ATTACHMENT A:
UPDATE ON MONITORING PROGRAM
NOVEMBER 10, 2015

Update on Monitoring Program

November 10, 2015

POSCD Offices

Milam, TX

Presented by:

INTERA
GEOSCIENCE & ENGINEERING SOLUTIONS

Agenda

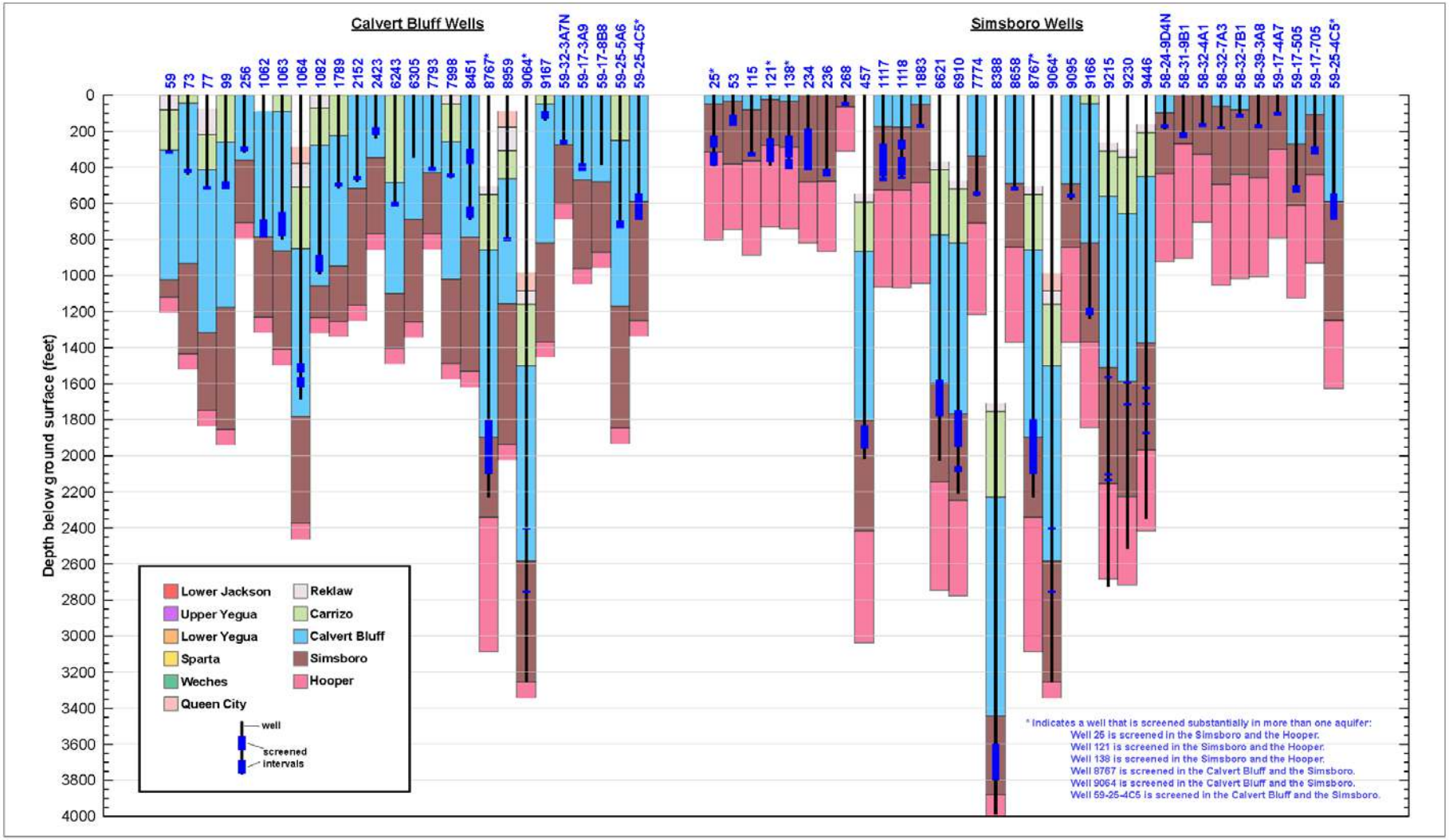
- Monitoring Data
  - Well Assignments
  - Hydrographs
- Calculated Drawdowns versus DFCs
- Methods
  - Averaging of Single Point Values
  - Interpolating Values Across Areas
- Discussion Topics/Possible Future Actions
  - Well Assignments
  - Monitoring Locations
  - Shallow Zone Delineation
  - Analysis Methods

Well Assignments

- Previous Classification Approach
  - Assign Wells based on GAM Surfaces
  - Assignments Modified by “30%” rule for some Aquifers

- Today’s Classification Approach
  - Assign Wells based on GAM Surfaces
    - ~90 wells screened in only one aquifer
    - ~10 wells screened across two aquifers
  - Deemed More Defensible than TWDB and Previous POSGCD Approach
    - Discussions with TWDB
    - TCEQ Regulatory Perspective

Calvert Bluff and Simsboro Wells



Wells Plotted with Aquifer Positions

Calvert Bluff and Simsboro Wells

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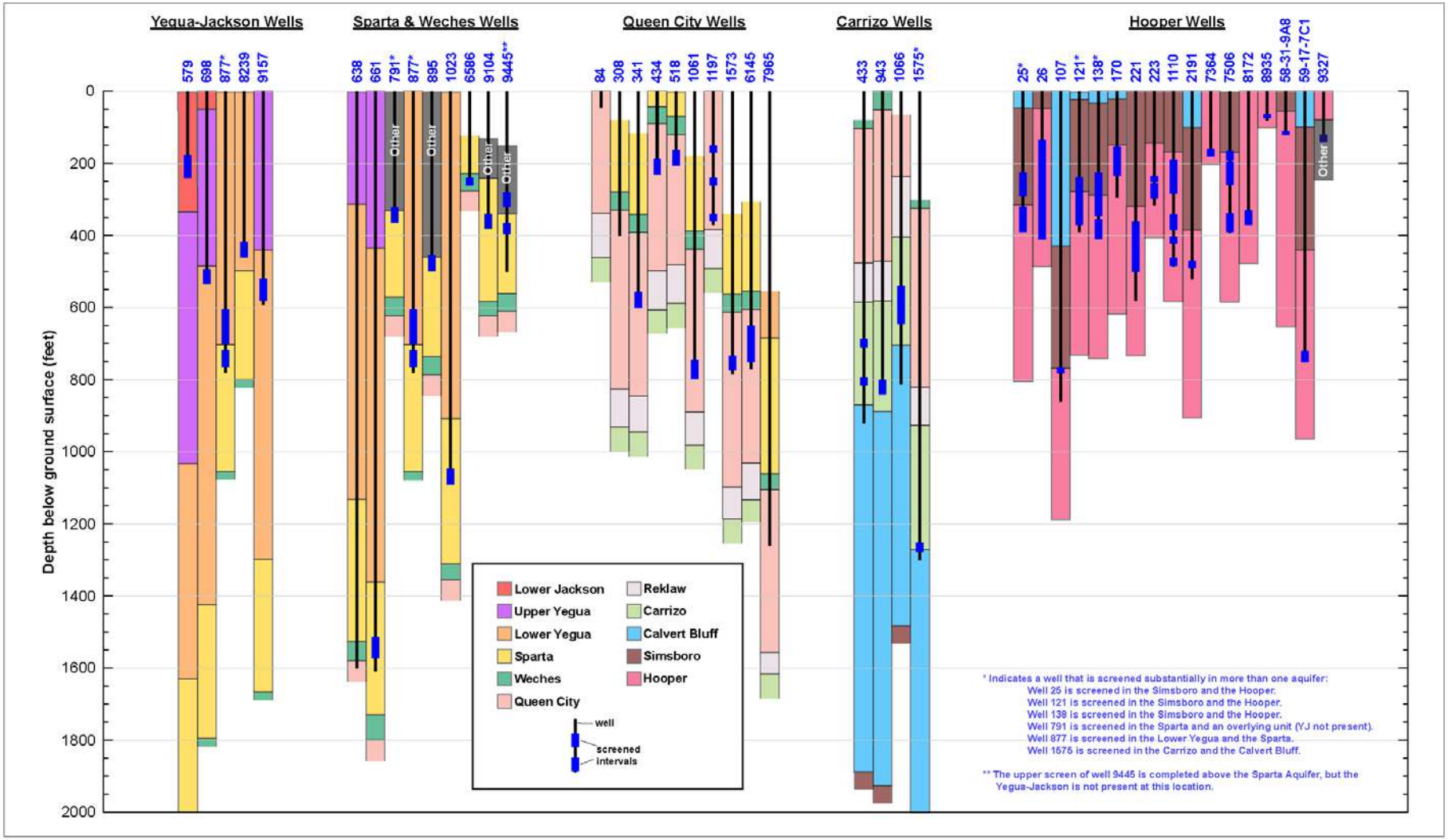
Sparta, Queen City, Carrizo, Hooper, and Yegua-Jackson Wells



Wells Plotted with Aquifer Positions

Yegua-Jackson, Sparta & Weches, Queen City, Carrizo, and Hooper Wells

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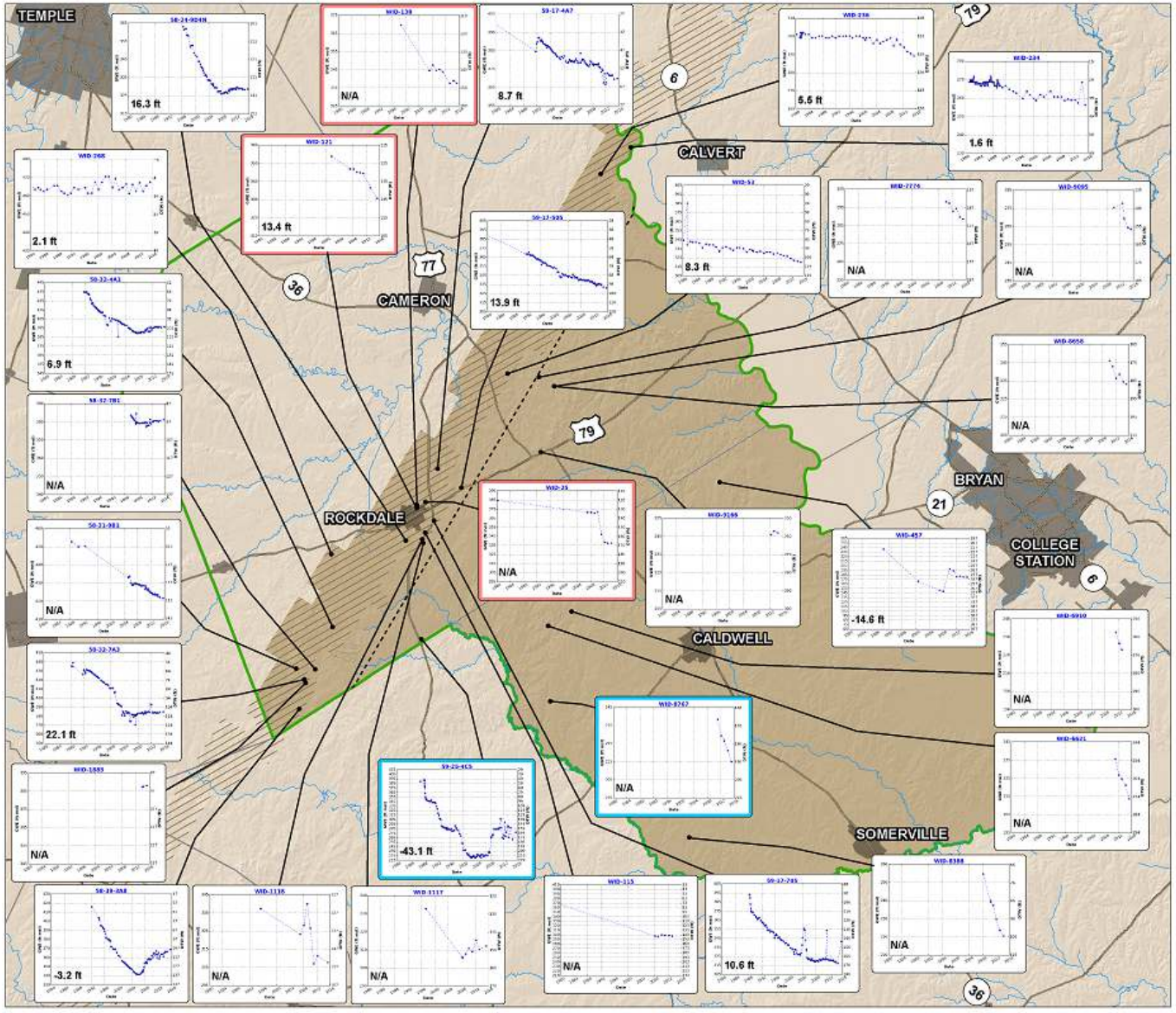
Comparisons of Well Assignments

Wells Screened in Only One Aquifer That TWDB Has Assigned					
Aquifer	**TWDB**	**Screen Match**	**Aquifer Above**	**Aquifer Below**	**Other**
Hooper	8	7	1	0	0
Simsboro	18	12	2	2	2
Calvert Bluff	10	9	0	1	0
Carrizo	2	1	0	1	0
Queen City	8	8	0	0	0
Sparta	5	4	0	1	0
BRAA	7	7	0	0	0
Yegua-Jackson	3	3	0	0	0
Wilcox*	4	0	0	0	0
COUNT	65				

*** 1 Simsboro, 1 Hooper, 2 Calvert Bluff**

Aquifer	**TWDB**	**Well Assignments Based on Partitioning Screen Interval Into Aquifer Layers***									
		Hooper	**Simsboro**	**Calvert Bluff**	**Carrizo**	**Queen City**	**Sparta**	**Yegua - Jackson**	**BRAA**	**Other**	**ND**
ND	**31**	3	13	8	0	2	1	0	0	2	2
Hooper	**9**	7	2	0	0	0	0	0	0	0	0
Simsboro	**21**	4	13	2	2	0	0	0	0	0	0
Calvert Bluff	**10**	0	1	9	0	0	0	0	0	0	0
Carrizo	**2**	0	0	1	1	0	0	0	0	0	0
Queen City	**9**	0	0	0	0	8	1	0	0	0	0
Sparta	**7**	0	0	0	0	0	5	2	0	0	0
BRAA	**7**	0	0	0	0	0	0	0	7	0	0
Yegua-Jackson	**3**	0	0	0	0	0	0	3	0	0	0
Wilcox	**4**	1	1	2	0	0	0	0	0	0	0
COUNT	**103**	***15***	***30***	***22***	***3***	***10***	***7***	***5***	***7***	***2***	***2***
	* Partitioning bases solely on length of well screen, aquifer transmissivity not considered										

Hydrographs: Simsboro Example

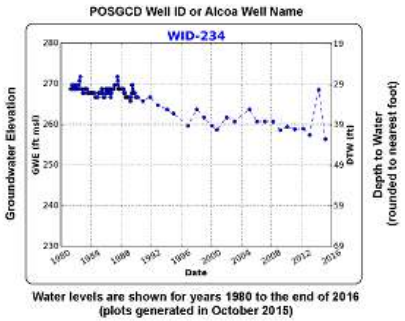


Simsboro Hydrographs

Post Oak Savannah Groundwater Conservation District

Legend

- POS GCD Boundary
- County lines
- Municipalities
- Unconfined Zone (Simsboro)
- Shallow Zone Extent (Simsboro)
- Simsboro Management Zone
- Major roads
- Rivers
- Well locations
- Hydrograph for well screened in both the Simsboro and the Hooper
- Hydrograph for well screened in both the Simsboro and the Calvert Bluff



Water levels are shown for years 1980 to the end of 2016 (plots generated in October 2015)

Map shown in the GAM coordinate system
North American Datum 1983
Projection: Albers
False Easting: 4921250
False Northing: 19685039

Central Meridian: -100.0
Standard Parallel 1: 27.5
Standard Parallel 2: 35.0
Latitude of Origin: 31.25
Linear Unit: US Foot

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Comparison Between DFC and Calculated Average Drawdown

