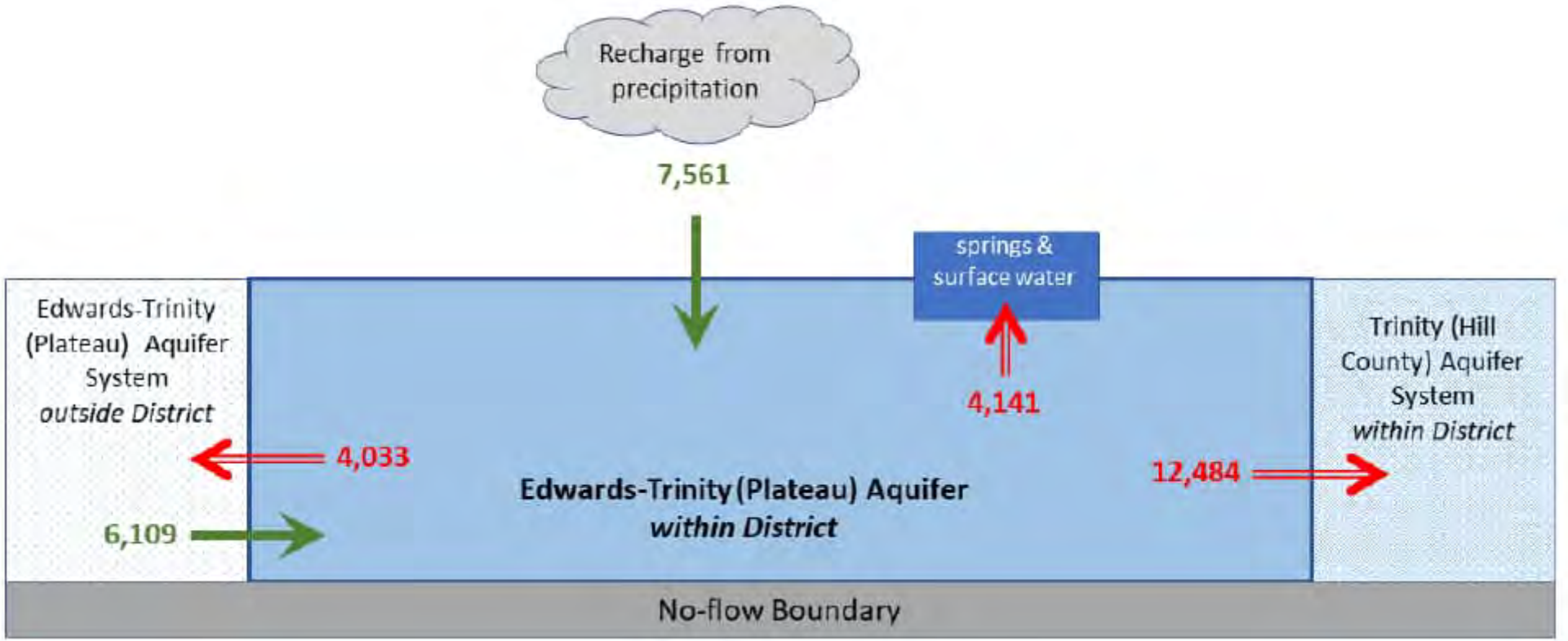
Annual Recharge, Inflows, and Discharge

- Provided by the TWDB in GAM Run reports in support of management plan development
- Blanco-Pedernales GCD = GAM Run 23-017
- Southwestern Travis County GCD = GAM Run 19-027
- Hays Trinity GCD = GAM Run 19-026
- Comal Trinity GCD = GAM Run 22-012
- Trinity Glen Rose GCD = GAM Run 19-025
- Cow Creek GCD = GAM Run 19-011
- Headwaters GCD = GAM Run 21-003
- Bandera County River Authority & GW District = GAM Run 22-010
- Medina County GCD = GAM Run 20-003

