Burleson & Milam Counties Groundwater Summit

Introduction to Aquifers, Groundwater Flow, and Groundwater Models

By Steven Young, Ph.D., PE. PG.

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August 13th, 2014

Presentation Outline

- Aquifers
- Aquifer Properties, Groundwater Flow, Water Levels
- Surface Water & Groundwater Interaction
- Mexia-Talco Fault
- Pumping
- Monitoring
- 3D-PDF of Aquifers, Water Levels, & Wells
- Summary

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AQUIFERS

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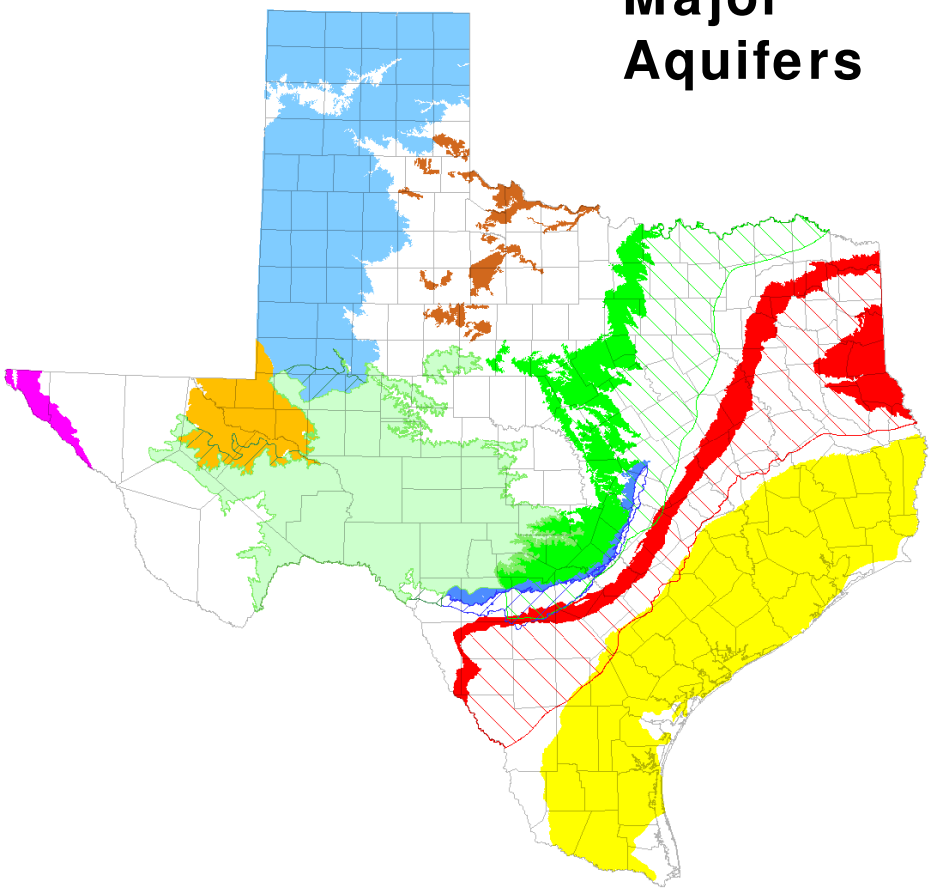
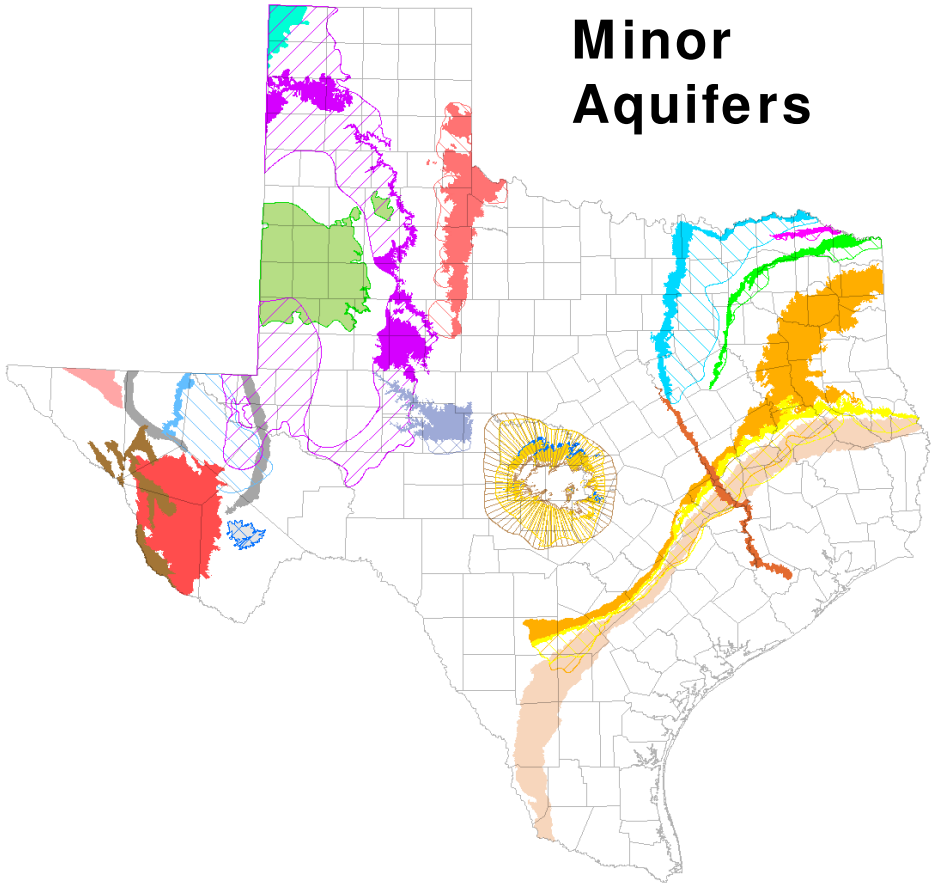
Aquifers of Texas





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Geologic Column

Age (Million.Years.)	Stratigraphic Unit	Dominant Lithology	Hydrogeologic Unit	
0.02	Alluvium	sand	Alluvium/Beaumont Aquifer	Gulf Coast Aquifer
	Beaumont	sand		
1.8 5.3	Lissie/Alta Loma	sand	Chicot Aquifer	
	Willis	sand		
	Goliad	sand	Evangeline Aquifer	
	Fleming/Lagarto	mud	Burkeville Aquitard	
23.9	Fleming/Oakville	sand	Jasper Aquifer	
	Catahoula/Frio/Anahuac	sand and mud	aquitard	
33.9	Vicksburg	mud	aquitard	
	Jackson	sand and mud	Yegua-Jackson Aquifer	
	Yegua	sand and mud		
	Sparta	sand	Queen City-Sparta Aquifer	
	Queen City	sand and mud		
	Reklaw	mud	aquitard	
55.8	Upper Wilcox/Carrizo	sand	Carrizo-Wilcox Aquifer	
	Middle Wilcox	mud		
	Lower Wilcox/Simsboro	sand and mud		
65.5	Midway	mud	aquitard	
		carbonate		
145.5	Edwards	carbonate	Edwards (BFZ) Aquifer	
		carbonate		
201.6	Louann salt	evaporite	salt domes	

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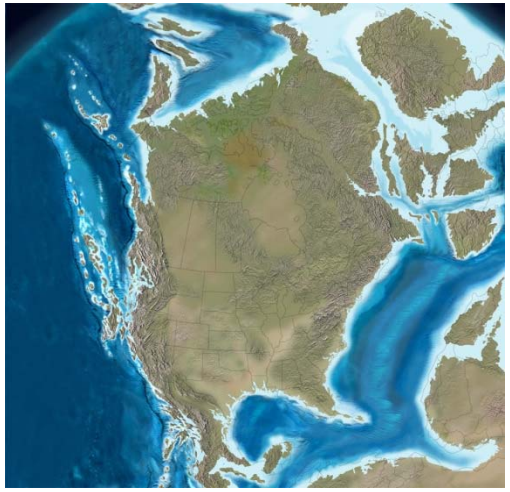
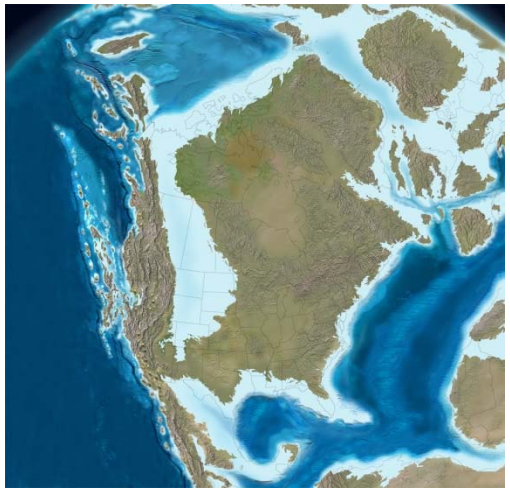
Geologic Time and Sea Level Changes

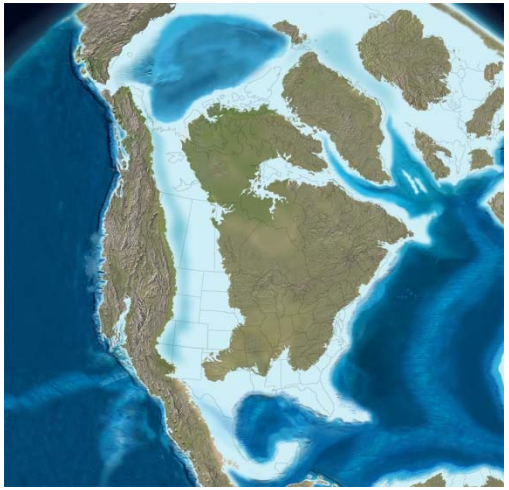
130 million years



115 million years



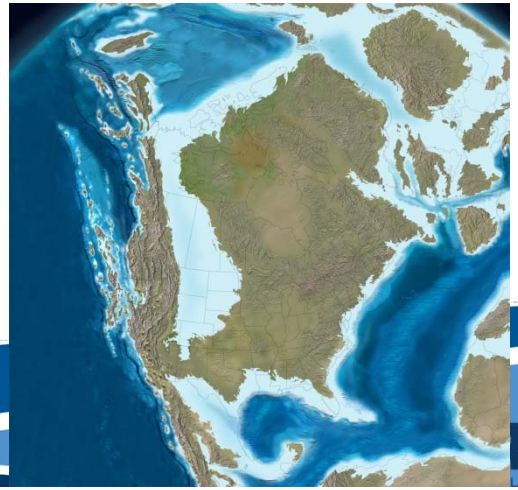
85 million years



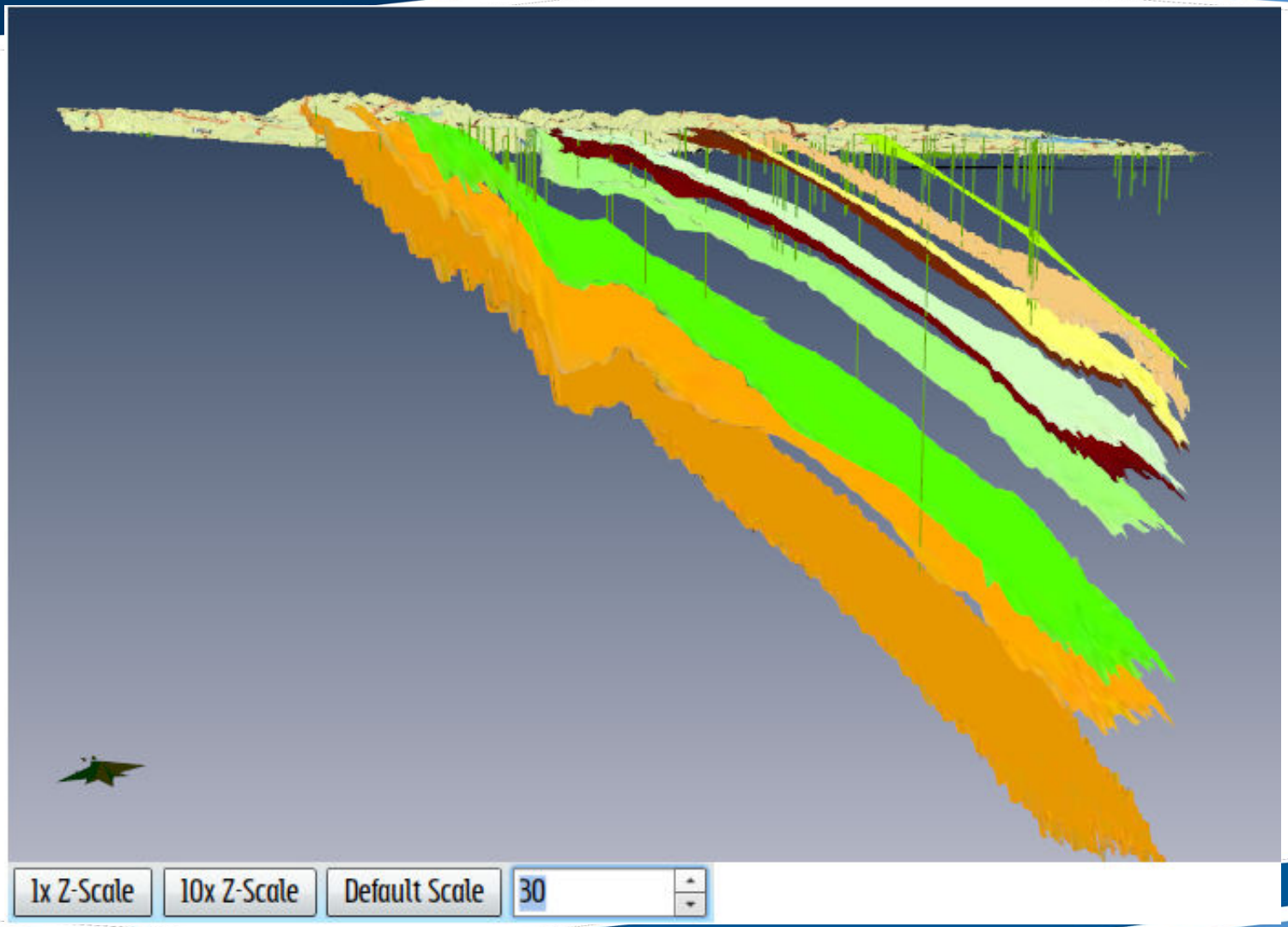
60 million years

25 million years

15 million years



3-D View of Aquifer Surfaces Showing Permitted Wells



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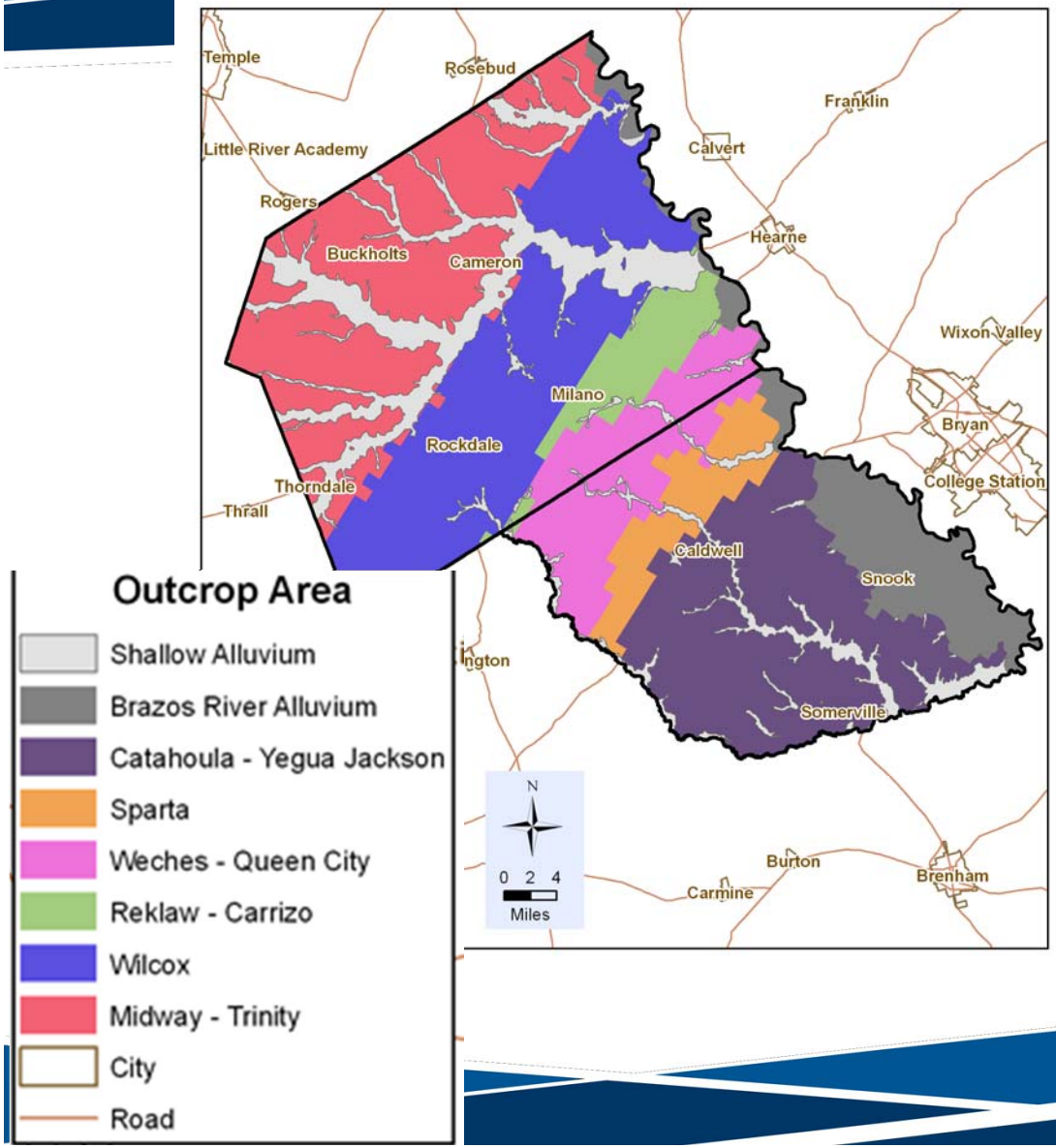
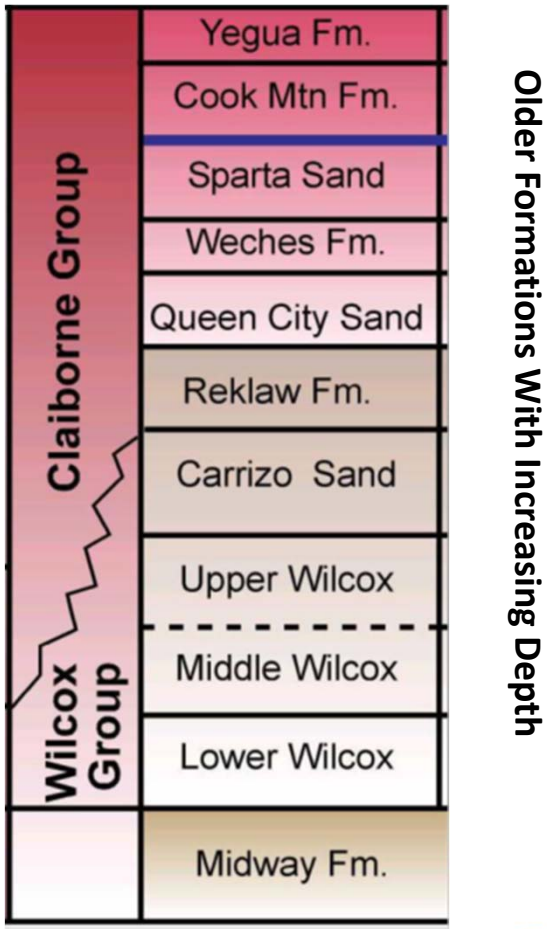
Surface Geology Showing Aquifer Outcrops