Aquifer	Management Zone	Desired Future Condition Average[1]	Number of Wells with Three-year Average				Average Based on Measured Water Levels in Same Wells in POSGCD from 2000 to 2012				Average Based on Interpolated Points		DFC Compliant[4]	Percent of Average Drawdown of DFC[5]
			2000		2012		Number of Wells	Straight Average	Group by Cluster	Four Zones in Shallow	All 2000 Wells and All 2012 Wells	Only Wells Common to 2000 and 2012[2]		
			POSGCD	All	POSGCD	All								
Sparta	Shallow	10	0		0		0	na	na	na	22.2	**3.6**	yes	36.0%
	Entire	30	3	12	6	27	3	4.6	4.6		33.6	**3.5**	yes	11.7%
Queen City	Shallow	10	4		5		4	2.5	3.0	3	12	**3.1**	yes	31.0%
	Entire	30	5	12	9	24	5	2.8	3.2		17.3	**3.1**	yes	10.3%
Carrizo	Shallow	20	0		1		0	na	na	na	7.7	**6.5**	yes	32.5%
	Entire	65	1	7	4	11	1	10.1	10.1		33.9	**6.7**	yes	10.3%
Calvert Bluff (Upper Wilcox)	Shallow	20	8		17		7	9.2	9.1	11.2	-11.1	**0**	yes	0.0%
	Entire	140	11	18	20	33	11	-1.7	-7.5		-6	**-11.4**	yes	-8.1%
Simsboro (Middle Wilcox)	Shallow	20	12		19		12	8.9	7.8	6	12	**9.6**	yes	48.0%
	Entire	300	14	31	29	71	14	3.5	-0.4		20.3	**11.1**	yes	3.7%
Hooper (Lower Wilcox)	Shallow	20	4		9		4	5.9	5.9	5.6	40	**6.2**	yes	31.0%
	Entire	180	5	6	11	25	5	7.4	7.4		84.5	**7.1**	yes	3.9%
Yegua Jackson	Shallow	15	0		0		0	na	na	na	na	**na**	unknown	unknown
	Entire	100	1	9	4	27	1	7.3	7.3		12.3	**16.4**	yes	16.4%
Brazos River Alluvium	Milam	5					0	na					unknown	unknown
	Burleson[3]	6					7	4.5	5.0	5.1			yes	81.1%

[1] all DFCs are from Jan. 2000 to Dec. 2059 except the BRAA DFC, which is from Jan. 2010 to Dec. 2059

[2] best estimate of calculated average drawdown from 2000 to 2012

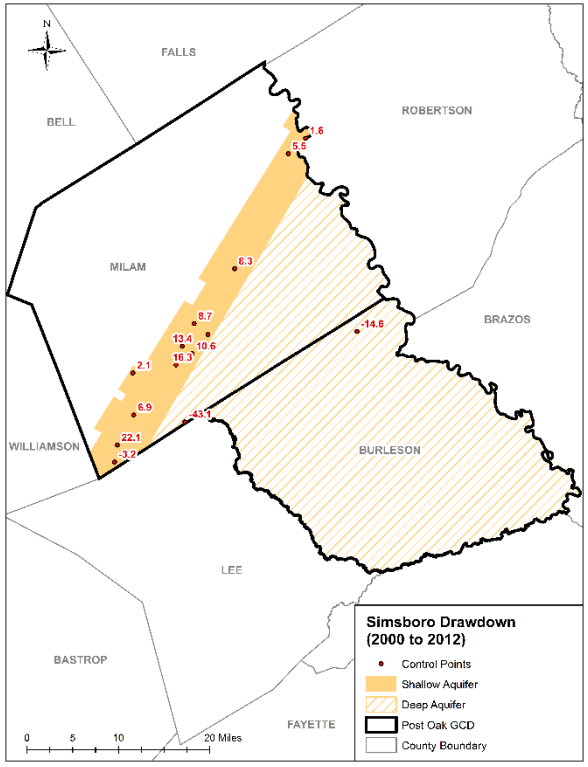
[3] number of wells from 2010 to 2014

[4] likely is based on review of all available data; insuff. data requires additional information

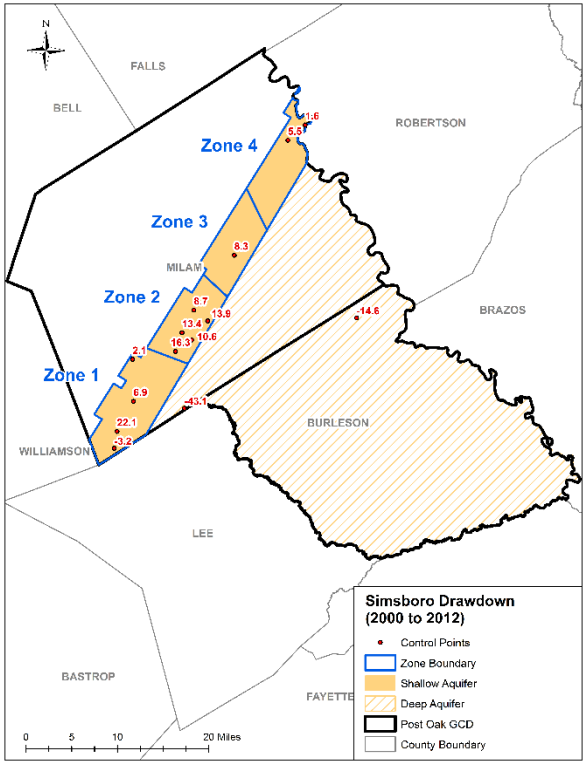
[5] Threshold Level 1 criteria is 60%

Averaging of Single Points: Simsboro

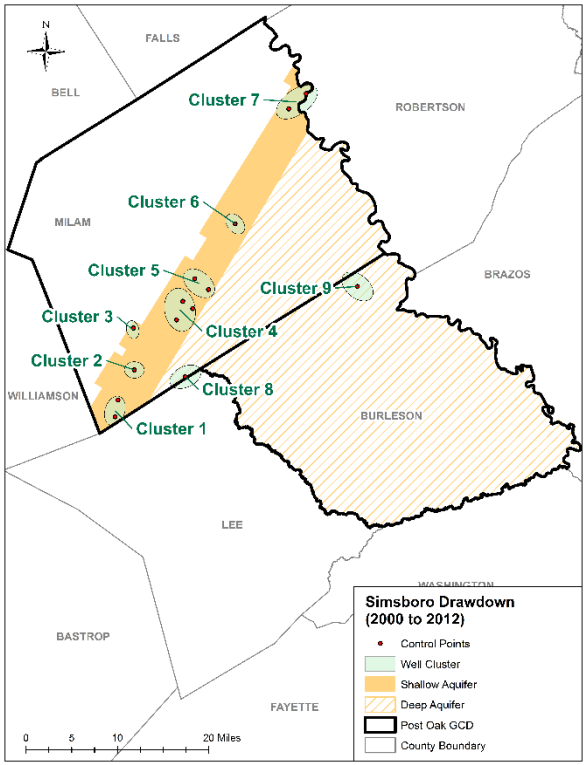
Straight Average
(shallow: 8.9 ft, deep: 3.5 ft)



Four Zones in Shallow
(shallow: 6 ft)

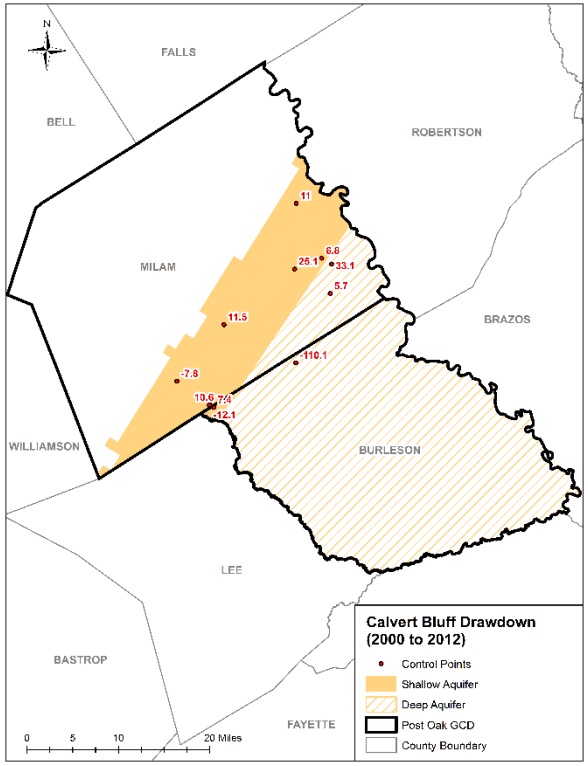


Group by Cluster
(shallow: 8.6 ft, deep: 1.8)

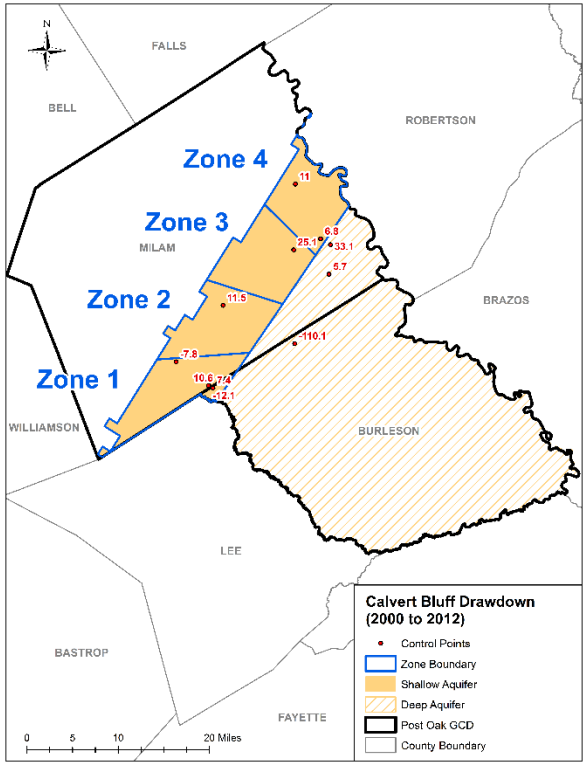


Averaging of Single Points: Calvert Bluff

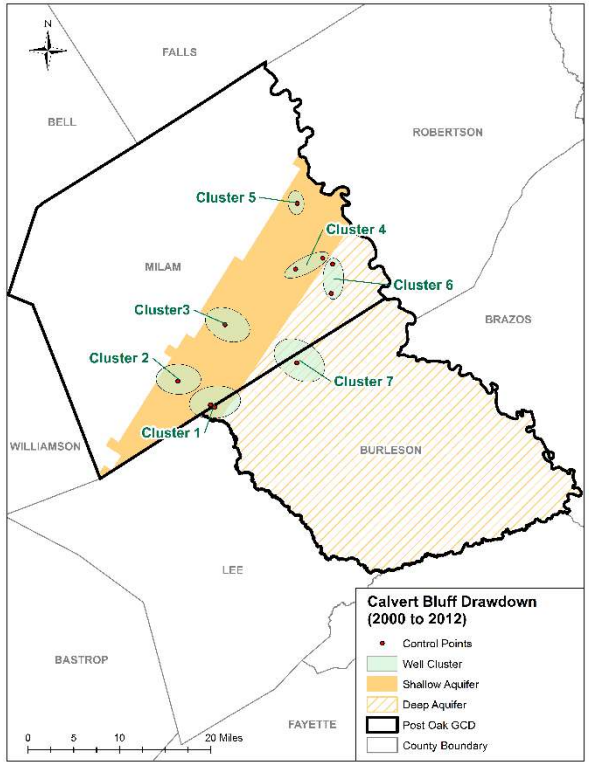
Straight Average
(shallow: 9.2 ft, deep: -1.7 ft)



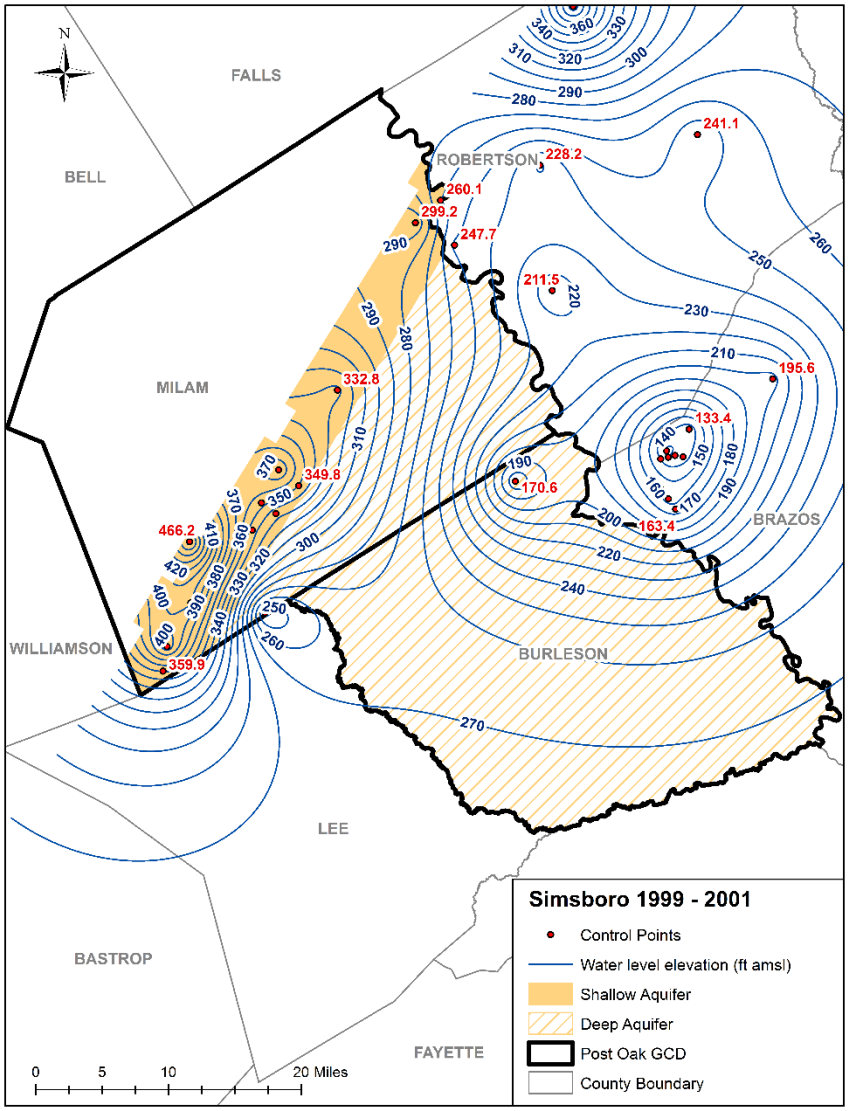
Four Zones in Shallow
(shallow: 11.2 ft)

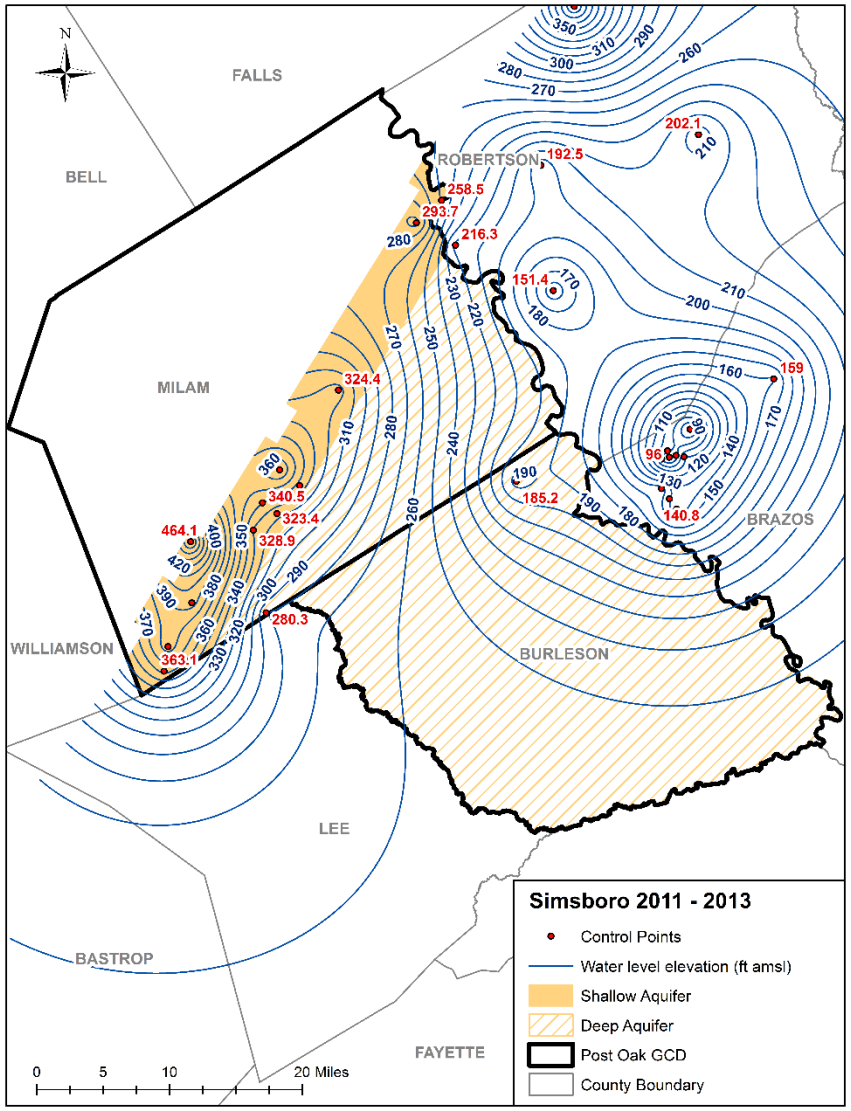


Group by Cluster
(shallow: 9.1 ft, deep: -7.5)