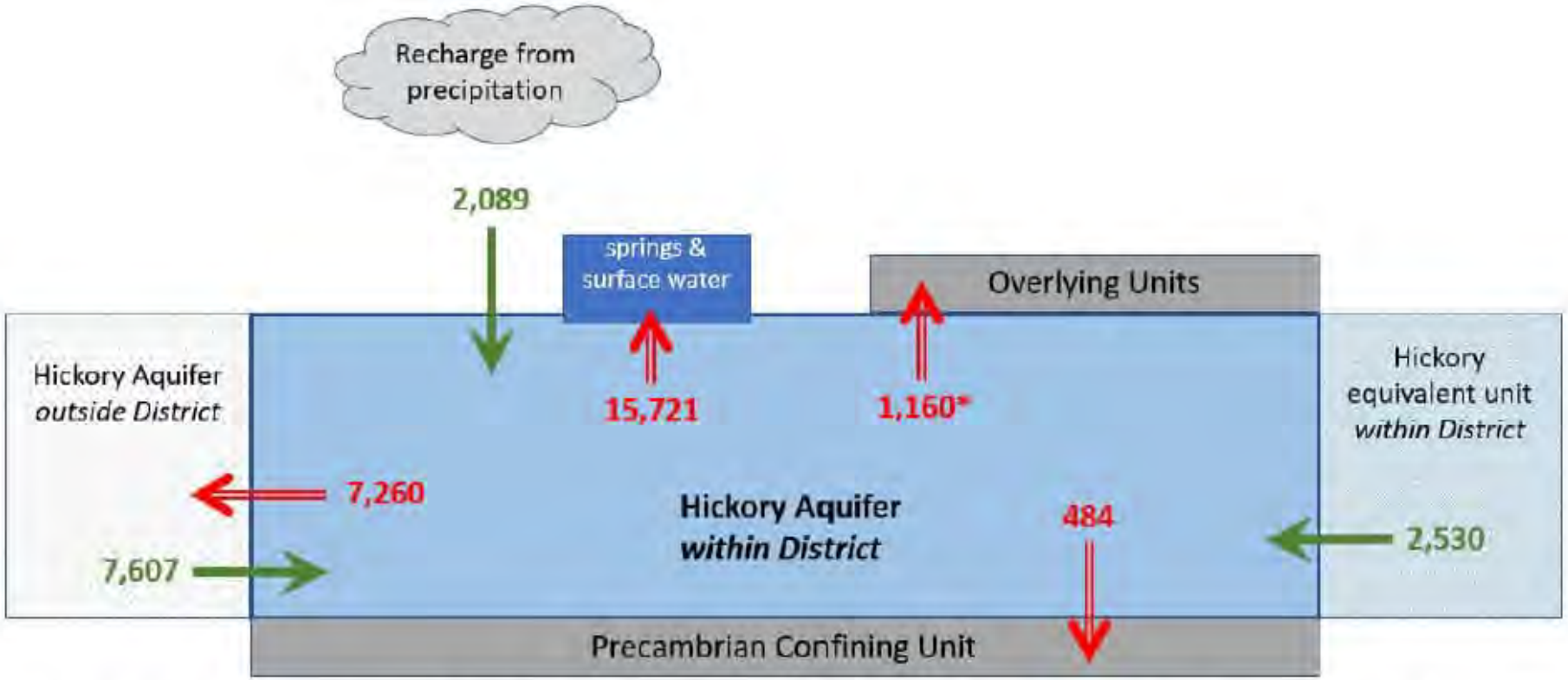
Bandera County- Trinity Aquifer



Bandera County- Edwards-Trinity (Plateau) Aquifer

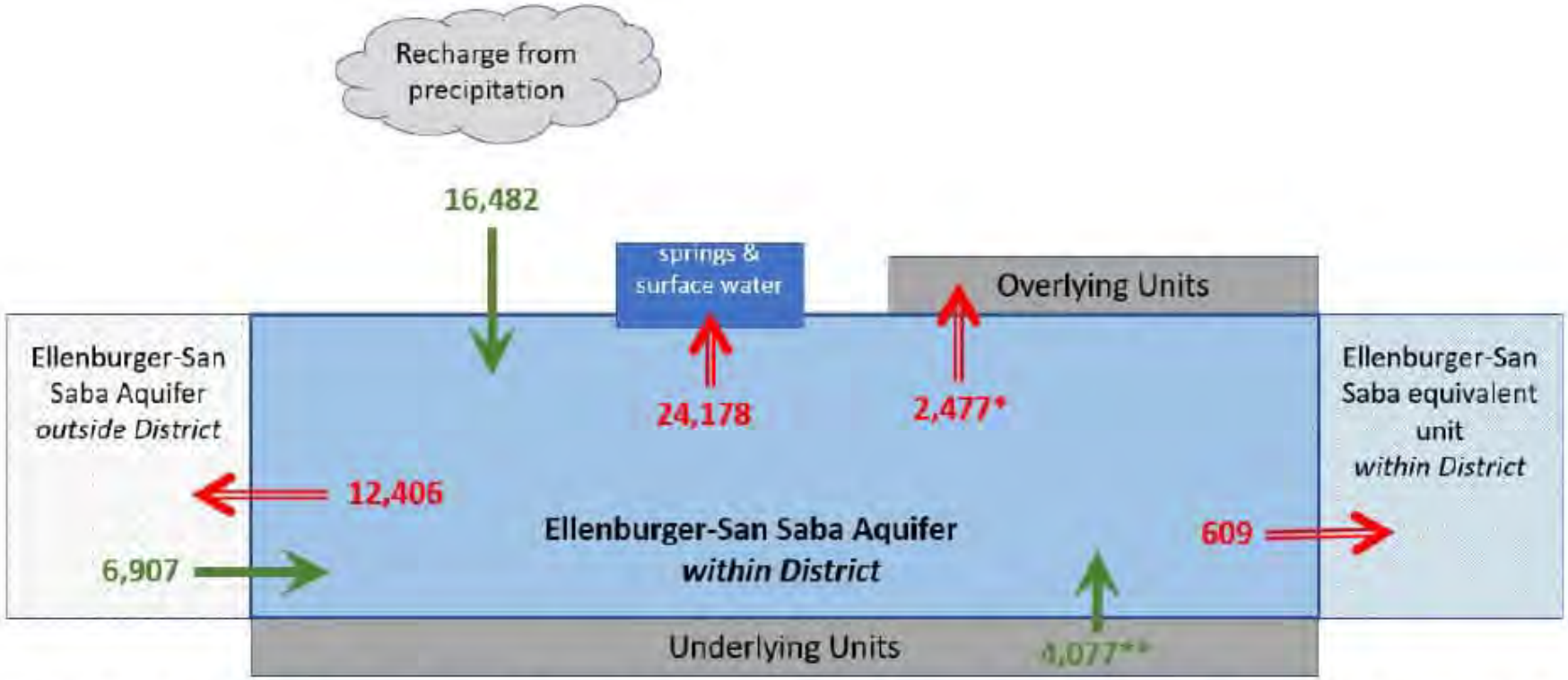


Blanco County- Hickory Aquifer



*Flow to Overlying units within district includes net flow of 61 acre-feet per year from Hickory Aquifer to Trinity Aquifer, 19 acre-feet per year from Hickory Aquifer to Quaternary alluvium, 24 acre-feet per year from Hickory Aquifer to Marble Falls equivalent units, 39 acre-feet per year from Hickory Aquifer to Ellenburger-San Saba Aquifer, 4,159 acre-feet per year from Hickory Aquifer to Ellenburger-San Saba Aquifer, 975 acre-feet per year from Hickory Aquifer to Ellenburger-San Saba Aquifer Equivalent, and 4,117 acre-feet per year to Hickory Aquifer from Cambrian Confining unit.

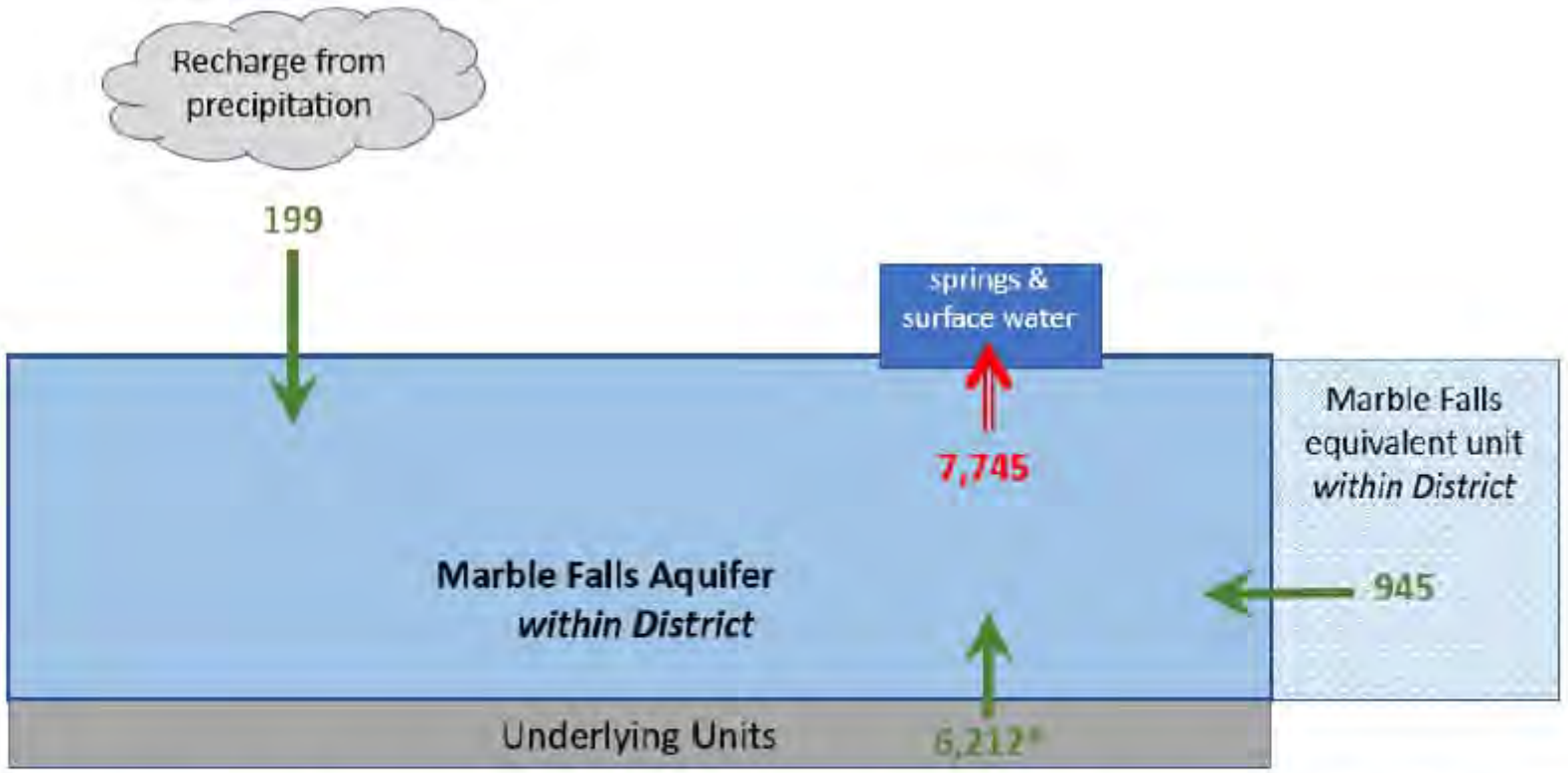
Blanco County- Ellenburger- San Saba Aquifer



*Flow to Overlying units within district includes net flow of 990 acre-feet per year from Trinity Aquifer, 242 acre-feet per year from Marble Falls equivalent units, 75 acre-feet from Quaternary Alluvium, 374 acre-feet per year to Permian and Pennsylvanian Confining Unit, 480 acre-feet per year to Marble Falls Aquifer, and 2,930 acre-feet per year to Mississippian Confining Unit.