Geologic Column



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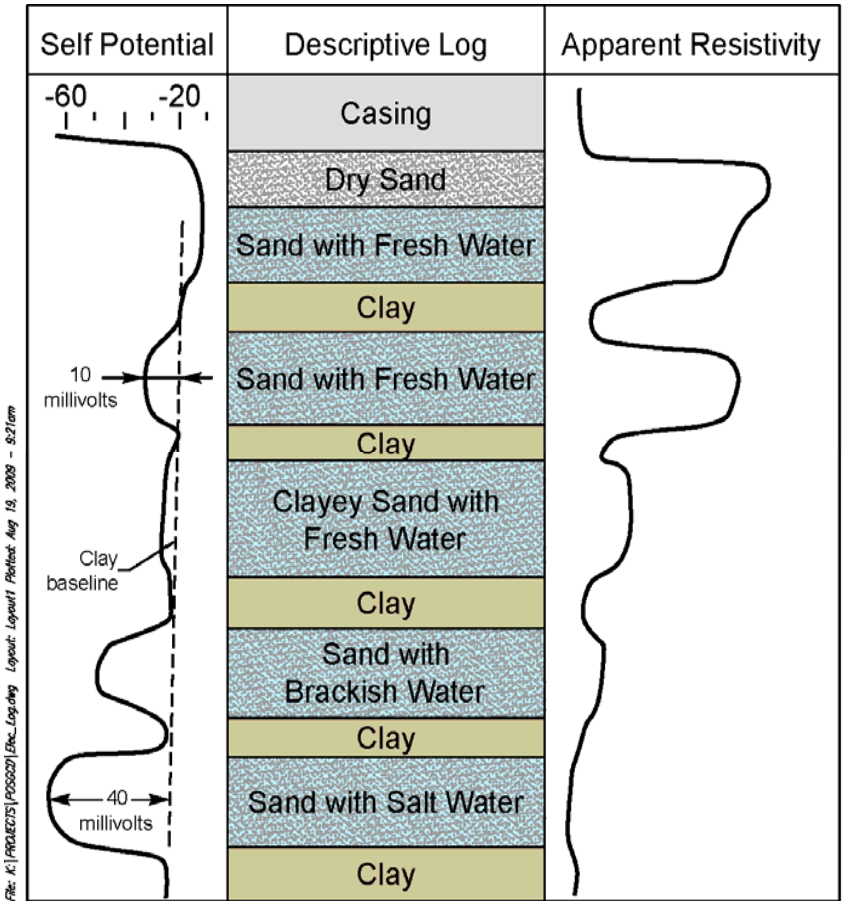
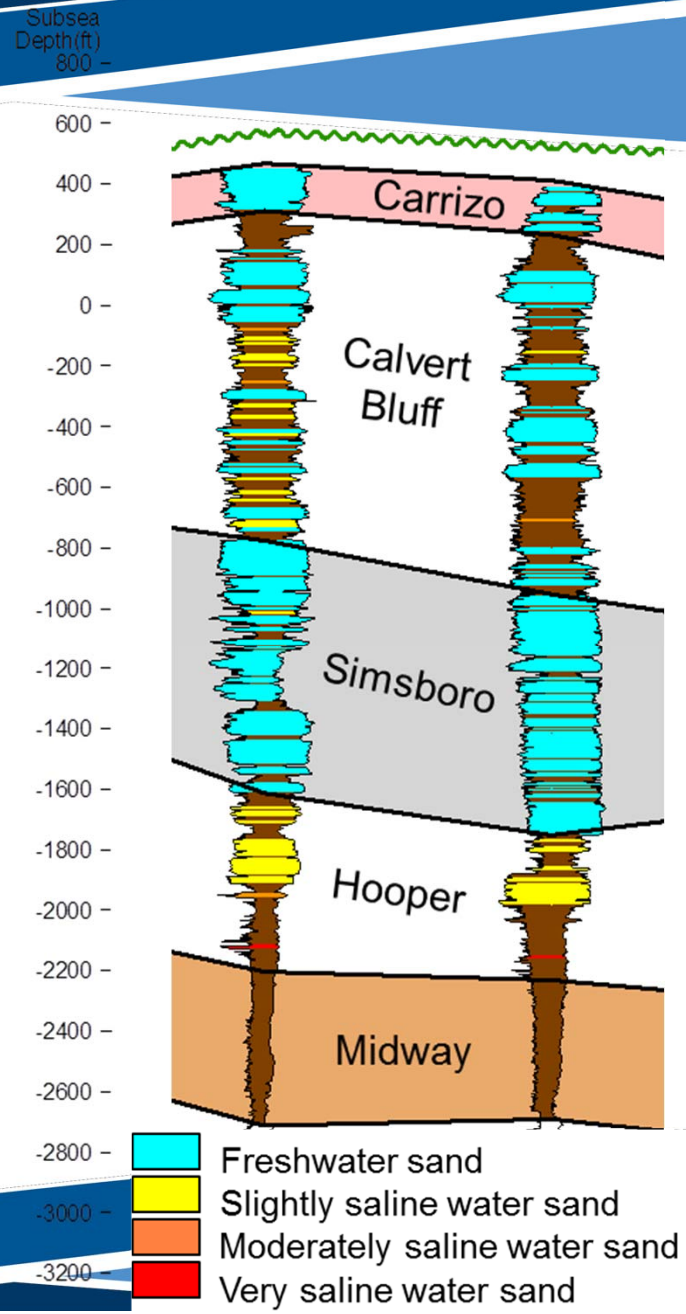
- **Analysis of Geophysical Logs to Identity Sand & Clays and Water Quality**

Geophysical Logs

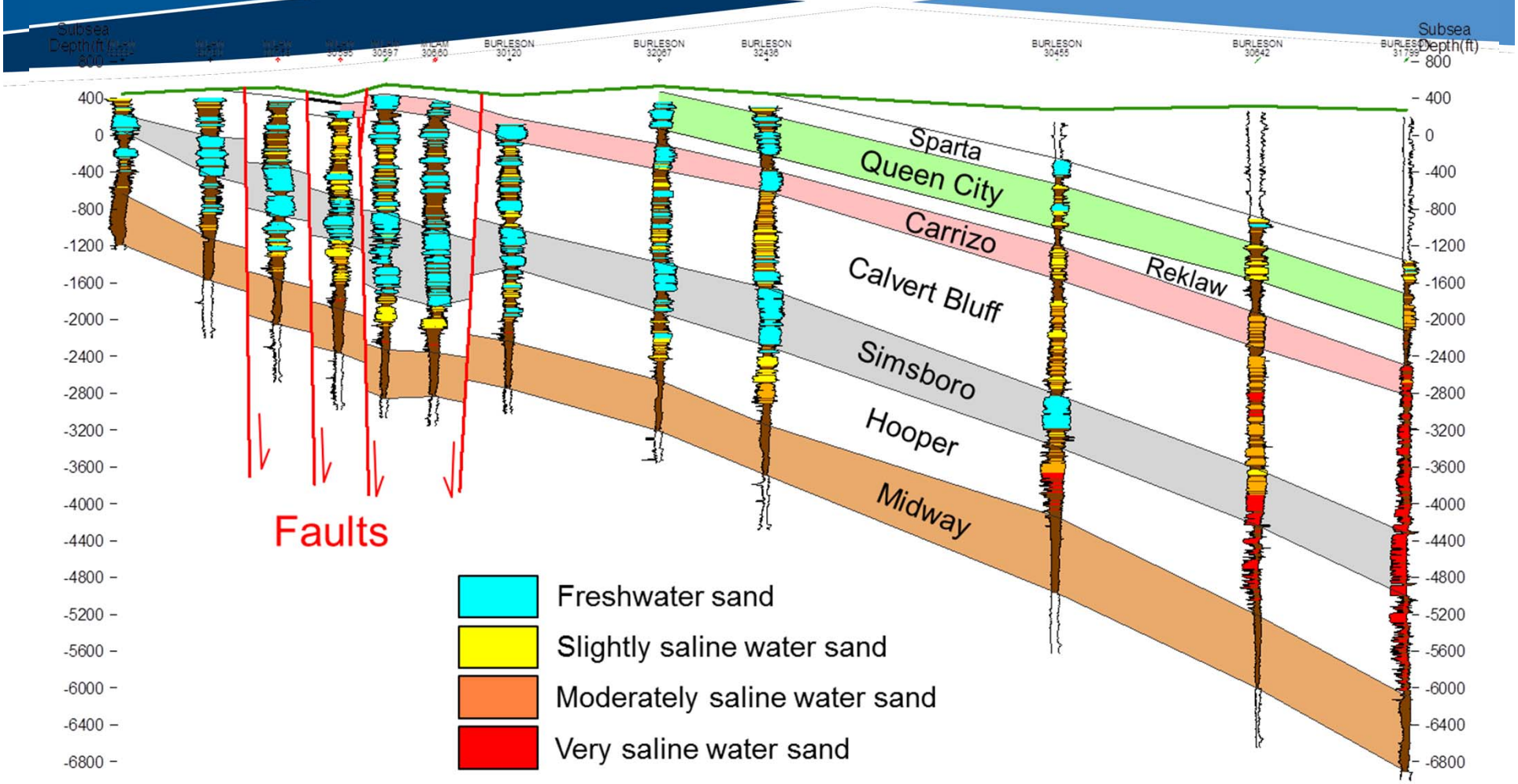




- **Groundwater Classification Based on Total Dissolved Solid Concentrations**

Description	Total Dissolved Solid (ppm)	
Fresh	Less than 1,000	
Slightly Saline	1,000 to 3,000	***Brackish Groundwater***
Moderately Saline	3,000 to 10,000	
Very Saline	10,000 to 35,000	
Brine	More than 35,000	

Geologic Time and Sea Level Changes



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Factors Controlling Physical and Hydraulic Characteristics of Aquifers

Environmental Factors → ***Depositional Environments/ Facies*** → ***Deposit/Aquifer Characteristics***

Climate

River/Lake Hydraulics

Sediment Composition

Sediment Load

Tectonics

Sea Level Change

Biota/Chemistry

Alluvial Fans

Flood Plains

Incised Rivers

Bay Head Deltas

Wave-dominated Deltas

Bay Deposits

Barrier Islands

Sand Size

Clay types

Sorting

Dimensions and Geometry of

Heterogeneity

Trace Minerals/Color

Hydraulic Properties

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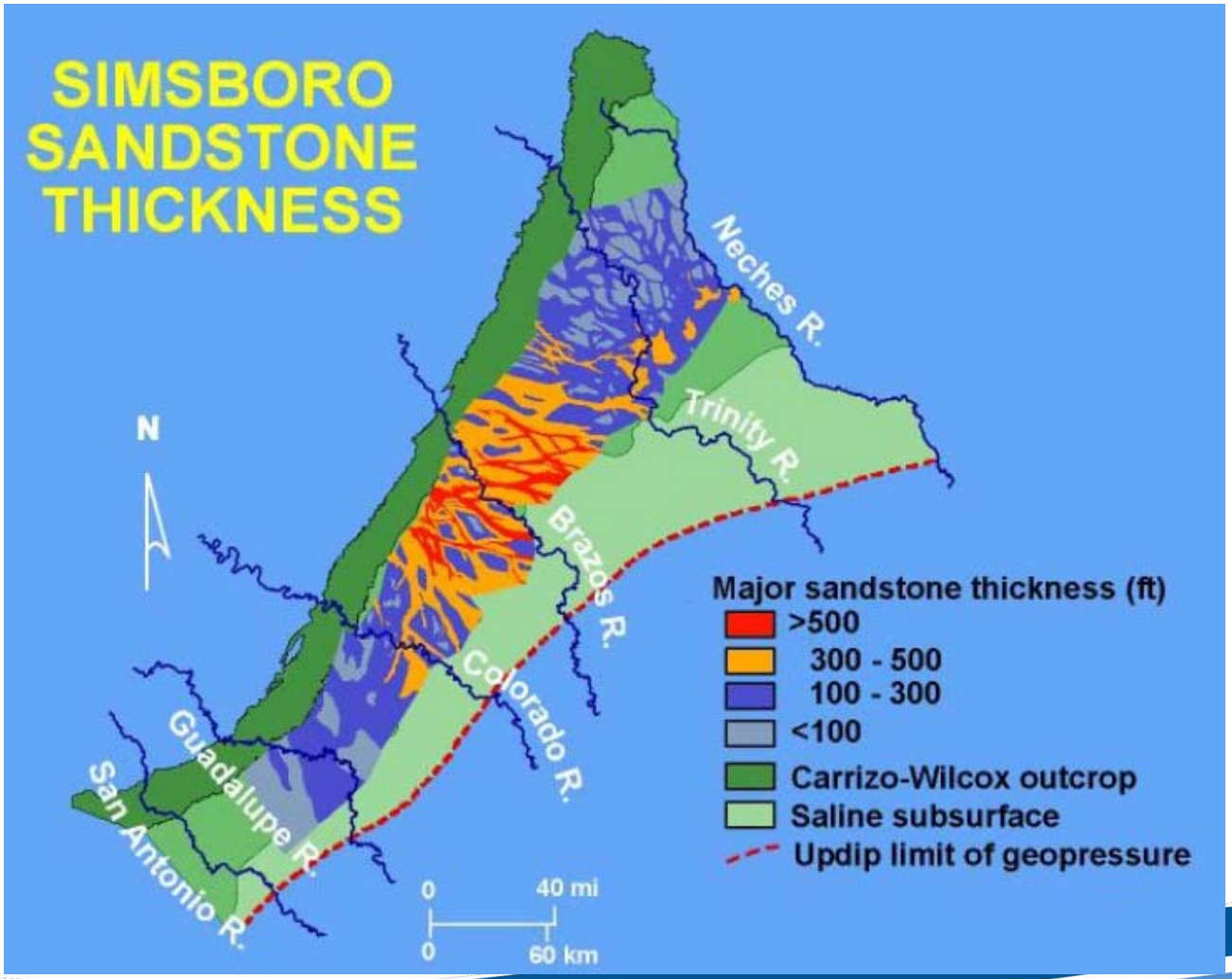
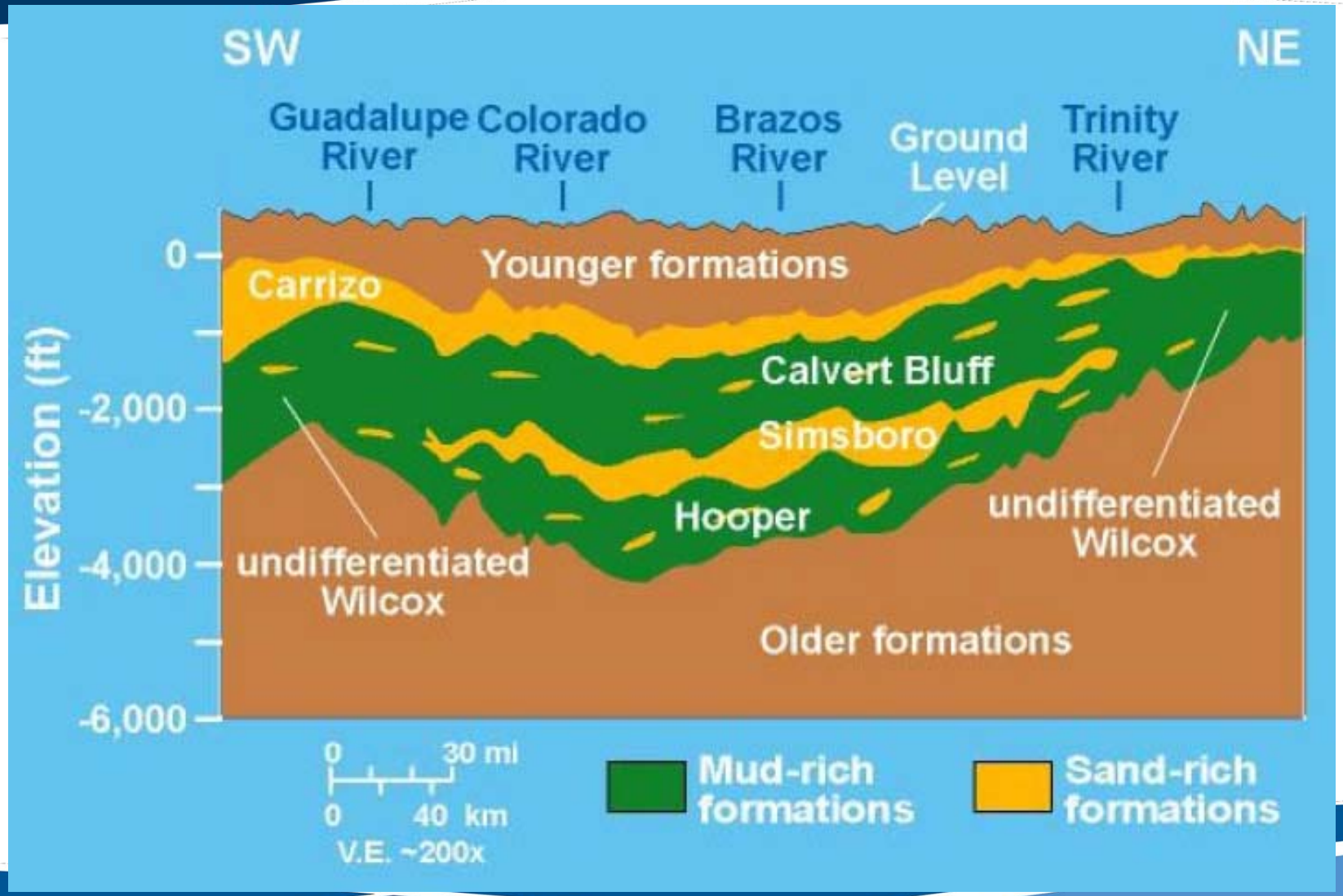
Spatial Variation in Sand Thicknesses of Simsboro Aquifer



Note: From Carrizo-Wilcox GAM Stakeholder Advisory Forum Meeting (July, 2001)

Vertical Structure of Carrizo-Wilcox Aquifer Parallel to Coastline



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AQUIFER PROPERTIES

GROUNDWATER FLOW

WATER LEVELS

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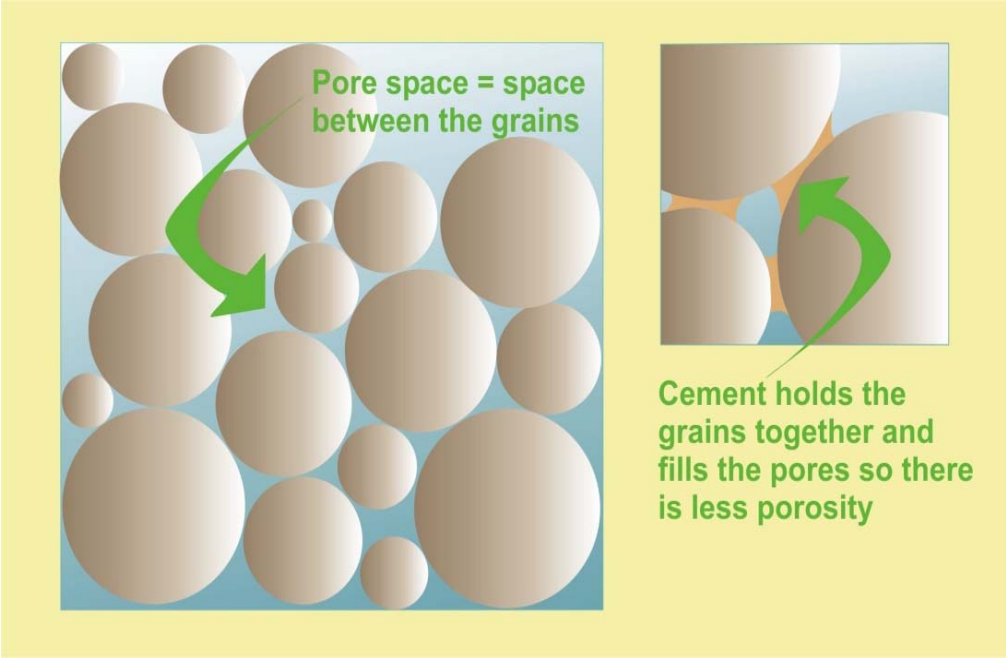
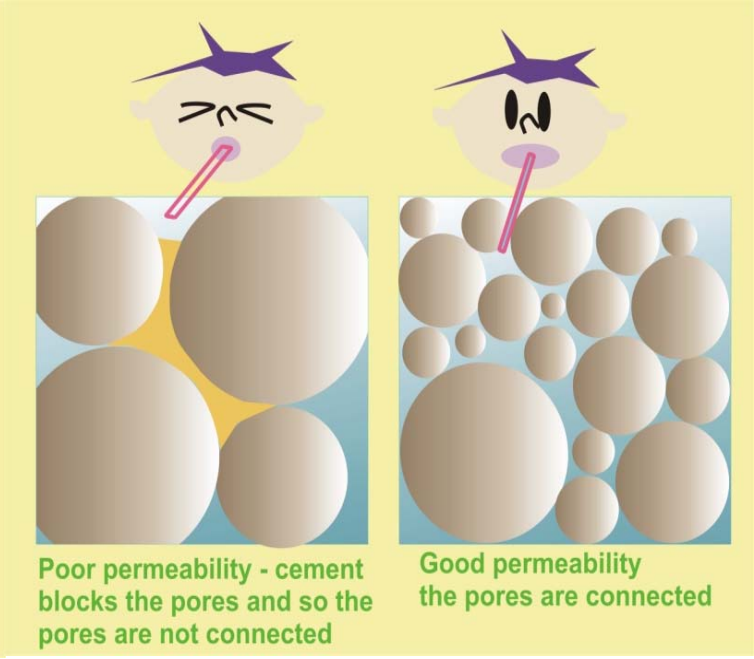
Storage and Transmissive Properties

