
Information Relevant to Selection of Preliminary DFCs for the Brazos Alluvium and the Yegua-Jackson Aquifer

Presentation to the POSGCD DFC Committee

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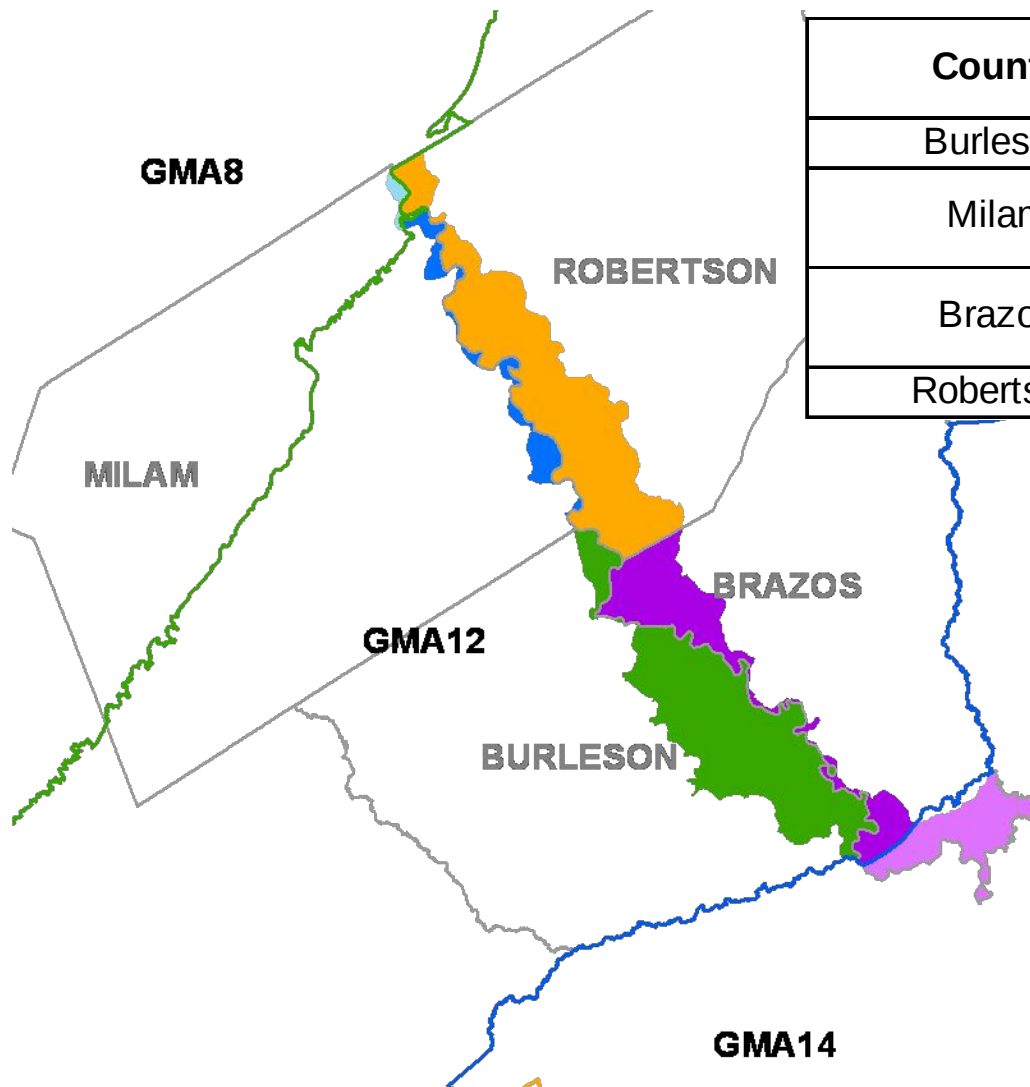
Outline

- Brazos Alluvium
 - General information
 - Drawdown & DFC considerations
 - MAG considerations
- Yegua-Jackson
 - general information
 - GAM info
 - GAM simulation
 - Drawdown and DFC considerations

Brazos Alluvium

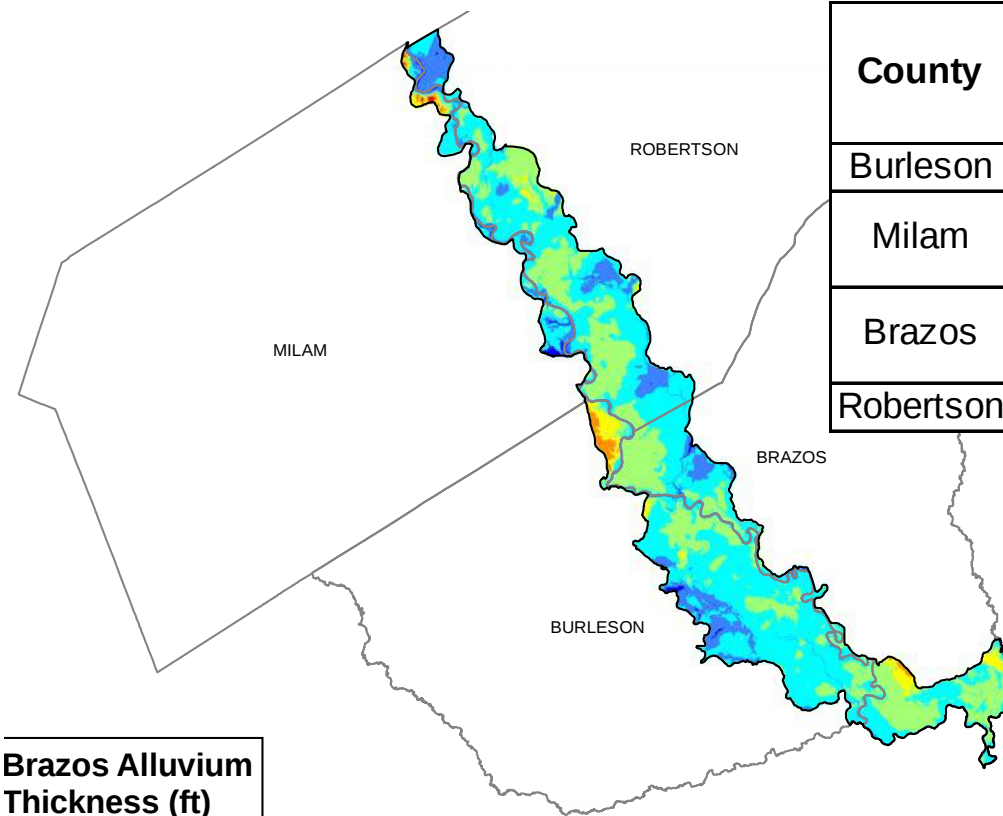
- Designated as a minor aquifer
- Average thickness in GMA 12 is about 55 feet
- Aquifer composed of deposits from Brazos River; average hydraulic conductivity ~ 100 ft/day (very permeable)
- No groundwater availability model
- Recent USGS study defined the areal and extent (Shah and Houston, 2007)

Brazos Alluvium: Areal Extent



County	GMA	Area (sq. miles)	
		GMA	Total
Burleson	12	130	130
Milam	8	3	22
	12	19	
Brazos	12	61	97
	14	36	
Robertson	12	132	132

Brazos Alluvium: Total Thickness



County	GMA	Average Thickness		Maximum Thickness
		GMA Area	Total Area	GMA
Burleson	12	55	55	113
Milam	8	55	51	129
	12	49		147
Brazos	12	58	58	125
	14	59		119
Robertson	12	54	54	104

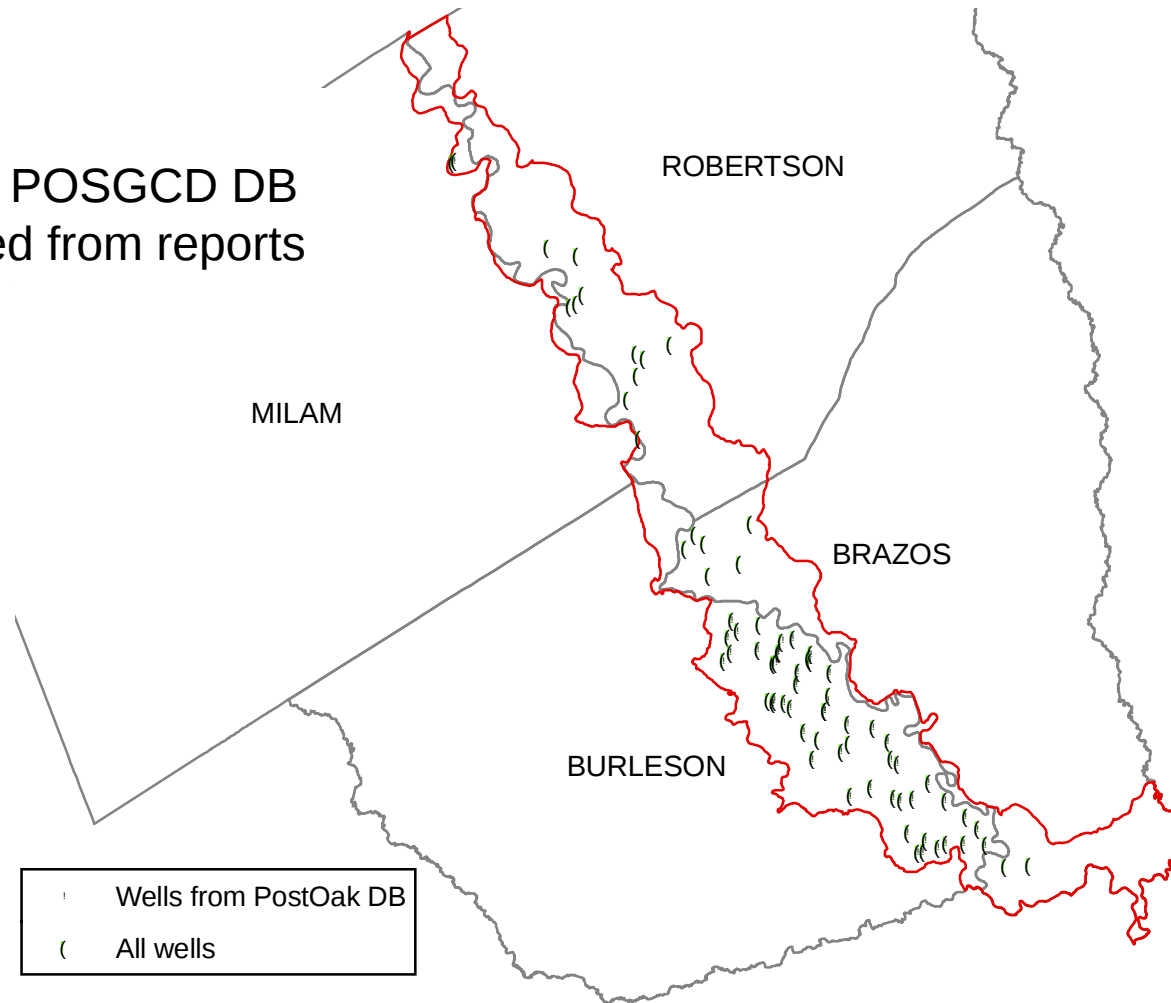
Note: Thickness = ground surface – base of aquifer (from Shah and Houston, 2007)