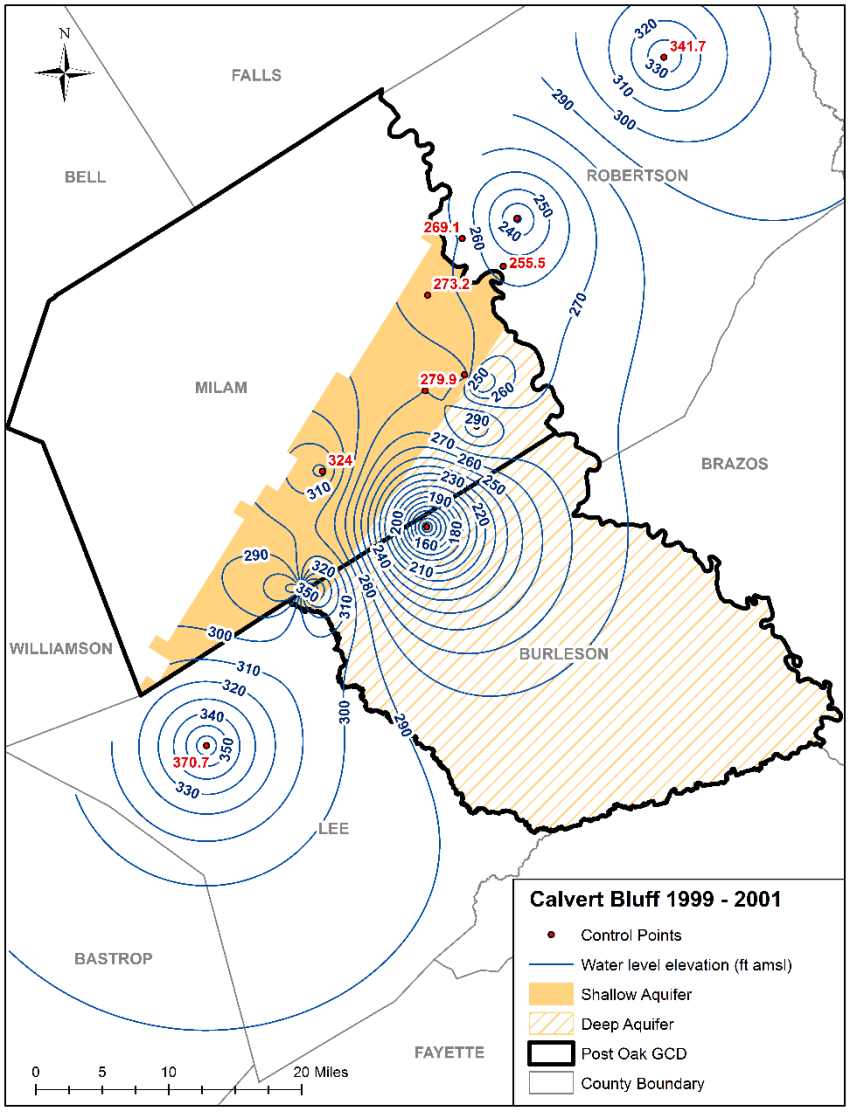


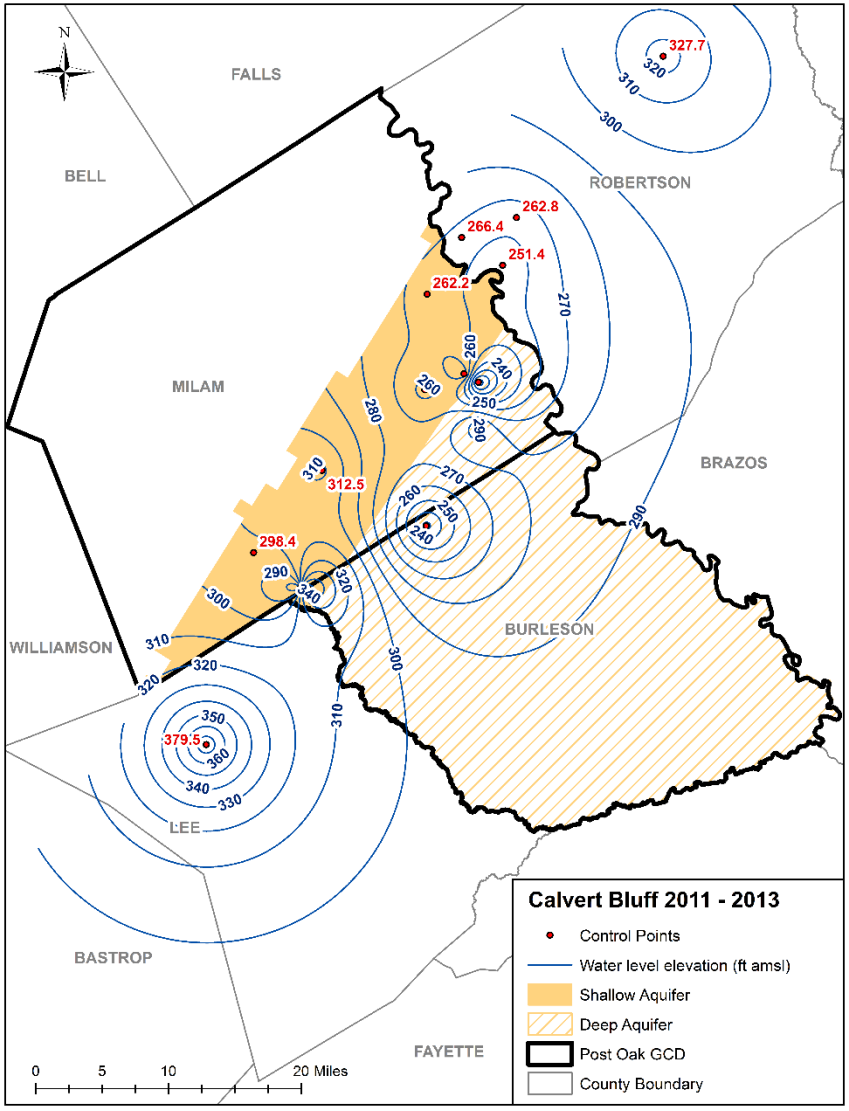
Interpolating Values Across Areas: Simsboro (same wells in 2000 and in 2012)





Interpolating Values Across Areas: Calvert Bluff (same wells in 2000 and in 2012)





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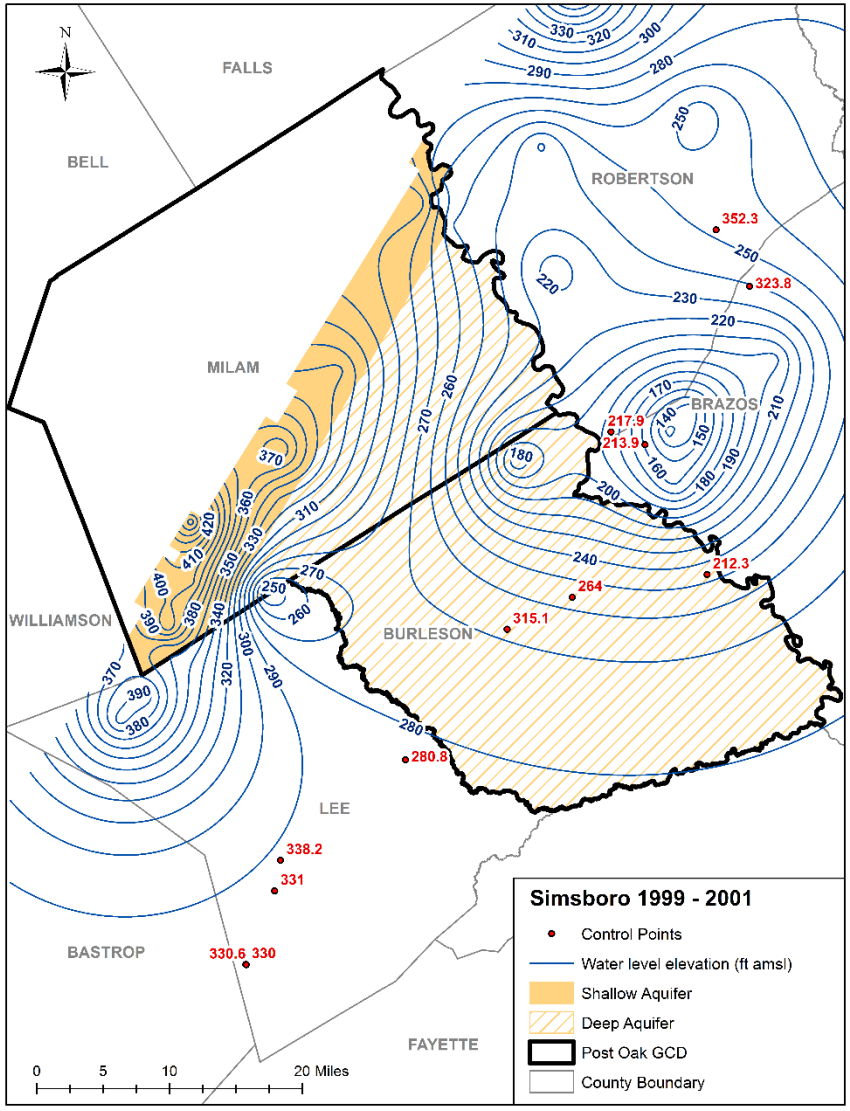
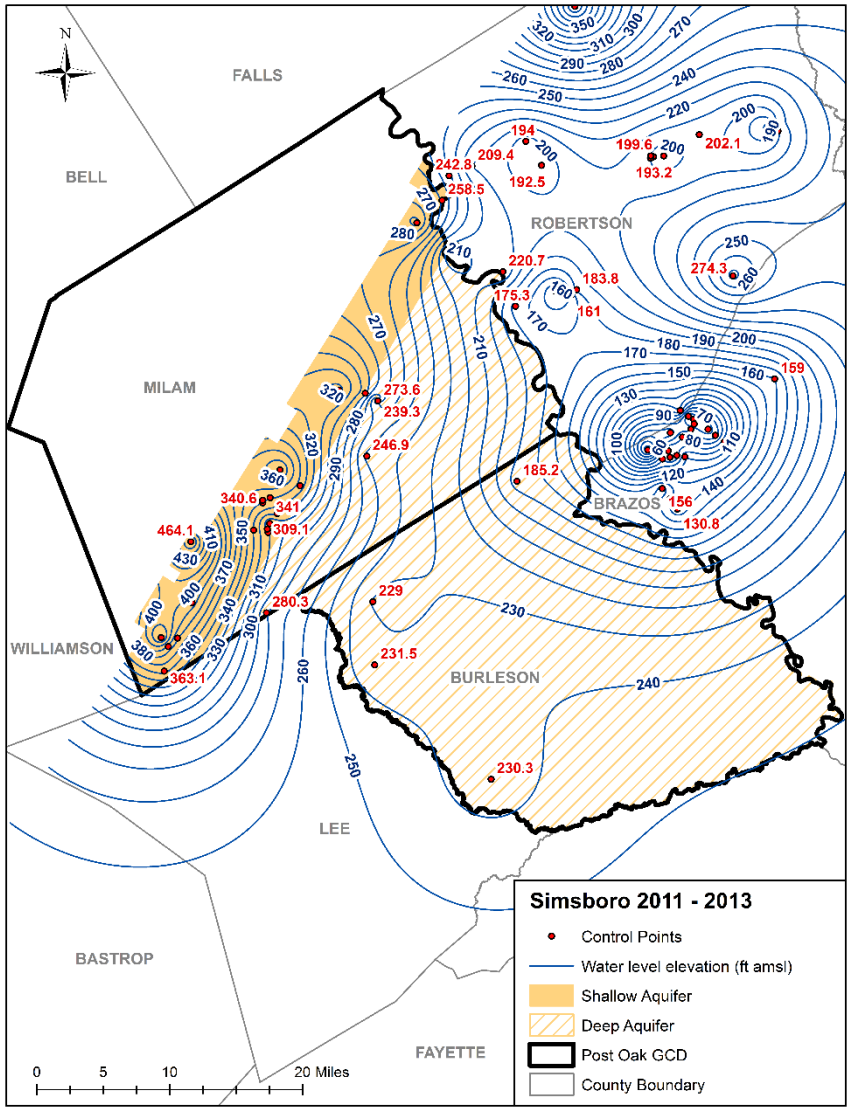
Interpolating Values Across Areas: Simsboro (more wells in 2012 and than in 2000)





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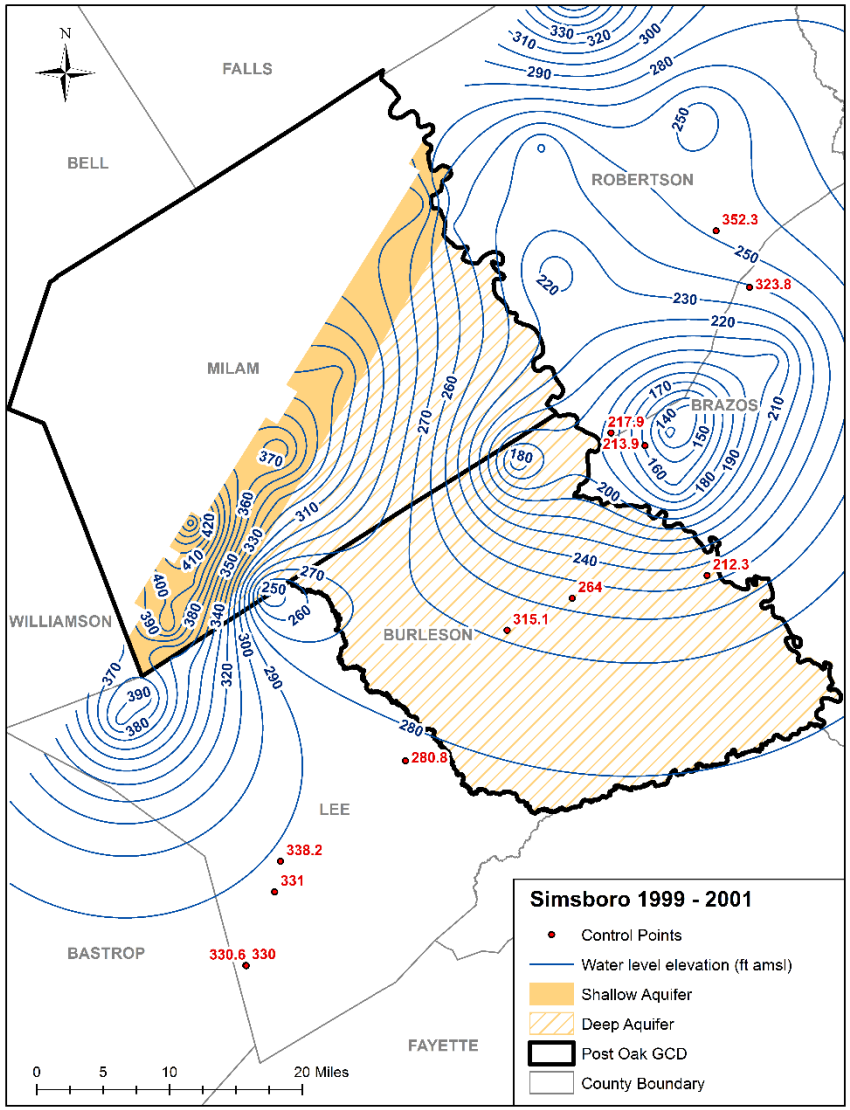
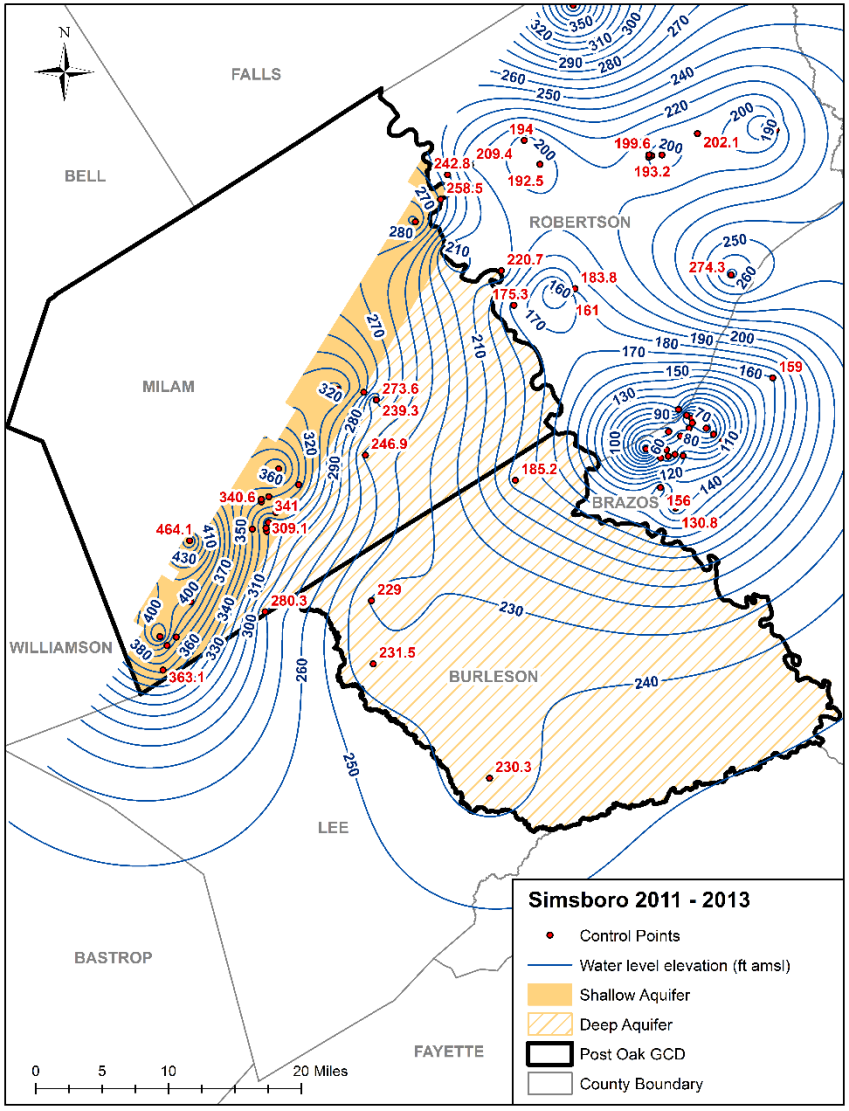
Interpolating Values Across Areas: Calvert Bluff (more wells in 2012 and than in 2000)