STORAGE



Porosity = the gaps between the soil and rock particles

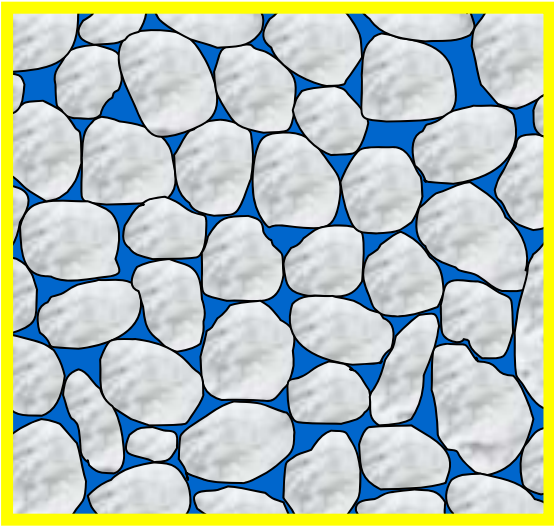
TRANSMISSIVE



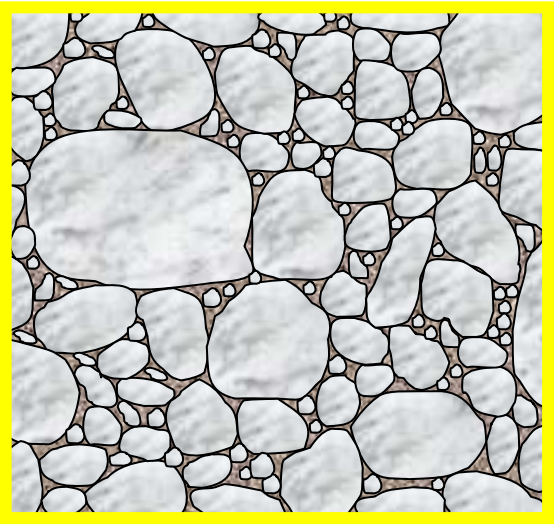
Hydraulic Conductivity = how well the gaps are connected to allow water to move between them

Hydraulic Conductivity

WELL SORTED
Coarse (sand-gravel)



POORLY SORTED
Coarse - Fine



WELL SORTED
Fine (silt-clay)

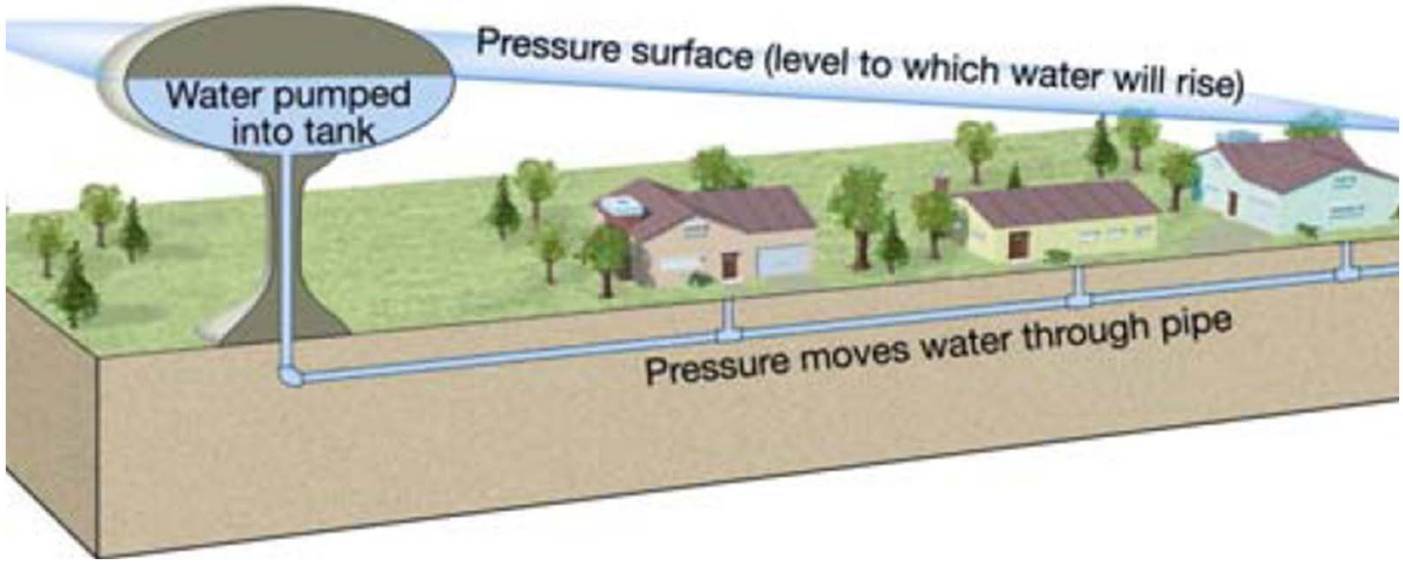
Permeability and Hydraulic Conductivity

High ⟷ **Low**

Sorting of material affects groundwater movement. Poorly sorted (well graded) material is less porous than well-sorted material.

S. Hughes, 2003

Water Flows from High to Low Water Level



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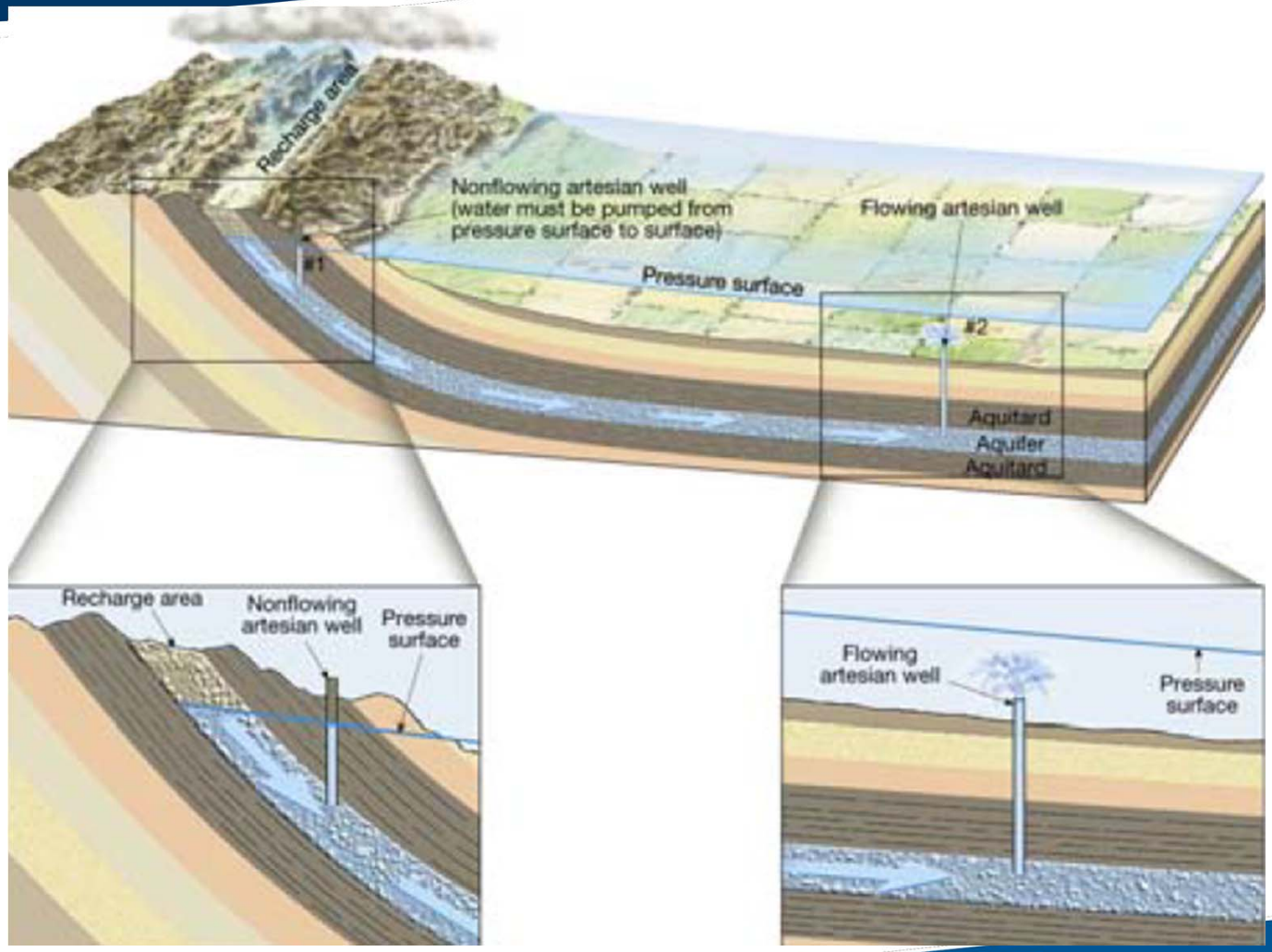
Groundwater Flows from High to Low Water Level



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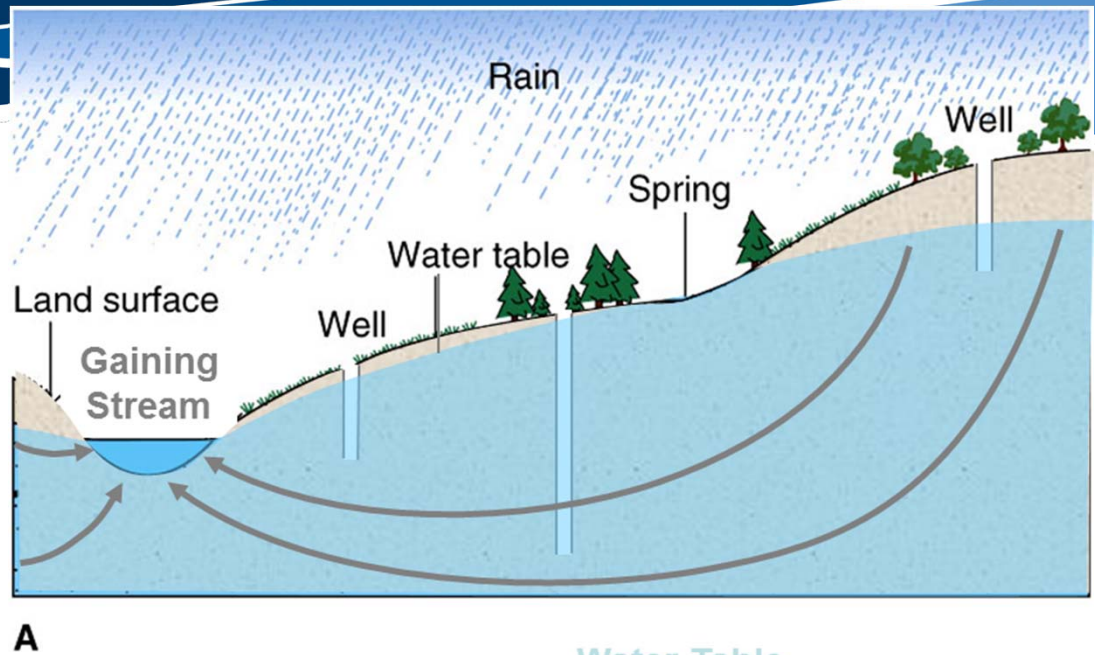
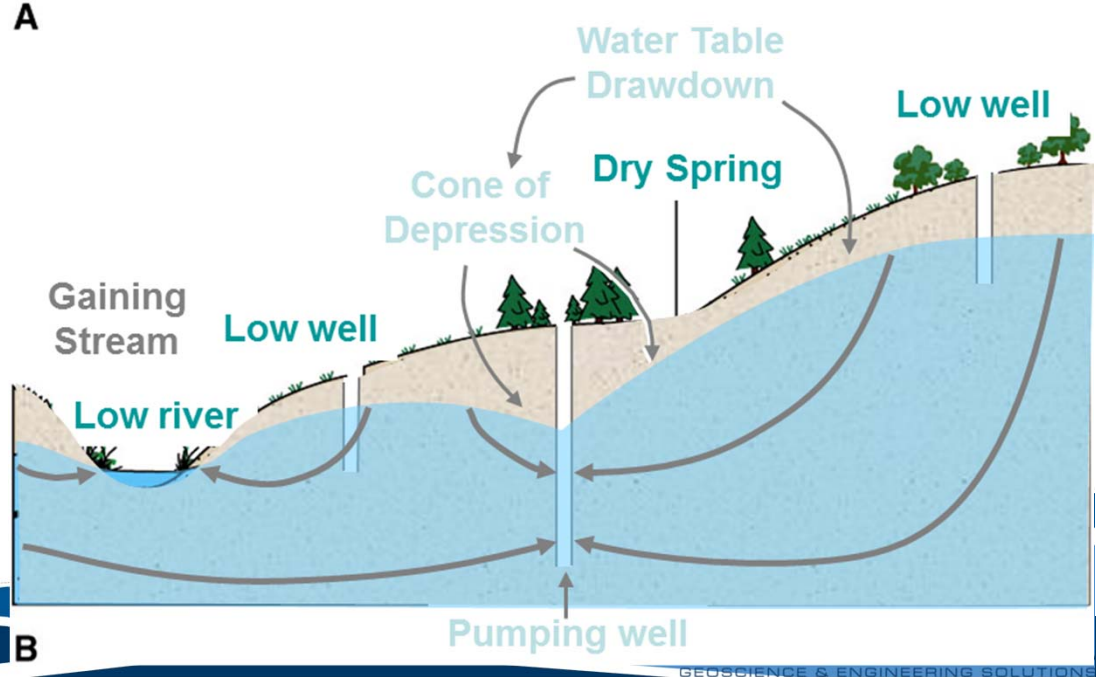
Regional Impacts of Pumping

- Accelerate flows to well
- Reverse flow
- Cause water table drawdown
- Form cones of depression

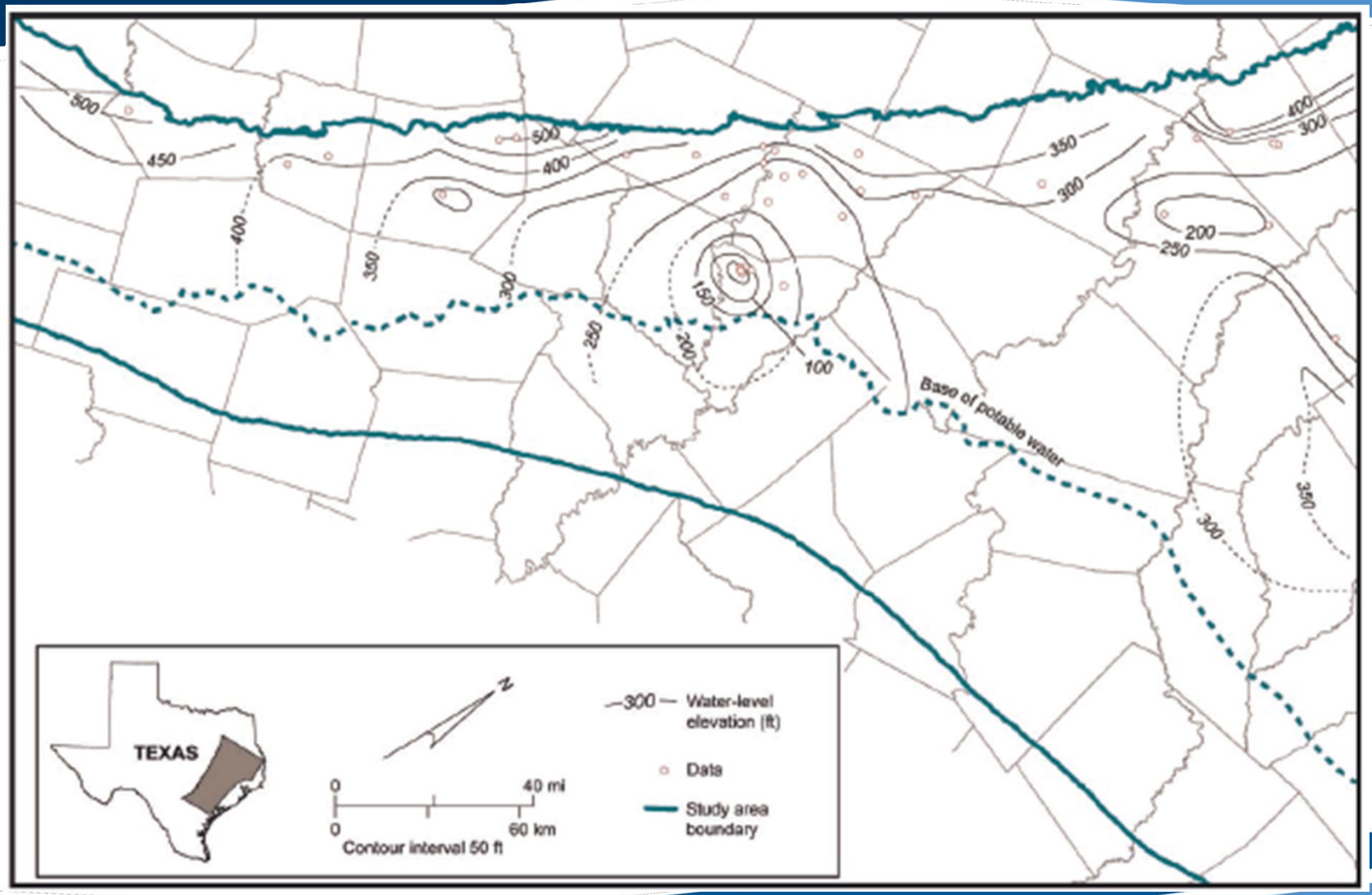


A



B

Water Level in the Simsboro (2000) as Estimated by Central Carrizo-Wilcox Groundwater Availability Model



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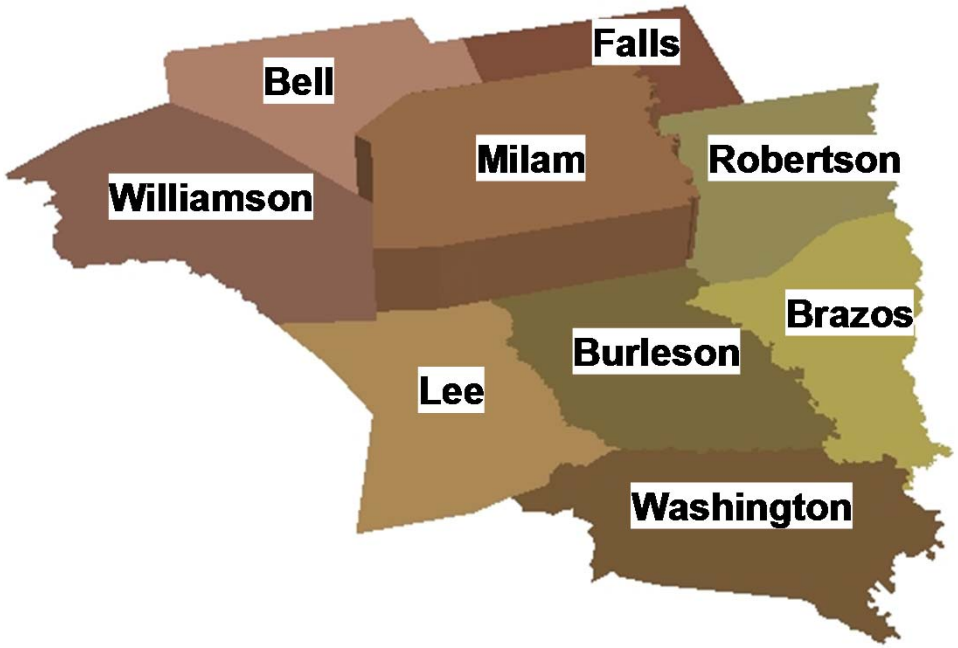
Water Budget for Milam County Based on GAM Simulation