Water Level Data

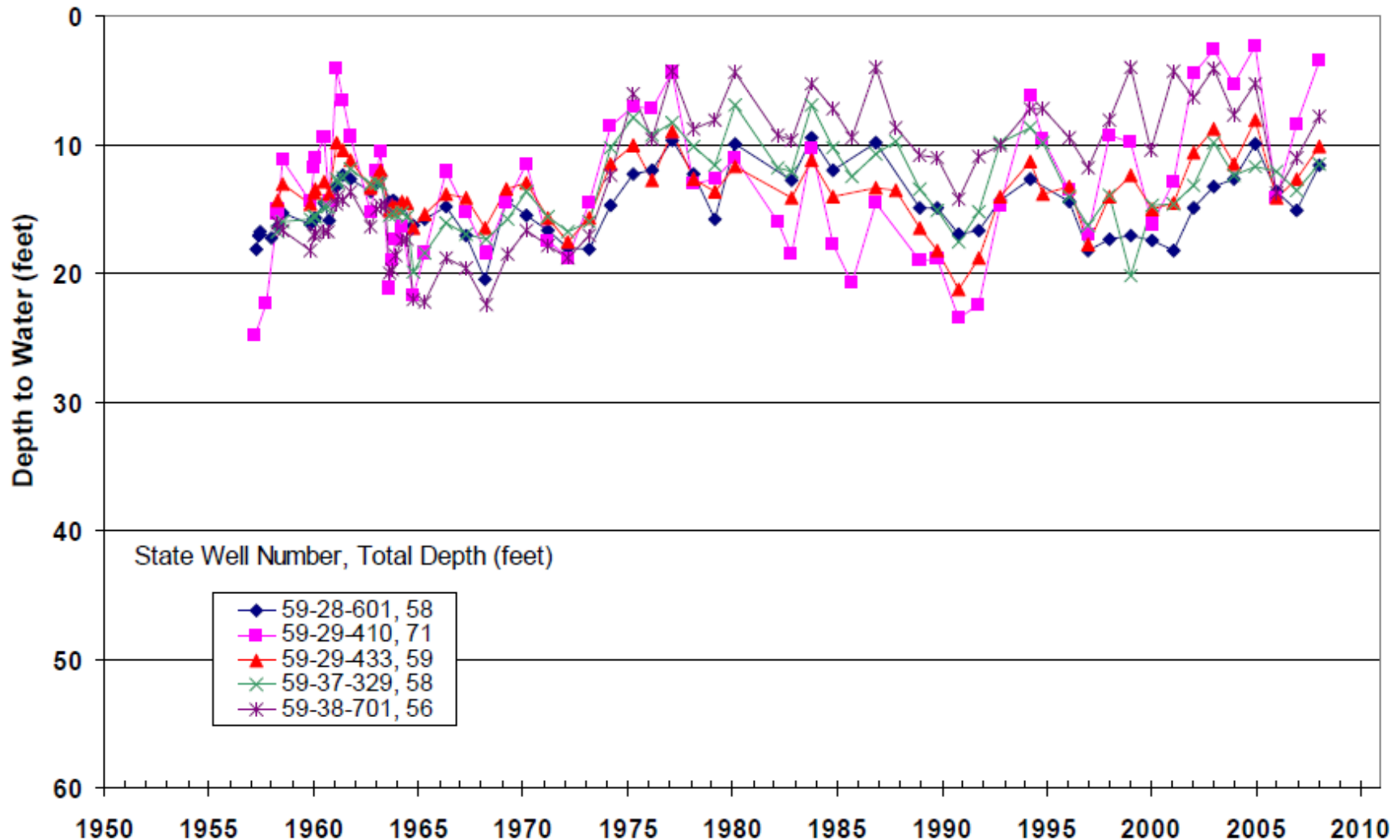
- POSGCD Database
- TWDB Water Well Database
- Reports
 - Follet, C.R., 1974, “Groundwater-Resources of Brazos Counties, Texas” USGS
 - Cronin, James, G and Wilson, C. A., 1967, “Groundwater in the Flood-Plain Alluvium of the Brazos River, Whitney Dam to Vicinity of Richmond, TX

Well Locations with Water Level Data

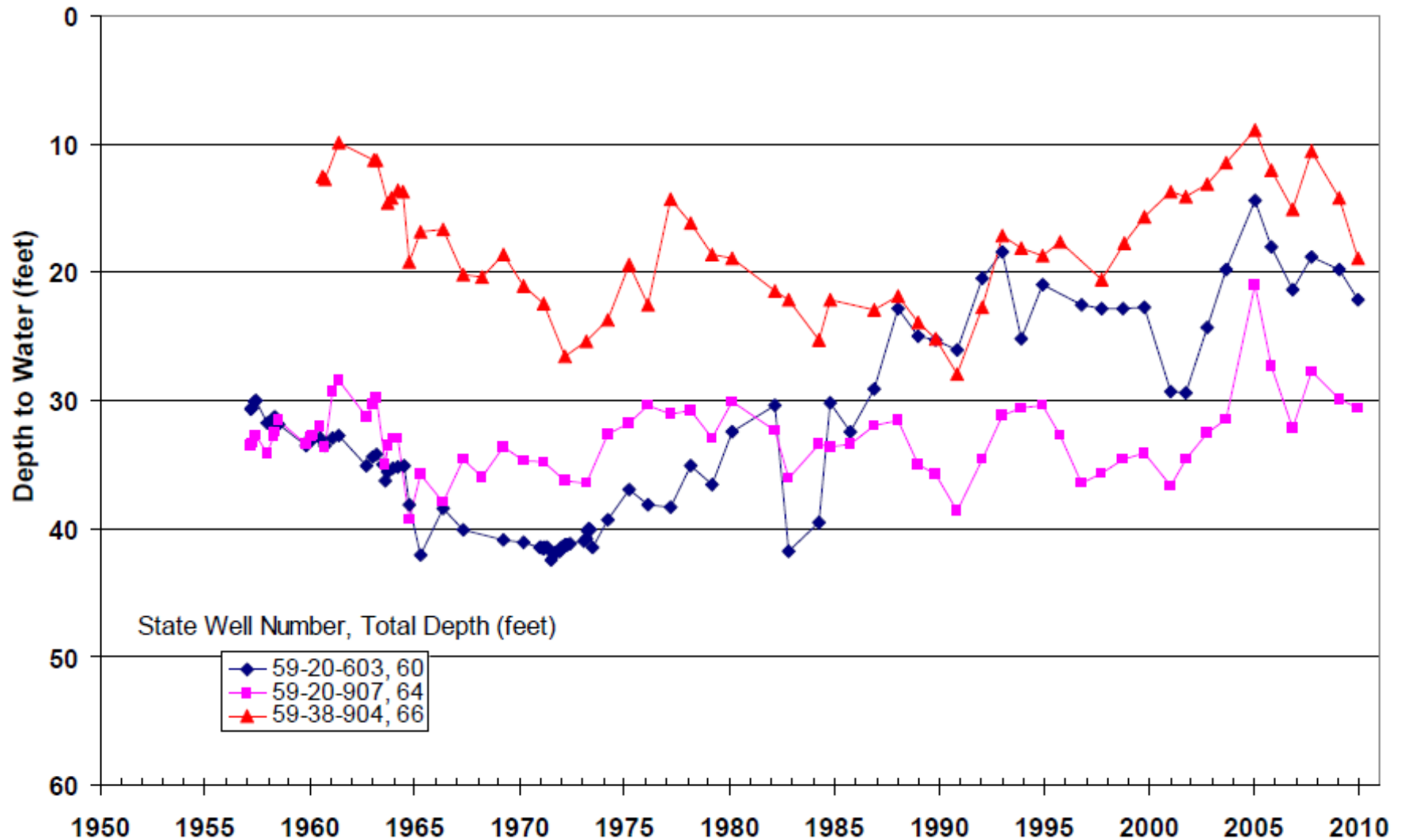
75 wells total
51 wells from POSGCD DB
24 wells added from reports