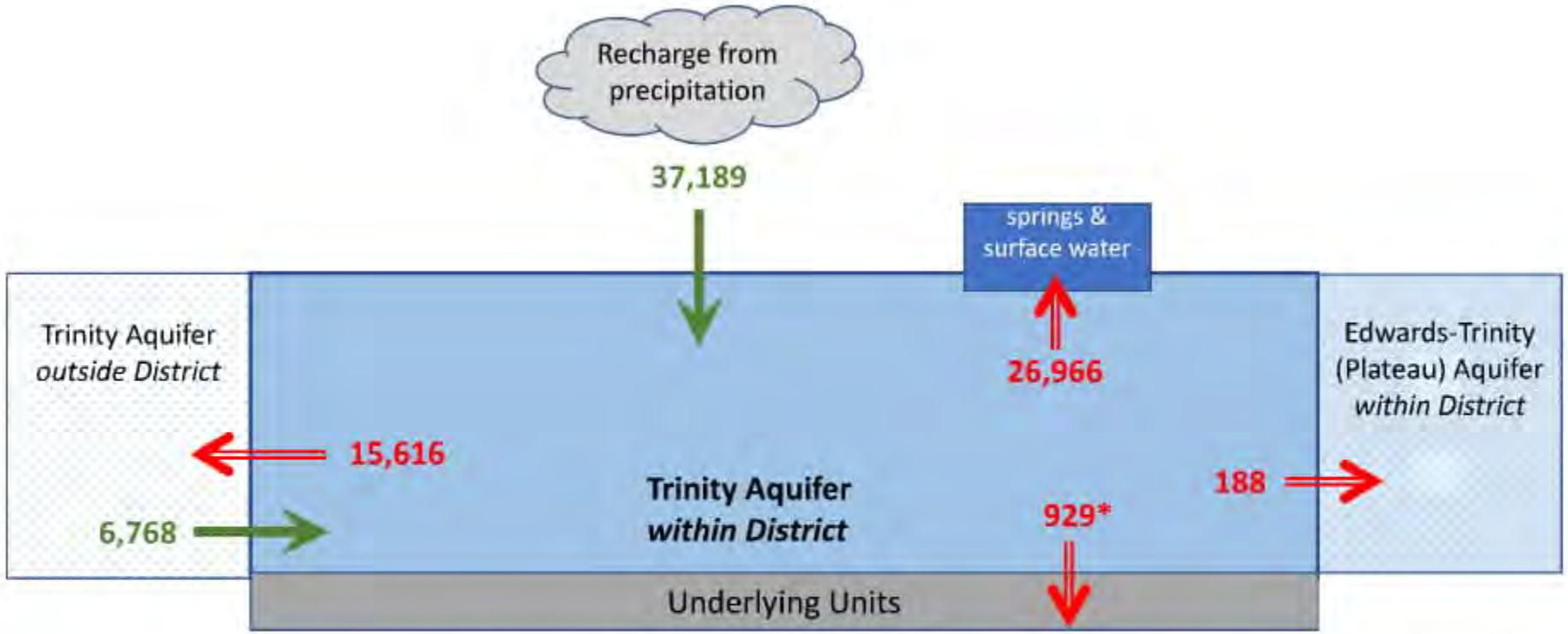
**Flow from Underlying units within district includes net flow of 598 acre-feet per year to Cambrian Confining Unit, 4,159 acre-feet per year from Hickory Aquifer, and 516 acre-feet per year from Precambrian Confining Unit.

Blanco County- Marble Falls Aquifer



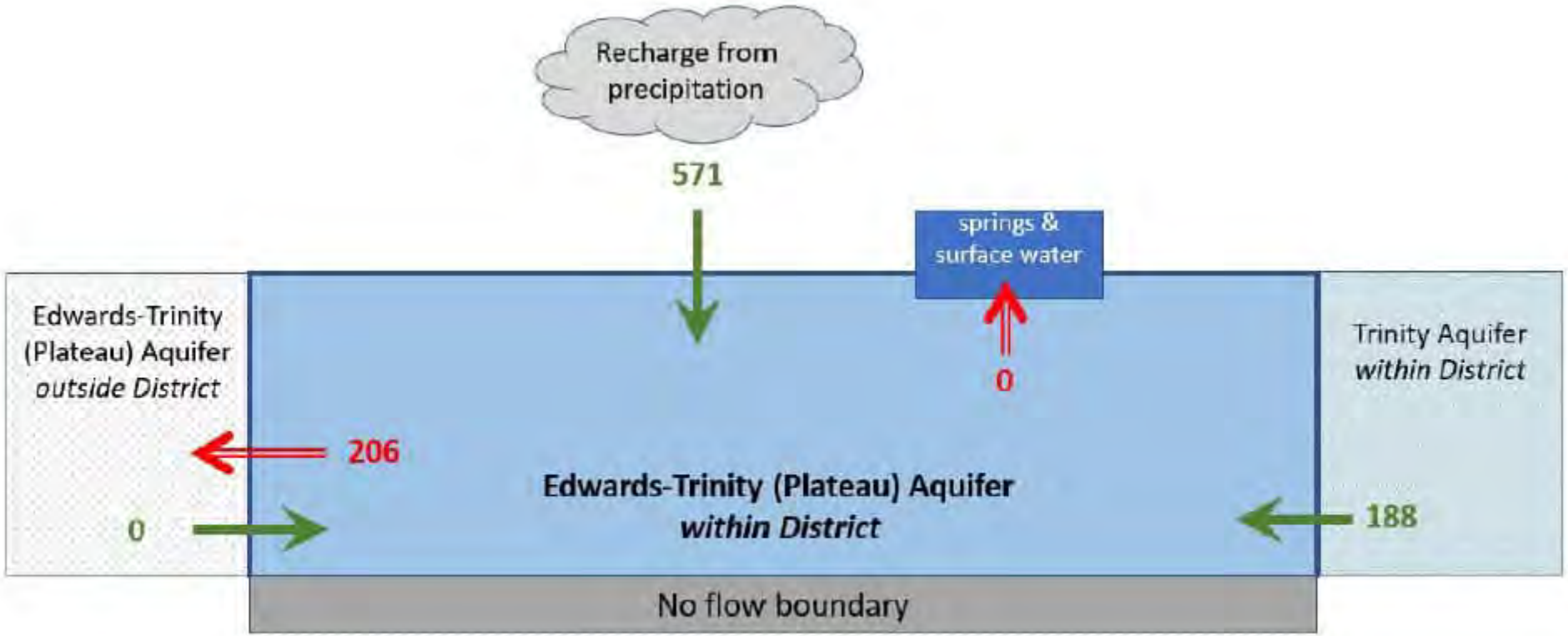
* Flow from Underlying units within district includes net flow of 148 acre-feet per year from Marble Falls Aquifer to Permian and Pennsylvanian Confining unit, 5,878 acre-feet per year to Marble Falls Aquifer from Mississippian Confining unit, 480 acre-feet per year to Marble Falls Aquifer from Ellenburger-San Saba Aquifer, and 2 acre-feet per year to Marble Falls Aquifer from Cambrian Confining Unit.

Blanco County- Trinity Aquifer



*Flow to underlying units within district includes net flow of 990 acre-feet per year from Trinity to Ellenburger-San Saba Aquifer, and 61 acre-feet per year to Trinity Aquifer from Hickory Aquifer.

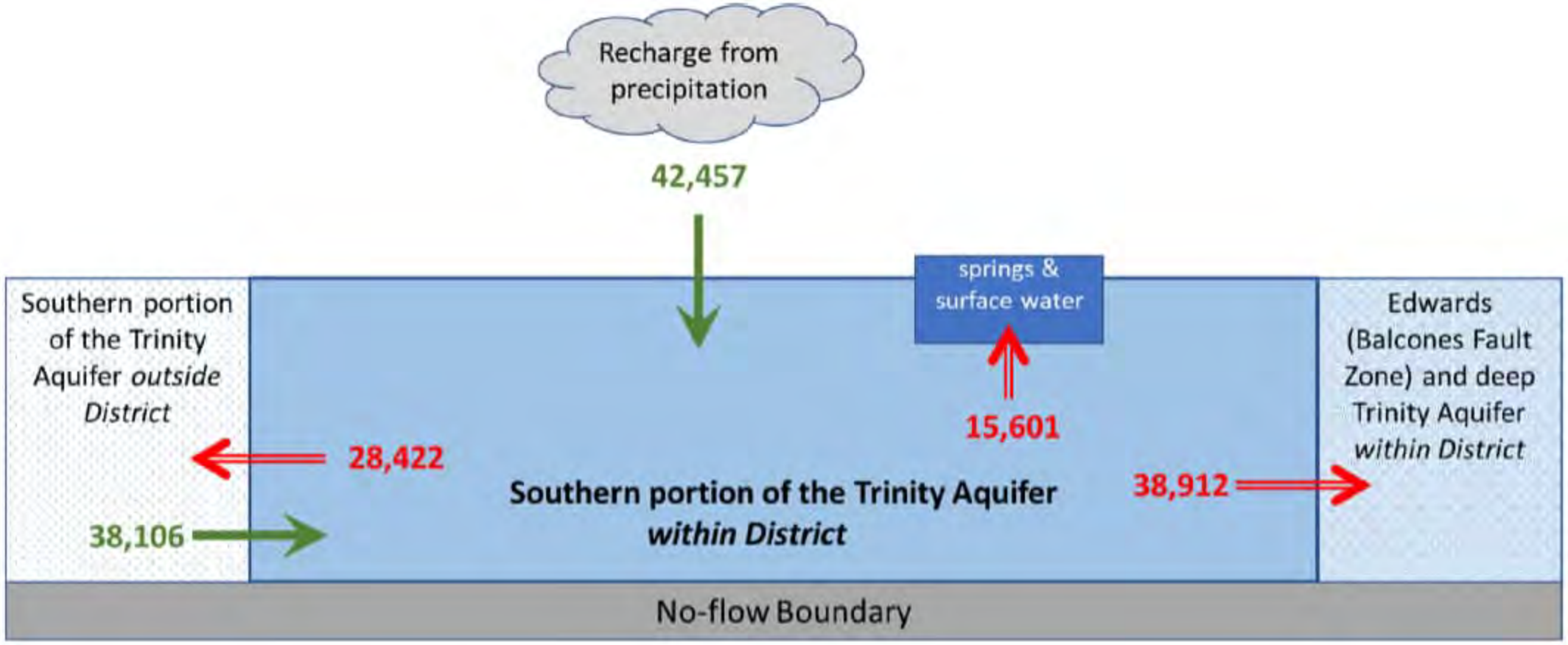
Blanco County- Edwards-Trinity (Plateau) Aquifer