Milam County 2000 With HFB			
County	Flux In (acre-ft/yr)	Flux Out (acre-ft/yr)	Flux (acre-ft/yr)
Robertson	5900	12144	-6244
Brazos	0	0	0
Burleson	4907	14515	-9609
Washington	0	0	0
Williamson	337	50	287
Lee	2654	9116	-6462
Bell	0	0	0
Milam	0	0	0
Falls	0	0	0
Source/Sink	Flux In (acre-ft/yr)	Flux Out (acre-ft/yr)	Flux (acre-ft/yr)
Above	0	0	0
Below	0	0	0
Storage	50187	3146	47040
Recharge	31021	0	31021
Well Discharge	0	35617	-35617
General Head	0	0	0
Evapotranspiration	0	3974	-3974
Springs	0	245	-245
Lakes	0	0	0
Rivers/Streams	10134	26333	-16199
Percent Error			0.00

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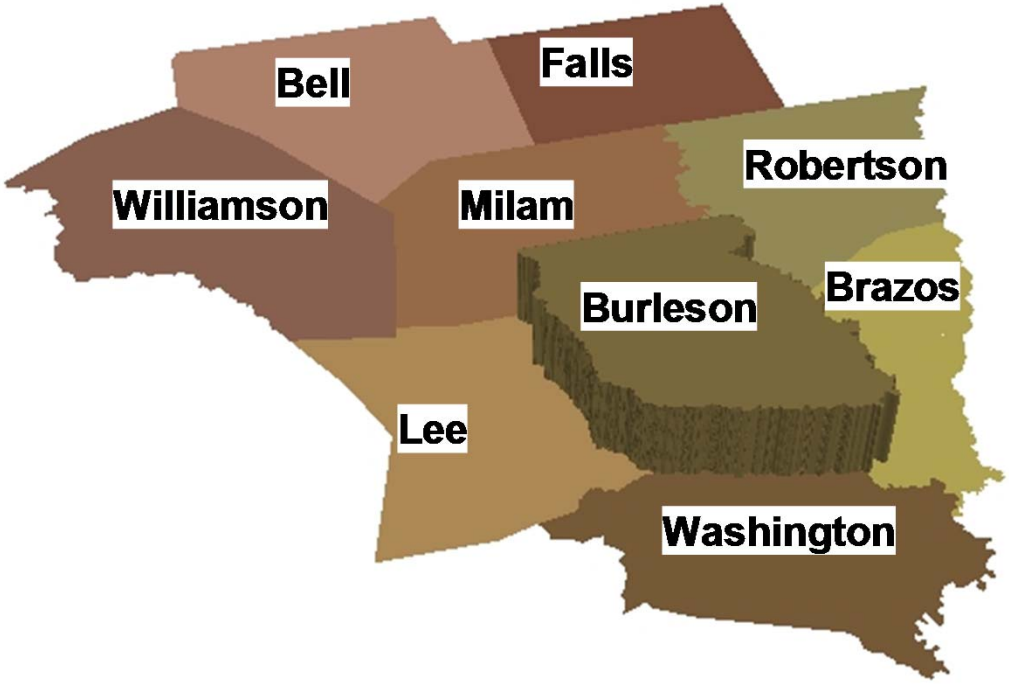
Water Budget for Burleson County Based on GAM Simulation



Burleson County Summary 2000 With HFB			
County	Flux In (acre-ft/yr)	Flux Out (acre-ft/yr)	Flux (acre-ft/yr)
Robertson	169	2156	-1987
Brazos	1814	16081	-14267
Burleson	0	0	0
Washington	3508	1214	2294
Williamson	0	0	0
Lee	10449	1868	8581
Bell	0	0	0
Milam	14515	4907	9609
Falls	0	0	0
Source/Sink	Flux In (acre-ft/yr)	Flux Out (acre-ft/yr)	Flux (acre-ft/yr)
Above	0	0	0
Below	0	0	0
Storage	6598	7739	-1140
Recharge	13500	0	13500
Well Discharge	0	4940	-4940
General Head	934	4141	-3206
Evapotranspiration	0	2339	-2339
Springs	0	217	-217
Lakes	0	0	0
Rivers/Streams	309	6195	-5886
Percent Error			0.00

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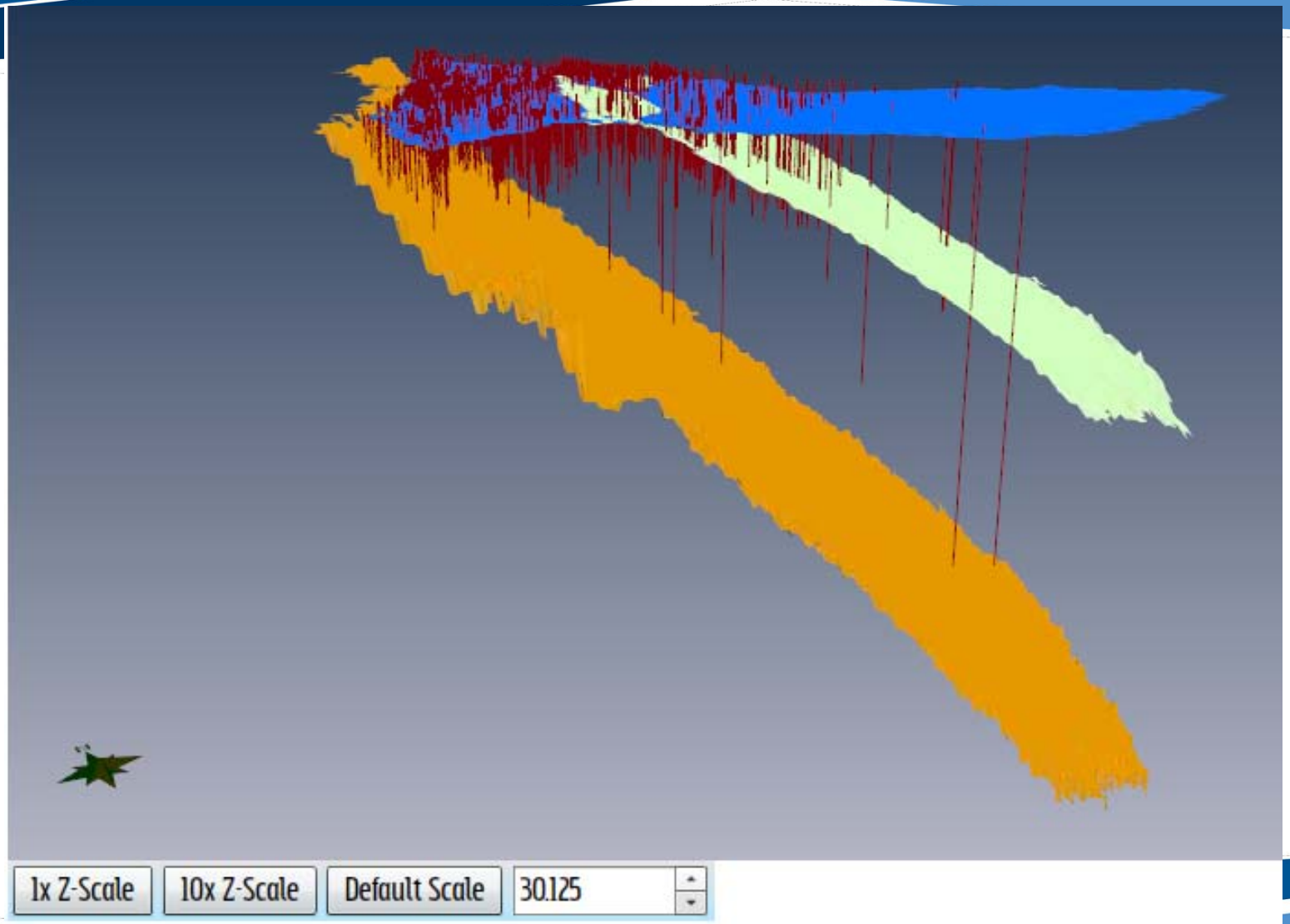
3-D View of Carrizo-Wilcox Surfaces, Carrizo-Wilcox Wells, and Simsboro 2000 Water Level



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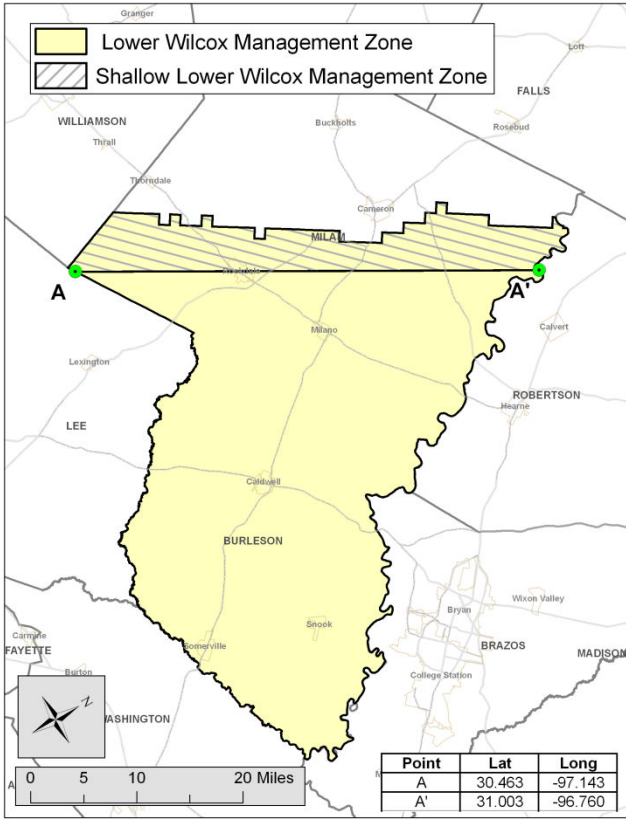
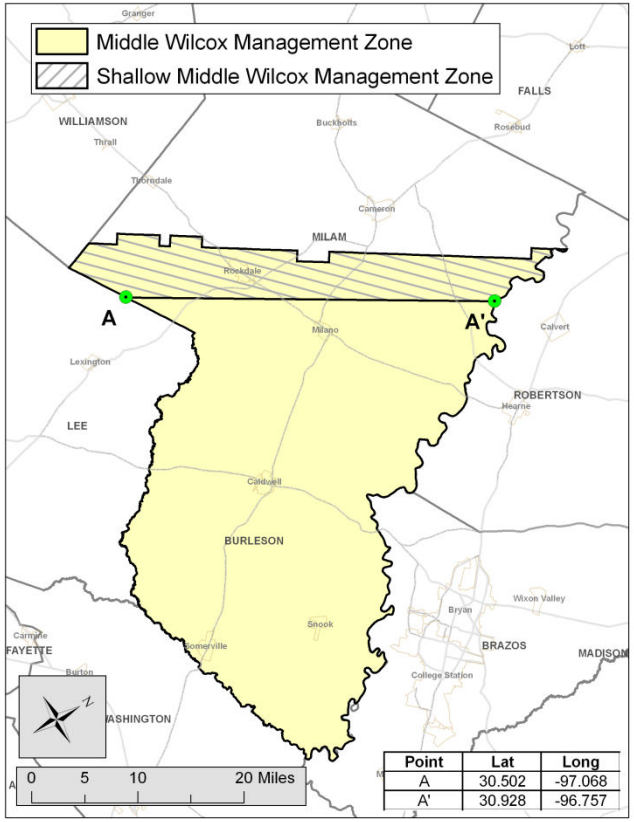
POSGCD Groundwater Management Zones

Hooper



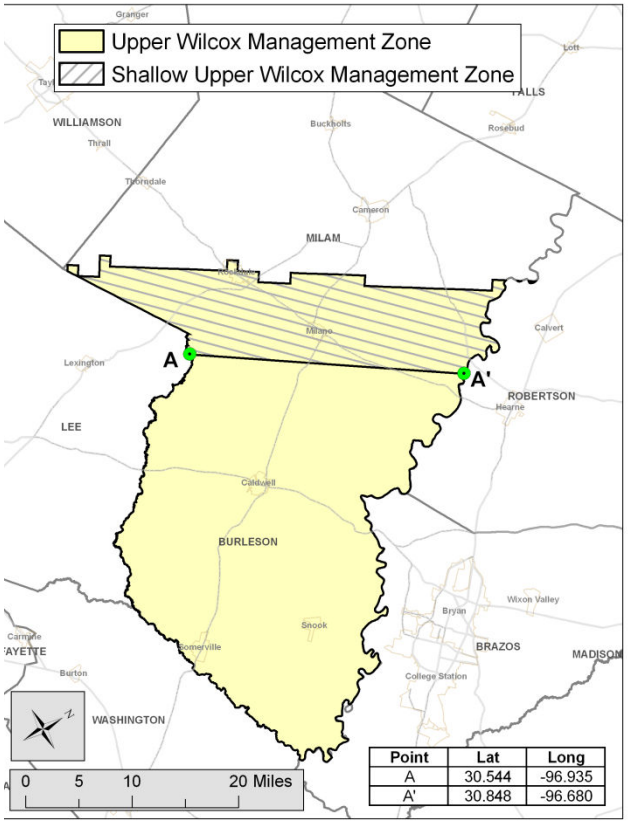
Point	Lat	Long
A	30.463	-97.143
A'	31.003	-96.760

Simsboro



Point	Lat	Long
A	30.502	-97.068
A'	30.928	-96.757

Calvert Buff



Point	Lat	Long
A	30.544	-96.935
A'	30.848	-96.680

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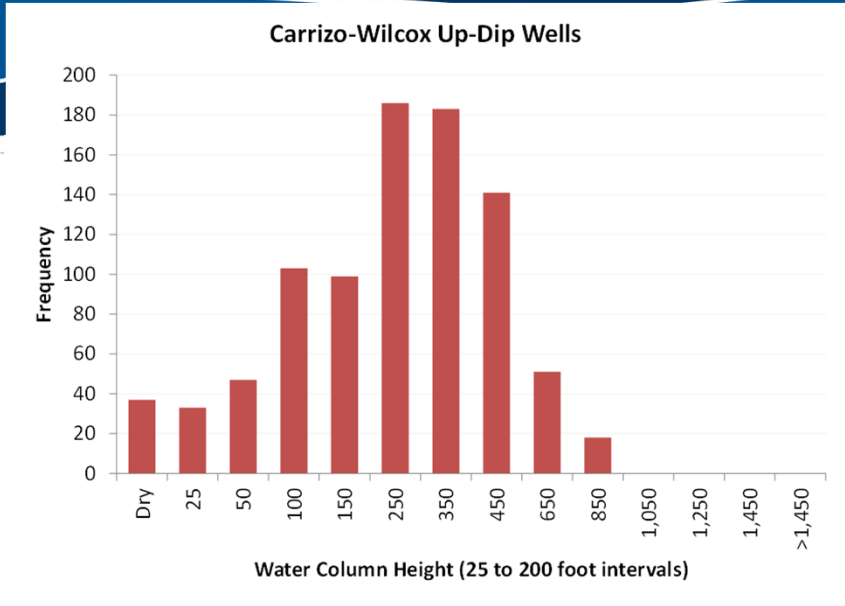
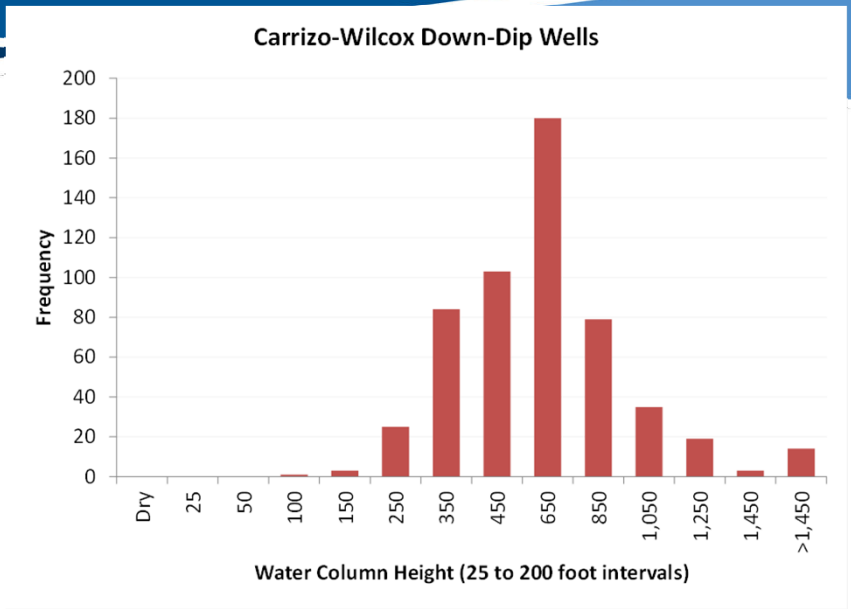
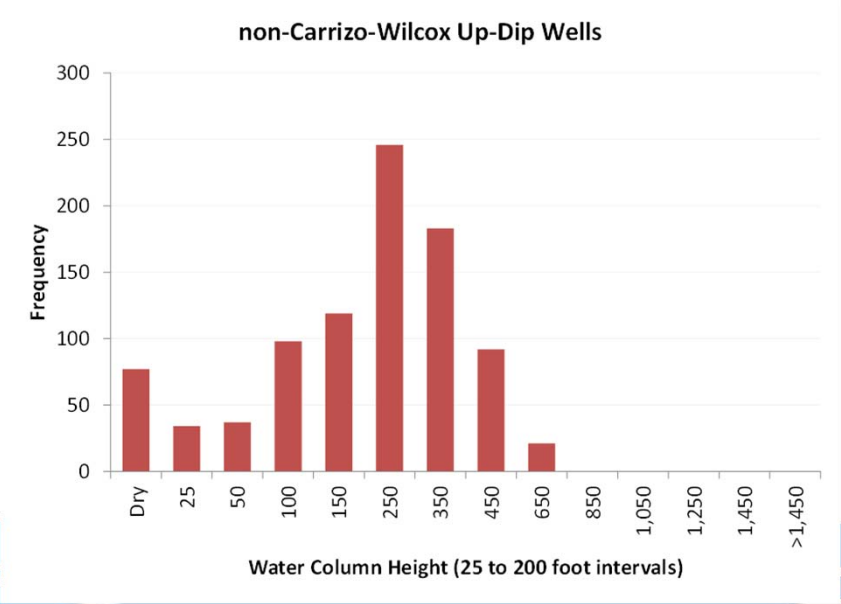
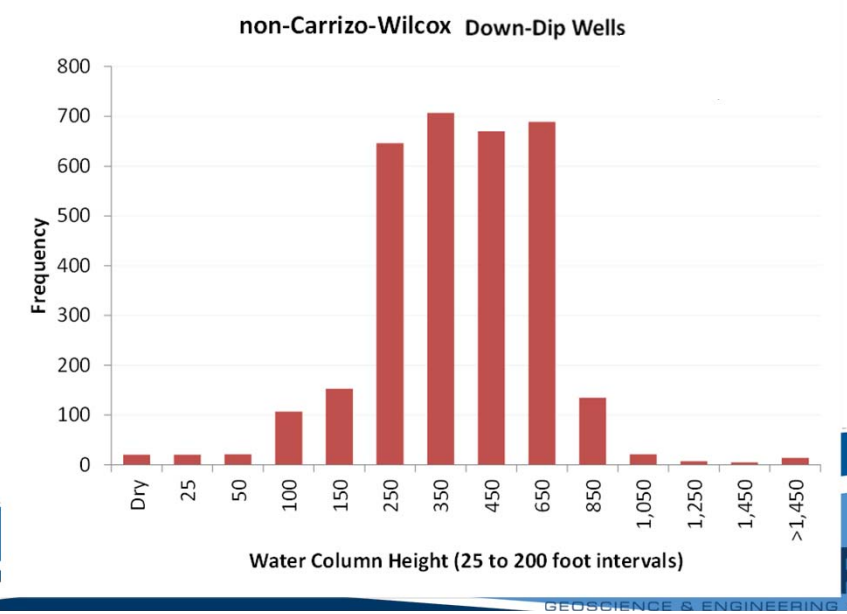
Height of Water Above the Base of the Aquifer