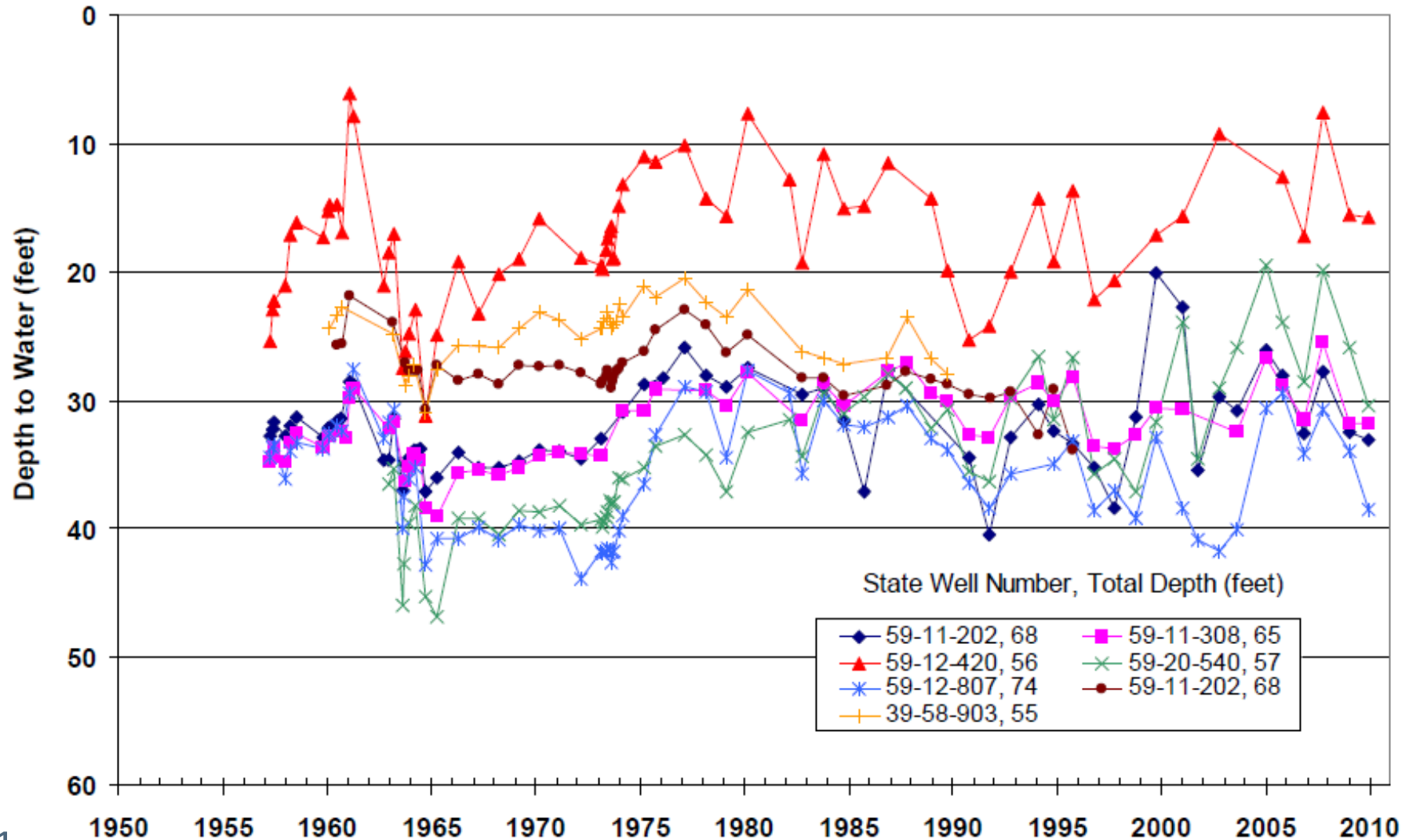
TWDB Brazos River Alluvium WL Data – Examples in Burleson County



TWDB Brazos River Alluvium WL Data – Examples in Brazos County



TWDB Brazos River Alluvium WL Data – Examples in Roberson County



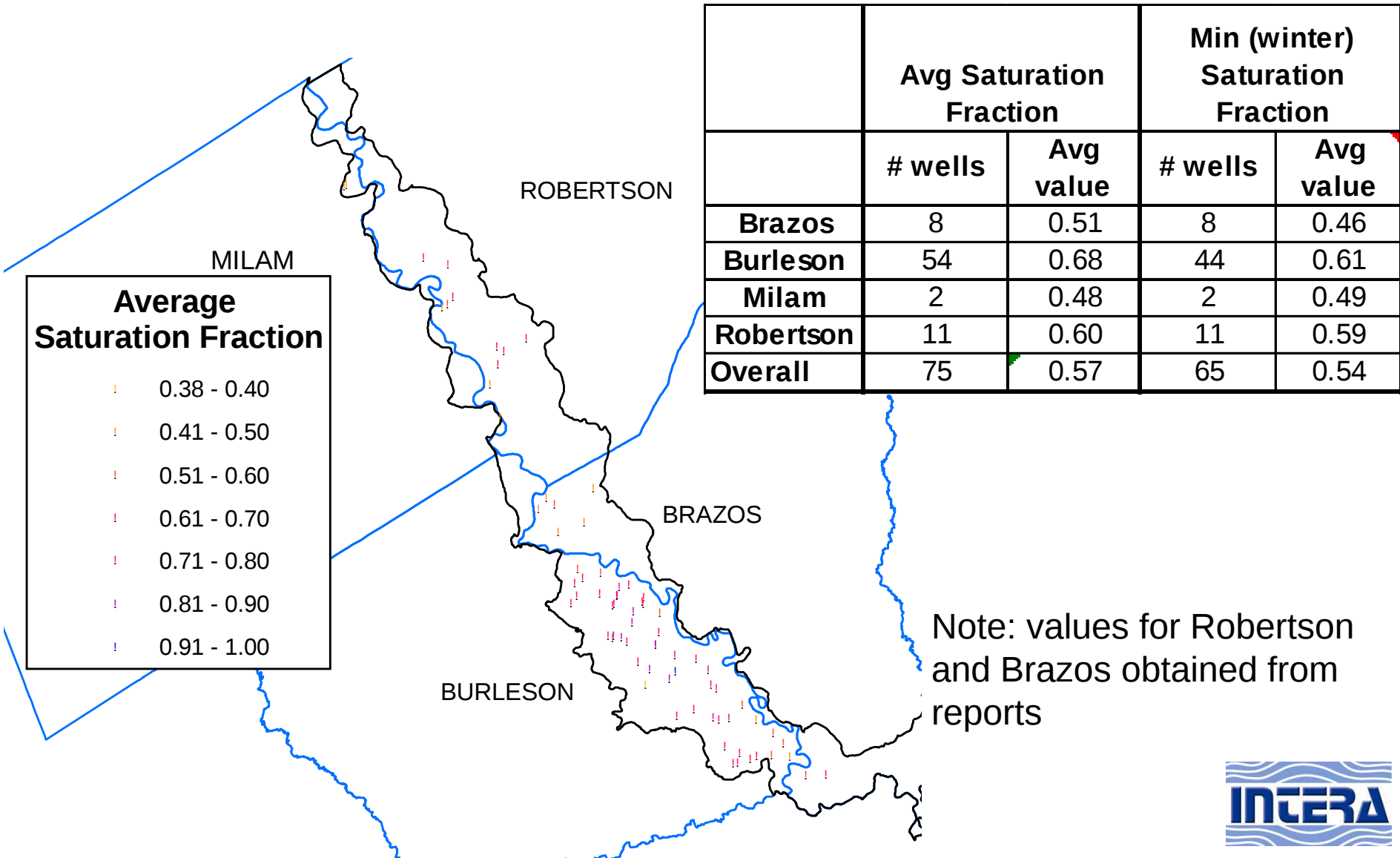
Saturation Fraction

WD = Well Depth (ft) (typically drill 1-3 ft below base of alluvium)

DTW = Estimated Depth of Water below ground surface (ft) (not yet corrected for well stick up)

Fraction Saturation = $(1 - \text{DTW}/\text{WD})$

Estimated Average Saturation based on Available Water Level Data



GMA-8 Brazos Alluvium DFC and MAG (TWDB GTA Assessment 07-05 mag)

- DFC for Milam County
 - Maintain 90% saturated thickness after 50 yrs
 - Estimated total thickness = 55 ft
 - Estimated current saturated thickness = 19 ft
- MAG
 - Total annual recharge + (total storage volume/50 year)
 - 464 AFY

Preliminary DFC Evaluation: Assumptions

- Estimated Precipitation
 - Milam estimated at 37 in/yr (35.5 to 37 in/yr)
 - Burleson estimated at 40 in/yr (38.5 to 40 in/yr)
- Recharge
 - 7.5% of precipitation
- Average Current Saturation
 - Milam ~ 24.5 ft ($0.5 * 49$ ft)
 - Burleson ~38.5 ft ($0.7 * 55$ ft)

Preliminary DFC Evaluation: MAG Based on a TWDB-like Approach

Recharge Component

County	Area in GMA 12		Recharge Estimate			Recharge (AFY)
			Average Precipitation (in/yr)	Recharge % of Precip	Recharge (in/yr)	
	sq. miles	acres				
Burleson	129.8	83,073	40	7.5	3.0	20,768
Milam	19.5	12,450	37	7.5	2.8	2,879

Storage Component

County	Area in GMA 12		Specific Yield	Drawdown (ft)	% Reduction in Saturated Thickness	Annual Storage (AFY)
	sq. miles	acres				
Burleson	129.8	83,073	0.15	2	5%	498
				4	11%	997
				5	13%	1,246
				6	16%	1,495
				8	21%	1,994
				10	27%	2,492
Milam	19.5	12,450	0.15	2	8%	75
				4	16%	149
				5	20%	187
				6	24%	224
				8	33%	299

Assumptions Used by TWDB for GMA-8 MAG Calculation

- Recharge
 - Average precipitation = 37 inches/yr
 - Recharge = 7.5% of precipitation
 - Estimated recharge = 464 AFY
- Total Storage
 - Decline in saturated thickness = 1.9 ft
 - Drainage porosity = 15%
 - Total volume = 571 AF
 - Yearly volume = 11.4 AFY

Considerations for MAG Evaluation

- Water Balance
 - Lateral flow into the Brazos Alluvium from other geologic formations
 - Stream-groundwater interaction
- Estimated Historical Pumping
 - Burleson in 1963 & 1964 is about 10,000 AFY
 - Burleson and Brazos in 1958, 1963, 1964, and 1969 ranged from 16,000 to 32,000 AFY
- POSGCD Brazos Alluvium Permits
 - Estimated from database ~ 45,000 AFY
 - Historical permits ~ 40,000 AFY