Bexar County- Trinity Aquifer

Management Plan requirement	Aquifer or confining unit	Results
Estimated annual amount of recharge from precipitation to the district	Trinity Aquifer	44,992
Estimated annual volume of water that discharges from the aquifer to springs and any surface-water body including lakes, streams, and rivers	Trinity Aquifer	10,347
Estimated annual volume of flow into the district within each aquifer in the district	Trinity Aquifer	36,079
Estimated annual volume of flow out of the district within each aquifer in the district	Trinity Aquifer	26,417
Estimated net annual volume of flow between each aquifer in the district	From the Trinity Aquifer to the Edwards (Balcones Fault Zone) Aquifer.	39,006

Comal County- Trinity Aquifer



Hays County- Trinity Aquifer

Management Plan requirement	Aquifer or confining unit	Results
Estimated annual amount of recharge from precipitation to the district	Trinity Aquifer	26,105
Estimated annual volume of water that discharges from the aquifer to springs and any surface-water body including lakes, streams, and rivers	Trinity Aquifer	22,439
Estimated annual volume of flow into the district within each aquifer in the district	Trinity Aquifer	17,716
Estimated annual volume of flow out of the district within each aquifer in the district	Trinity Aquifer	11,610
*Estimated net annual volume of flow between each aquifer in the district	From the Trinity Aquifer to the Edwards (Balcones Fault Zone) Aquifer	7,440

Hays County- Hickory Aquifer

Management Plan requirement	Aquifer or confining unit	Results
Estimated annual amount of recharge from precipitation to the district	Hickory Aquifer	0
Estimated annual volume of water that discharges from the aquifer to springs and any surface-water body including lakes, streams, and rivers	Hickory Aquifer	0
Estimated annual volume of flow into the district within each aquifer in the district	Hickory Aquifer	2,798
Estimated annual volume of flow out of the district within each aquifer in the district	Hickory Aquifer	4,336
Estimated net annual volume of flow between each aquifer in the district	From overlying units into the Hickory Aquifer	1,603
	To underlying units from the Hickory Aquifer	66

Kendall County- Trinity Aquifer

Management Plan requirement	Aquifer or confining unit	Results
Estimated annual amount of recharge from precipitation to the district	Trinity Aquifer	50,110
Estimated annual volume of water that discharges from the aquifer to springs and any surface-water body including lakes, streams, and rivers	Trinity Aquifer	31,131
Estimated annual volume of flow into the district within each aquifer in the district	Trinity Aquifer	7,917
Estimated annual volume of flow out of the district within each aquifer in the district	Trinity Aquifer	30,915
Estimated net annual volume of flow between each aquifer in the district	Flow from the Edwards-Trinity (Plateau) Aquifer into the Trinity Aquifer	6,429
	Flow from the Edwards Group into the Trinity Aquifer	58

Kendall County- Edwards-Trinity (Plateau) Aquifer

Management Plan requirement	Aquifer or confining unit	Results
Estimated annual amount of recharge from precipitation to the district	Edwards-Trinity (Plateau) Aquifer	6,046
Estimated annual volume of water that discharges from the aquifer to springs and any surface-water body including lakes, streams, and rivers	Edwards-Trinity (Plateau) Aquifer	3,061
Estimated annual volume of flow into the district within each aquifer in the district	Edwards-Trinity (Plateau) Aquifer	4,020
Estimated annual volume of flow out of the district within each aquifer in the district	Edwards-Trinity (Plateau) Aquifer	290
Estimated net annual volume of flow between each aquifer in the district	Flow from the Edwards-Trinity (Plateau) Aquifer into the Trinity Aquifer	6,429

Kendall County- Ellenburger-San Saba Aquifer

Management Plan requirement	Aquifer or confining unit	Results
Estimated annual amount of recharge from precipitation to the district	Ellenburger-San Saba Aquifer	0
Estimated annual volume of water that discharges from the aquifer to springs and any surface-water body including lakes, streams, and rivers	Ellenburger-San Saba Aquifer	0
Estimated annual volume of flow into the district within each aquifer in the district	Ellenburger-San Saba Aquifer	5,059
Estimated annual volume of flow out of the district within each aquifer in the district	Ellenburger-San Saba Aquifer	4,811
Estimated net annual volume of flow between each aquifer in the district	Flow into the Ellenburger-San Saba Aquifer from the Hickory Aquifer	1,626
	Flow from the Ellenburger-San Saba Aquifer to brackish units	3,948
	Flow into the Ellenburger-San Saba Aquifer from overlying confining unit	4,743
	Flow from the Ellenburger-San Saba Aquifer into underlying confining unit	2,746
	Flow into the Ellenburger-San Saba Aquifer from underlying Precambrian units	75