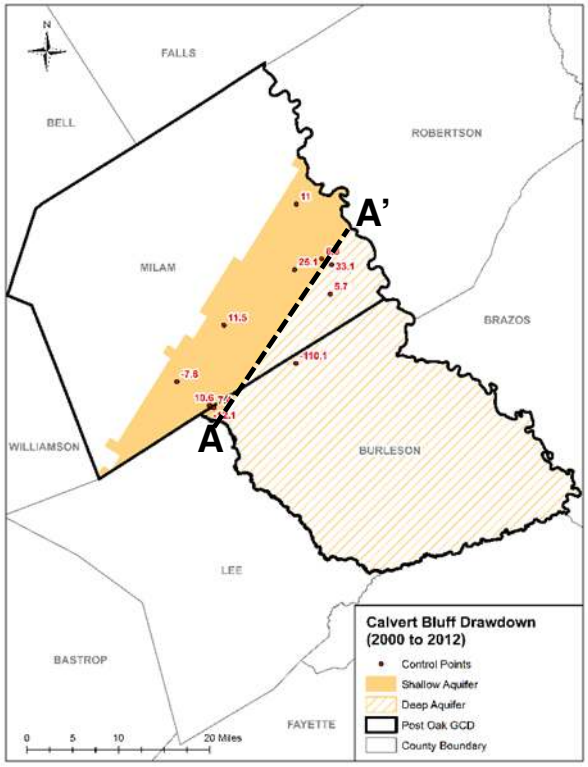
Discussion Topics: Well Assignments

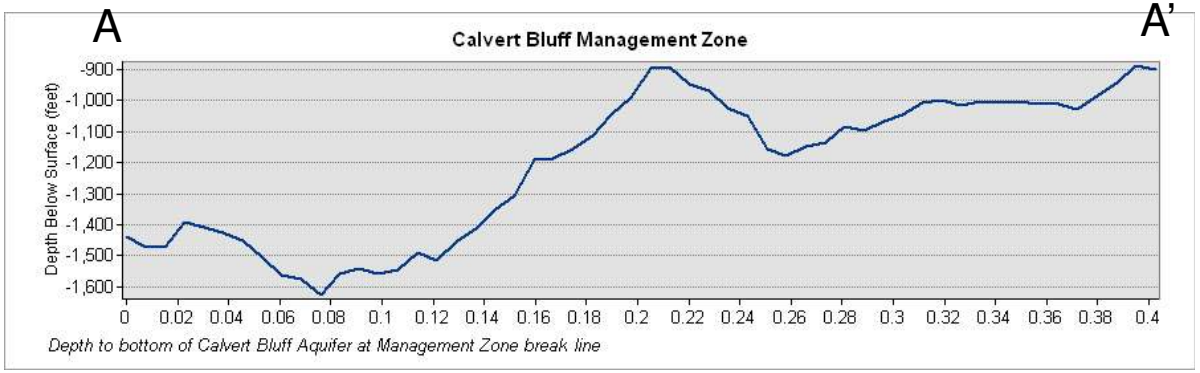
- Meeting with TWDB to Agree to Wells Assignments
  - Considerations beside GAM Aquifer Surfaces
  - Criteria for Well Screens Across Multiple Aquifers
  - Policy or guidelines from TWDB
- Meeting with Other GMA 12 GCDs and TCEQ
  - Consistency of well assignments across GCDs in GMA 12
  - Policy or guidelines from TCEQ

Discussion Topics: Monitoring Locations

- No Coverage
  - Milam Brazos River Alluvium
  - Shallow Yegua Jackson
- Sparse Coverage
  - Shallow Carrizo (1 well)
  - Entire Carrizo (4 wells)
  - Shallow Sparta (1 wells)
- Additional Coverage
  - Down-dip or Deep Areas
  - Southwest of Bryan/College Station

Discussion Topics: Shallow Zone Delineation





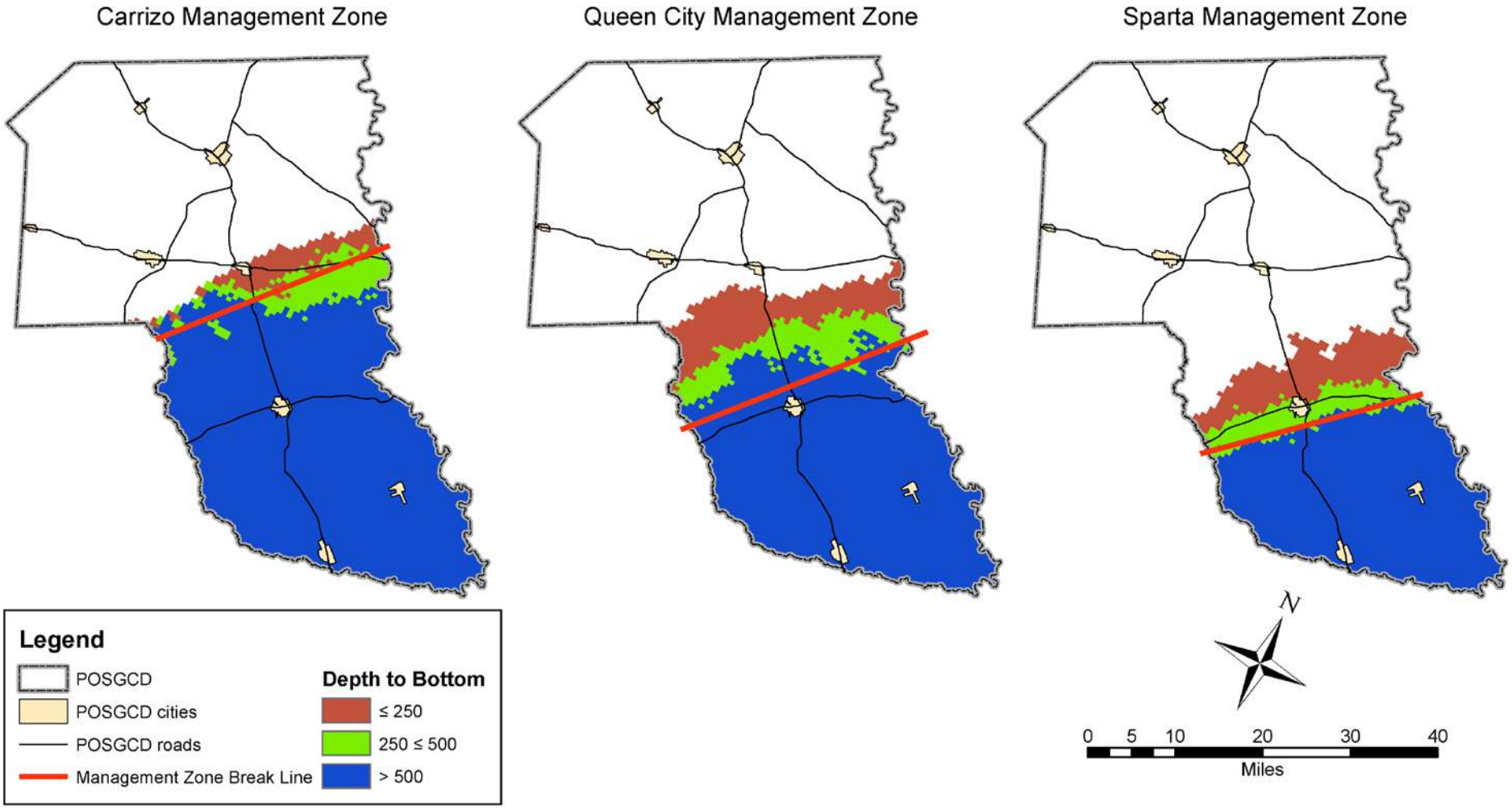
		Depth (ft) to Base of Aquifer					
		Sparta	Queen City	Carrizo	Calvert Bluff	Simsboro	Hooper
At Downdip Extent of Shallow Zone	Average	474	627	425	1221	735	747
	Median	467	658	351	1146	729	772
	Minimum	619	823	693	1639	1174	1185
	Maximum	338	441	206	858	515	493
	Range	281	383	487	780	658	693
At Downdip Extent of Unconfined Zone	Average	294	450	295	972	532	507
	Median	291	468	272	959	535	510
	Minimum	463	688	682	1359	834	924
	Maximum	156	145	3	689	140	51
	Range	307	543	679	670	695	873

Discussion Topics: Shallow Zone Delineation

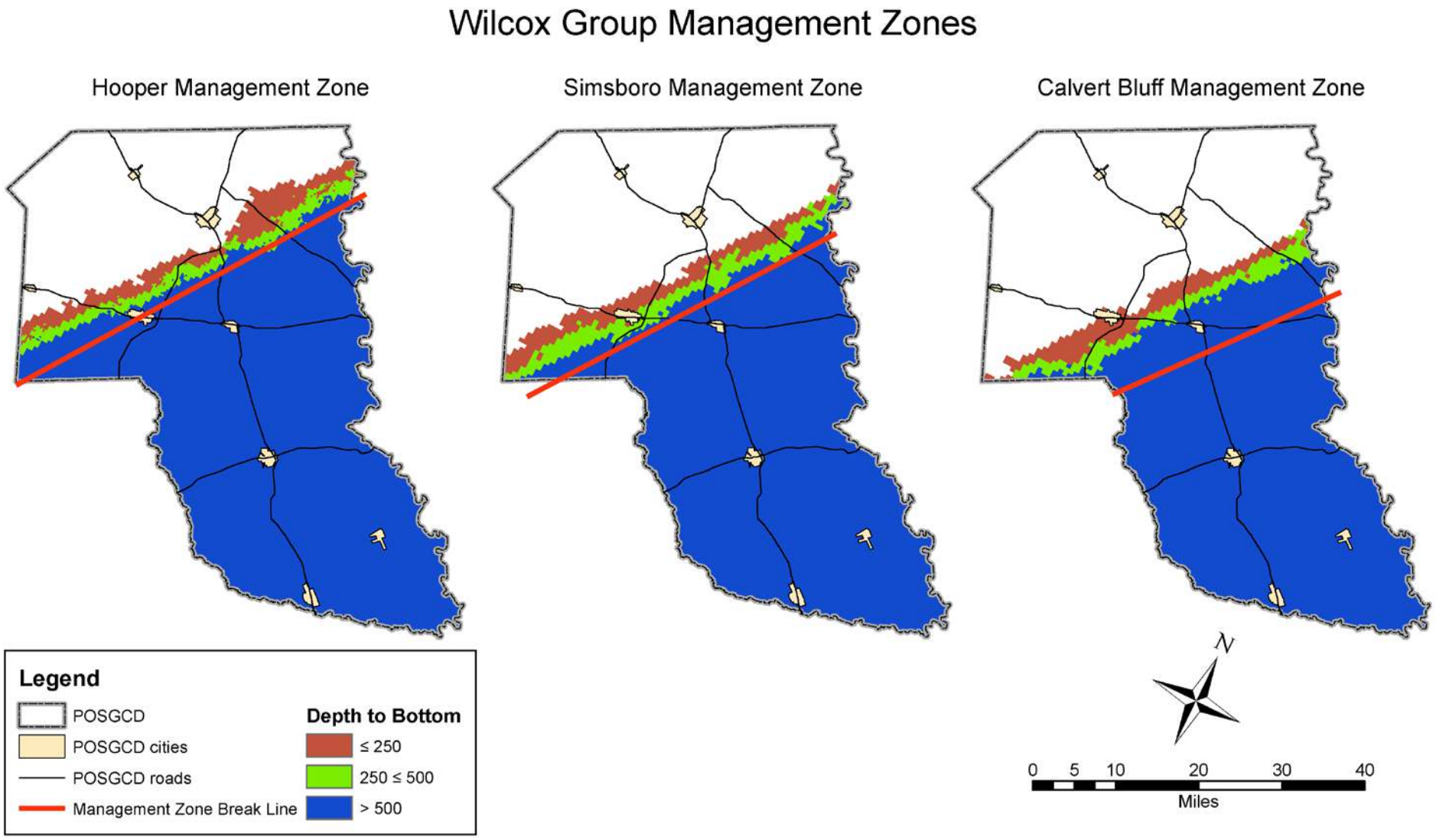
		Depth (ft) to Base of Aquifer					
		Sparta	Queen City	Carrizo	Calvert Bluff	Simsboro	Hooper
Across the Entire Shallow Zone	Average	207	338	277	597	372	377
	Median	174	329	240	570	352	343
Across the Entire Unconfined Zone	Average	131	268	208	453	266	254
	Median	106	215	165	440	251	225

- Shallow Zone Considerations: Aquifer
  - Consistency of Depth Among Different Aquifers
  - Ratio of Drawdown to Well Depth (Available Water Column)
- Shallow Zone Consideration: Wells
  - Depth of Wells
  - Number of Wells

Discussion Topics: Shallow Zone Delineation



Discussion Topics: Shallow Zone Delineation



Discussion Topics: Analysis Methods

- Interim Results
  - Multiple analysis methods are recommended
  - Use of Adjacent GCD data is recommended
  - Advantages and Disadvantages to all analysis methods
- Sources of Uncertainty/Error
  - Localized impacts of pumping are ignored with current methods
  - Partially penetrating wells (do not intersect the full aquifer)
  - Shallow Sparta (1 wells)
- Possible improvements
  - Zones for points guided from model results and pumping distributions
  - “Smart” contouring programs that accounts for groundwater flow and pumping

ATTACHMENT B:
POSGCD DESIRED FUTURE COMMITTEE'S MEETING
JANUARY 12, 2016

POSGCD Desired Future Committee's Meeting

January 12, 2016

POSGCD Offices
Milano, Texas

Presented by:
:
Steven Young
Jevon Harding

Discussion Items

- GMA 12 DFCs
  - Results from Pumping Scenario 5 (PS5)
  - 2010 Joint Planning Values for 2060
  - Consideration for DFCs
- Shallow Zone Evaluation
  - Location of Exempt and Permitted Wells
  - Height of Water Column
  - Options for Reconfiguring shallow zone
- Recommendations for DFC
  - Entire Aquifer
  - Shallow Zone