Consideration for DFC

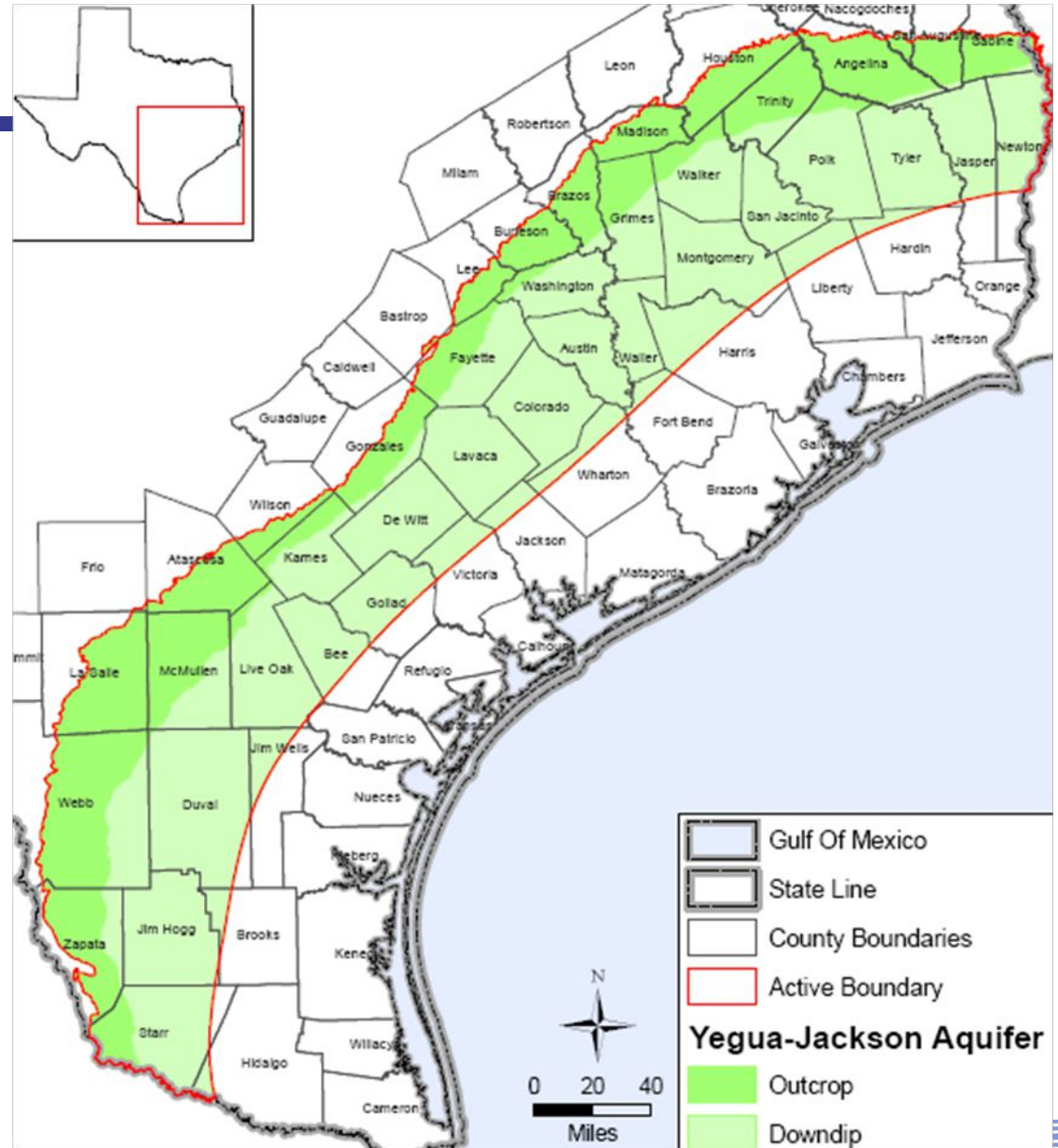
- Large Temporal Variation in Water Levels
 - Large compared to DFC values
 - Consider quantifying variation based on historical data
- Possible Solution
 - Consider a 50-yr DFC value in combination with a statistical analysis of a trend in average drawdown values that accounts for temporal variation present in historical data

Yegua-Jackson Aquifer

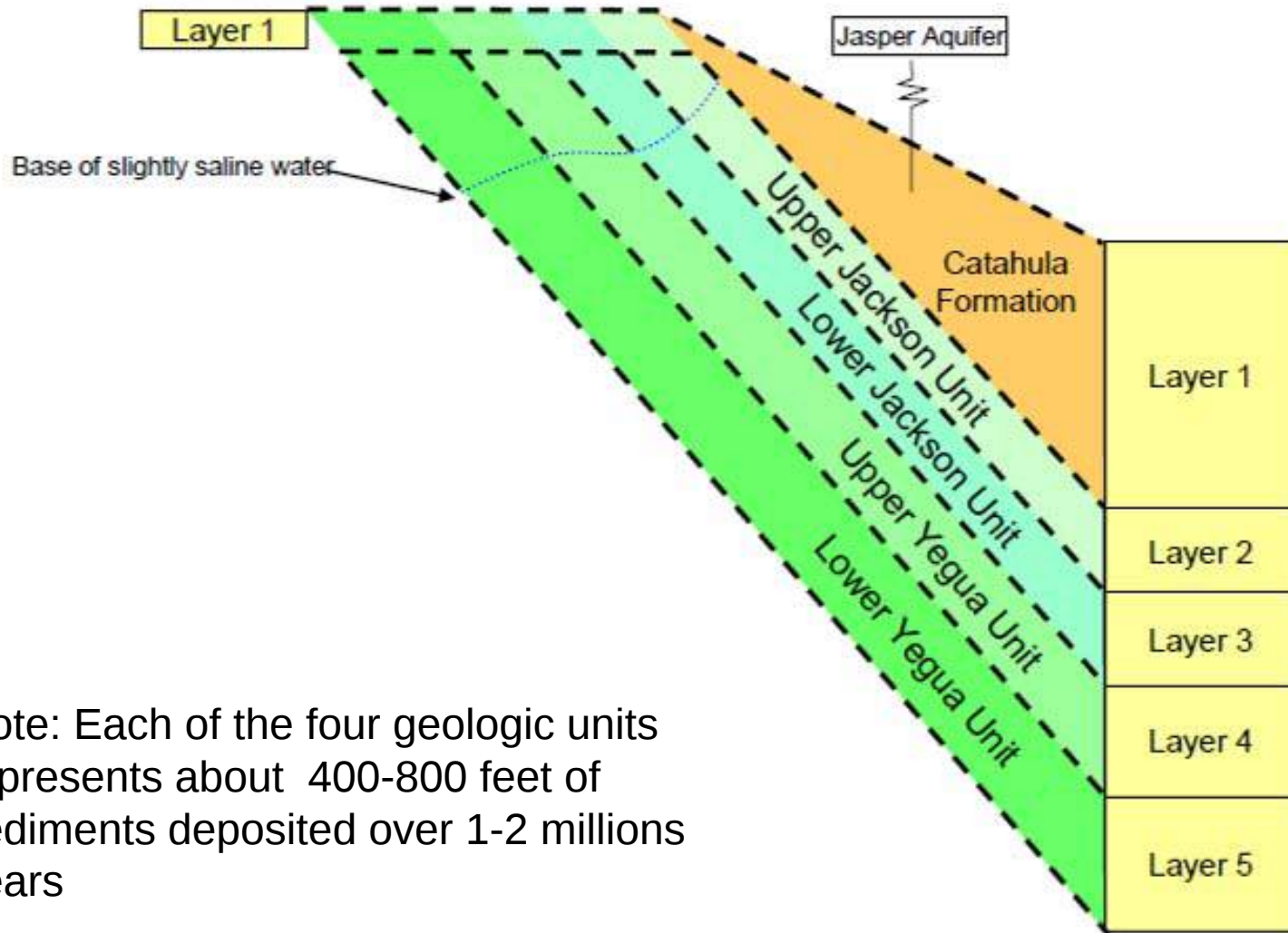
- Designated as a minor aquifer
- Located between the Wilcox Formation and the Gulf Coast Aquifer
- Groundwater Availability Model (GAM) finalized in April 2010
- Relatively little information readily accessible for model development
- General a sand-poor aquifer but isolated regions of moderate transmissivity exist

Model Coverage

Total pumping is less than 20,000 AFY for any given year of record

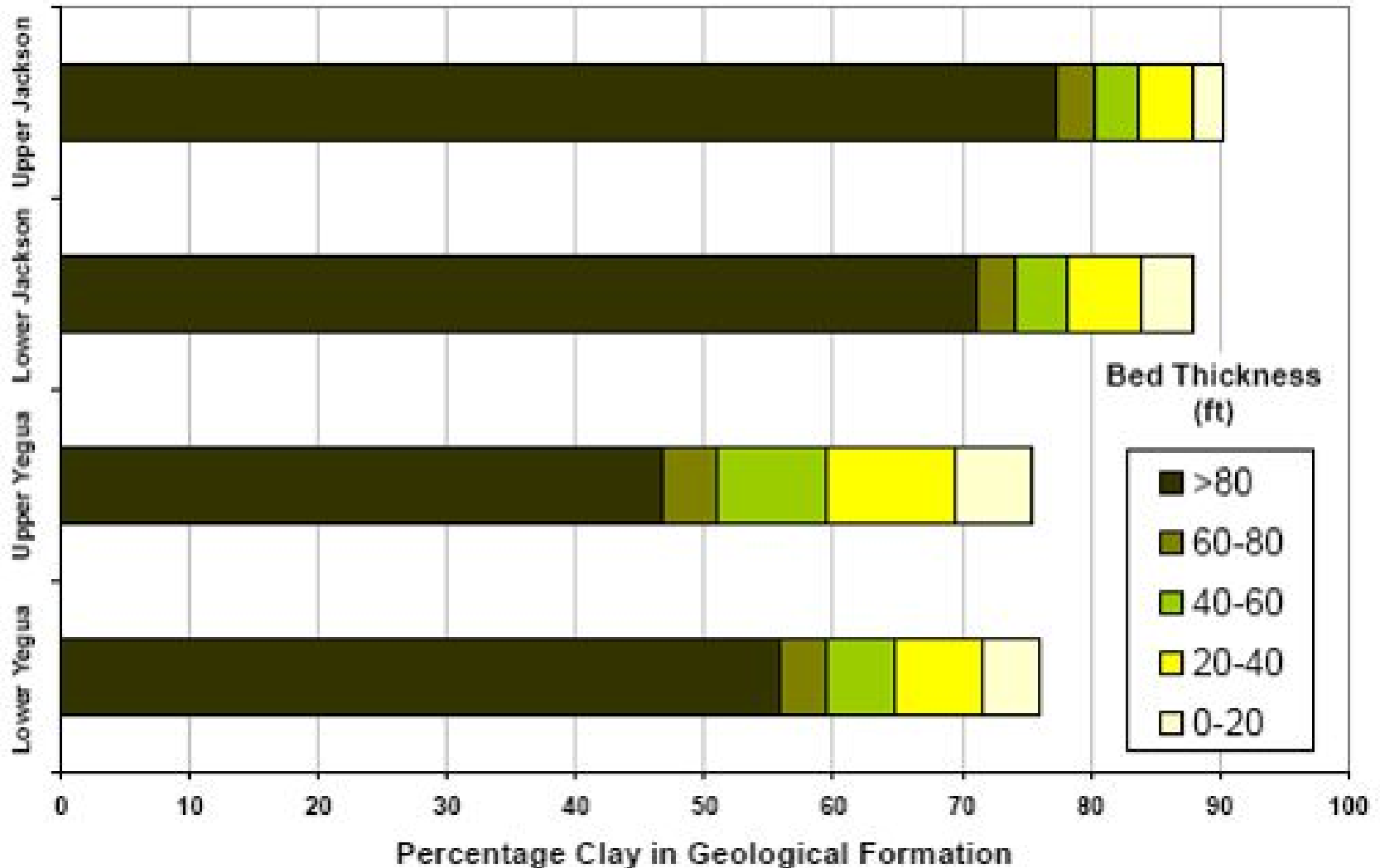


Model Layers



Note: Each of the four geologic units represents about 400-800 feet of sediments deposited over 1-2 millions years