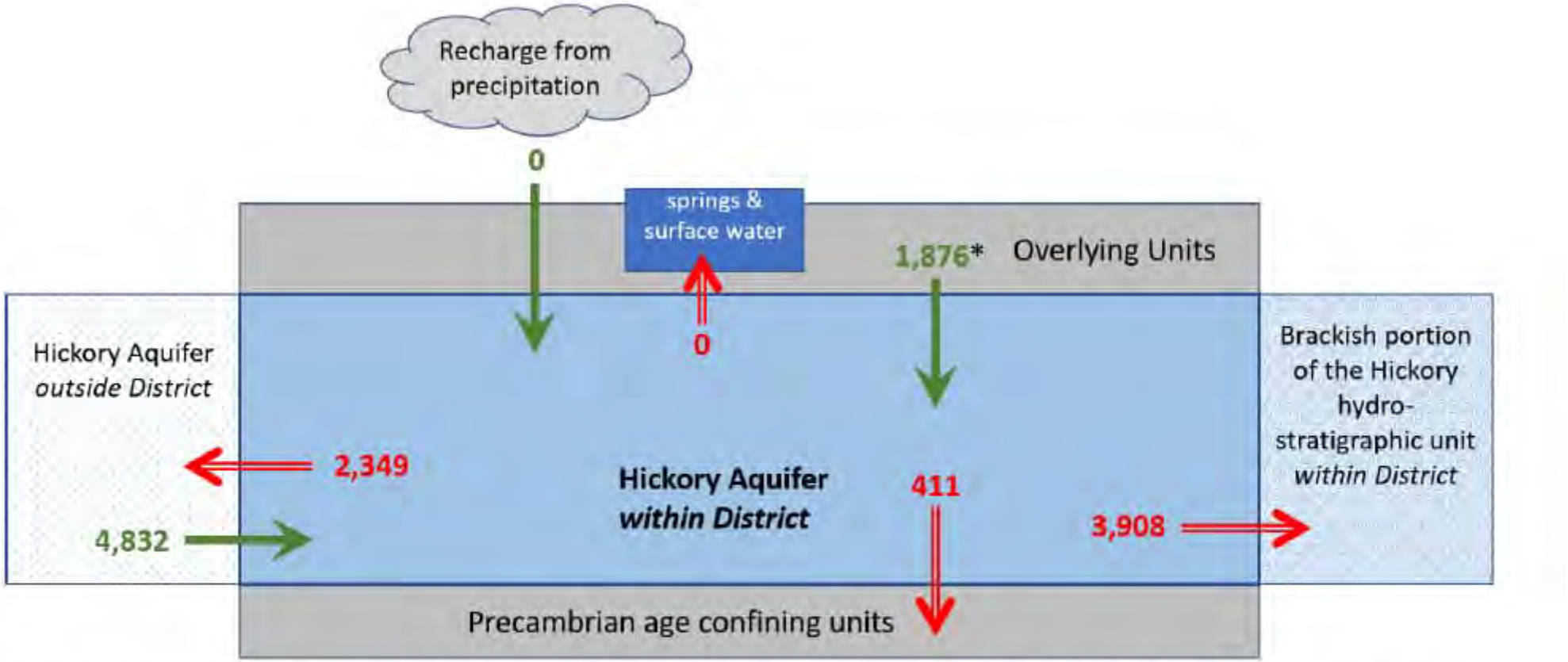
Kendall County- Hickory Aquifer

Management Plan requirement	Aquifer or confining unit	Results
Estimated annual amount of recharge from precipitation to the district	Hickory Aquifer	0
Estimated annual volume of water that discharges from the aquifer to springs and any surface-water body including lakes, streams, and rivers	Hickory Aquifer	0
Estimated annual volume of flow into the district within each aquifer in the district	Hickory Aquifer	2,696
Estimated annual volume of flow out of the district within each aquifer in the district	Hickory Aquifer	2,065
Estimated net annual volume of flow between each aquifer in the district	Flow from the Hickory Aquifer into the Ellenburger-San Saba Aquifer	1,623
	Flow into the Hickory Aquifer from overlying confining units	2,753
	Flow from the Hickory Aquifer into underlying confining units	200
	Flow into the Hickory Aquifer from brackish Ellenburger-San Saba	1,288
	Flow from the Hickory Aquifer into the brackish Hickory Formation	280

Kerr County- Trinity Aquifer

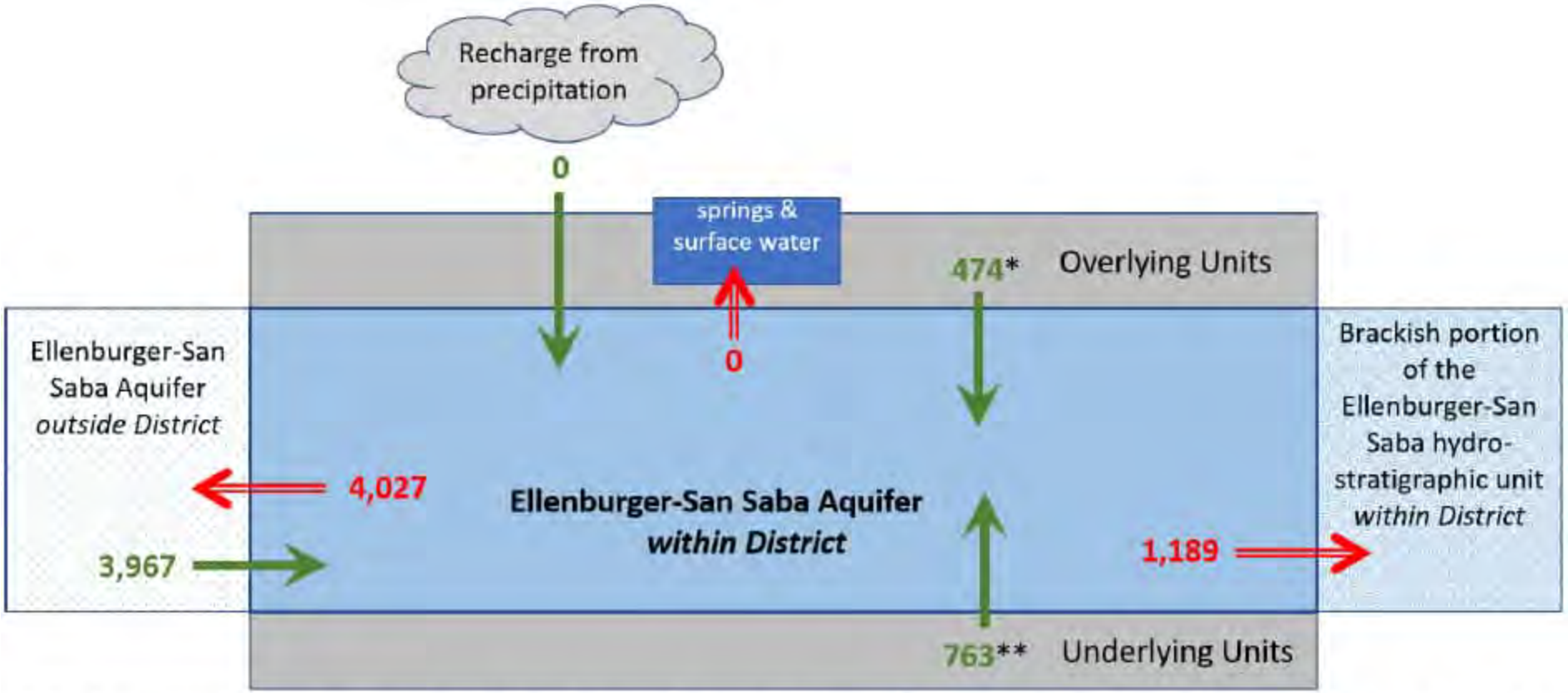
Management Plan requirement	Aquifer or confining unit	Results
Estimated annual amount of recharge from precipitation to the district	Trinity Aquifer	21,331
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers.	Trinity Aquifer	18,473
Estimated annual volume of flow into the district within each aquifer in the district	Trinity Aquifer	2,229
Estimated annual volume of flow out of the district within each aquifer in the district	Trinity Aquifer	7,861
Estimated net annual volume of flow between each aquifer in the district	Into the Trinity Aquifer from the Edwards-Trinity (Plateau) Aquifer	5,438

Kerr County- Hickory Aquifer



* Flow from overlying units includes net outflow of 15 AFY to Mississippian age confining units, 213 AFY to the Ellenburger-San Saba Aquifer and 2,113 AFY to the brackish portion of the Ellenburger-San Saba hydrostratigraphic unit and net inflow of 4,217 AFY from the Cambrian age confining units.

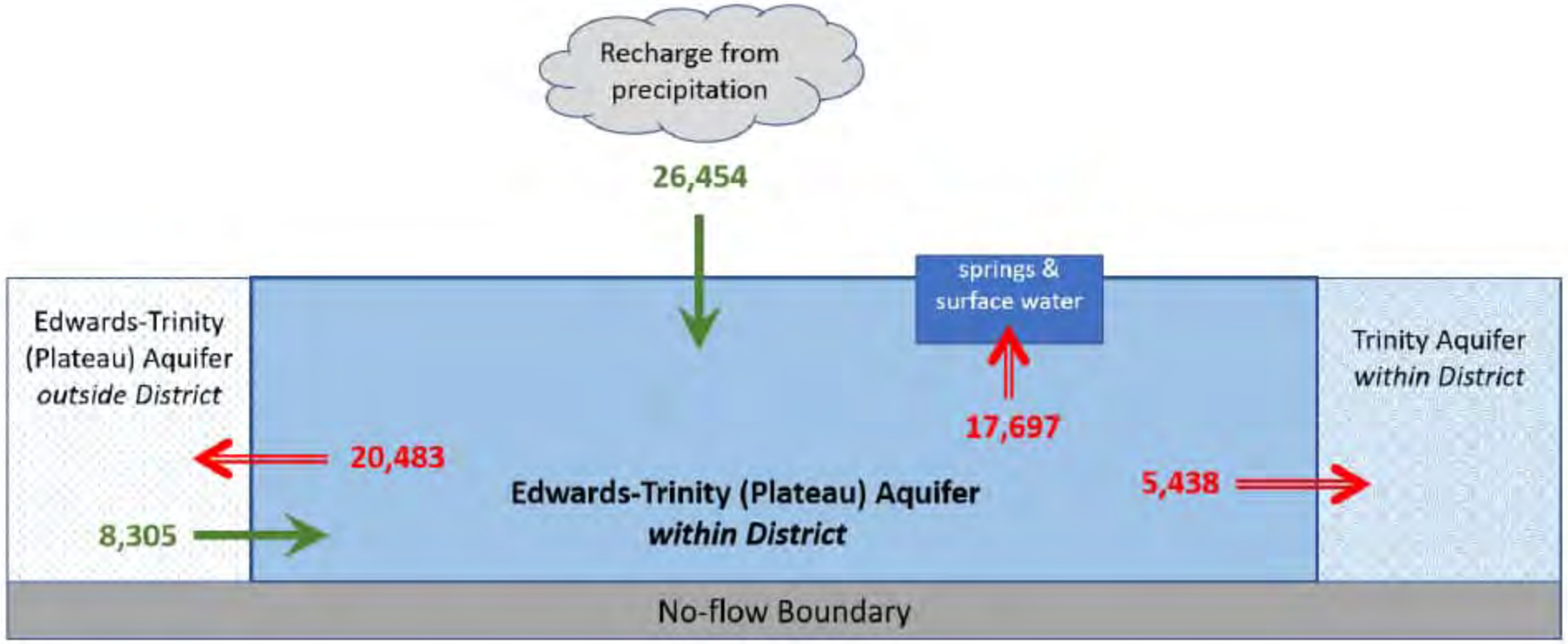
Kerr County- Ellenburger-San Saba Aquifer