DFCs from 2010 Joint Planning Compared to DFCs from PS5

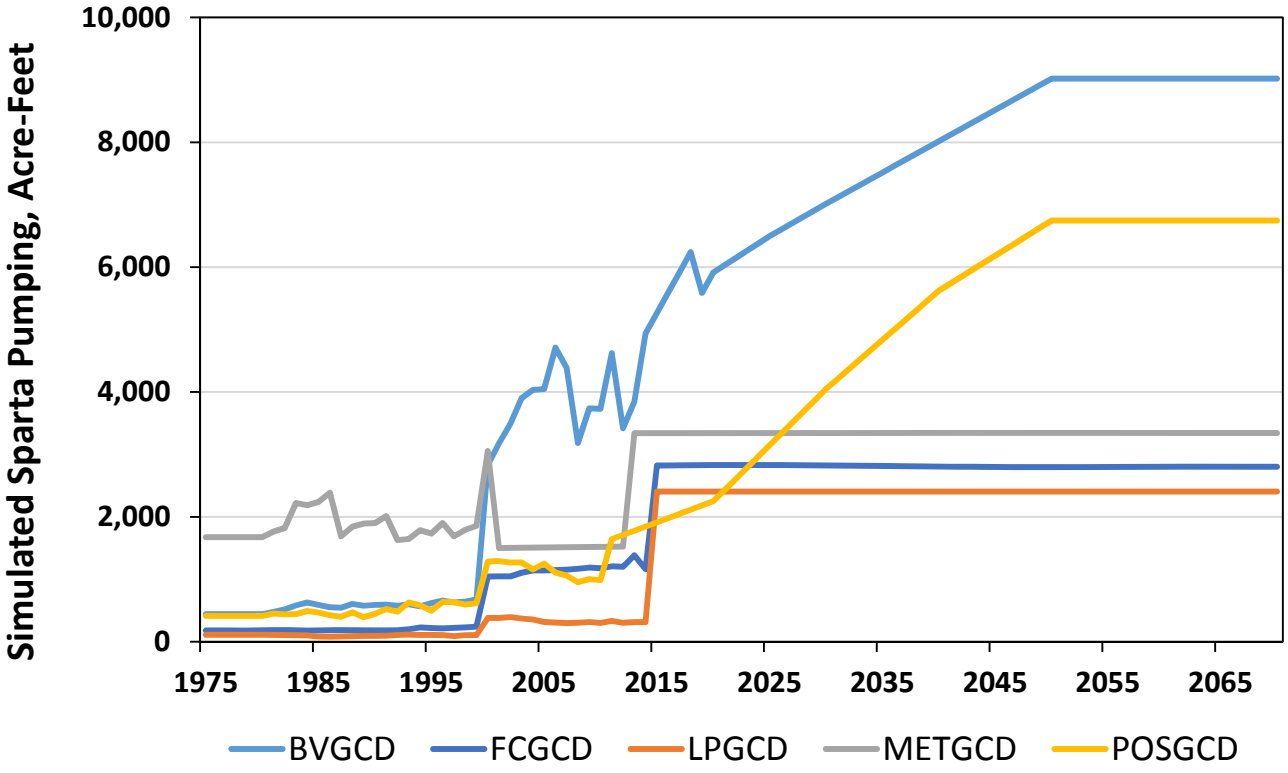
PS5 DFCs for 2070

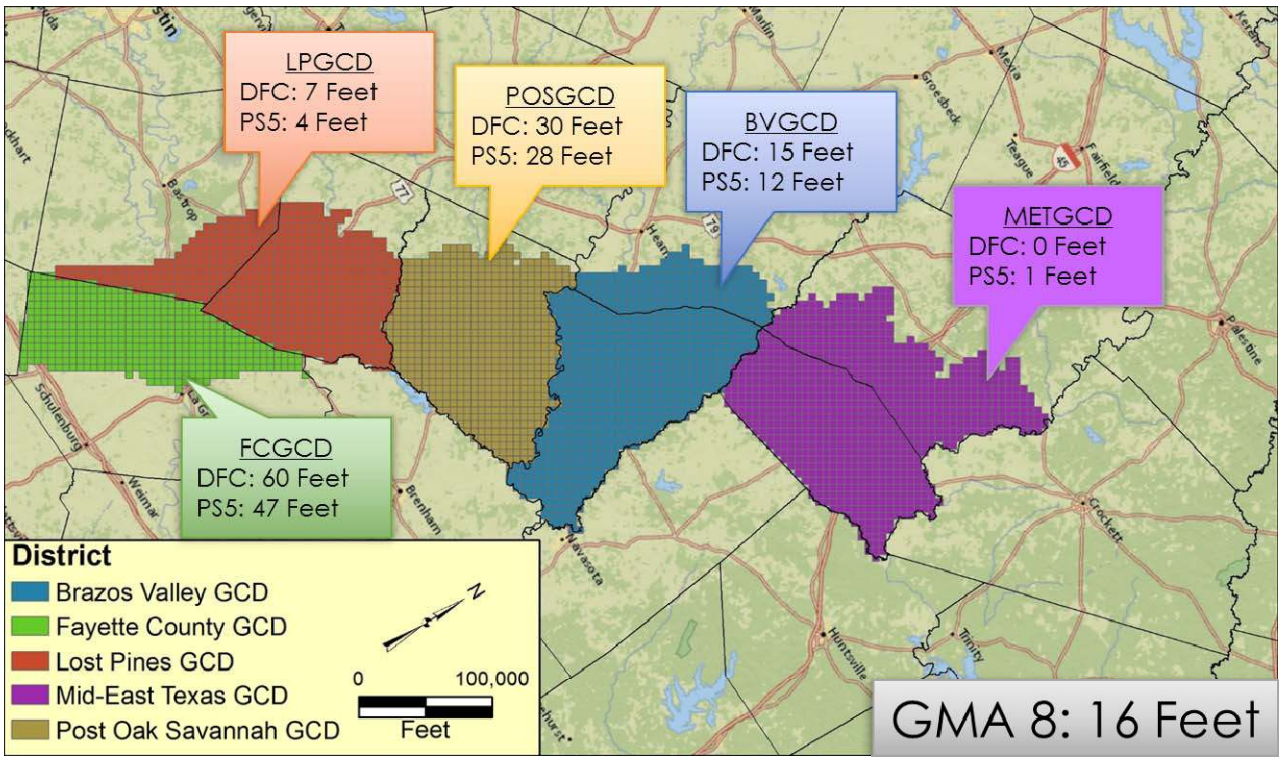
District	Sparta	Queen City	Carrizo	Calvert Bluff	Simsboro	Hooper	Total
Brazos Valley	9,019	1,200	5,494	1,758	96,187	2,001	115,659
Fayette County	2,802	2,708	5,474	—	—	—	10,984
Lost Pines	2,405	1,315	12,052	3,984	37,249	2,592	59,597
Mid-East Texas	3,343	974	11,091	3,917	7,181	835	27,341
Post Oak Savannah	6,747	504	7,063	1,037	48,503	4,480	68,334
GMA 12 GCDs	24,317	6,701	41,173	10,696	189,119	9,908	281,914

2010 Joint Planning DFCs for 2060

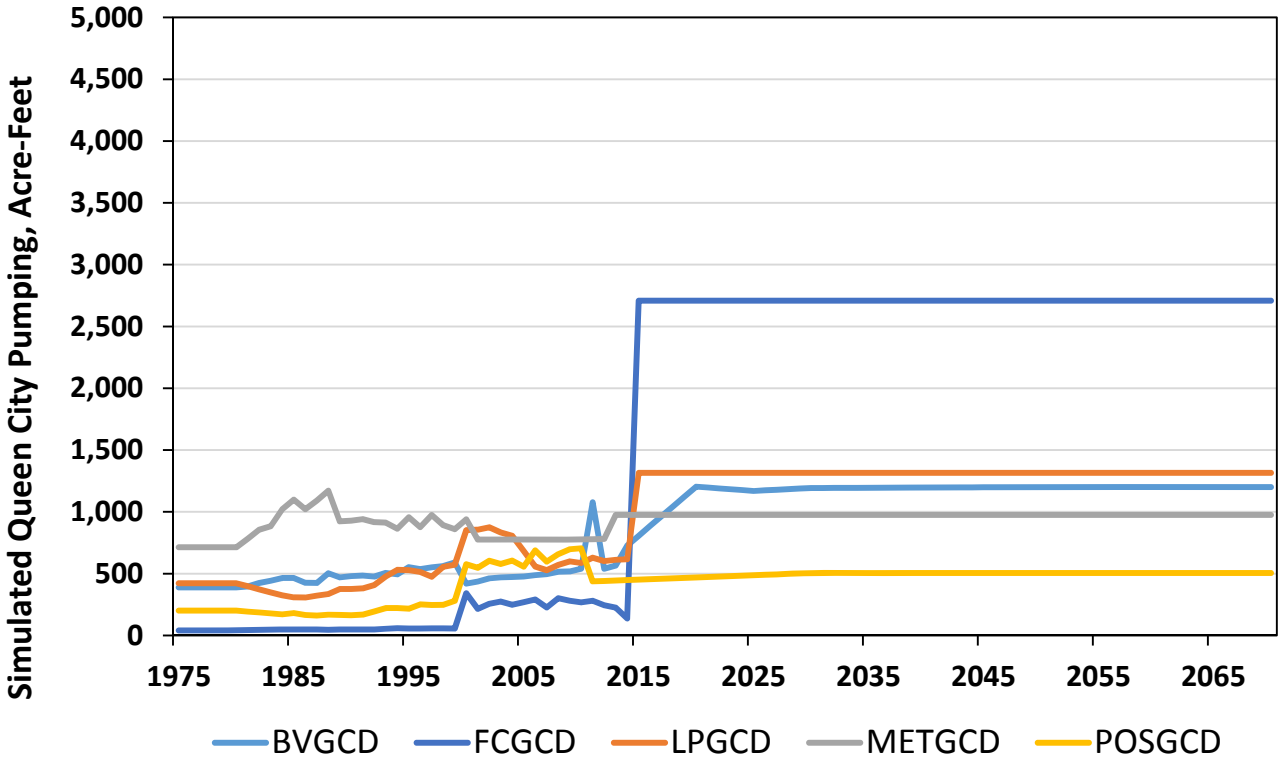
District	Brazos River Alluvium	Sparta	Queen City	Carrizo	Calvert Bluff	Simsboro	Hooper	Yegua-Jackson	Total
Brazos Valley	-	7,923	529	5,496	1,755	96,185	316	7,071	119,275
Fayette County	-	3,729	570	1,000	-	-	-	5,762	11,061
Lost Pines	-	1,877	1,133	12,052	3,985	37,249	2,592	-	58,888
Mid-East Texas	-	3,334	974	11,088	3,912	7,170	827	1,122	28,427
Post Oak Savannah	25,138	6,734	502	7,059	1,038	48,501	4,422	12,923	106,377
GMA 12 GCDs	-	23,597	3,688	36,695	10,690	189,105	8,157	26,878	323,968

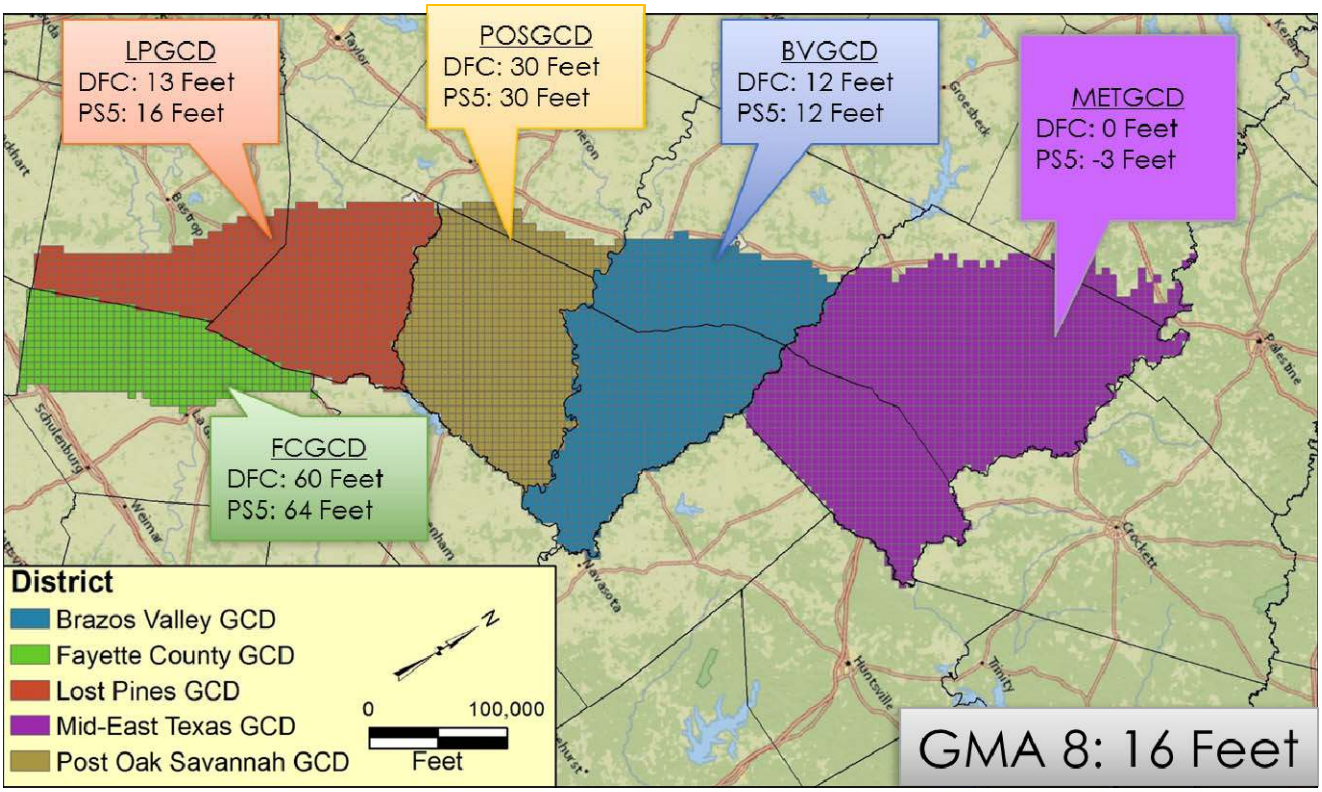
PS5 Predictions of Average Drawdown Sparta