Distribution of Clayey Deposits

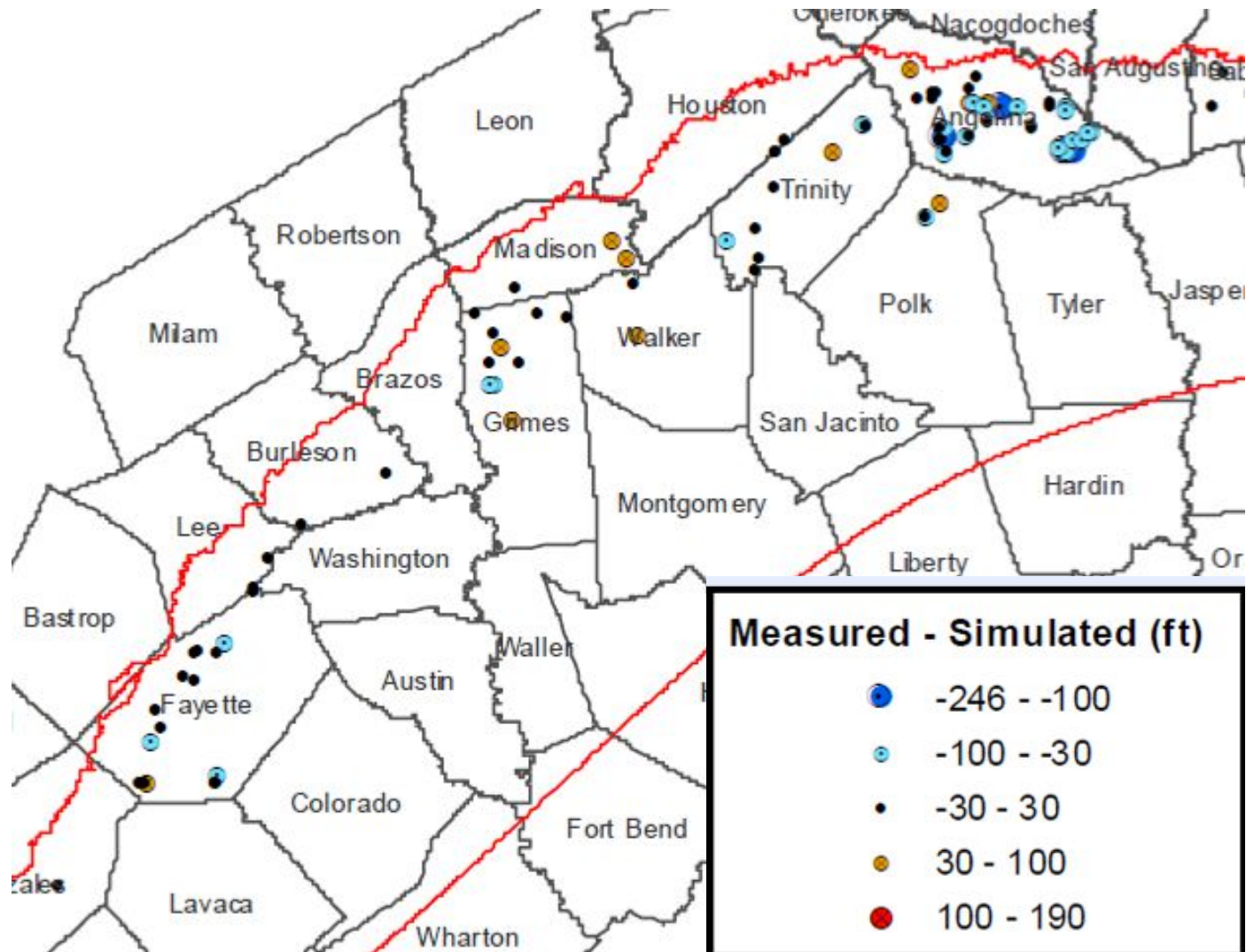


Note: Analysis based on sand analysis by Knox et al. (2007)

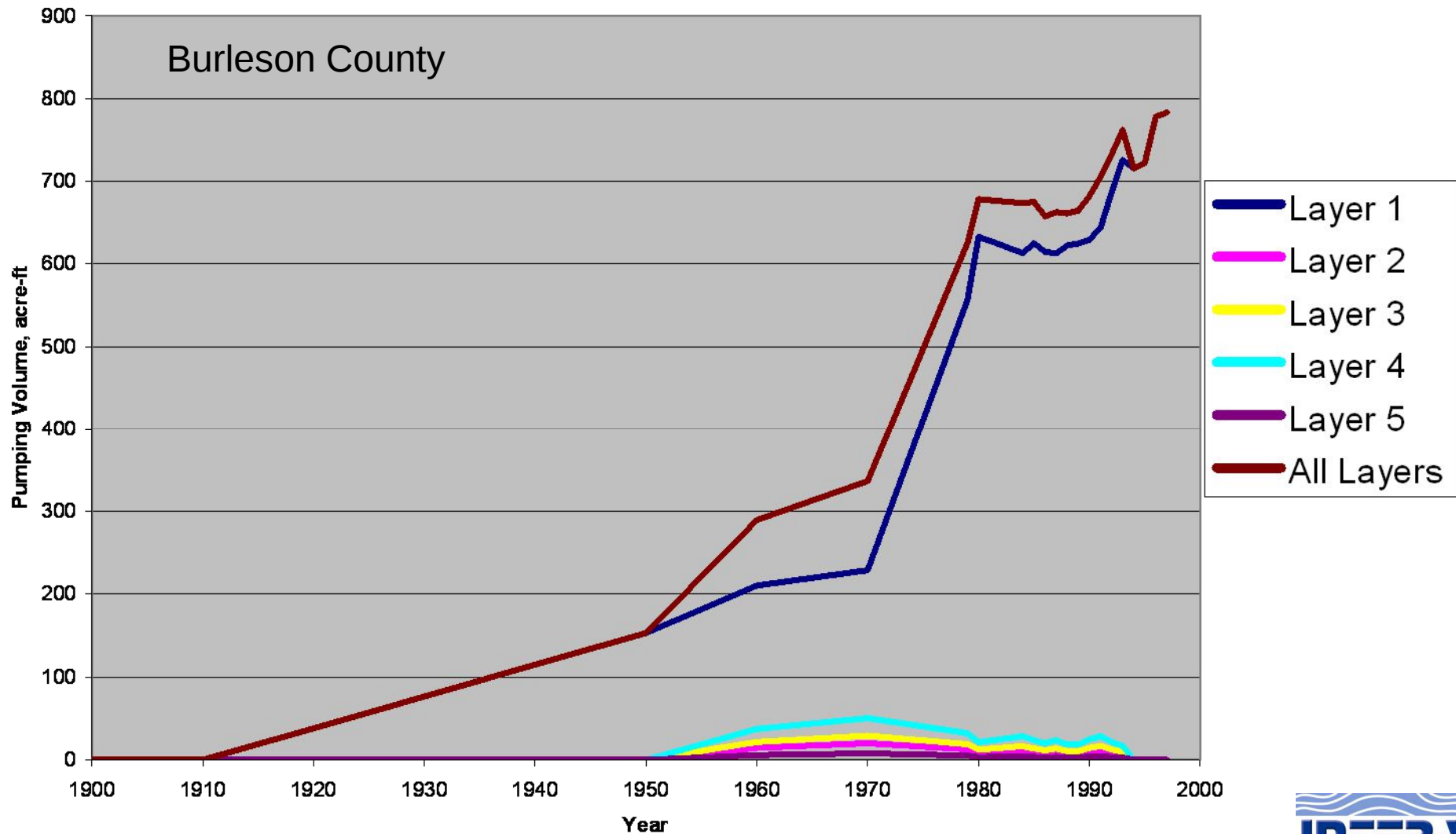
Preliminary Comments Regarding Yegua-Jackson GAM

- Reliable geologic framework
- Sand percentages may be skewed because of bias in analysis of geophysical logs
- Inadequate number of pumping tests and water level to support a reliable calibration
- Pumping distribution in model does not provide a reasonable representation of actual conditions
- Model predictions need to be evaluated in light of the model assumptions and approximations