* Flow from overlying units includes net outflow of 3 AFY to Permian & Pennsylvanian age confining units and 74 AFY to the Marble Falls Aquifer and net inflow of 551 AFY from the Mississippian age confining units

** Flow from underlying units includes net inflow of 549 AFY from the Cambrian age confining units, 213 AFY from the Hickory Aquifer and 1 AFY from the Precambrian age confining units.

Kerr County- Edwards-Trinity (Plateau) Aquifer



Caveat: This diagram only includes the water budget items provided in Table 4. A complete water budget would include additional inflows and outflows. If the District requires values for additional water budget items, please contact TWDB.

Medina County- Trinity Aquifer

Management Plan requirement	Aquifer or confining unit	Results
Estimated annual amount of recharge from precipitation to the district	Trinity Aquifer	6,918
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers.	Trinity Aquifer	6,412
Estimated annual volume of flow into the district within each aquifer in the district	Trinity Aquifer	21,749
Estimated annual volume of flow out of the district within each aquifer in the district	Trinity Aquifer	6,268
Estimated net annual volume of flow between each aquifer in the district	Flow from the Trinity Aquifer to the Edwards (Balcones Fault Zone) Aquifer and the confined portion of the Trinity Aquifer underlying the Edwards (Balcones Fault Zone) Aquifer.	15,911

Travis County- Trinity Aquifer

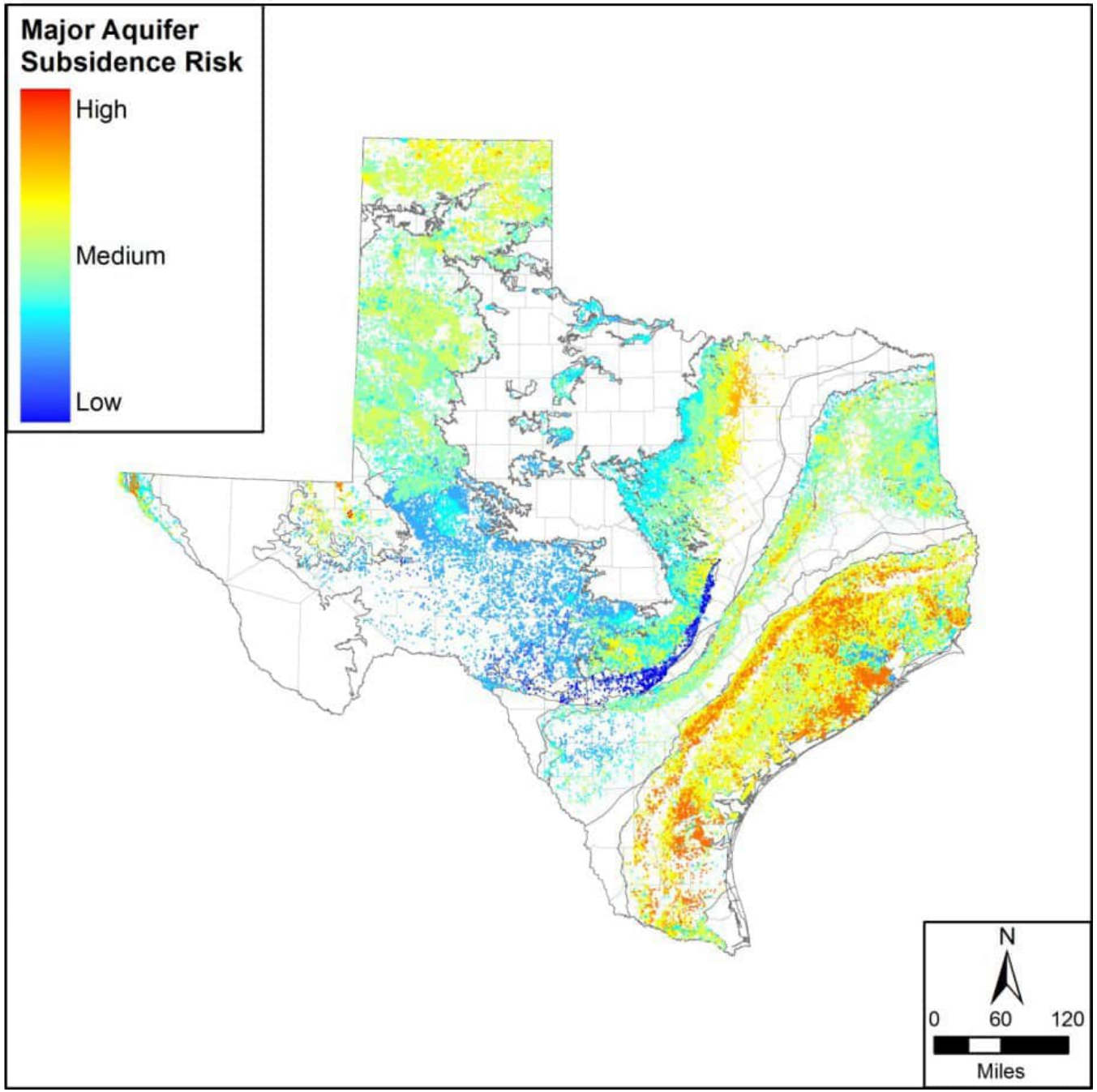
Management Plan requirement	Aquifer or confining unit	Results
Estimated annual amount of recharge from precipitation to the district	Trinity Aquifer	12,167
Estimated annual volume of water that discharges from the aquifer to springs and any surface-water body including lakes, streams, and rivers	Trinity Aquifer	12,654
Estimated annual volume of flow into the district within each aquifer in the district	Trinity Aquifer	10,024
Estimated annual volume of flow out of the district within each aquifer in the district	Trinity Aquifer	9,205
Estimated net annual volume of flow between each aquifer in the district	From the Hill Country portion of the Trinity Aquifer to the Edwards (Balcones Fault Zone) Aquifer and the Trinity Aquifer underlying the Edwards (Balcones Fault Zone) Aquifer.	2,333