SURFACE WATER AND GROUNDWATER INTERACTION

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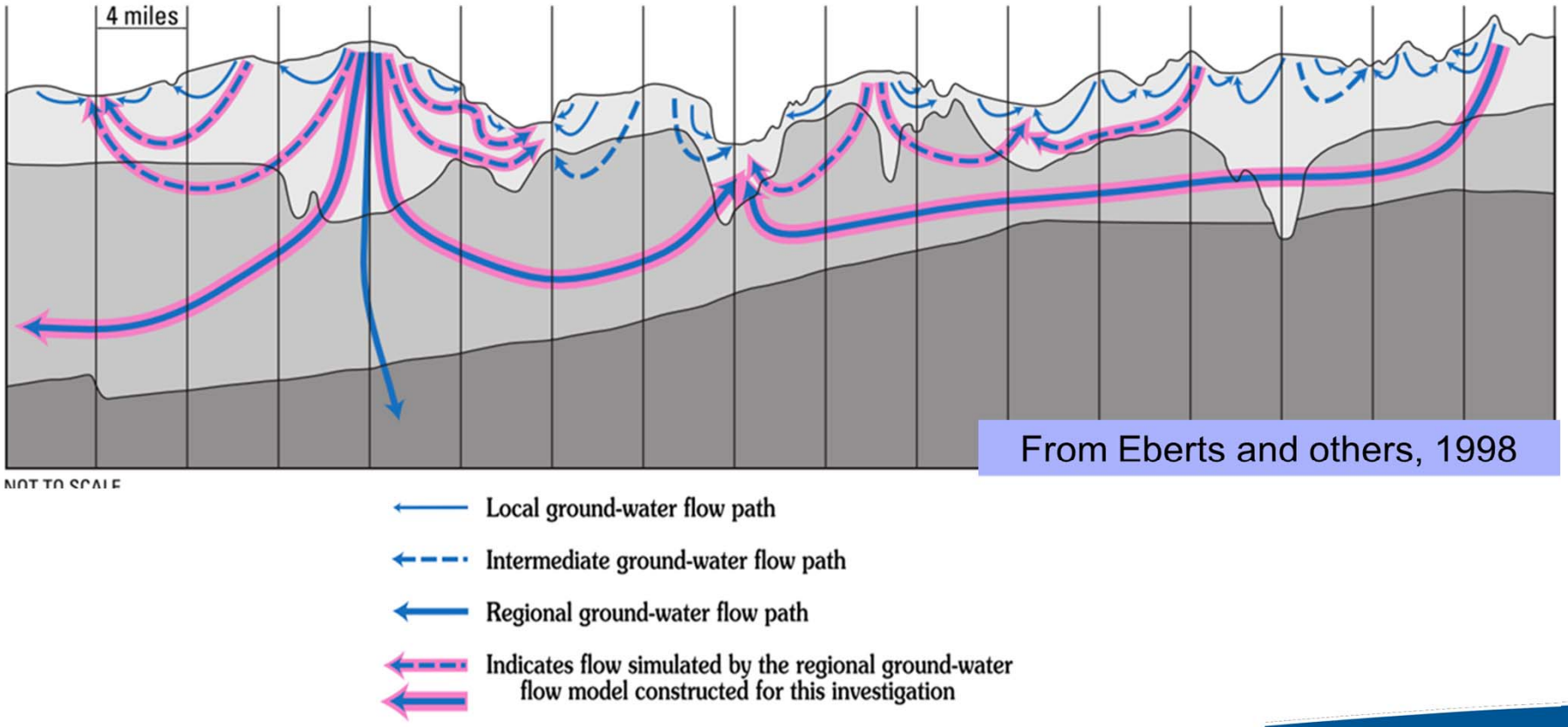
Heirarchy of Groundwater Flow Systems



From Eberts and others, 1998

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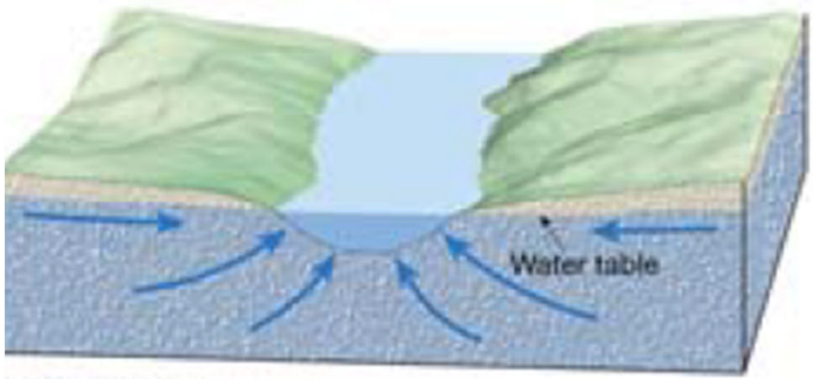
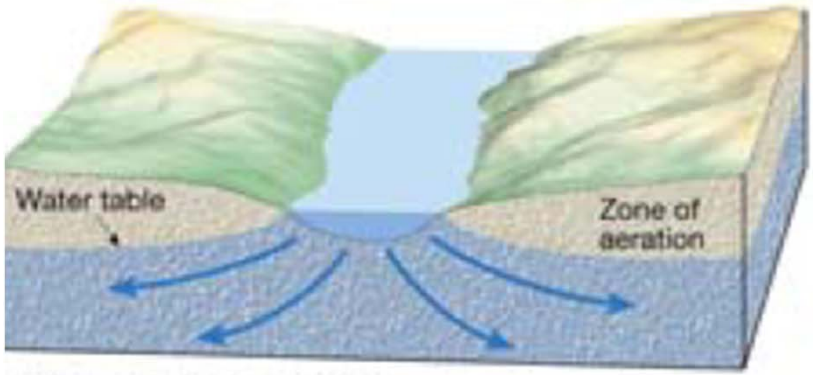
Groundwater – Surface Water Interaction

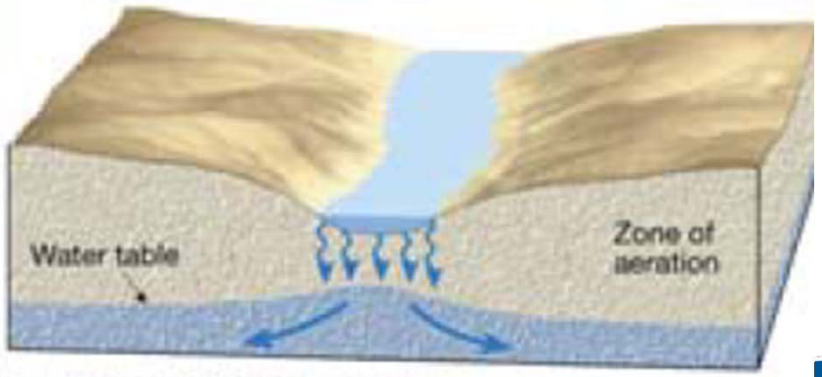
- Direction of flow is from high water level to low water level
- Rate of flow is controlled by type of deposits at stream bed and in shallow aquifer



A. Gaining stream



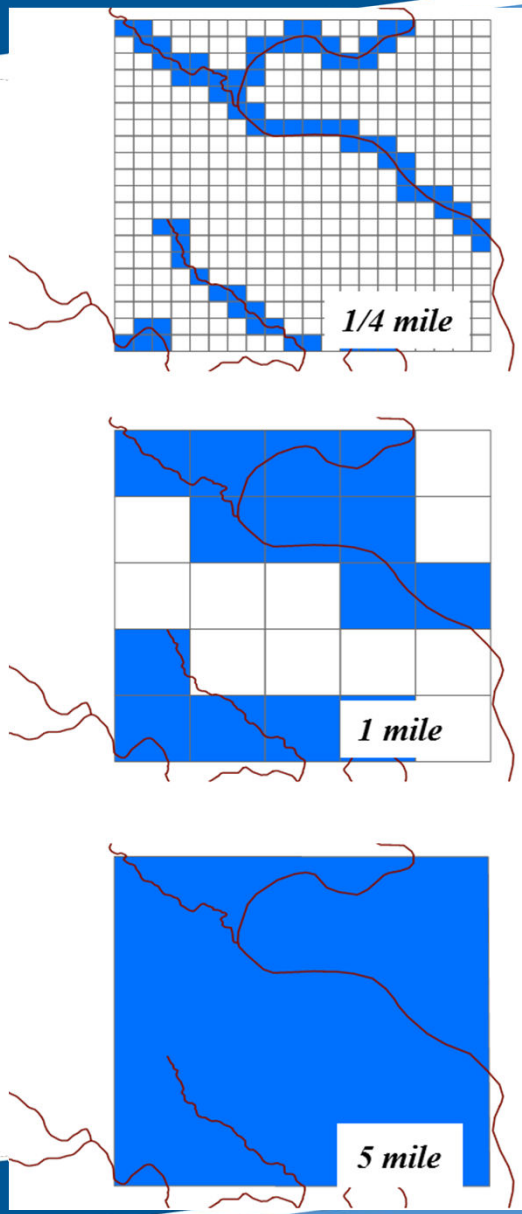
B. Losing stream (connected)



C. Losing stream (disconnected)

Modeling of Groundwater – Surface Water Interaction

- Areal grid refinement affects placement of streams elevations
- Layer refinement affects ability to represent vertical pressures differences in aquifer
- Generally, the smaller the grid spacing the greater the opportunity to more accurately model GW-SW interaction



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MEXIA-TALCO FAULT ZONE

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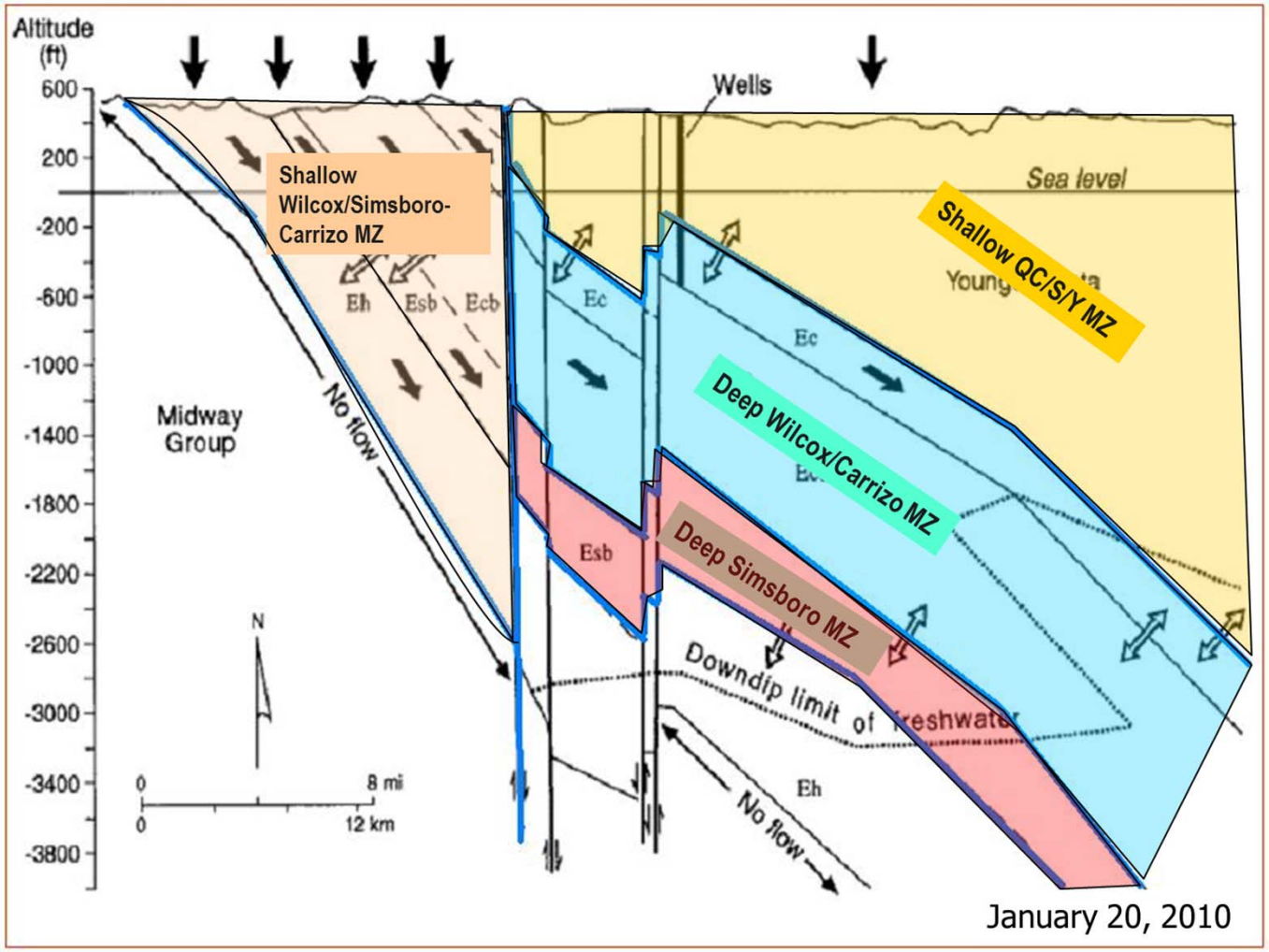
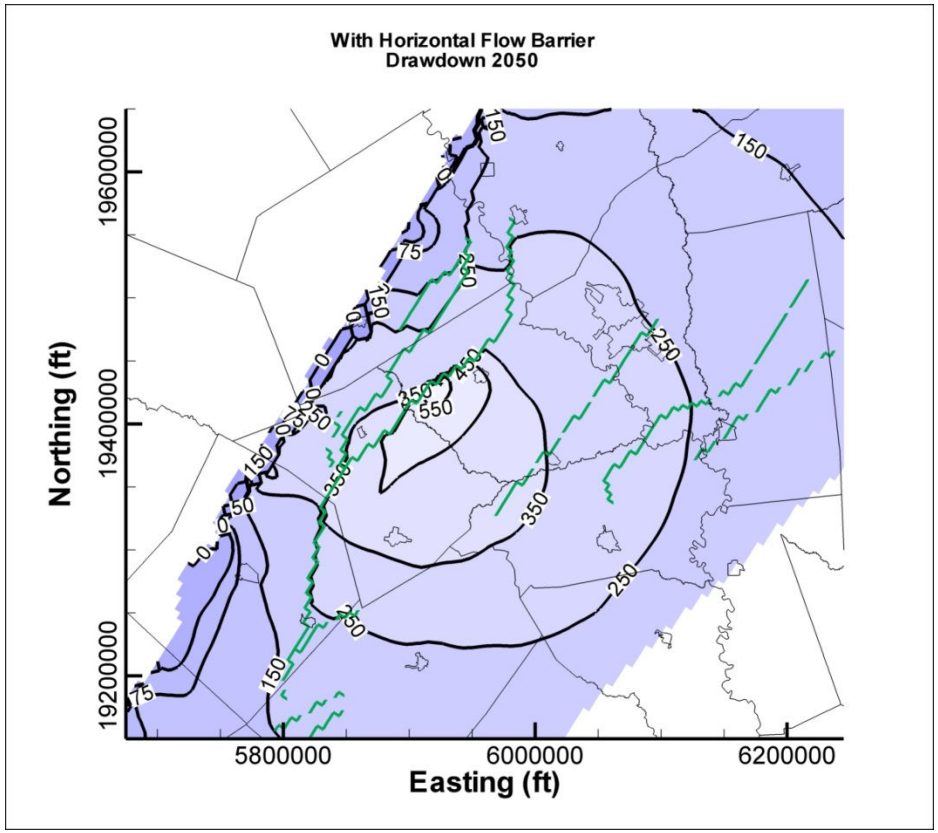
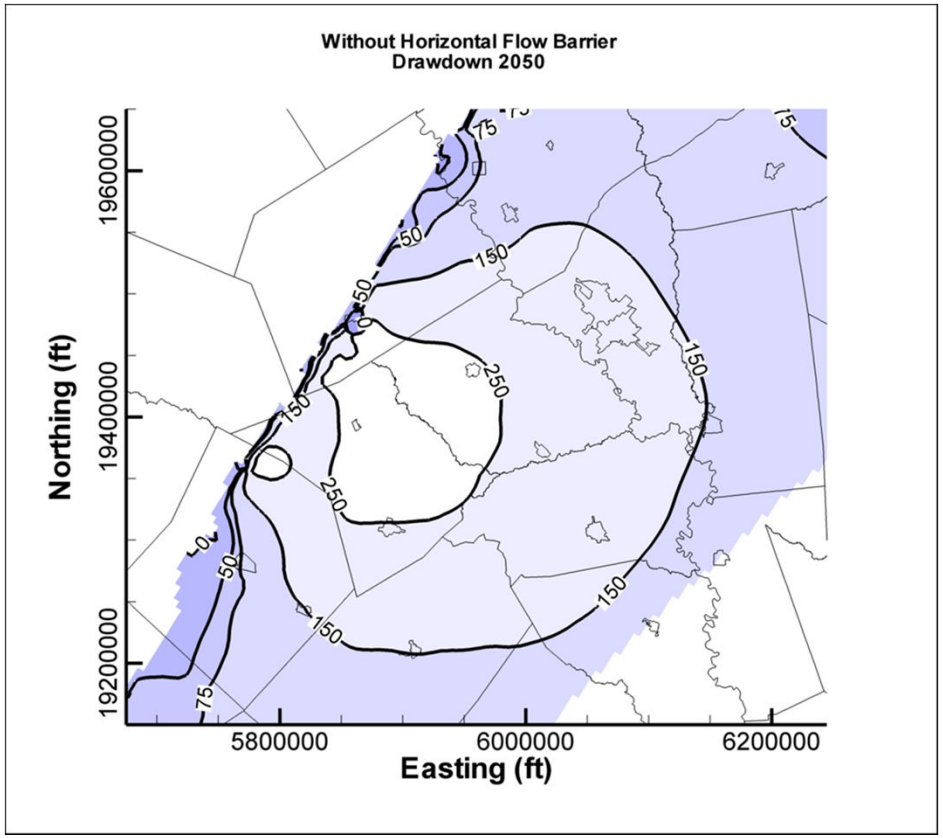
Mexia-Talco Faults (near Burleson-Milam Boundary)