Wells Used for Pumping (1901 - 1997) Calibration



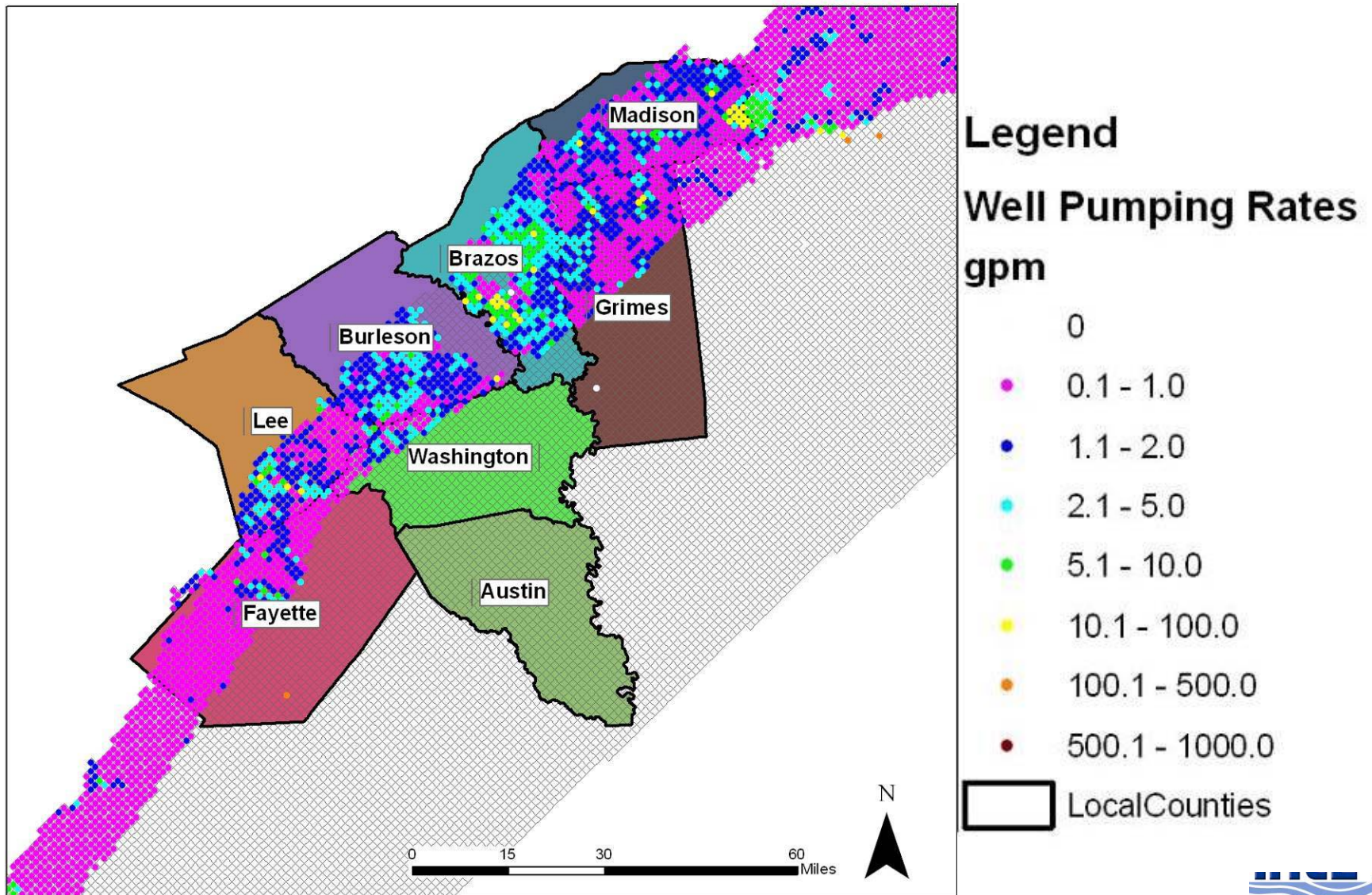
Pumping Over Time: Burleson County



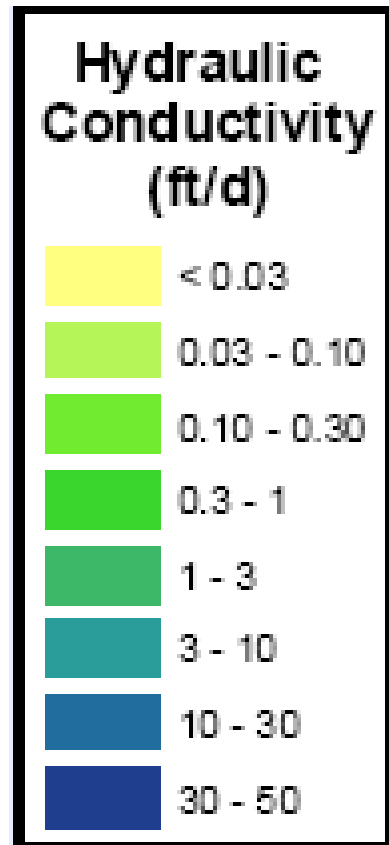
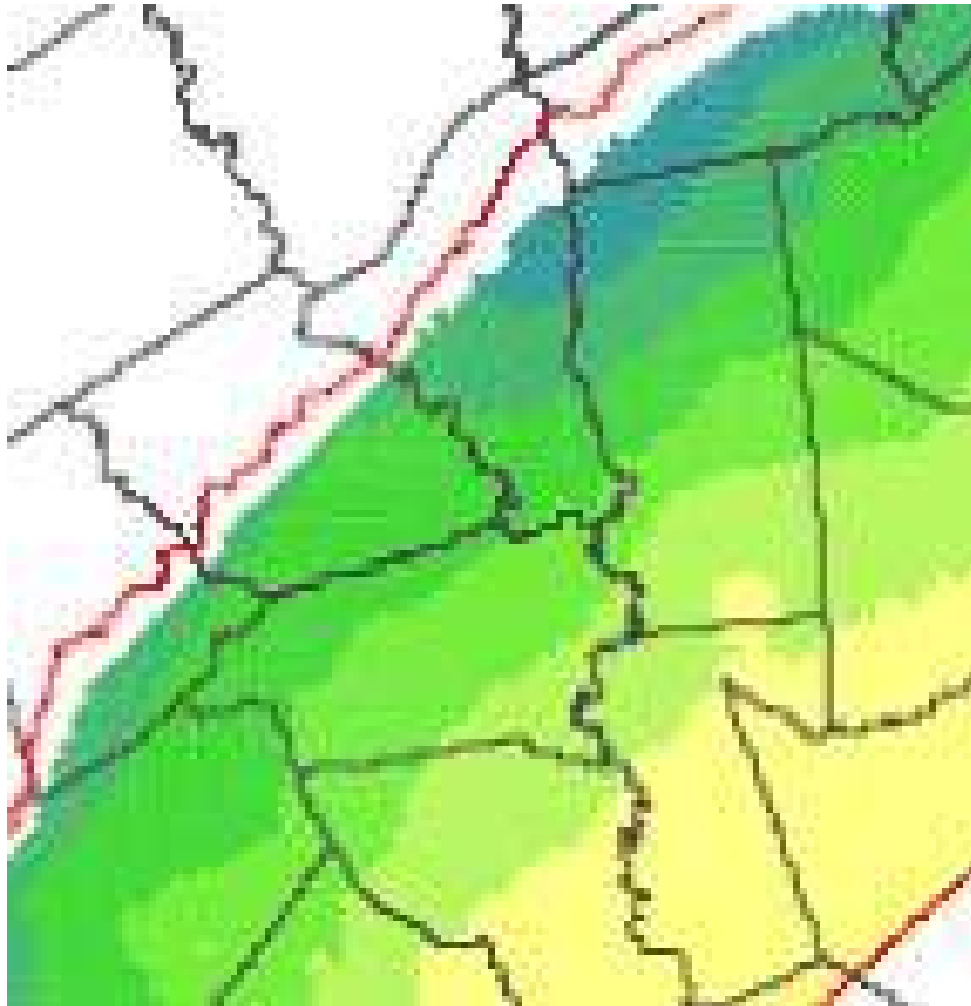
Estimated Pumping in Burleson County based on Current Database Information

Model Layer	Wells		Estimated Pumping (AFY)		
	Exempt	Non Exempt	Exempt (1.6 gpm per well)	Permitted	Total
1	88	3	1,950	232	2,182
2	317	4	1,620	838	2,458
3	960	4	102	2,537	2,639
4	710	2	83	1,877	1,960
5	0	0	0	0	0

Areal Distribution of Pumping (1997)



Hydraulic Conductivity Values for the Lower Yegua Aquifer



Average Drawdown from 1900 to 1997

Zone/Aquifer		Surficial	Upper Jackson	Lower Jackson	Upper Yegua	Lower Yegua
Washington County	1981	-2.8	-1.9	-1.1	-0.2	-0.2
	1991	-1.3	-1.7	-1.5	-0.6	-0.6
	1995	-1.0	-1.5	-1.7	-0.8	-0.8
	Average	-2.1	-1.7	-1.2	-0.4	-0.4
	Maximum	0.0	0.0	0.0	0.0	0.0
Lee County	1981	-0.7	-0.3	-0.3	-0.3	-0.3
	1991	-1.4	-0.9	-0.9	-0.9	-0.9
	1995	-1.5	-1.2	-1.2	-1.2	-1.2
	Average	-0.8	-0.6	-0.6	-0.6	-0.6
	Maximum	0.2	0.2	0.2	0.2	0.2
Burleson County	1981	-1.3	0.2	0.3	0.5	0.5
	1991	-2.5	-0.7	-0.6	-0.4	-0.4
	1995	-2.8	-1.1	-1.1	-0.8	-0.8
	Average	-1.5	-0.3	-0.3	-0.1	-0.1
	Maximum	0.1	1.0	1.1	1.1	1.1
Brazos County	1981	0.4	0.8	0.7	0.6	0.6
	1991	0.6	1.3	1.0	0.8	0.8
	1995	0.7	1.3	0.9	0.7	0.7
	Average	0.5	0.8	0.6	0.5	0.5
	Maximum	0.8	1.4	1.0	0.8	0.8

Note: negative numbers indicate a raise in the average water level

Simulated Water Budget for 1997 (AFY)

Water Budget Component	Groundwater Flux (AFY)
Recharge	22,459
Reservoirs	57
Streams	-11,071
E.T.	-4,525
Storage	-2,572
Lateral Flow	-3,454
Pumping	-778