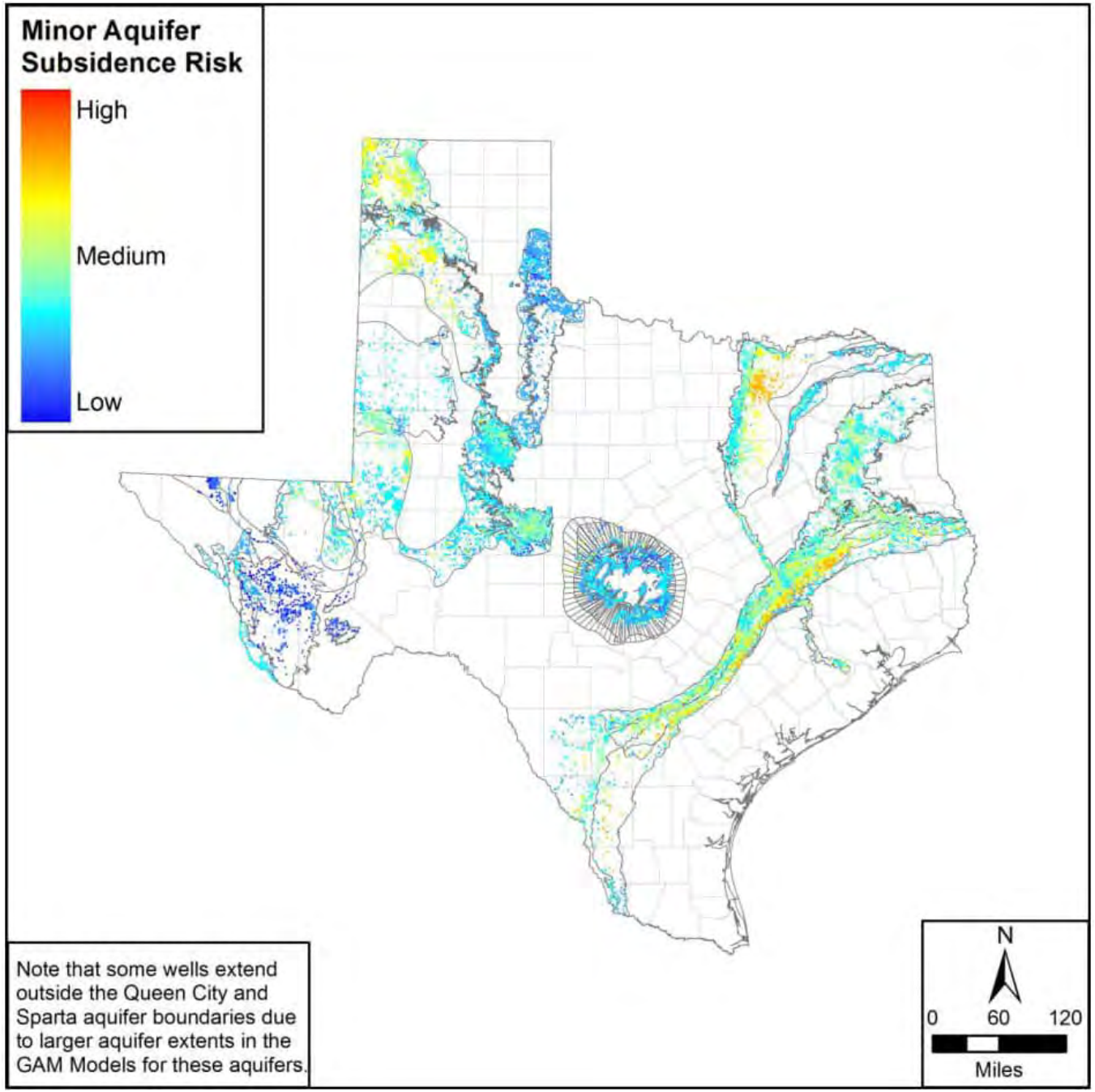
Travis County- Hickory Aquifer

Management Plan requirement	Aquifer or confining unit	Results
Estimated annual amount of recharge from precipitation to the district	Hickory Aquifer	0
Estimated annual volume of water that discharges from the aquifer to springs and any surface-water body including lakes, streams, and rivers	Hickory Aquifer	0
Estimated annual volume of flow into the district within each aquifer in the district	Hickory Aquifer	3,121
Estimated annual volume of flow out of the district within each aquifer in the district	Hickory Aquifer	1,114
Estimated net annual volume of flow between each aquifer in the district	From the Hickory Aquifer into overlying younger units.	2,153
	To the Hickory Aquifer from underlying Precambrian Formations	145

5th Factor (Section 36.108(d))- "Impacts on Subsidence"

- TWDB completed a new statewide subsidence study in 2017
- Subsidence potential exists with higher potential in downdip areas, but no significant risk outside of pumping hotspots
- Factor not applicable in GMA 9 GCD management plans due to either "low risk" or no observations of subsidence
- All aquifers occur in structurally sound geologic formations that do not exhibit significant compaction due to pumping
- 2017 study general considers GMA 9 as "low to medium" risk compared to all other subsidence risks in the state


Major Aquifer
Subsidence Risk
High
Medium
Low
N
0
60
120
Miles


Minor Aquifer
Subsidence Risk
High
Medium
Low
Note that some wells extend outside the Queen City and Sparta aquifer boundaries due to larger aquifer extents in the GAM Models for these aquifers.
N
0
60
120
Miles

Questions/Comments?

Supporting Slides

Annual Recharge, Inflows, and Discharge

- Provided by the TWDB in GAM Run reports in support of management plan development
- Blanco-Pedernales GCD = GAM Run 23-017
- Southwestern Travis County GCD = GAM Run 19-027
- Hays Trinity GCD = GAM Run 19-026
- Comal Trinity GCD = GAM Run 22-012
- Trinity Glen Rose GCD = GAM Run 19-025
- Cow Creek GCD = GAM Run 19-011
- Headwaters GCD = GAM Run 21-003
- Bandera County River Authority & GW District = GAM Run 22-010
- Medina County GCD = GAM Run 20-003

Bandera County- Trinity Aquifer

Management Plan requirement	Aquifer or confining unit	Results
Estimated annual amount of recharge from precipitation to the district	Trinity Aquifer	47,239
Estimated annual volume of water that discharges from the aquifer to springs and any surface-water body including lakes, streams, and rivers	Trinity Aquifer	32,750
Estimated annual volume of flow into the district within each aquifer in the district	Trinity Aquifer	7,819
Estimated annual volume of flow out of the district within each aquifer in the district	Trinity Aquifer	30,409
Estimated net annual volume of flow between each aquifer in the district	To the Trinity Aquifer from the Edwards-Trinity (Plateau) Aquifer	12,484

Bandera County- Edwards-Trinity (Plateau) Aquifer

Management Plan requirement	Aquifer or confining unit	Results
Estimated annual amount of recharge from precipitation to the district	Edwards-Trinity (Plateau) Aquifer	7,561
Estimated annual volume of water that discharges from the aquifer to springs and any surface-water body including lakes, streams, and rivers	Edwards-Trinity (Plateau) Aquifer	4,141
Estimated annual volume of flow into the district within each aquifer in the district	Edwards-Trinity (Plateau) Aquifer	6,109
Estimated annual volume of flow out of the district within each aquifer in the district	Edwards-Trinity (Plateau) Aquifer	4,033
Estimated net annual volume of flow between each aquifer in the district	From the Edwards-Trinity (Plateau) Aquifer to the Trinity Aquifer	12,484

Blanco County- Hickory Aquifer

Management plan requirement	Aquifer or confining unit	Results
Estimated annual amount of recharge from precipitation to the district	Hickory Aquifer	2,089
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Hickory Aquifer	15,721
Estimated annual volume of flow into the district within each aquifer in the district	Hickory Aquifer	7,607
Estimated annual volume of flow out of the district within each aquifer in the district	Hickory Aquifer	7,260
Estimated net annual volume of flow between each aquifer in the district	From Hickory Aquifer to Trinity Aquifer	61
	From Hickory Aquifer to Quaternary alluvium	19
	From Hickory Aquifer to Marble Falls equivalent units	24
	From Hickory Aquifer to Mississippian Confining unit	39
	From Hickory Aquifer to Ellenburger-San Saba Aquifer	4,159
	From Hickory Aquifer to Ellenburger-San Saba Equivalent	975
	To Hickory Aquifer from Cambrian Confining unit	4,117
	To Hickory Aquifer from Hickory equivalent unit	2,530
	From Hickory Aquifer to Precambrian confining unit	484

Blanco County- Ellenburger- San Saba Aquifer

Management plan requirement	Aquifer or confining unit	Results
Estimated annual amount of recharge from precipitation to the district	Ellenburger-San Saba Aquifer	16,482
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Ellenburger-San Saba Aquifer	24,178
Estimated annual volume of flow into the district within each aquifer in the district	Ellenburger-San Saba Aquifer	6,907
Estimated annual volume of flow out of the district within each aquifer in the district	Ellenburger-San Saba Aquifer	12,406
Estimated net annual volume of flow between each aquifer in the district	To Ellenburger-San Saba Aquifer from Trinity Aquifer	990
	To Ellenburger-San Saba Aquifer from Quaternary alluvium	75
	From Ellenburger-San Saba Aquifer to Permian/Pennsylvanian Confining Unit	374
	From Ellenburger-San Saba Aquifer to Marble Falls Aquifer	480
	To Ellenburger-San Saba Aquifer from Marble Falls equivalent units	242
	From Ellenburger-San Saba Aquifer to Mississippian Confining unit	2,930
	From Ellenburger-San Saba Aquifer to Ellenburger-San Saba equivalent units	609
	From Ellenburger-San Saba Aquifer to Cambrian Confining unit	598
	To Ellenburger-San Saba Aquifer from Hickory Aquifer	4,159
	To Ellenburger-San Saba Aquifer from Precambrian confining unit	516