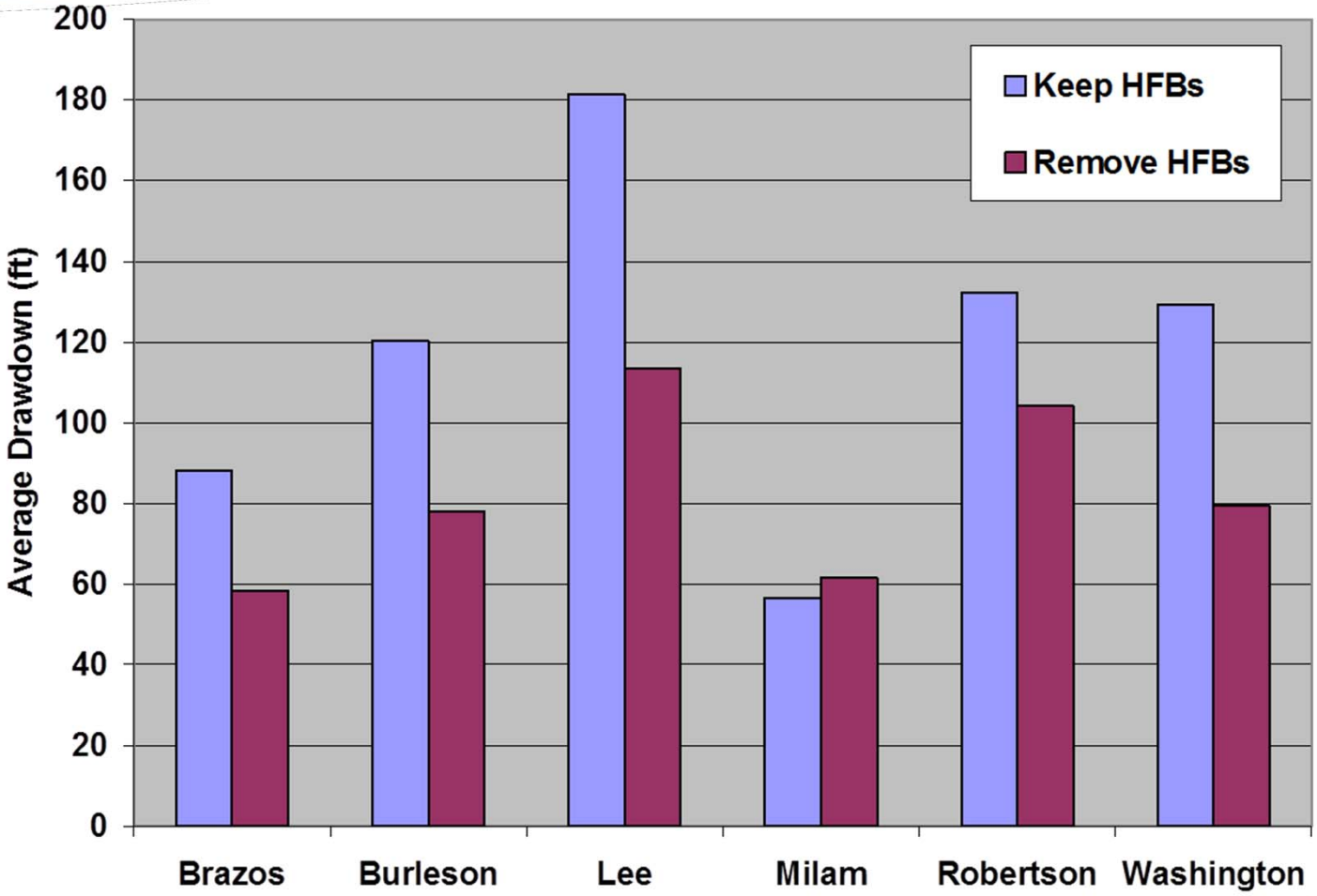
INTERA
GEOSCIENCE & ENGINEERING SOLUTIONS

GMA12 Run – Drawdown at 2050



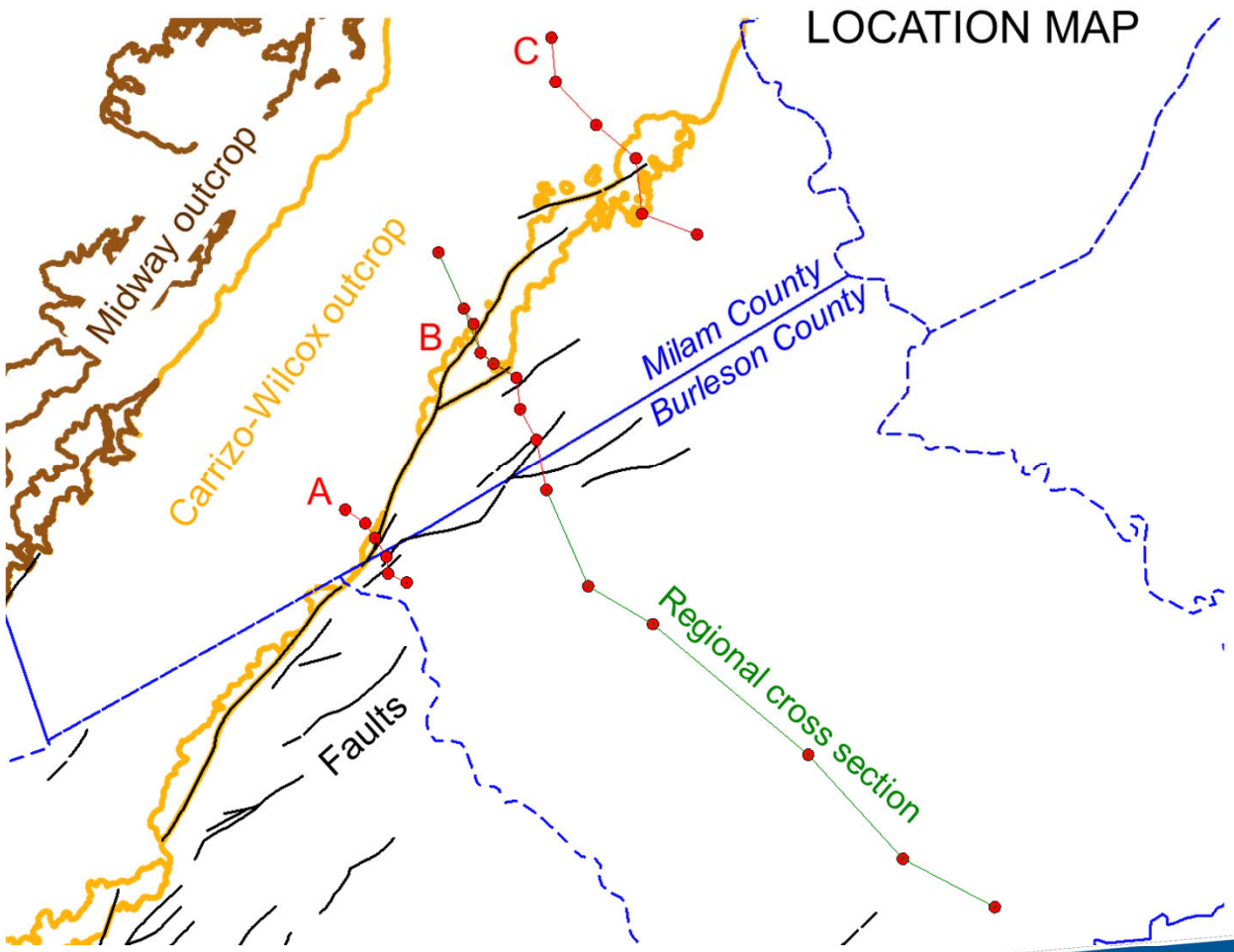


GMA12 Run – Drawdown at 2050

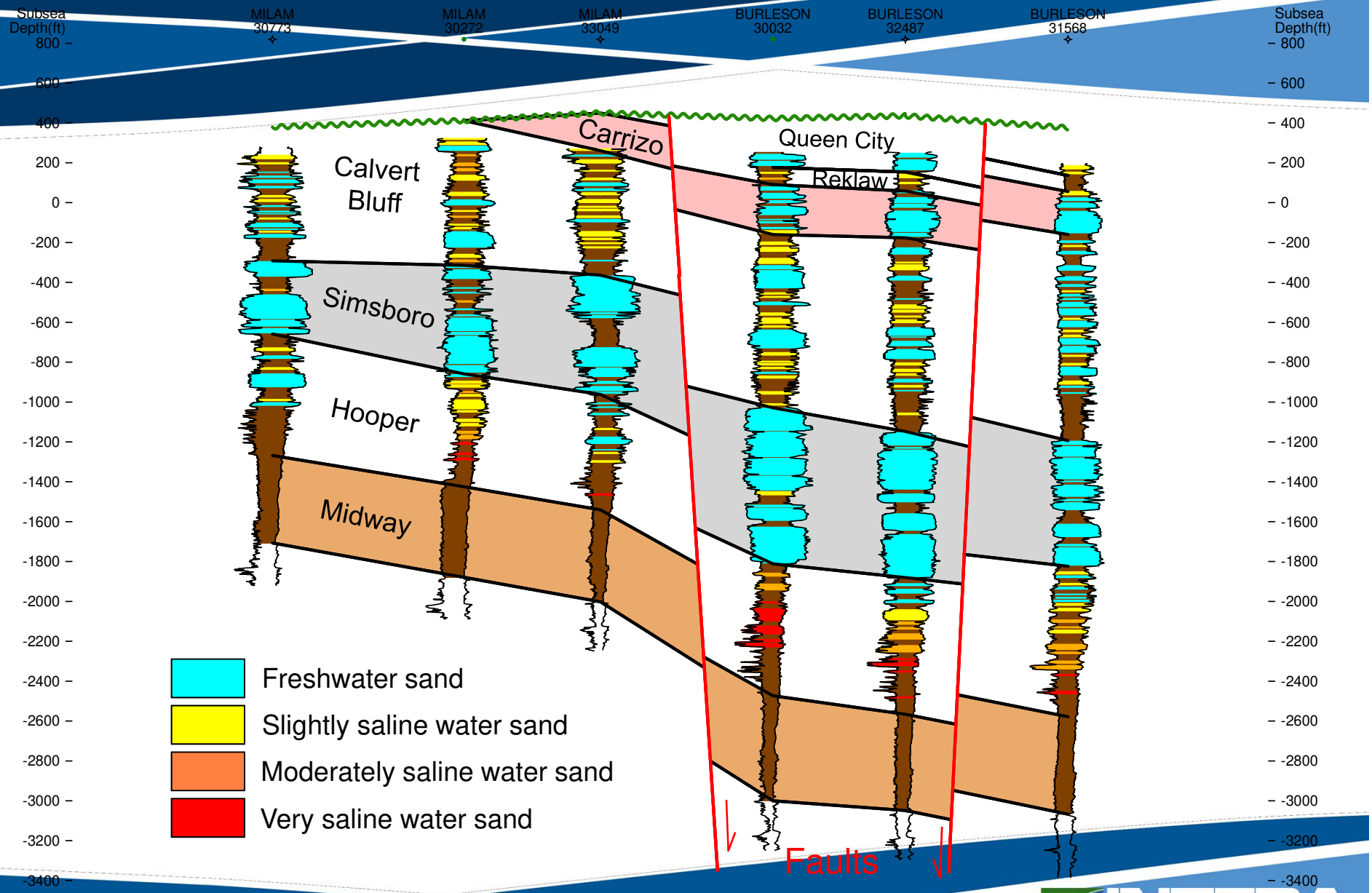


INTERA
GEOSCIENCE & ENGINEERING SOLUTIONS

Cross-sections Through Mexia-Talco Fault

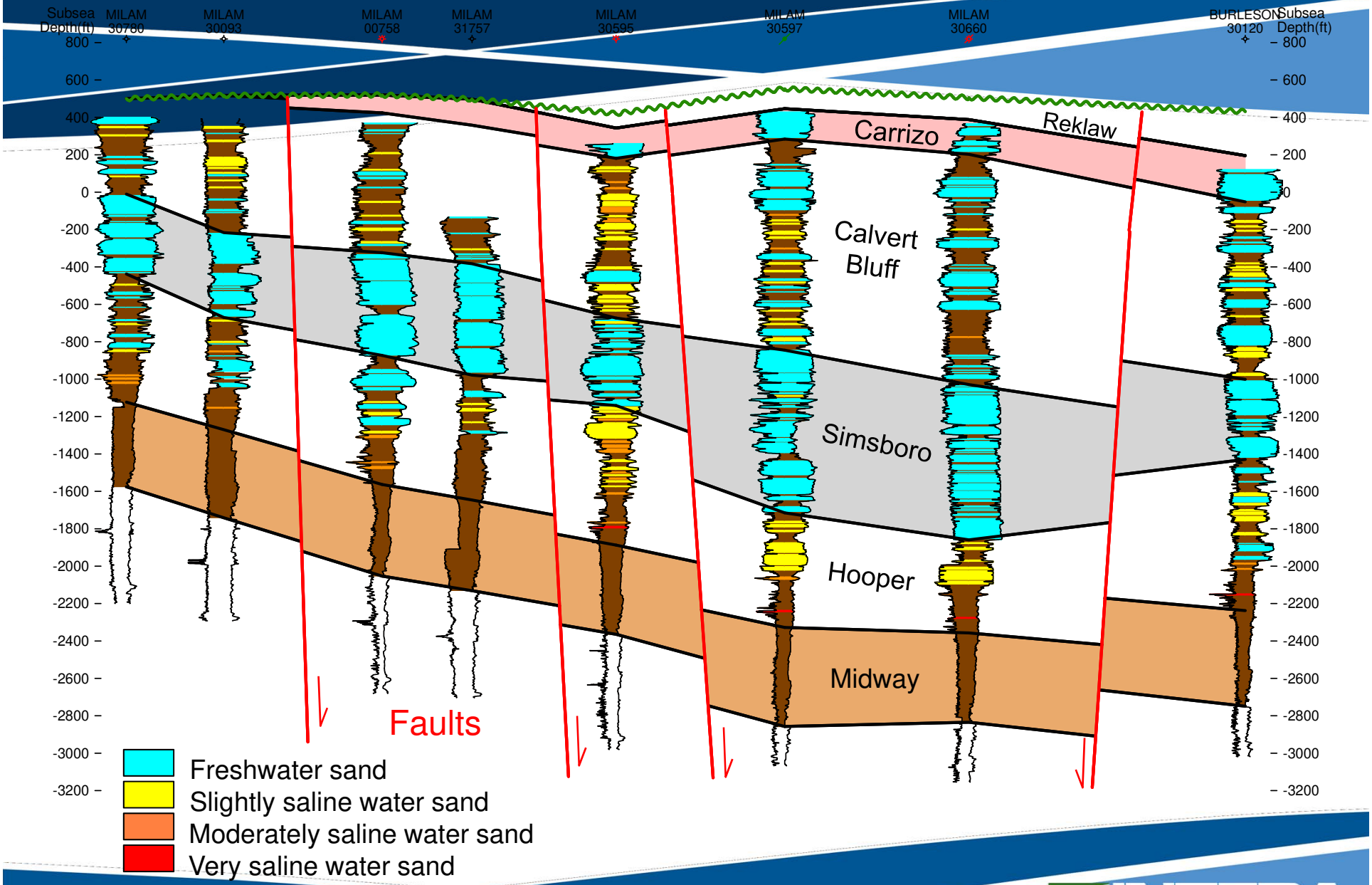


Cross Section A

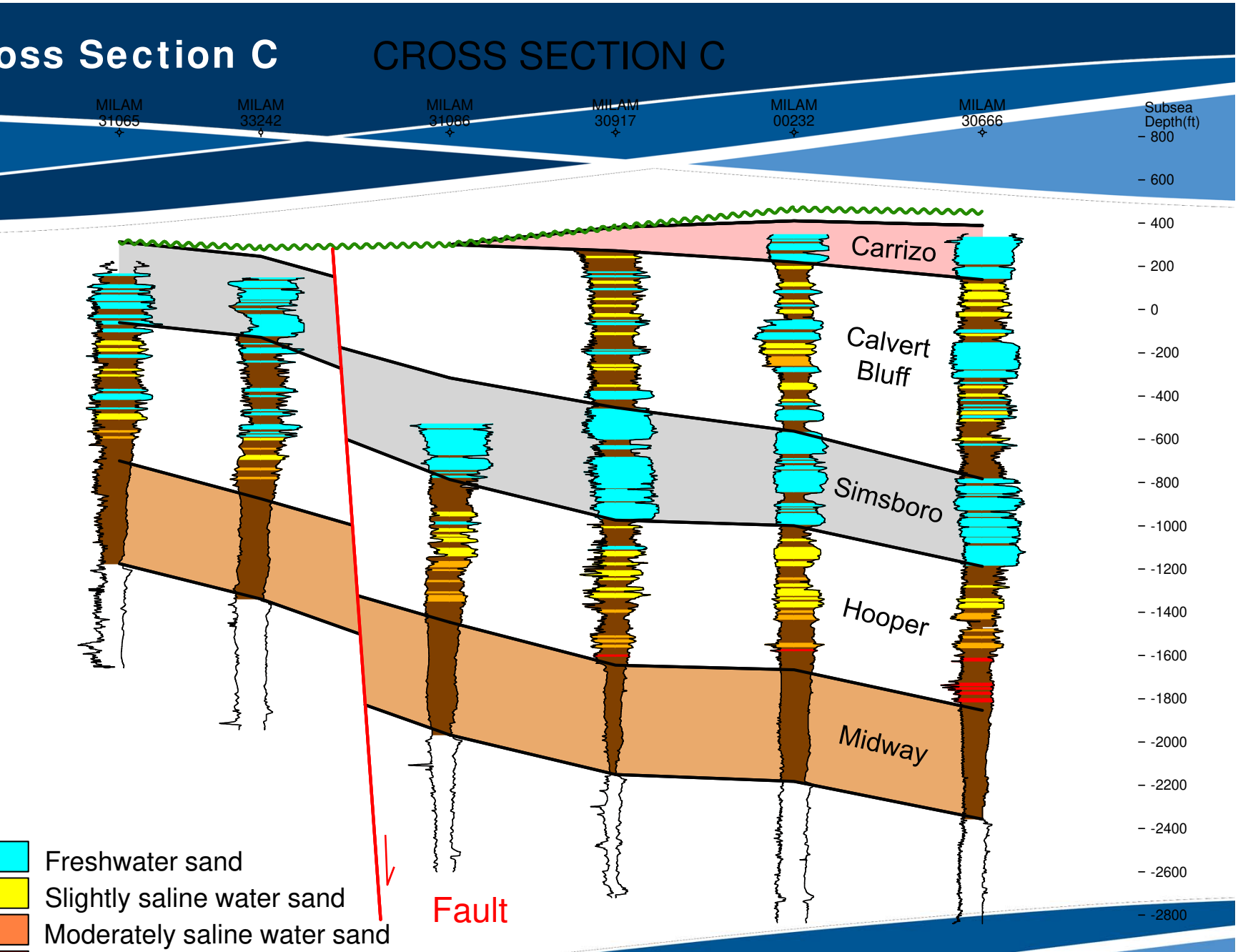


INTERA
GEOSCIENCE & ENGINEERING SOLUTIONS

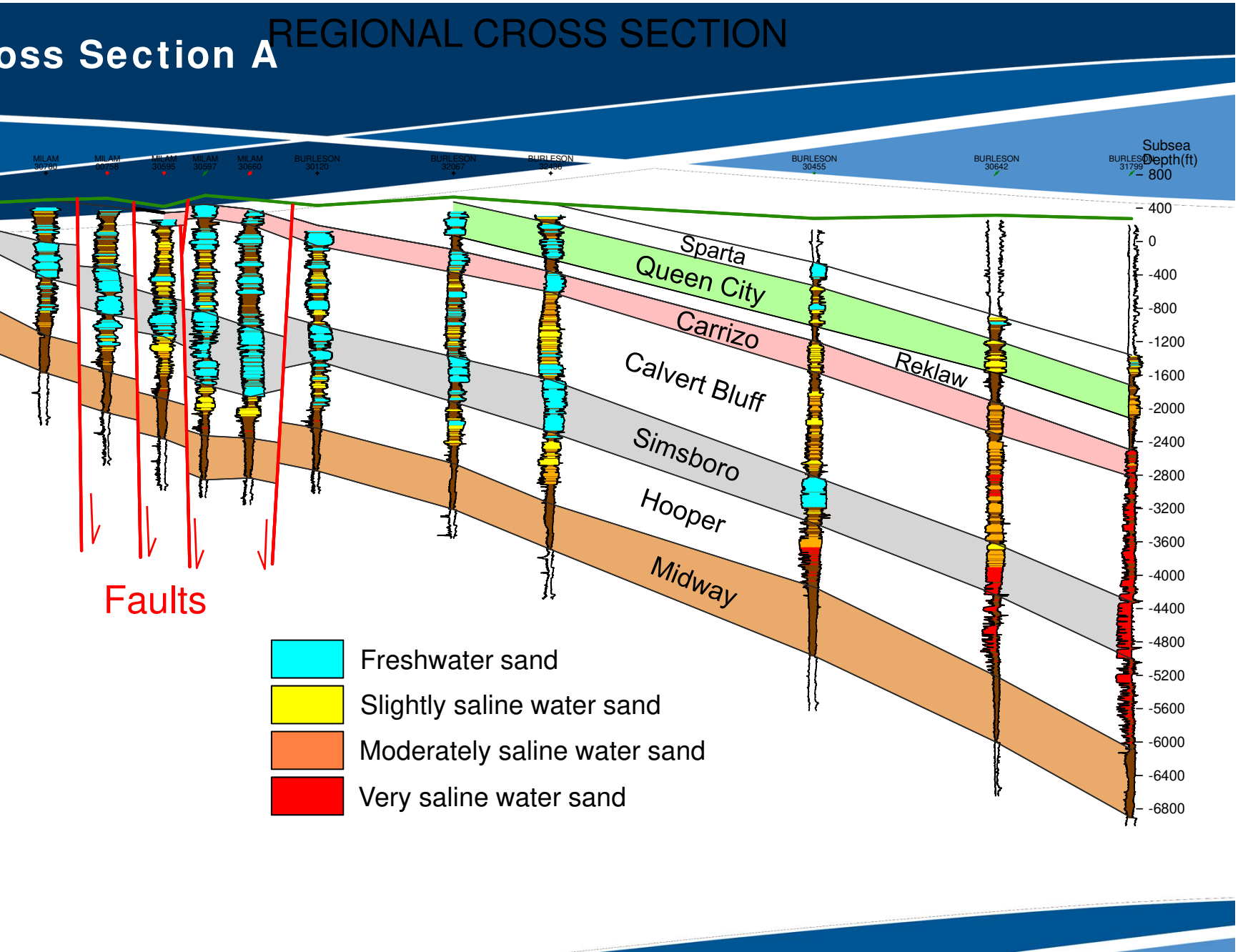
Cross Section B



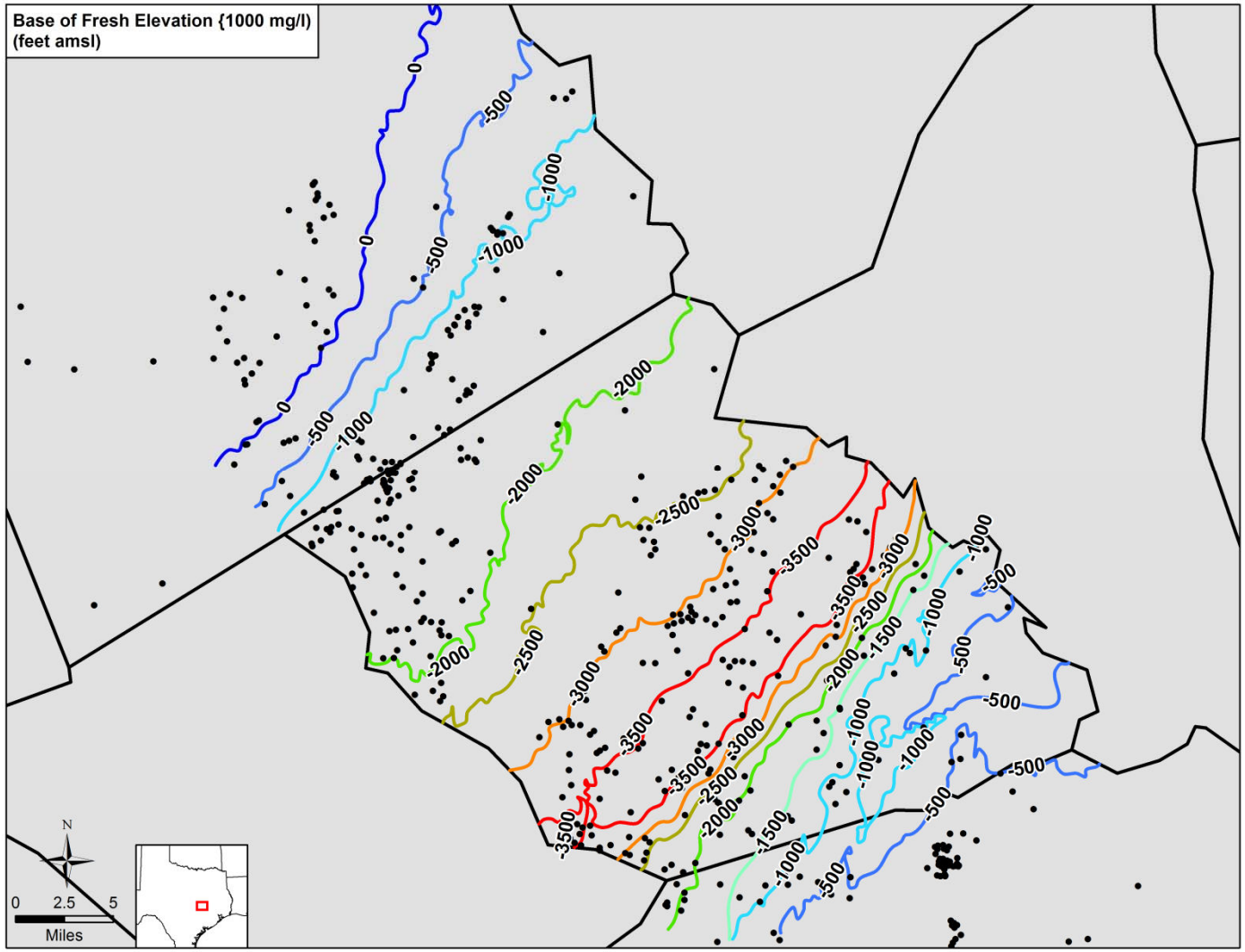
INTERA
GEOSCIENCE & ENGINEERING SOLUTIONS


oss Section C
CROSS SECTION C
MILAM 31665
MILAM 33242
MILAM 31686
MILAM 30917
MILAM 00232
MILAM 30666
Subsea Depth(ft)
800
600
400
200
0
-200
-400
-600
-800
-1000
-1200
-1400
-1600
-1800
-2000
-2200
-2400
-2600
-2800
Carrizo
Calvert Bluff
Simsboro
Hooper
Midway
Fault
Freshwater sand
Slightly saline water sand
Moderately saline water sand