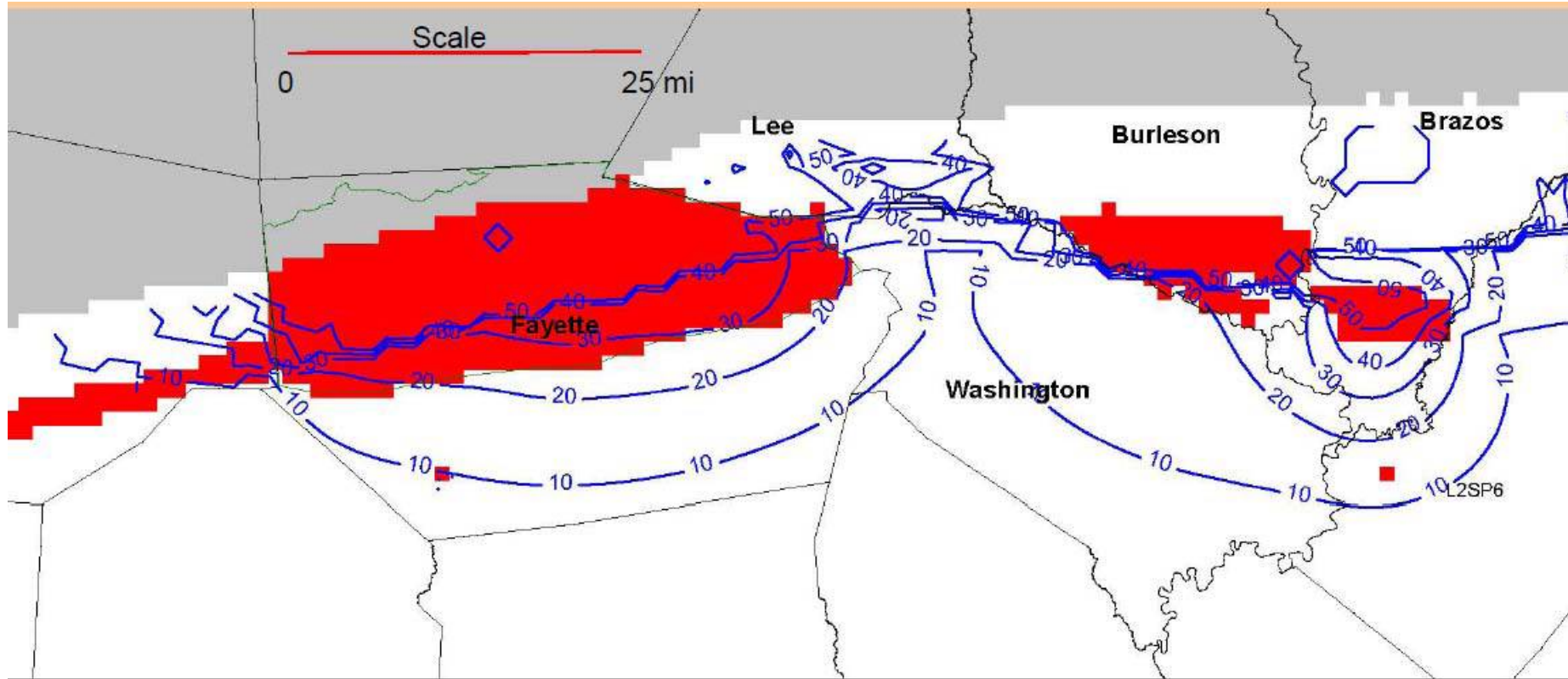
1997 Pumping for Adjacent Districts

Brazos Valley = 1658 AFY

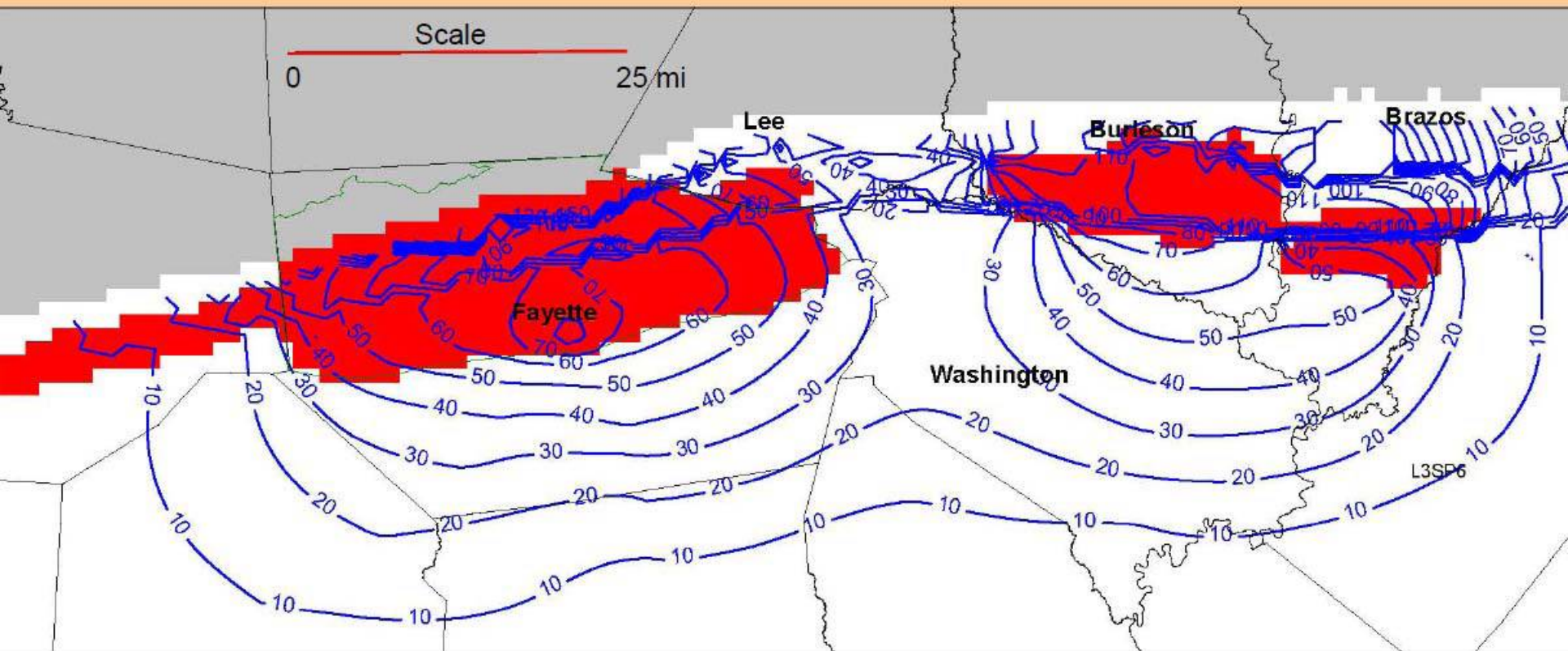
Lost Pines = 651 AFY



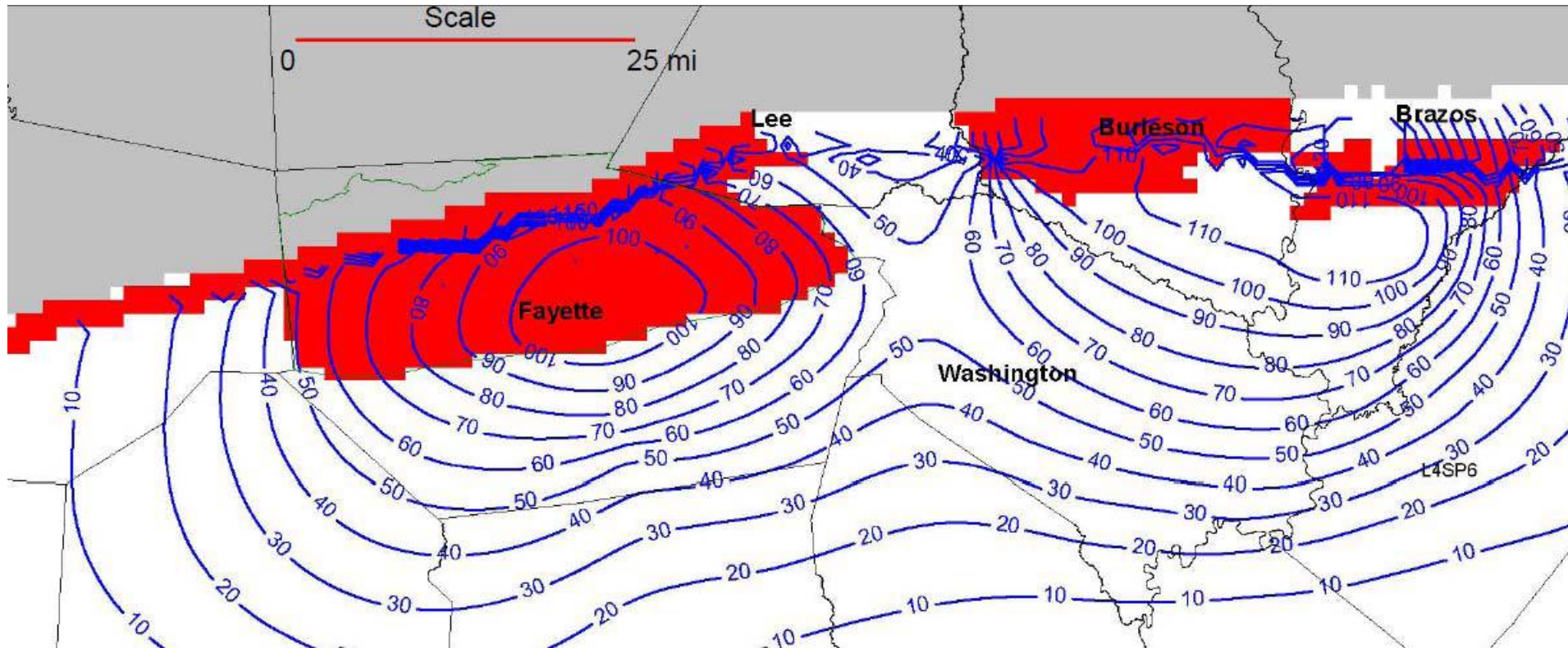
50-yr GAM Simulation: Upper Jackson



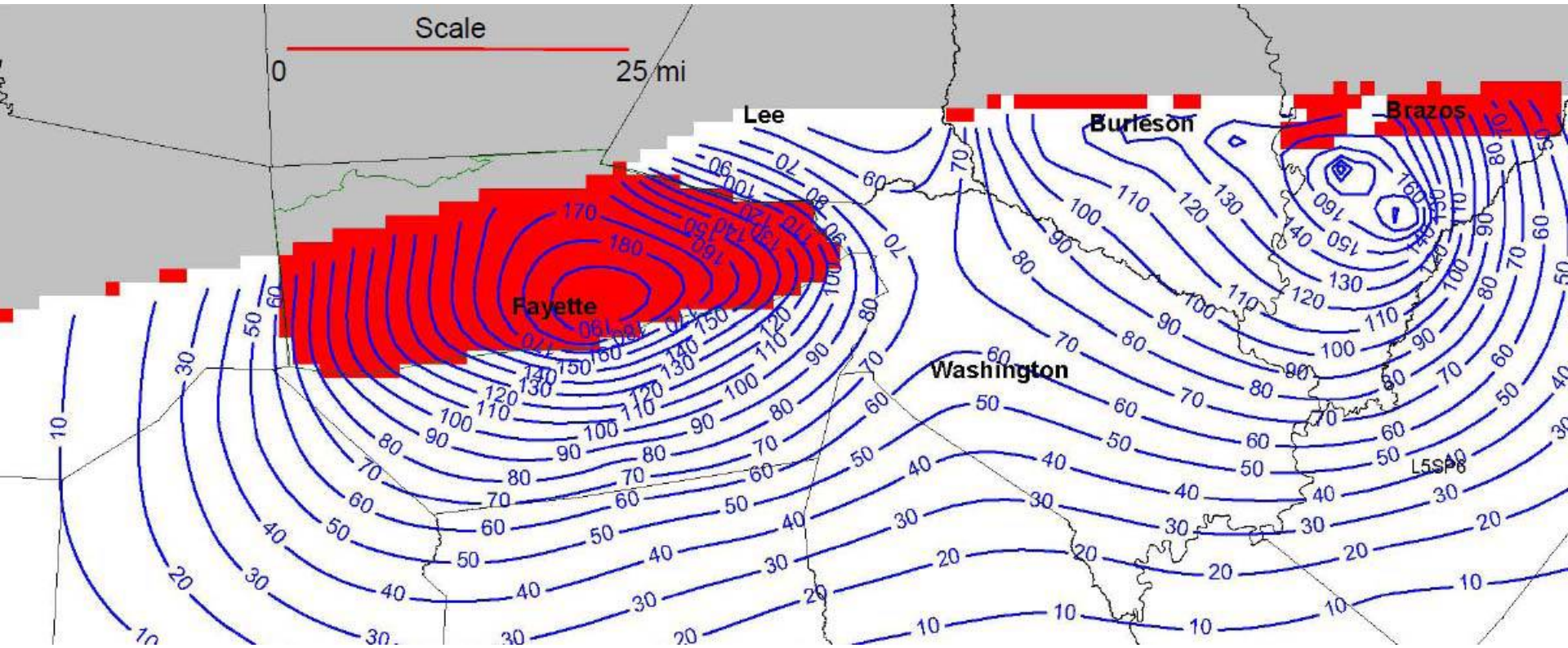
50-yr GAM Simulation: Lower Jackson



50-yr GAM Simulation: Upper Yegua



50-yr GAM Simulation: Lower Yegua



Note: Constant pumping rate is: BVGCD= 6,100 AFY, POSGCD=10,000 AFY, FCGCD=8,000 AFY, LPGCD=0 AFY, METGCD=0 AFY

Average Drawdown for 50-year Simulation

Geologic Formation	Model Layer	Average Drawdown (ft)	Number of Dry Cells
Upper Jackson	2	97	1
Lower Jackson	3	100	0
Upper Yegua	4	111	0
Lower Yegua	5	116	0

Note: Constant pumping rate is: BVGCD= 6,100 AFY, POSGCD=10,000 AFY, FCGCD=8,000 AFY, LPGCD=0 AFY, METGCD=0 AFY



Estimated Average Drawdown Based on Confined and Unconfined Drawdown Limits

Drawdown Limits			Calculated Average Drawdown					
Average drawdown in unconfined area (ft)	% Decline in artesian pressure	Maximum drawdown in confined area (ft)	Layer1	Layer2	Layer3	Layer4	Layer5	All layers
10	0.25	50	10	49	49	49	49	35
		75	10	51	58	60	65	43
		100	10	51	64	69	80	49
		150	10	51	71	82	104	60
	0.33	50	10	50	50	50	50	35
		75	10	67	68	69	71	48
		100	10	67	77	80	87	56
		150	10	67	88	96	114	68
20	0.25	50	20	49	49	49	49	38
		75	20	51	58	60	65	46
		100	20	51	64	69	80	53
		125	20	51	68	76	92	59
		150	20	51	71	82	104	64
	0.33	50	20	50	50	50	50	39