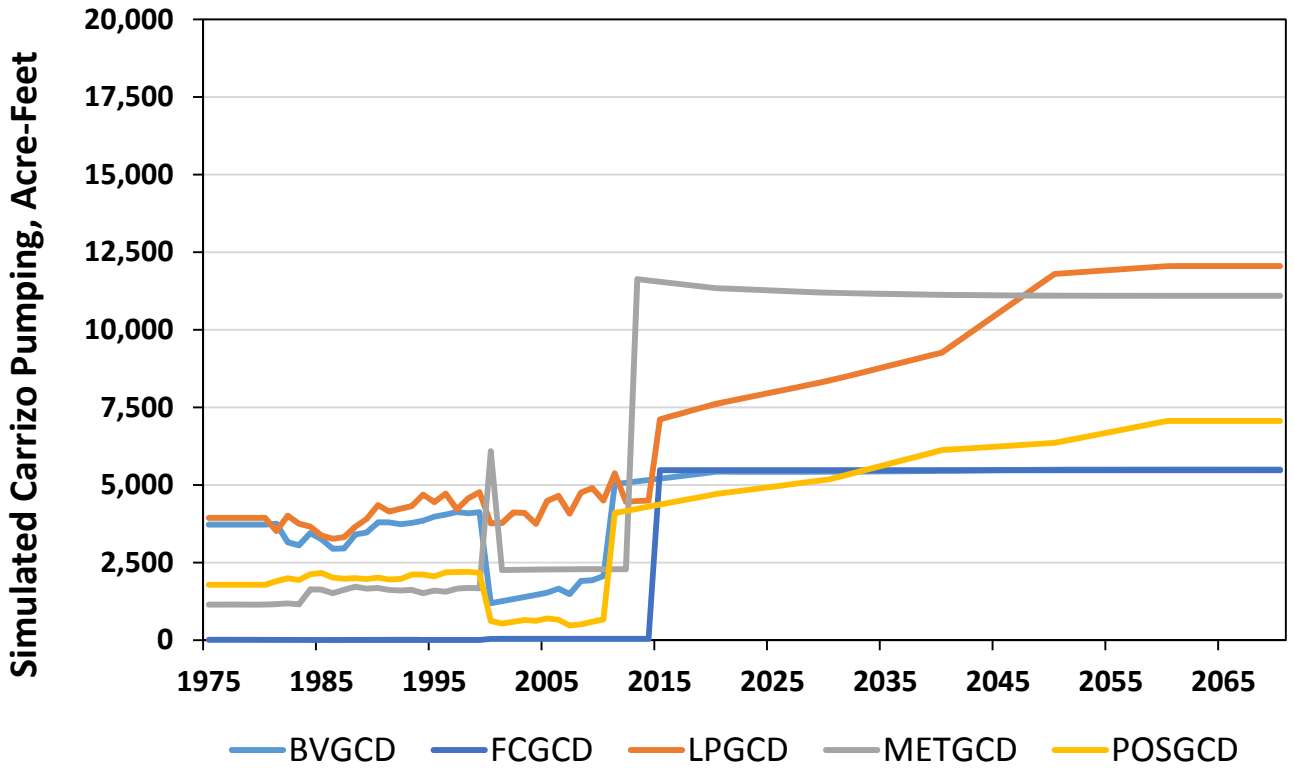


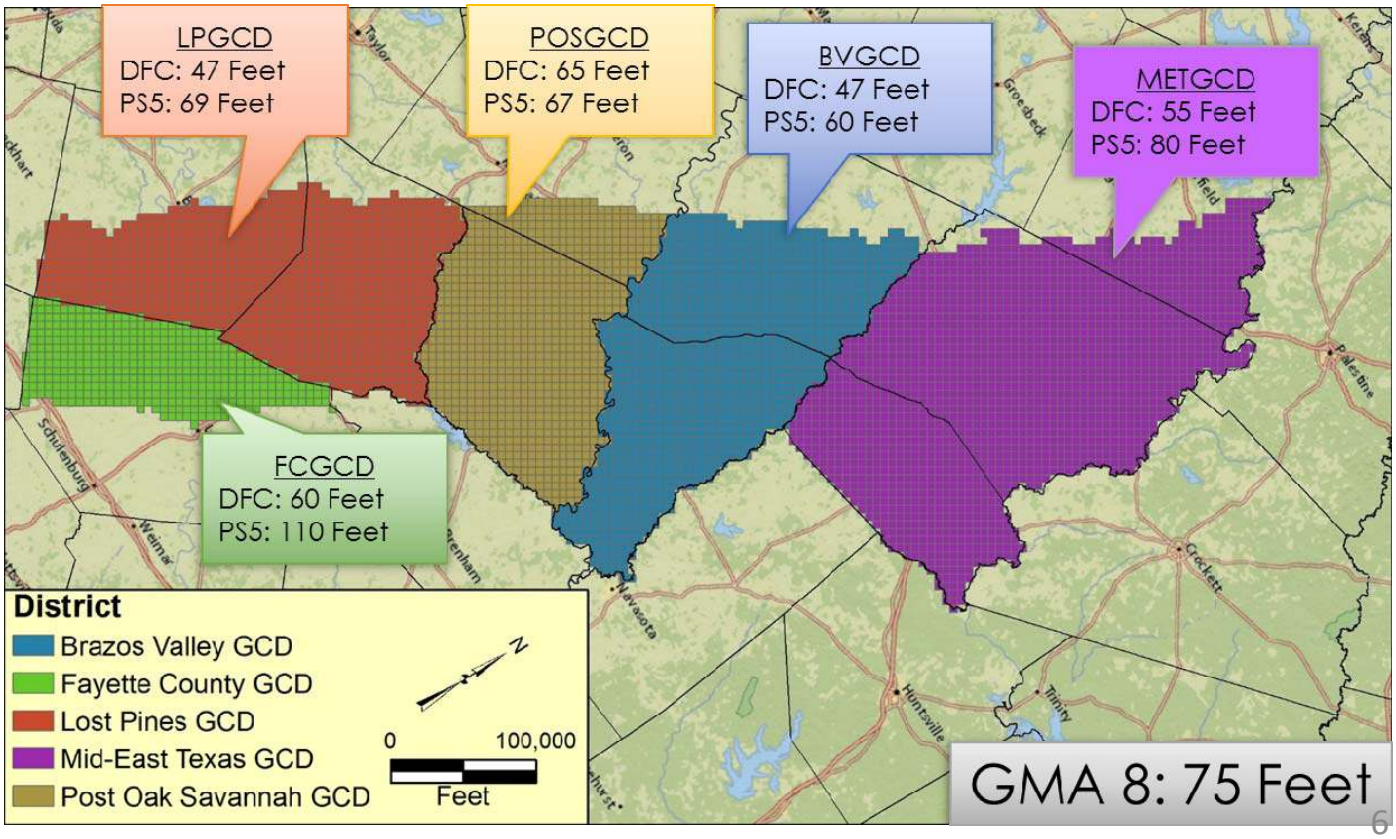
PS5 Predictions of Average Drawdown Queen City



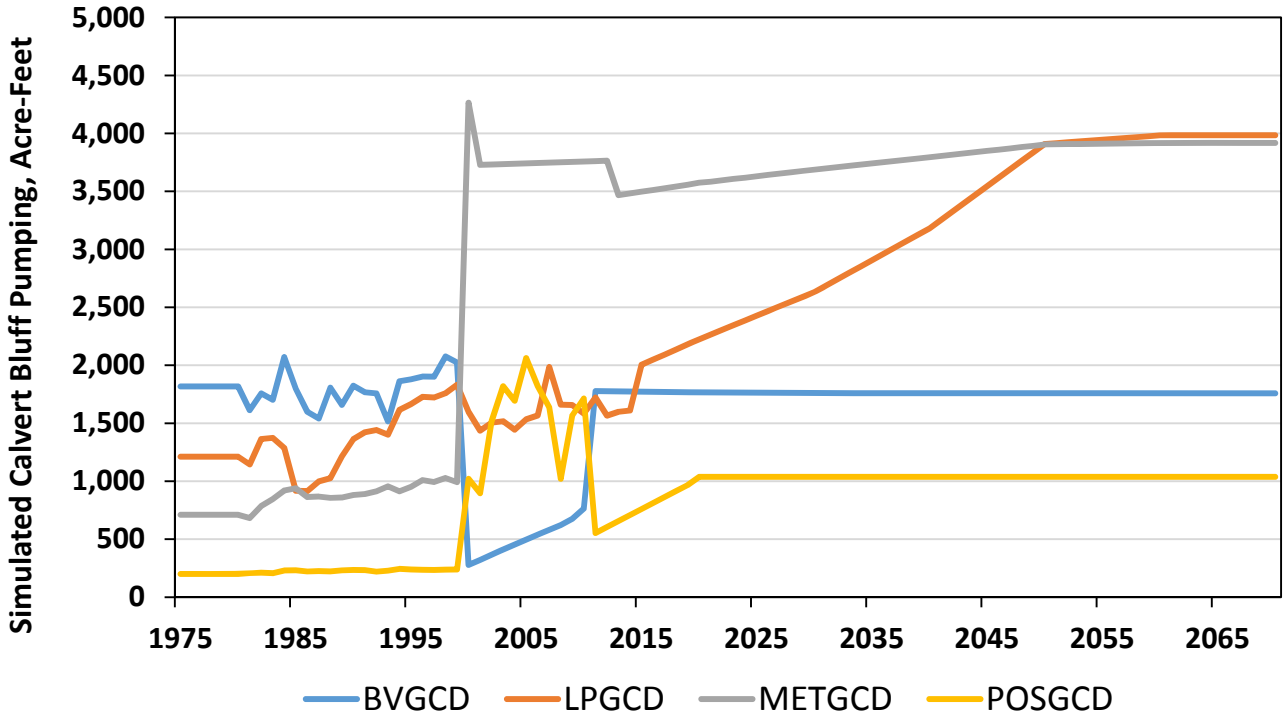


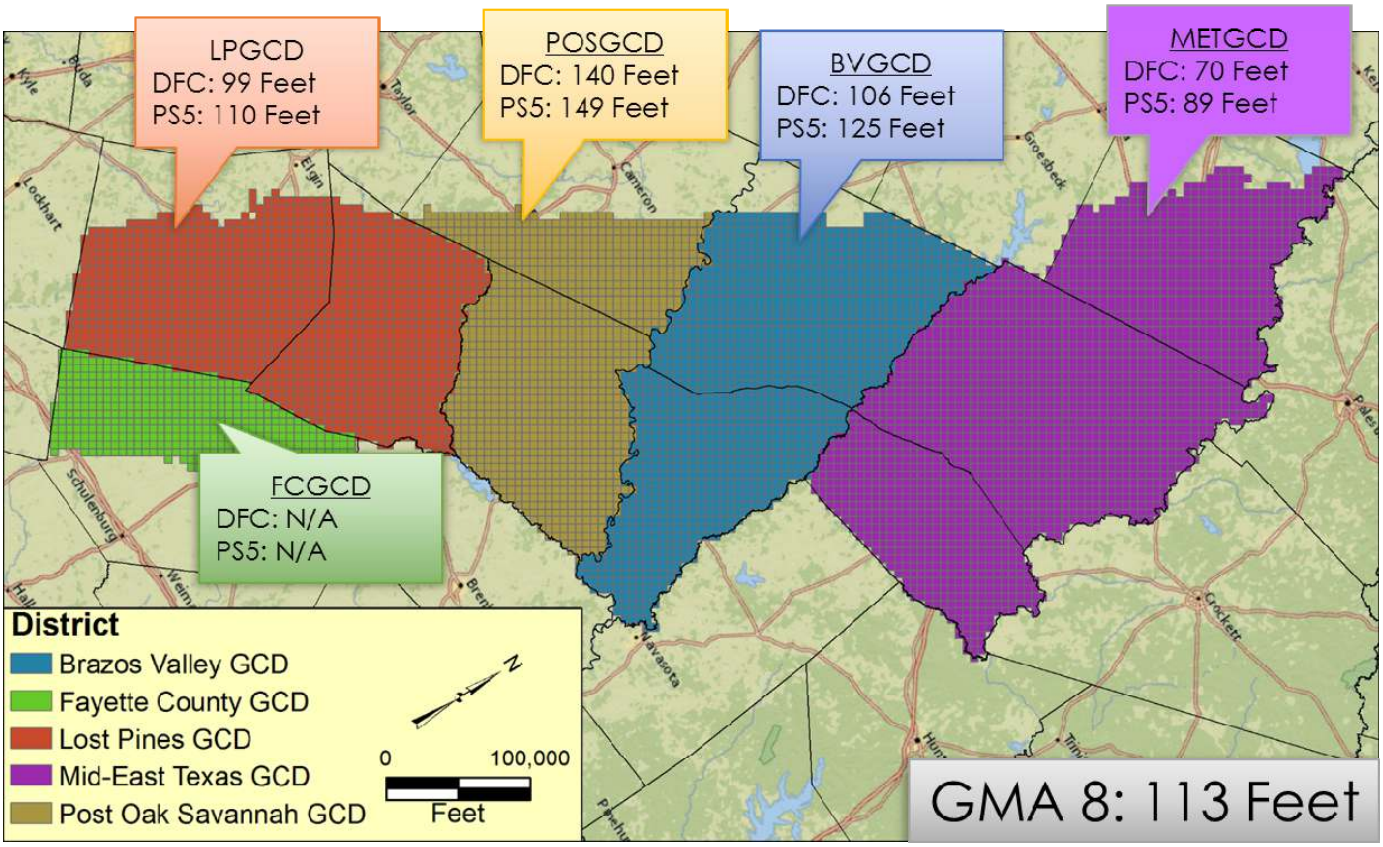
PS5 Predictions of Average Drawdown Carrizo



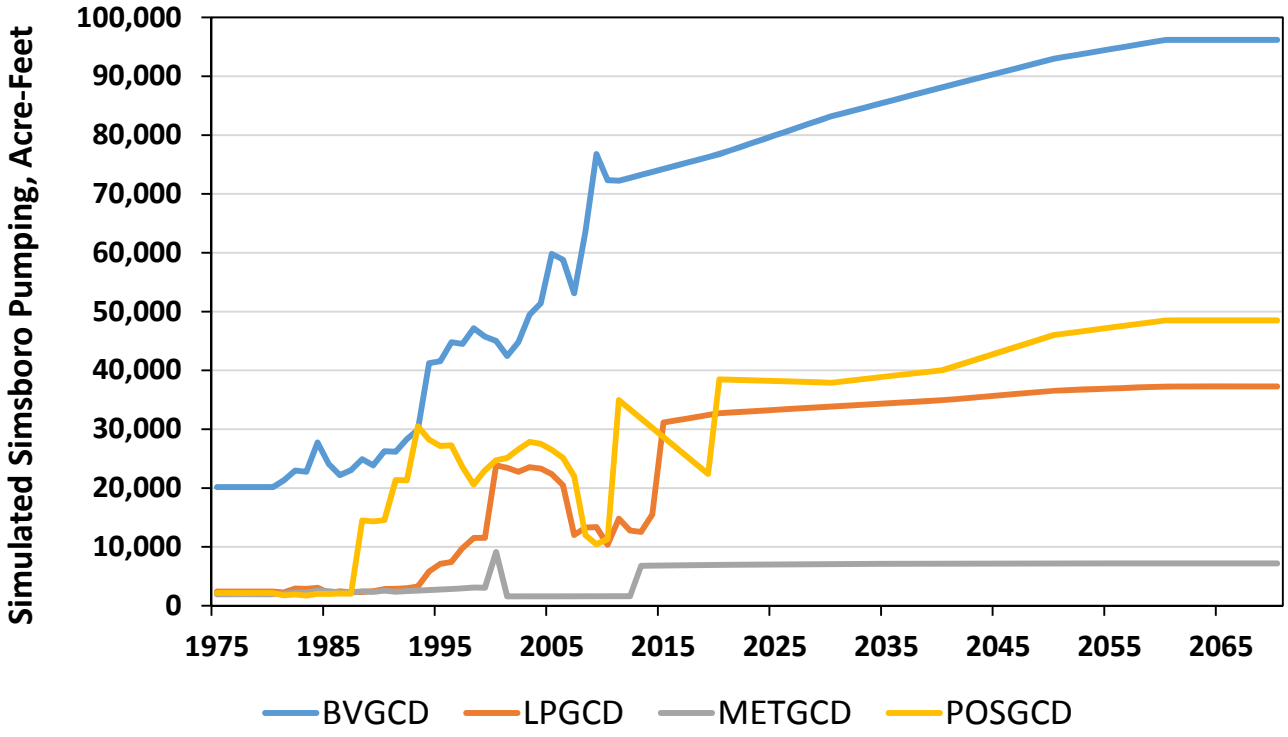


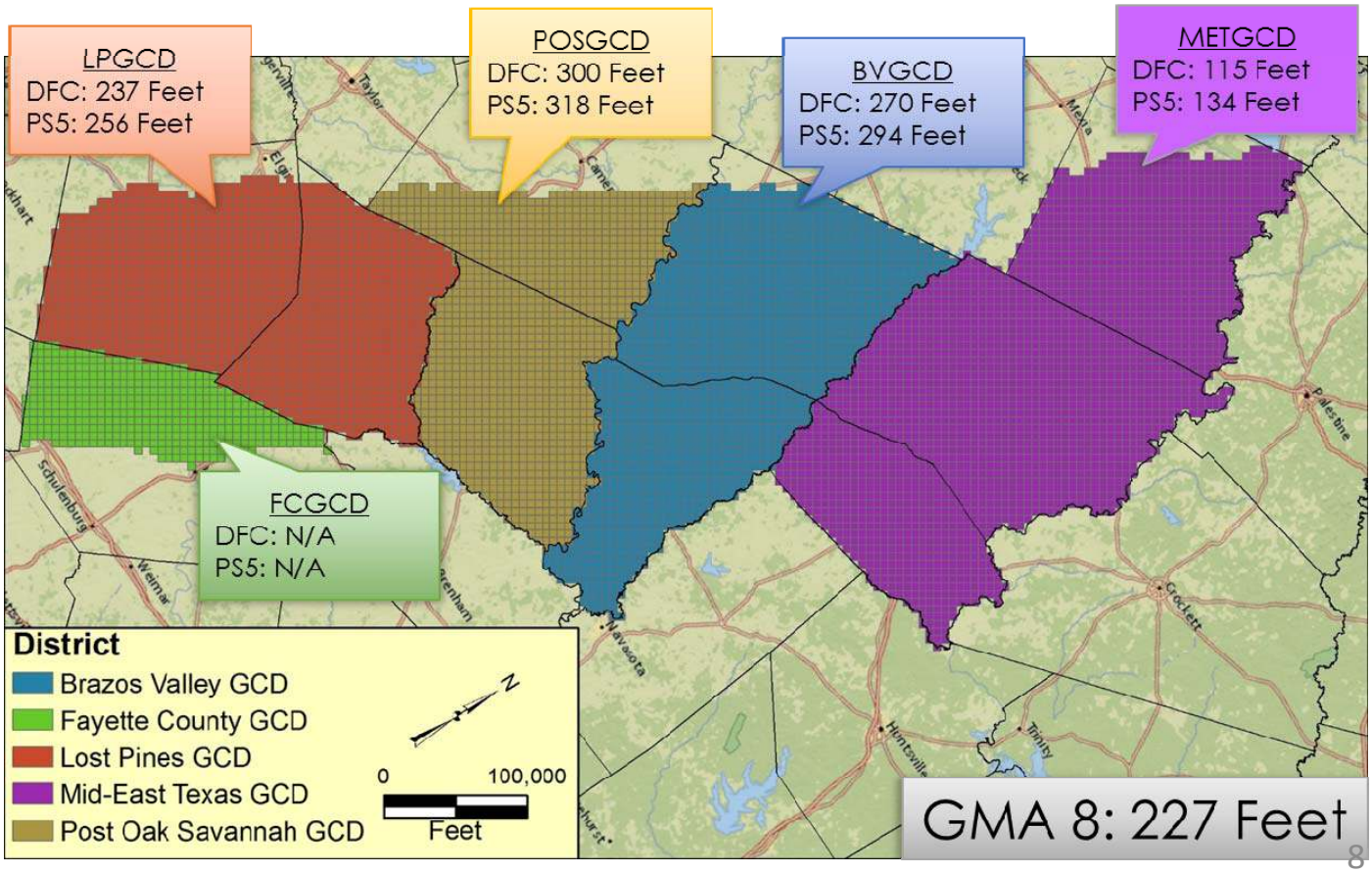
PS5 Predictions of Average Drawdown Calvert Bluff