REGIONAL CROSS SECTION

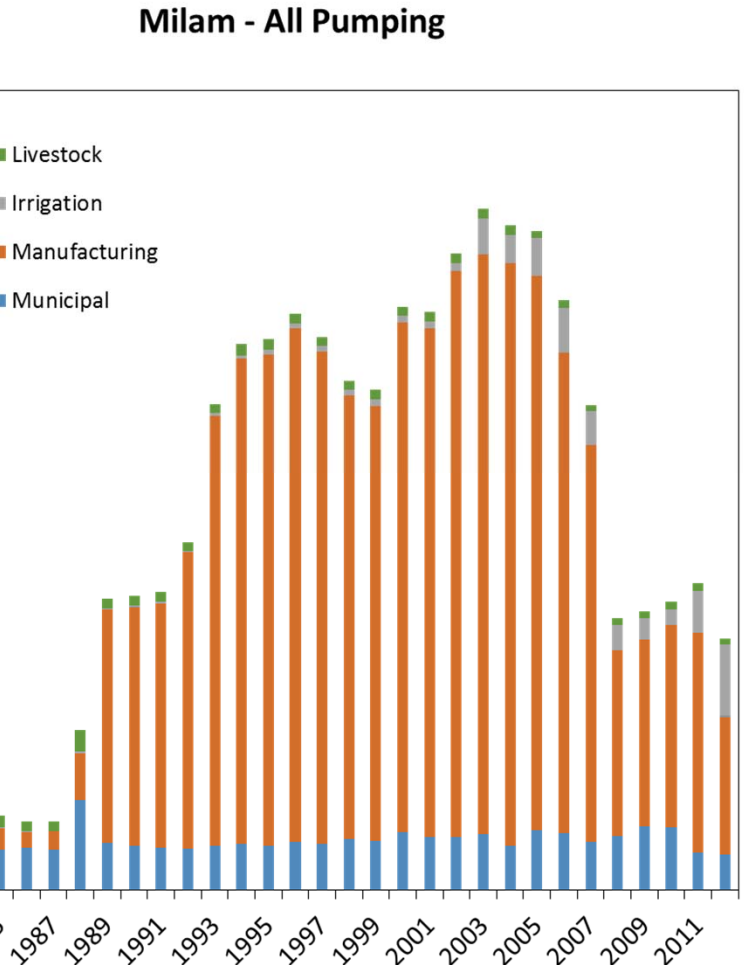


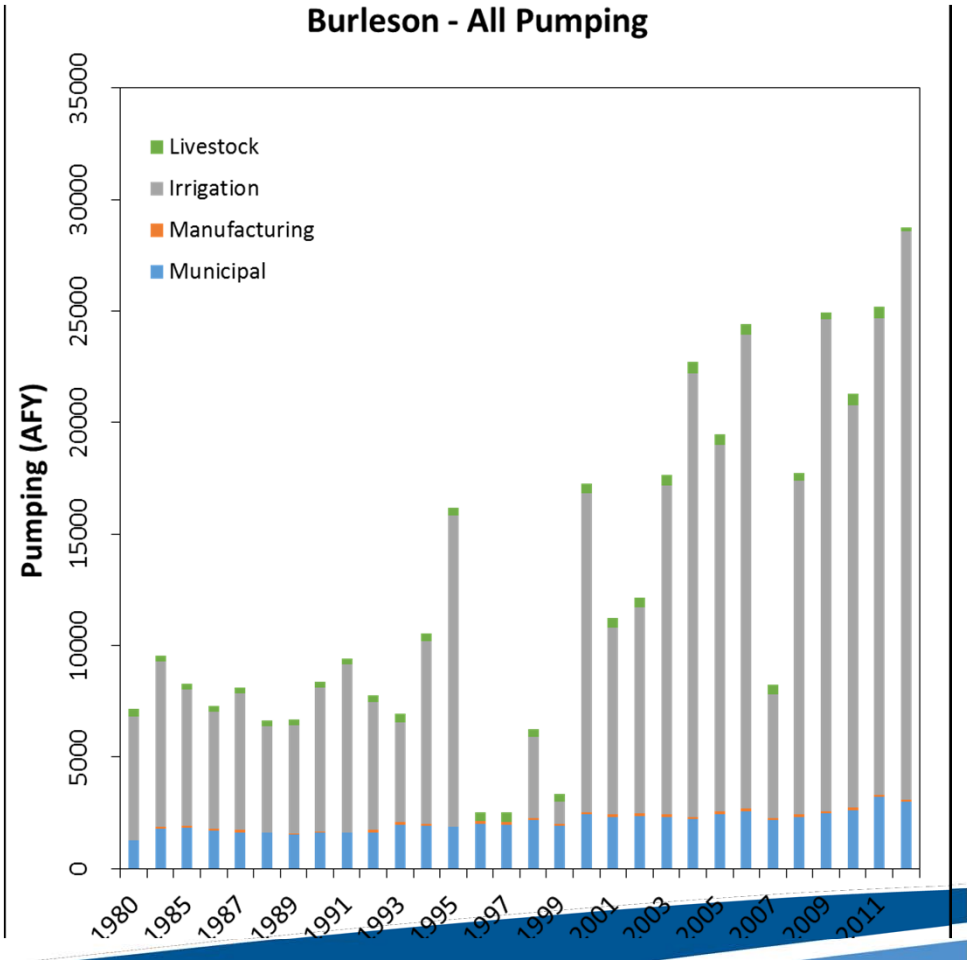
pth to Base of Fresh Water in Simsboro



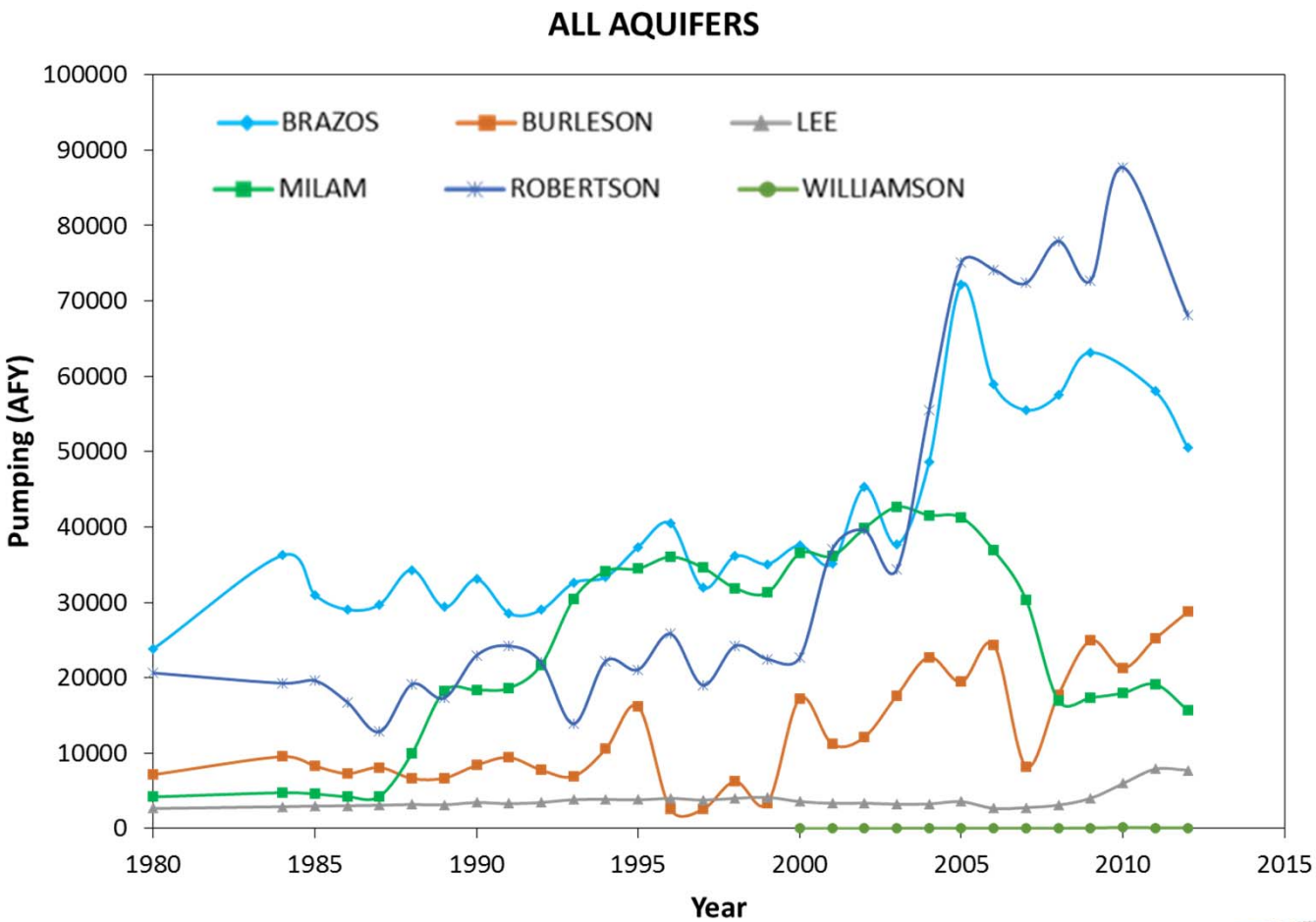
PUMPING

/DB Historical Pumping

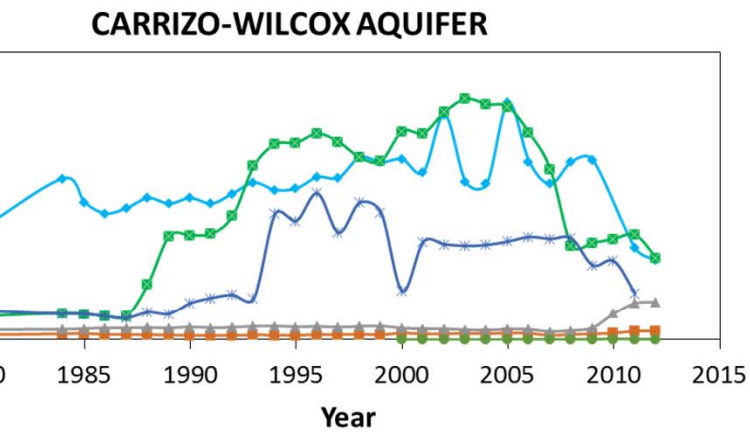


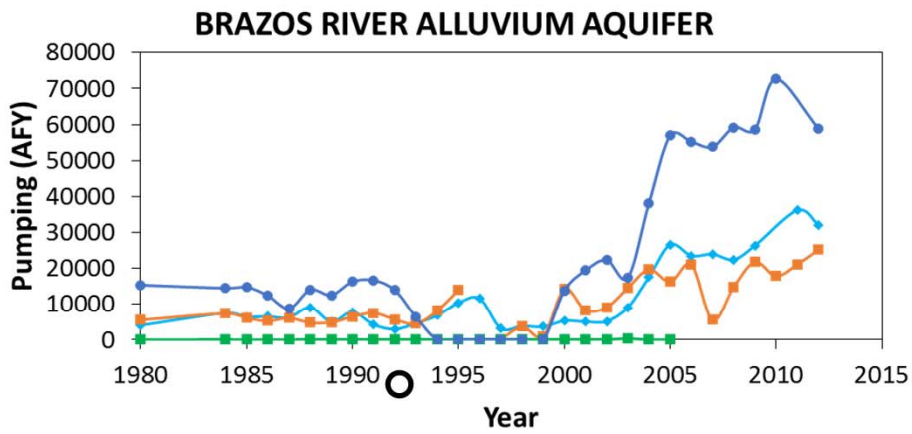


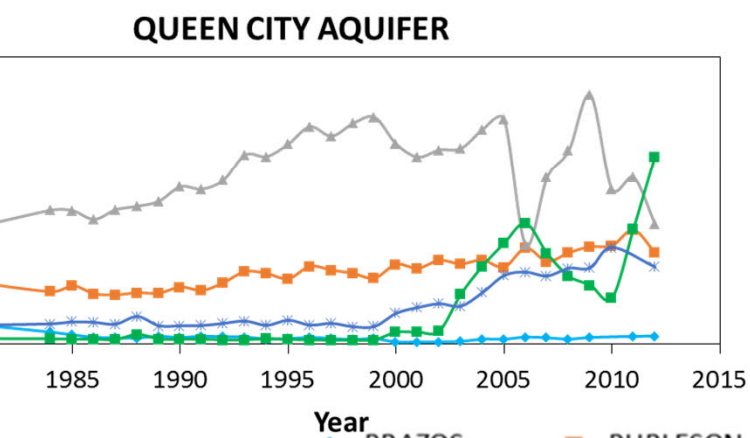
DB Historical Pumping

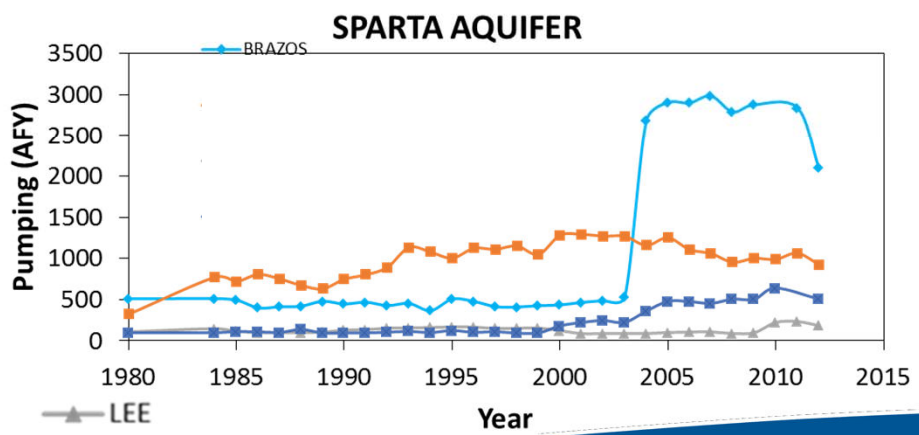


DB Historical Pumping



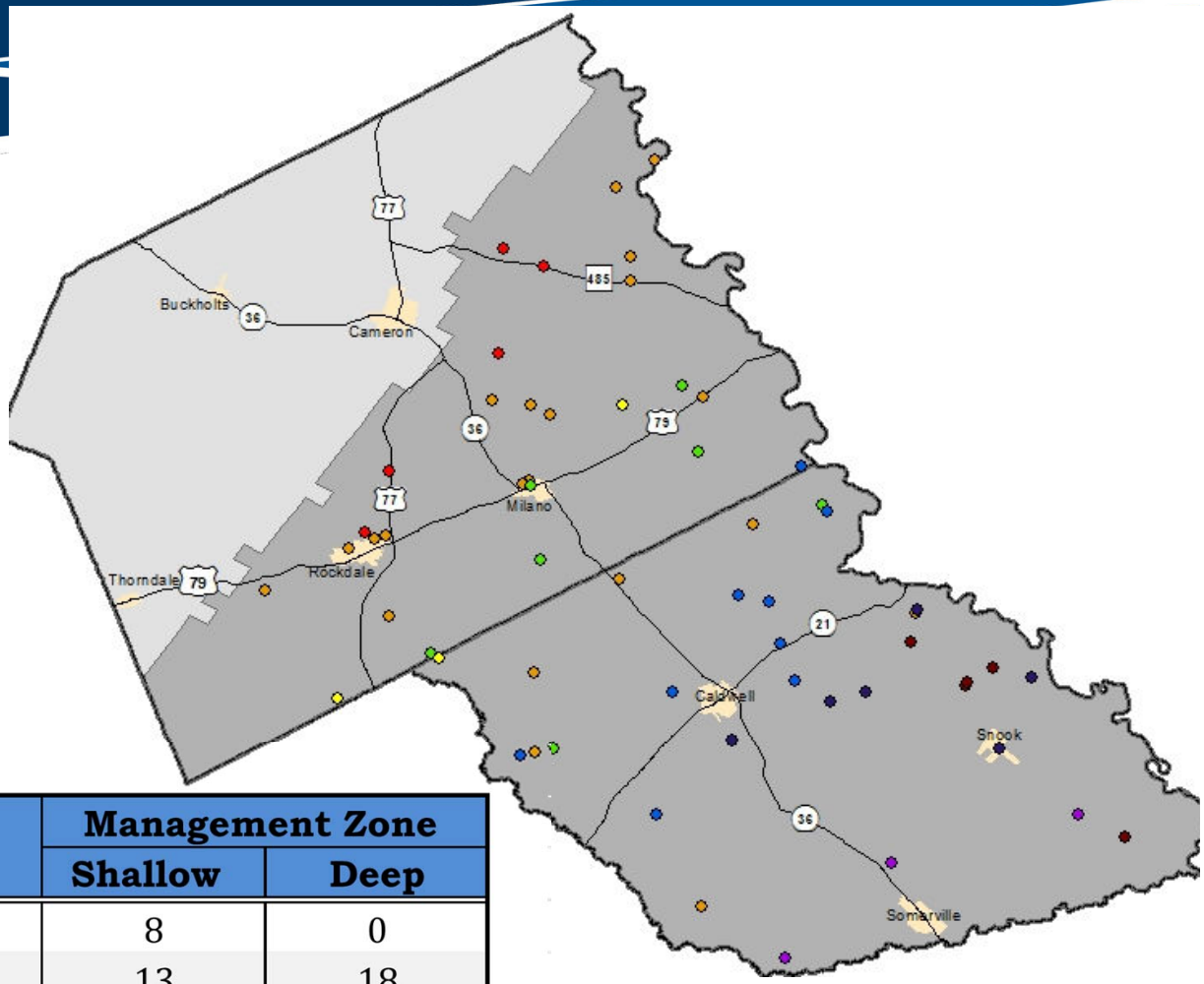






GROUNDWATER MONITORING

SGCD Monitoring Wells (~80 Wells)

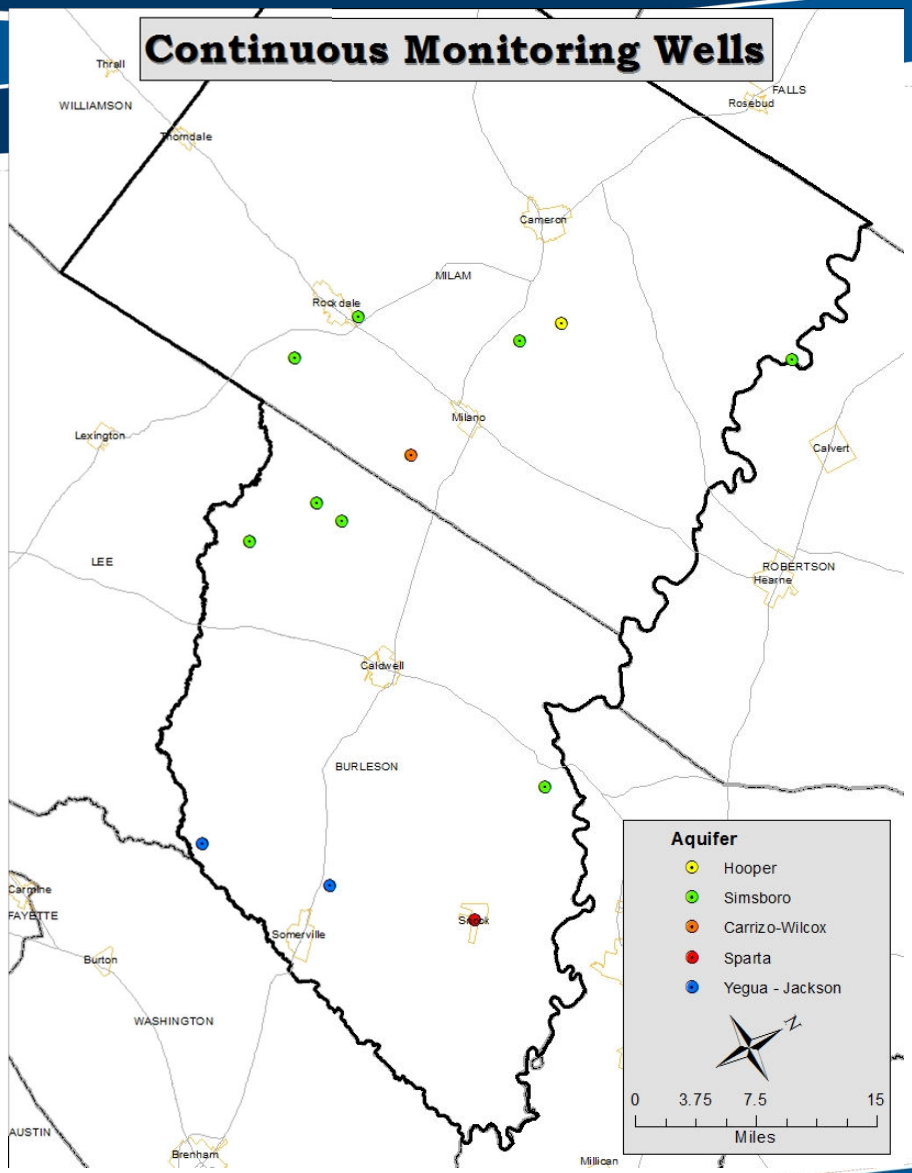


onitor Wells

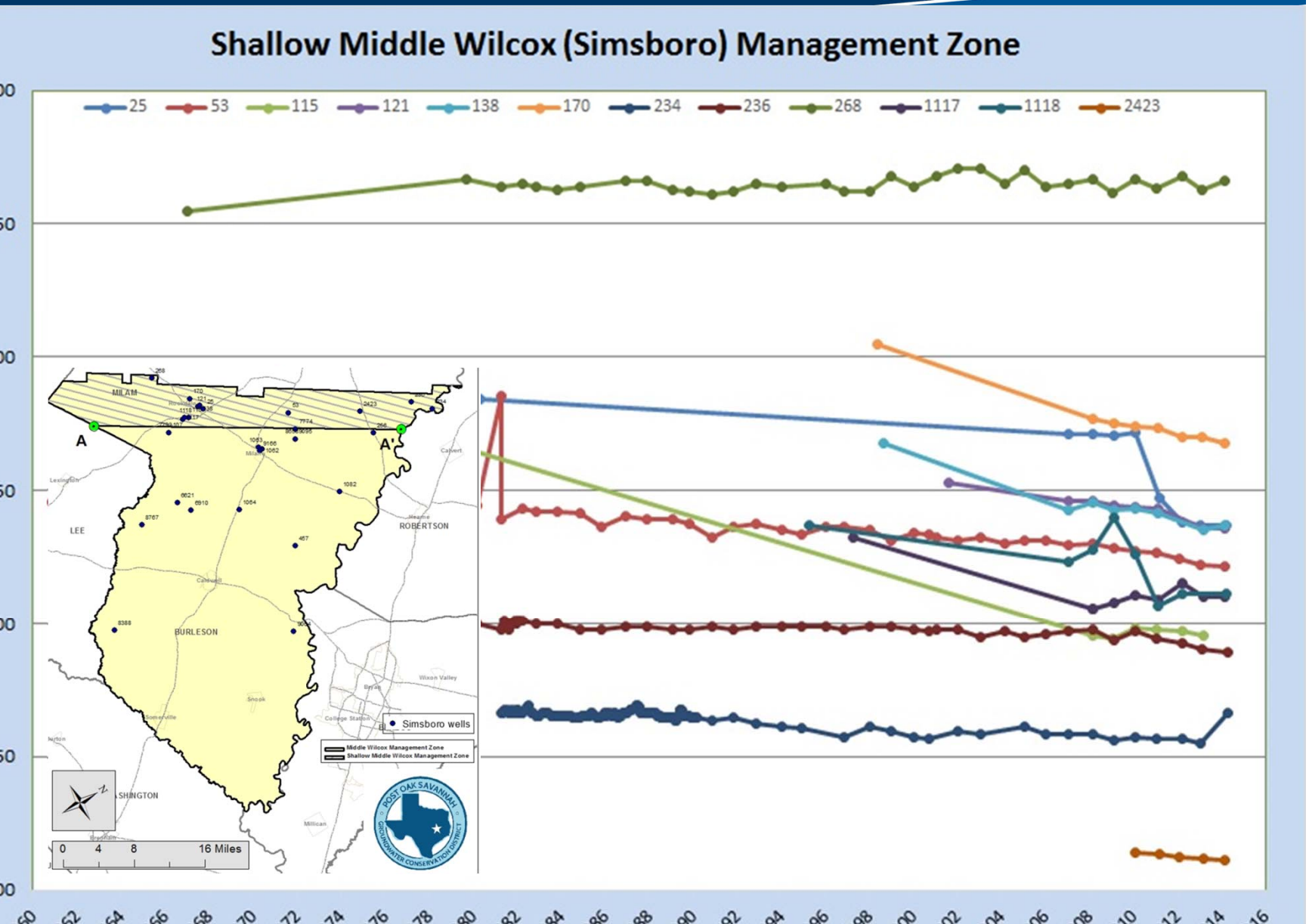
- Hooper
- Simsboro
- Calvert Bluff
- Carrizo
- Queen City
- Sparta
- Yegua - Jackson
- Brazos River Alluvium

Aquifer	Management Zone	
	Shallow	Deep
Hooper	8	0
Simsboro	13	18
Calvert Bluff	5	0
Carrizo	4	4
Queen City	5	6
Sparta	0	8

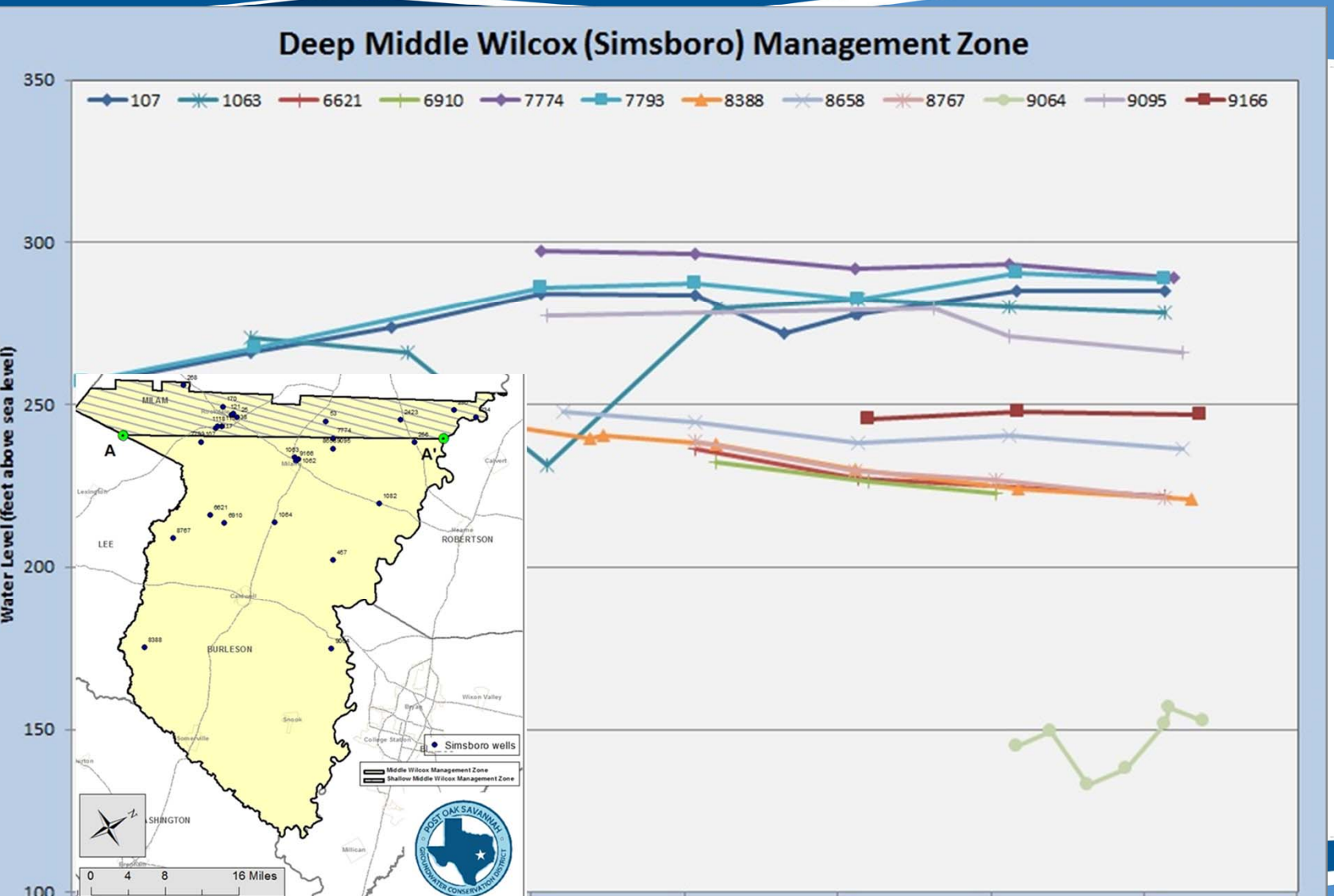
ntinuous Monitoring Network

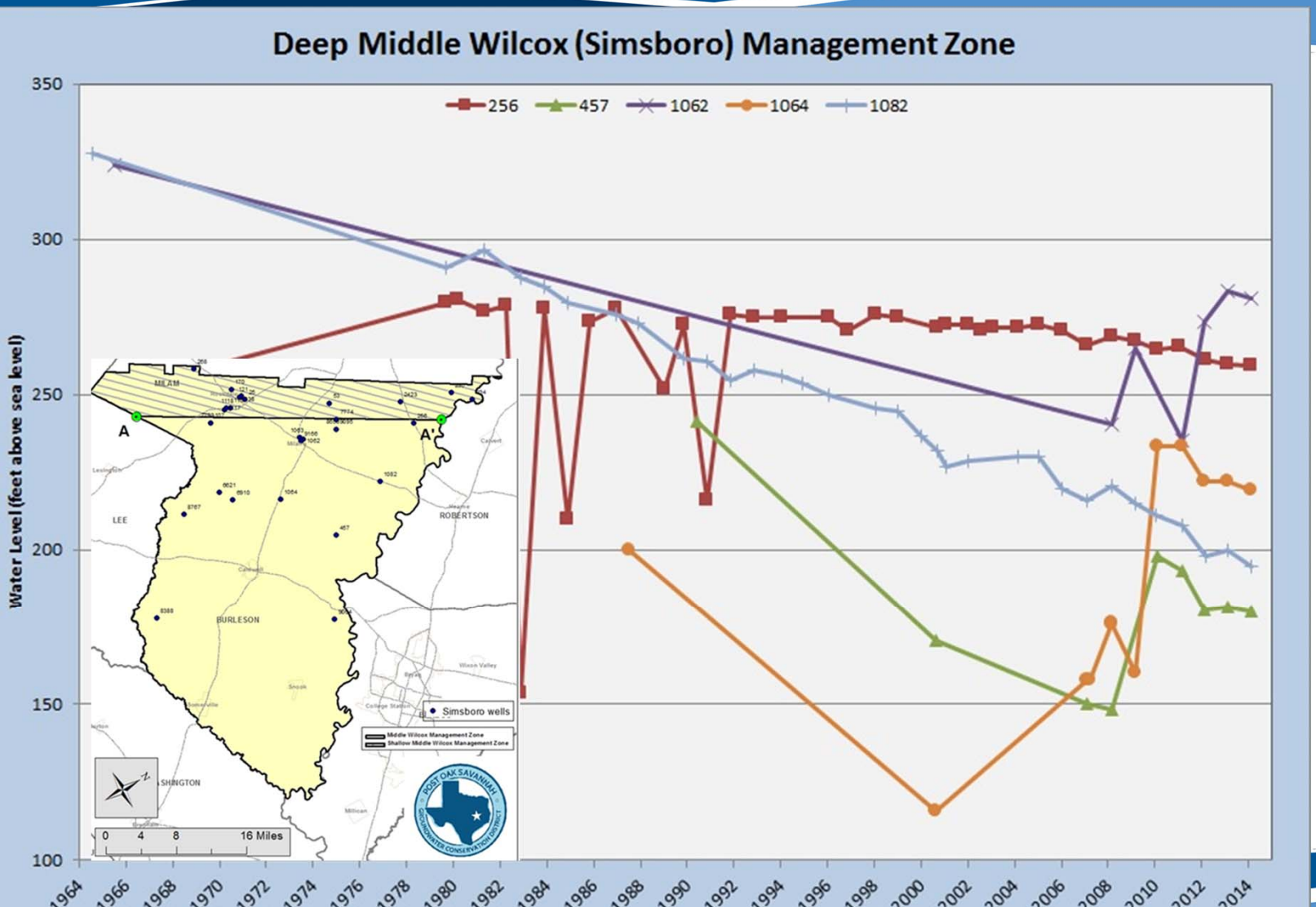


nsboro Monitoring Network



nsboro Monitoring Network




Deep Middle Wilcox (Simsboro) Management Zone
256
457
1062
1064
1082
Water Level (feet above sea level)
350
300
250
200
150
100
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
A
A'
LEE
BURLESON
ROBERTSON