		75	20	67	68	69	71	52
		100	20	67	77	80	87	59
		150	20	67	88	96	114	72

Note: Constant pumping rate is: BVGCD= 6,100 AFY, POSGCD=10,000 AFY, FCGCD=8,000 AFY, LPGCD=0 AFY, METGCD=0 AFY



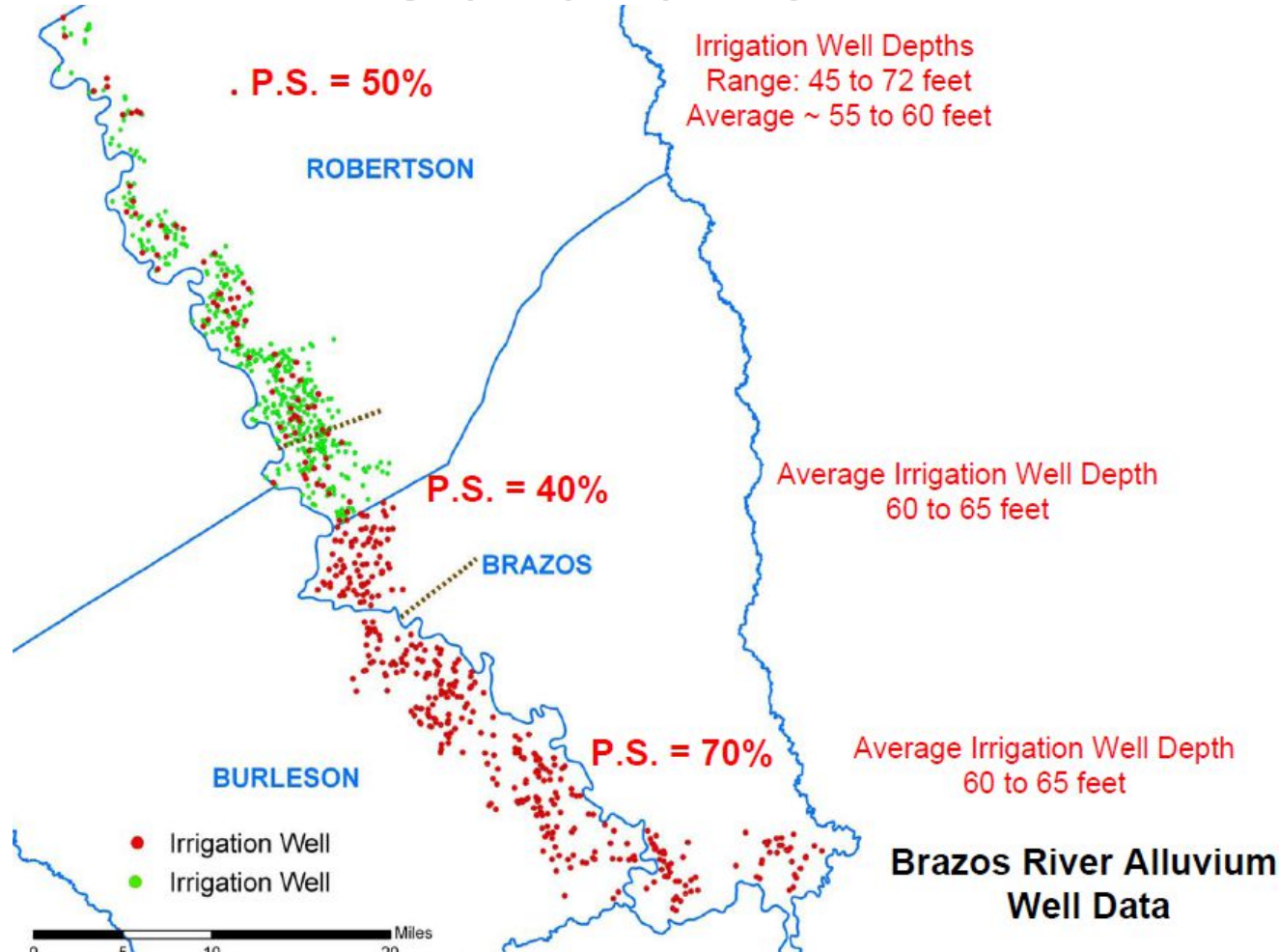
Estimated Average Drawdown Based on Confined and Unconfined Drawdown Limits

Drawdown Limits			Calculated Average Drawdown					
Average drawdown in unconfined area (ft)	% Decline in artesian pressure	Maximum drawdown in confined area (ft)	Layer1	Layer2	Layer3	Layer4	Layer5	All layers
15	0.25	50	15	49	49	49	49	37
		75	15	51	58	60	65	45
		100	15	51	64	69	80	51
		150	15	51	71	82	104	62
	0.33	50	15	50	50	50	50	37
		75	15	67	68	69	71	50
		100	15	67	77	80	87	57
		150	15	67	88	96	114	70
25	0.25	50	25	49	49	49	49	40
		75	25	51	58	60	65	48
		100	25	51	64	69	80	55
		150	25	51	71	82	104	65
	0.33	50	25	50	50	50	50	41
		75	25	67	68	69	71	53
		100	25	67	77	80	87	61
		150	25	67	88	96	114	74

Note: Constant pumping rate is: BVGCD= 6,100 AFY, POSGCD=10,000 AFY, FCGCD=8,000 AFY, LPGCD=0 AFY, METGCD=0 AFY



Lowest Measured Percent Saturation



Note: Calculations and figure completed by LGB Guyton and presented to Brazos Valley GCD on 4/8/2010

References for Precipitation Data

Texas Water Development Board, 1998, Annual Texas Precipitation shapefile

Narasimhan, B., Srinivasan, R., Quiring, S., and Nielsen-Gammon, J.W., 2008, Digital Climatic Atlas of Texas: Texas A&M University, Texas Water Development Board Contract, Report 2005-483-5591, 108 p.