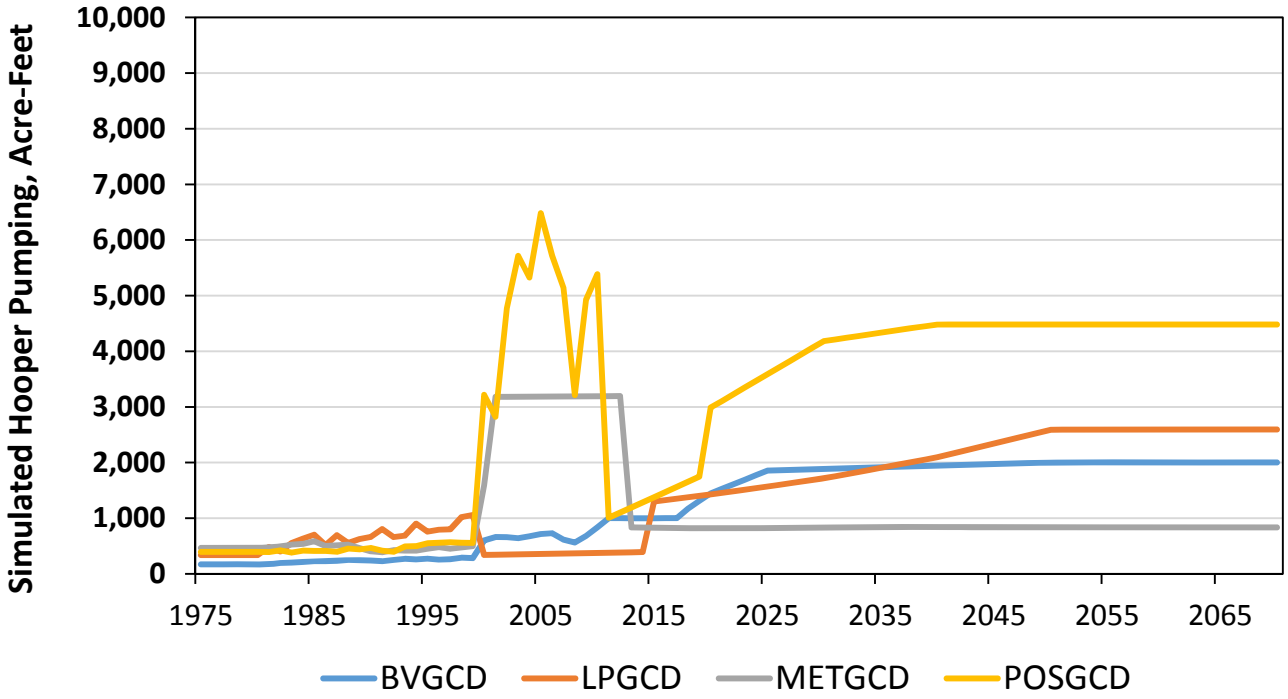


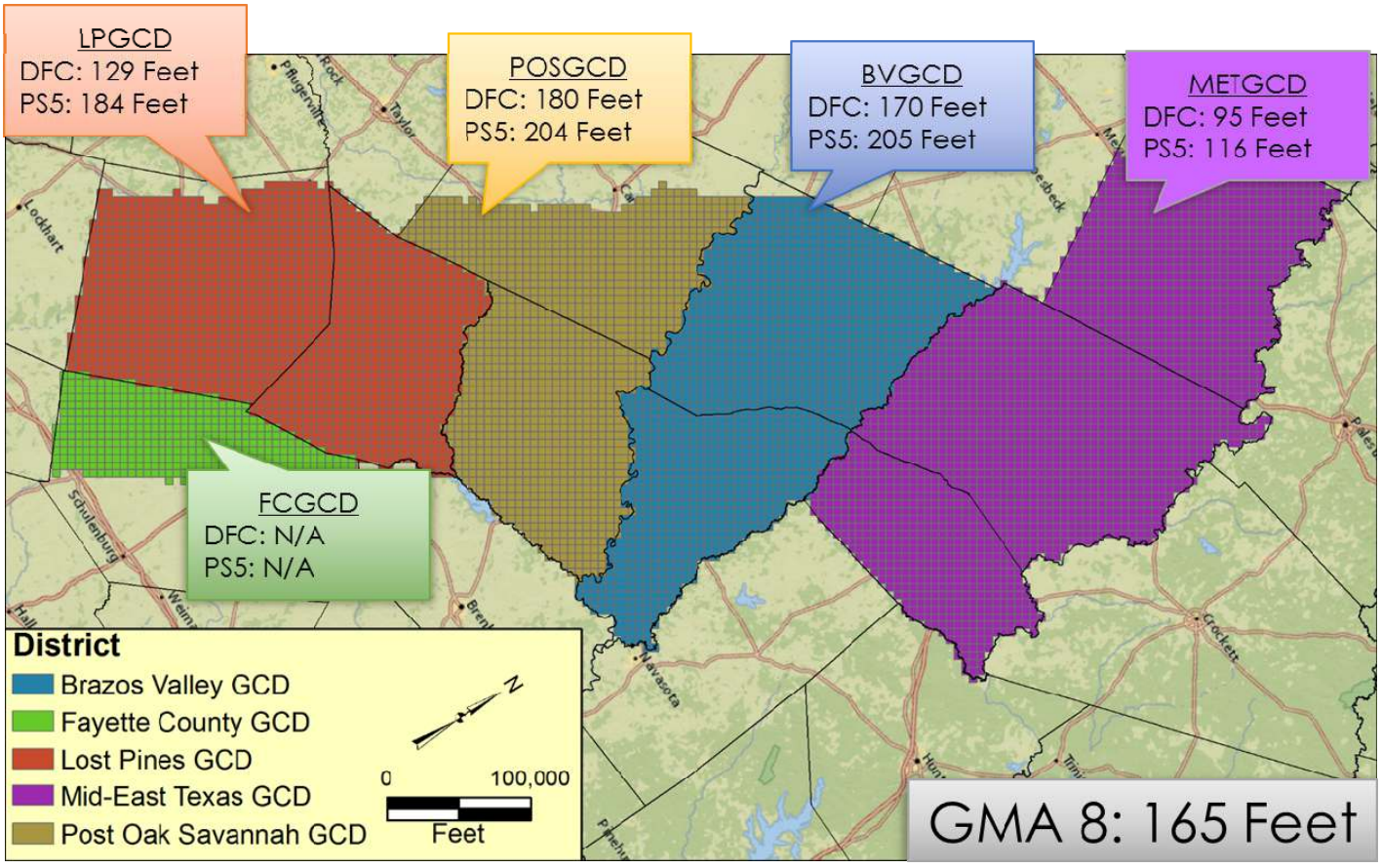
PS5 Predictions of Average Drawdown Simsboro



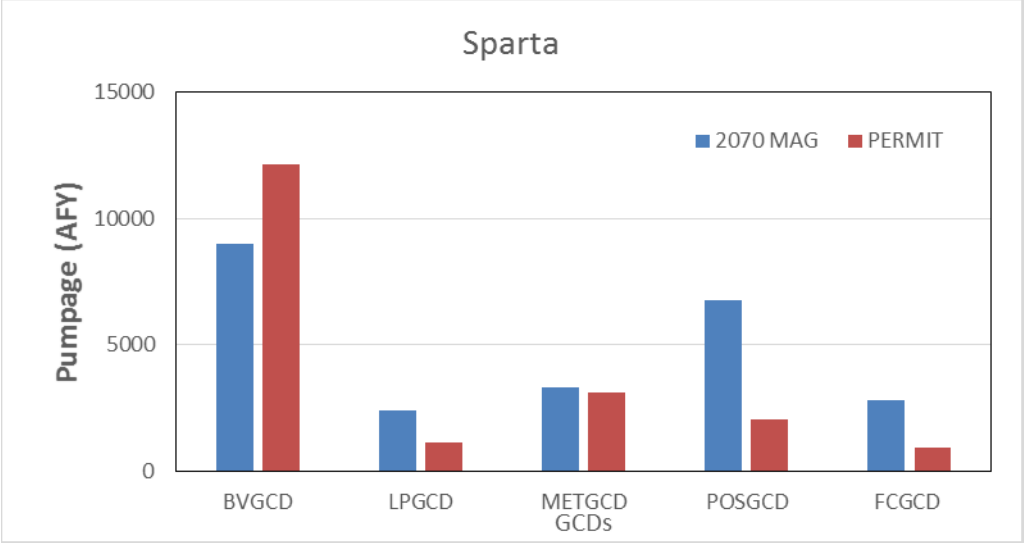


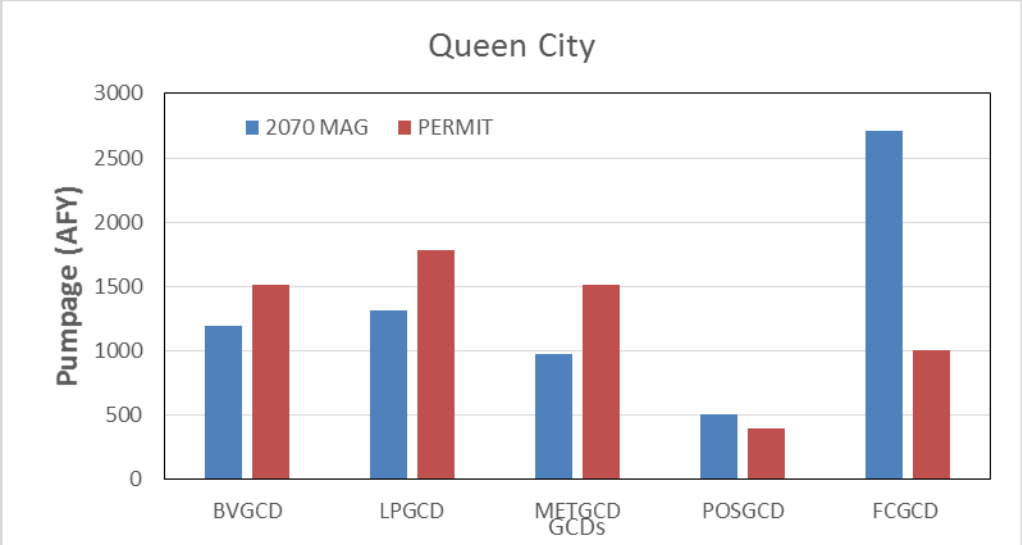
PS5 Predictions of Average Drawdown Hooper

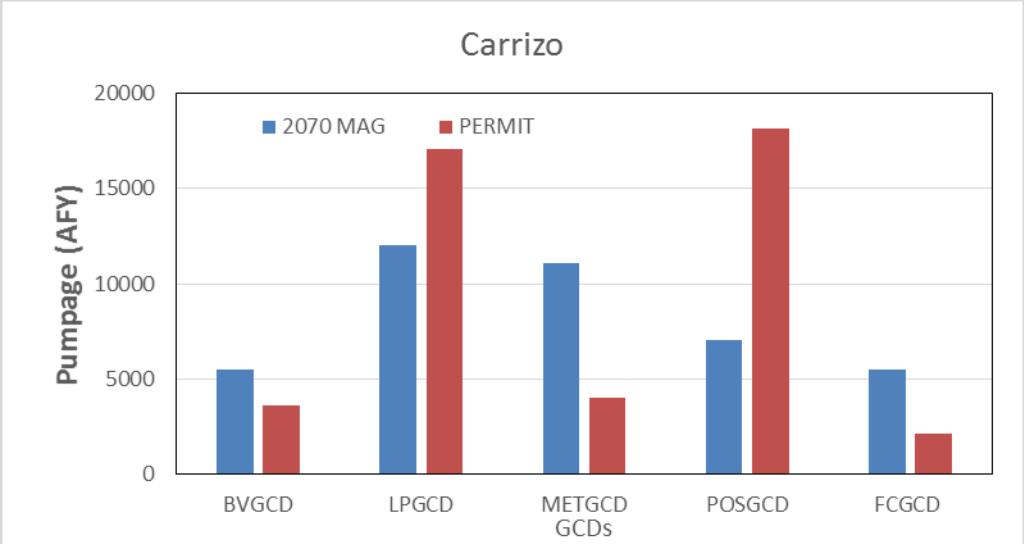




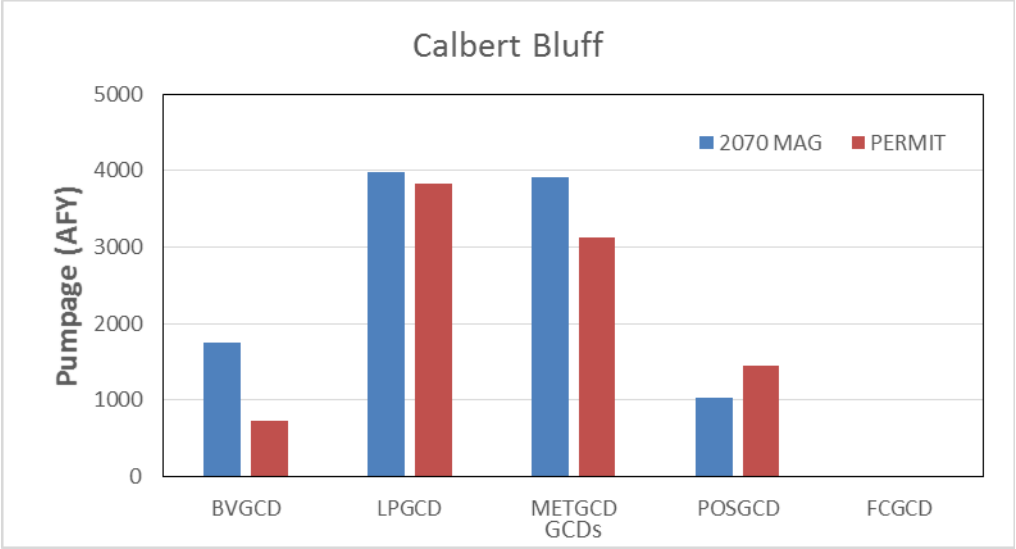
DFCs from 2010 Joint Planning Compared GCD Permits