Blanco County- Marble Falls Aquifer

Management plan requirement	Aquifer or confining unit	Results
Estimated annual amount of recharge from precipitation to the district	Marble Falls Aquifer	199
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Marble Falls Aquifer	7,745
Estimated annual volume of flow into the district within each aquifer in the district	Marble Falls Aquifer	NA
Estimated annual volume of flow out of the district within each aquifer in the district	Marble Falls Aquifer	NA
Estimated net annual volume of flow between each aquifer in the district	To Marble Falls Aquifer from Marble Falls equivalent unit	945
	From Marble Falls Aquifer to Permian and Pennsylvanian Confining unit	148
	To Marble Falls Aquifer from Mississippian Confining unit	5,878
	To Marble Falls Aquifer from Ellenburger-San Saba Aquifer	480
	To Marble Falls Aquifer from Cambrian Confining Unit	2

Blanco County- Trinity Aquifer

Management plan requirement	Aquifer or confining unit	Results
Estimated annual amount of recharge from precipitation to the district	Trinity Aquifer	37,189†
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Trinity Aquifer	26,966†
Estimated annual volume of flow into the district within each aquifer in the district	Trinity Aquifer	6,768†
Estimated annual volume of flow out of the district within each aquifer in the district	Trinity Aquifer	15,616†
Estimated net annual volume of flow between each aquifer in the district	From Trinity Aquifer to Edwards-Trinity (Plateau) Aquifer	188*
	From Trinity Aquifer to Ellenburger-San Saba Aquifer	990**
	To Trinity Aquifer from Hickory Aquifer	61**

†Flow values are combined results from the groundwater availability model for the southern portion of the Trinity Aquifer and the groundwater availability model for the Edwards-Trinity (Plateau) and Pecos Valley aquifers.
*Flow value from the groundwater availability model for the Edwards-Trinity (Plateau) Aquifer
** Flow values come from the groundwater availability model for the minor aquifers of the Llano Uplift.

Blanco County- Edwards-Trinity (Plateau) Aquifer

Management plan requirement	Aquifer or confining unit	Results
Estimated annual amount of recharge from precipitation to the district	Edwards-Trinity (Plateau) Aquifer	571
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Edwards-Trinity (Plateau) Aquifer	0
Estimated annual volume of flow into the district within each aquifer in the district	Edwards-Trinity (Plateau) Aquifer	0
Estimated annual volume of flow out of the district within each aquifer in the district	Edwards-Trinity (Plateau) Aquifer	206
Estimated net annual volume of flow between each aquifer in the district	To Edwards-Trinity (Plateau) Aquifer from Trinity Aquifer	188

Comal County- Trinity Aquifer

Management Plan requirement	Aquifer or confining unit	Results
Estimated annual amount of recharge from precipitation to the district	Trinity Aquifer	42,457
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Trinity Aquifer	15,601
Estimated annual volume of flow into the district within each aquifer in the district	Trinity Aquifer	38,106
Estimated annual volume of flow out of the district within each aquifer in the district	Trinity Aquifer	28,422
Estimated net annual volume of flow between each aquifer in the district	From the Trinity Aquifer to the Edwards (Balcones Fault Zone) Aquifer and deep Trinity Aquifer	38,912*

Kerr County- Hickory Aquifer

Management Plan requirement	Aquifer or confining unit	Results
Estimated annual amount of recharge from precipitation to the district	Hickory Aquifer	0
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Hickory Aquifer	0
Estimated annual volume of flow into the district within each aquifer in the district	Hickory Aquifer	4,832
Estimated annual volume of flow out of the district within each aquifer in the district	Hickory Aquifer	2,349
Estimated net annual volume of flow between each aquifer in the district	From the Hickory Aquifer to the Mississippian age confining units	15
	From the Hickory Aquifer to the Ellenburger-San Saba Aquifer	213
	From the Hickory Aquifer to the brackish portion of the Ellenburger-San Saba hydrostratigraphic unit	2,113
	Into the Hickory Aquifer from the Cambrian age confining units	4,217
	From the Hickory Aquifer to the brackish portion of the Hickory hydrostratigraphic unit	3,908
	From the Hickory Aquifer to the Precambrian age confining units	411

Kerr County- Ellenburger-San Saba Aquifer

Management Plan requirement	Aquifer or confining unit	Results
Estimated annual amount of recharge from precipitation to the district	Ellenburger-San Saba Aquifer	0
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Ellenburger-San Saba Aquifer	0
Estimated annual volume of flow into the district within each aquifer in the district	Ellenburger-San Saba Aquifer	3,967
Estimated annual volume of flow out of the district within each aquifer in the district	Ellenburger-San Saba Aquifer	4,027
Estimated net annual volume of flow between each aquifer in the district	From the Ellenburger-San Saba Aquifer to the Permian & Pennsylvanian age confining units	3
	From the Ellenburger-San Saba Aquifer to the brackish portion of the Marble Falls hydrostratigraphic unit	74
	Into the Ellenburger-San Saba Aquifer from the Mississippian age confining units	551
	From the Ellenburger-San Saba Aquifer to the brackish portion of the Ellenburger-San Saba hydrostratigraphic unit	1,189
	Into the Ellenburger-San Saba Aquifer from the Cambrian age confining units	549
	Into the Ellenburger-San Saba Aquifer from the Hickory Aquifer	213
	Into the Ellenburger-San Saba Aquifer from the Precambrian age confining units	1

Kerr County- Edwards-Trinity (Plateau) Aquifer

Management Plan requirement	Aquifer or confining unit	Results
Estimated annual amount of recharge from precipitation to the district	Edwards-Trinity (Plateau) Aquifer	26,454
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers.	Edwards-Trinity (Plateau) Aquifer	17,697
Estimated annual volume of flow into the district within each aquifer in the district	Edwards-Trinity (Plateau) Aquifer	8,305
Estimated annual volume of flow out of the district within each aquifer in the district	Edwards-Trinity (Plateau) Aquifer	20,483
Estimated net annual volume of flow between each aquifer in the district	From the Edwards-Trinity (Plateau) Aquifer into the Trinity Aquifer	5,438

5th Factor (Section 36.108(d))- "Impacts on Subsidence"

- Bandera County River Authority and Groundwater District (2023)
  - *The district has reviewed the TWDB subsidence risk report for applicability to Bandera County. Figure 1.1 'Major aquifer subsidence risk' shows That the District has a low–medium subsidence risk. Therefore, this is not applicable.*
- Blanco-Pedernales (2019)
  - *The rigid geologic framework of the region precludes significant subsidence from occurring. Therefore, this goal is not applicable to the operations of this District.*
- Comal Trinity GCD (2023)
  - *The rigid geologic framework of the region precludes subsidence from occurring. Therefore, this goal is not applicable to the operations of this district.*
- Cow Creek GCD (2020)
  - *Figure I on page L7 (Map on following page) of the subsidence report shows that the District has a medium level of major aquifer subsidence risk. Going forward the District will monitor for any evidence of subsidence in areas of healy pumping of groundwater*
- Hays Trinity GCD (2021)
  - *Essentially, the structurally rigid geologic framework of the region has a low to moderate risk, and there has been no evidence of subsidence in the District occurring as a result of past groundwater withdrawals. Therefore, this goal is not applicable to the District.*

5th Factor (Section 36.108(d))- "Impacts on Subsidence"

- Headwaters UWCD (2022)
  - *Land surface subsidence has not been observed in the District. This goal is not applicable at this time.*
- Medina County GCD (2022)
  - *This goal is not applicable to the Medina County Groundwater Conservation District.*
- Southwestern Travis County GCD (2020)
  - *The District has considered the vulnerability of the District to subsidence associated with groundwater withdrawals from aquifers in the District, including a review of TWDB's subsidence risk assessment report (LRE Water and others 2017). Essentially, the structurally rigid geologic framework of the region has a low to moderate risk, and there has been no evidence of subsidence in the District occurring as a result of past groundwater withdrawals. Therefore, this goal is not applicable to the District.*
- Trinity Glen Rose GCD (2021)
  - *Essentially, the structurally rigid geologic framework of the region has a low to moderate risk, and there has been no evidence of subsidence in the District occurring as a result of past groundwater withdrawals. Therefore, this goal is not applicable to the District.*