Simsboro wells
Middle Wilcox Management Zone
Shallow Middle Wilcox Management Zone
0 4 8 16 Miles

mmary of Well Monitoring Data (June 10, 2014)

- **83 monitoring wells**
  - **70 incidental wells**
  - **13 continual wells**

- **Preliminary Analysis:**

ifer	Zone	# wells	Water Levels				Trend Last Five (5) Years
			Mean	Max	Min	Range	
per	Shallow	6	354	401	239	162	relatively constant, most wells dropping ~5 ft.
boro	Shallow	12	309	471	212	259	relatively constant, most wells dropping ~2-10 ft, a couple dropped >10 ft
boro	Deep	17	248	328	116	212	some wells dropping, but several raising as much as 30 ft.
t Bluff	Shallow	5	329	411	254	158	Mixed results, No apparent trend
rizo	Shallow	4	330	458	268	190	relatively constant, mostly dropping ~2-6 ft.
rizo	Deep	4	303	319	273	46	relatively constant, mostly dropping ~2-6 ft.
City	Shallow	5	299	352	251	101	relatively constant, a couple wells dropping ~10 ft.
City	Deep	3	302	321	291	30	need more data, but trending downward
rta	Deep	7	251	294	173	121	relatively constant, mostly dropping no more than ~10 ft.
lackson		3	209	220	199	22	Mixed results, No apparent trend
r Alluvium		7	210	246	172	74	Relavtively constant, dropping ~10 ft.

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QUESTIONS