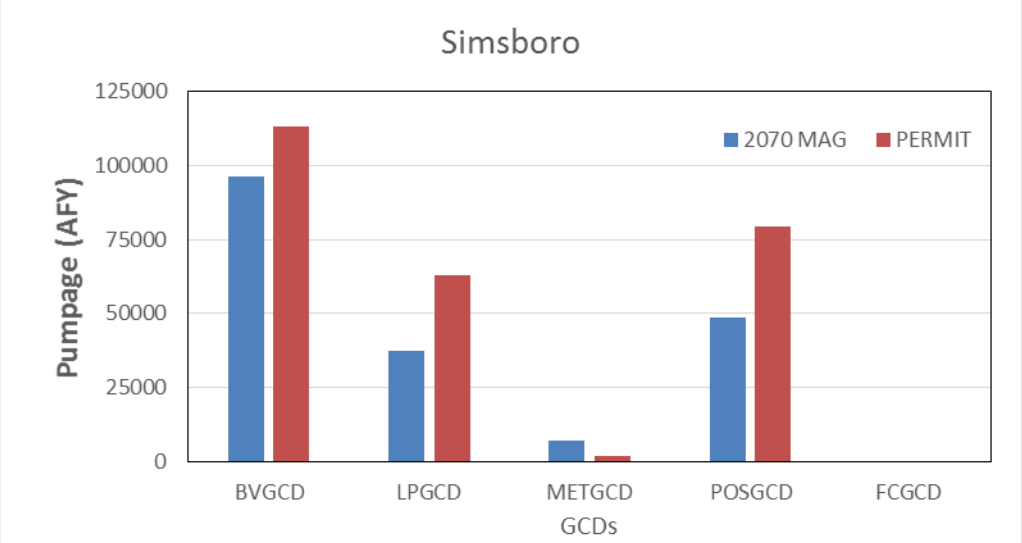


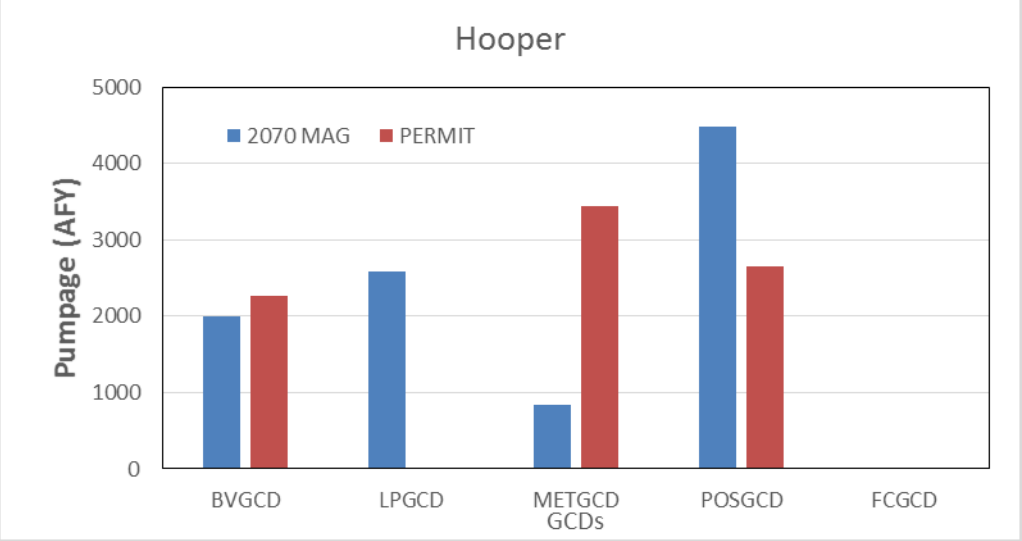




DFCs from 2010 Joint Planning Compared GCD Permits







POSGCD Current Pumping

PS5 DFCs for 2070

District	Sparta	Queen City	Carrizo	Calvert Bluff	Simsboro	Hooper	Total
Brazos Valley	9,019	1,200	5,494	1,758	96,187	2,001	115,659
Fayette County	2,802	2,706	5,474	–	–	–	10,984
Lost Pines	2,405	1,315	12,052	3,984	37,249	2,592	59,597
Mid-East Texas	3,343	974	11,091	3,917	7,161	835	27,341
Post Oak Savannah	6,747	504	7,063	1,037	48,503	4,480	68,334
GMA 12 GCDs	24,317	6,701	41,173	10,696	189,119	9,908	281,914

POSGCD Current Pumping

Aquifer	2008		2009		2010		2011		2012		2013		2014		5-yr Avg (ac-ft)
	Count	Sum	Count	Sum	Count	Sum	Count	Sum	Count	Sum	Count	Sum	Count	Sum	
Brazos River Alluvium	192	14,256	172	10,507	241	18,708	277	24,448	257	15,850	226	19,240	217	15,063	18,661.8
Carrizo	30	848	29	446	34	1,052	39	1,773	39	1,329	32	433	14	1,307	1,178.8
Simsboro	44	3,614	108	11,165	109	10,954	56	17,355	113	12,545	117	14,307	86	15,668	14,165.8
Calvert-Bluff	5	201	6	222	7	186	6	256	7	158	11	585	8	151	267.2
No Assignment	19	428	24	764	40	808	43	1,822	39	1,003	28	735	28	601	993.8
Queen City	5	164	5	194	9	205	7	225	7	186	7	193	8	192	200.2
Sparta	9	243	8	334	17	563	20	678	18	754	16	751	16	564	662.0
Hooper	11	521	14	590	17	648	17	912	20	624	16	843	18	389	683.2
Yegua - Jackson	17	425	14	337	25	451	30	1,066	29	645	22	399	14	177	547.6

Aquifer	No. Permits	Permitted[1] (ac-ft)	% Permitted	% Produced† (5-yr avg.)	Modeled Available Groundwater (MAG) (ac-ft)	% Produced‡ (5-yr avg.)
Brazos River Alluvium	331	46,279.19	25.95%	40%	25,138	74%
Carrizo	42	18,521.85	10.39%	6%	7,059	17%
Simsboro	122	103,517.35	58.05%	14%	48,501	29%
Calvert-Bluff	9	1,034.98	0.58%	26%	1,038	26%
No Assignment	59	3,046.14	1.71%	33%	-	-
Queen City	10	320.37	0.18%	62%	502	40%
Sparta	27	1,800.70	1.01%	37%	6,734	10%
Hooper	21	2,624.91	1.47%	26%	4,422	15%
Yegua - Jackson	29	1,181.61	0.66%	46%	12,923	4%

† Percentage of 5-year average produced as compared to total permitted.

‡ Percentage of 5-year average produced as compared to the MAG.

[1] *Per District Rules, as aquifer conditions and conditions of water use change, permitted amounts can be reduced or altered*

Note: As drawdown approaches Desired Future Conditions (DFCs), permitted amount will be reduced.

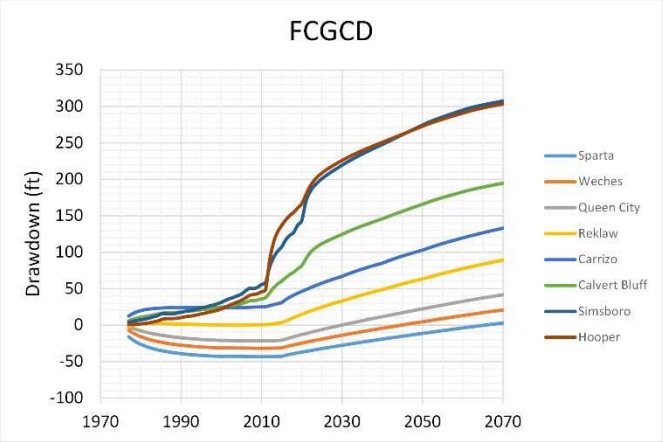
PS5 Predictions of Average Drawdown in POSGCD Shallow Zones

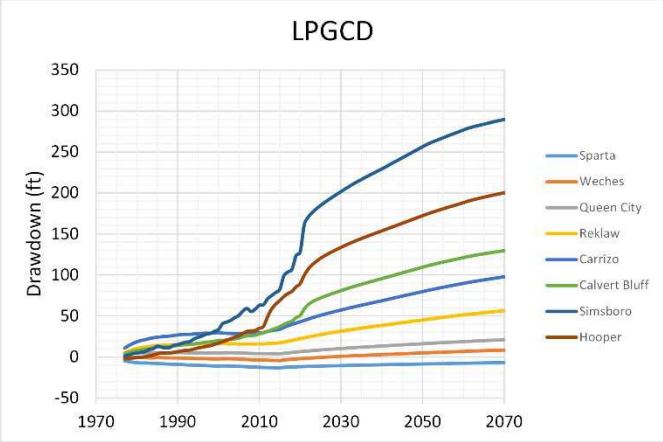
Zone	Aquifer	Area (sq miles)	1975 to 1980	1975 to 2000	1975 to 2070	2000 to 2070
Shallow	Carrizo	89	6	12	27	15
Shallow	Calvert Bluff	266	11	20	57	38
Shallow	Simsboro	193	8	48	141	93
Shallow	Hooper	192	4	10	70	60
Deep	Carrizo	745	18	36	108	72
Deep	Calvert Bluff	759	22	50	237	186
Deep	Simsboro	940	24	78	441	363
Deep	Hooper	1046	16	45	275	230
Entire	Carrizo	834	17	34	99	66
Entire	Calvert Bluff	1025	19	43	190	148
Entire	Simsboro	1133	21	73	390	317
Entire	Hooper	1238	14	40	243	203

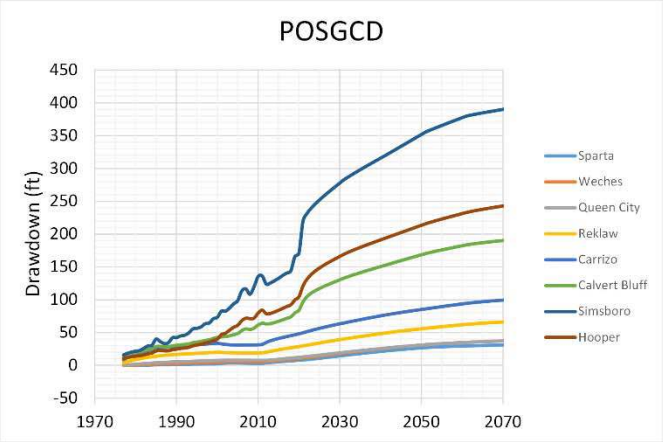
Discussion Items

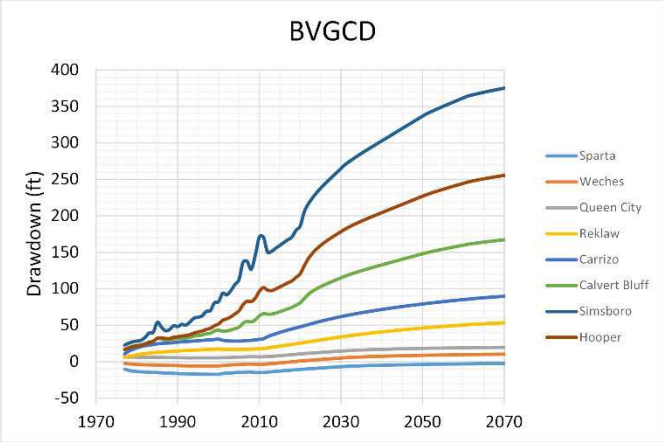
- Similare
  - Results from Pumping Scenario 5 (PS5)
  - 2010 Joint Planning Values for 2060
  - Consideration for DFCs
- Shallow Zone Evaluation
  - Location of Exempt and Permitted Wells
  - Height of Water Column
  - Options for Reconfiguring shallow zone
- Recommendations for DFC
  - Entire Aquifer
  - Shallow Zone

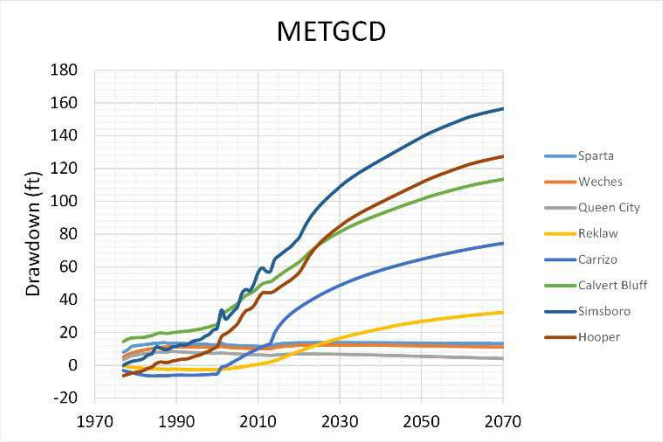
PS5 Predictions of Average Drawdown Since 1975 by GCDs



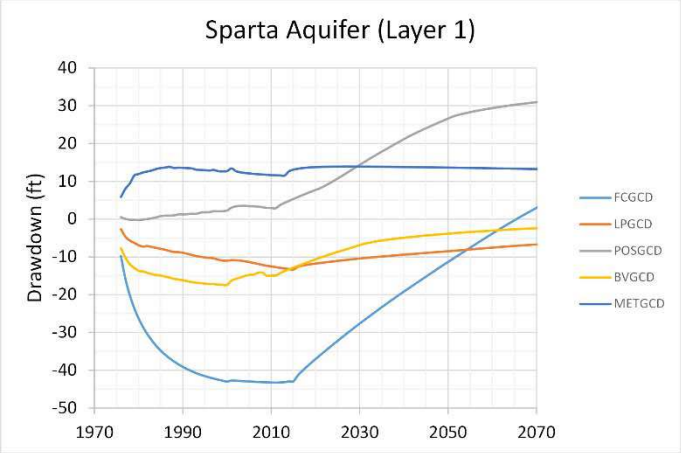


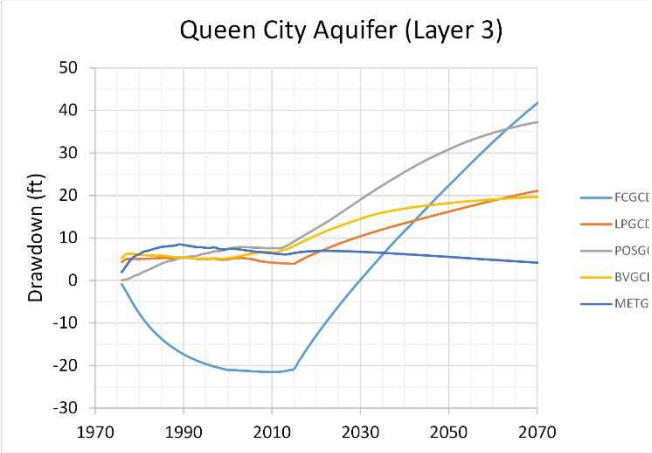


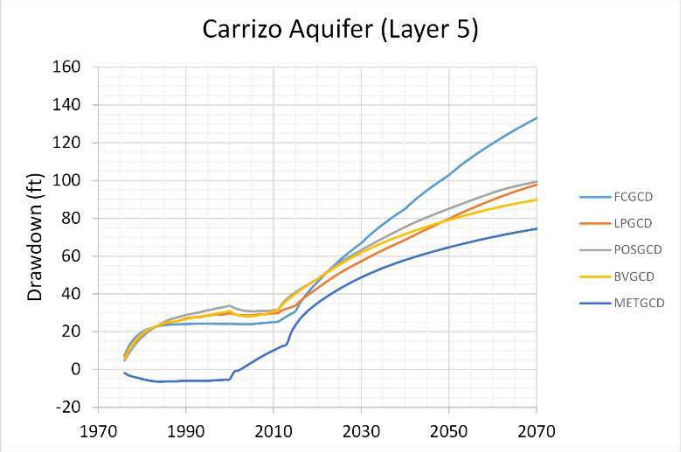


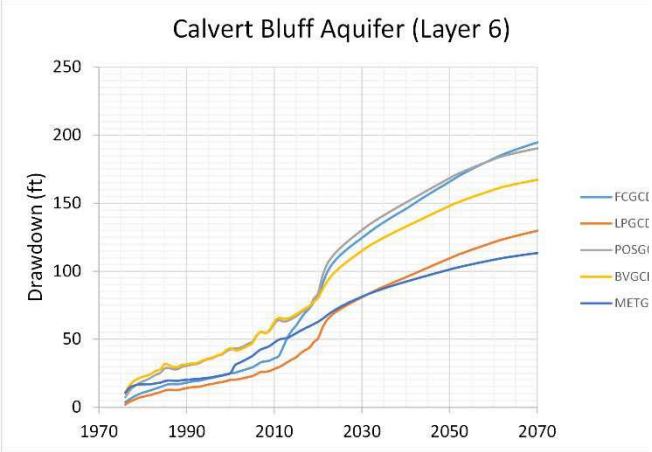


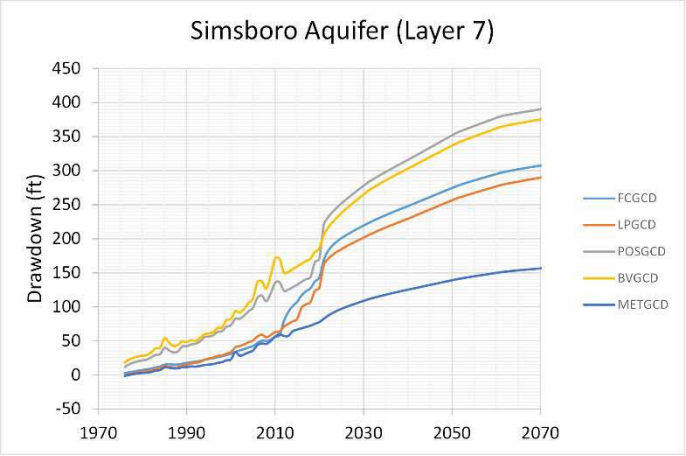
PS5 Predictions of Average Drawdown Since 1975 by Aquifer

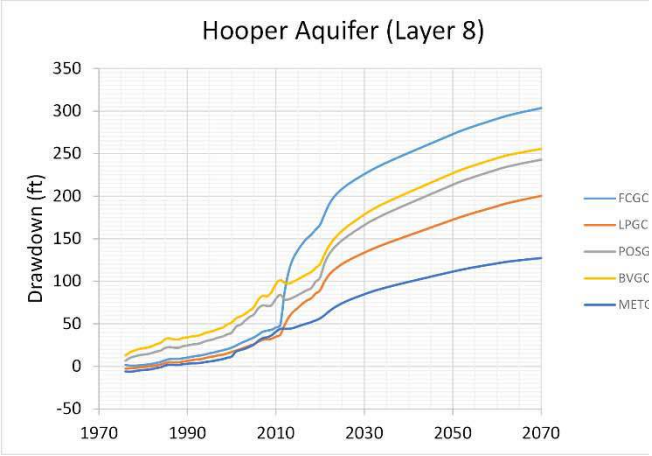




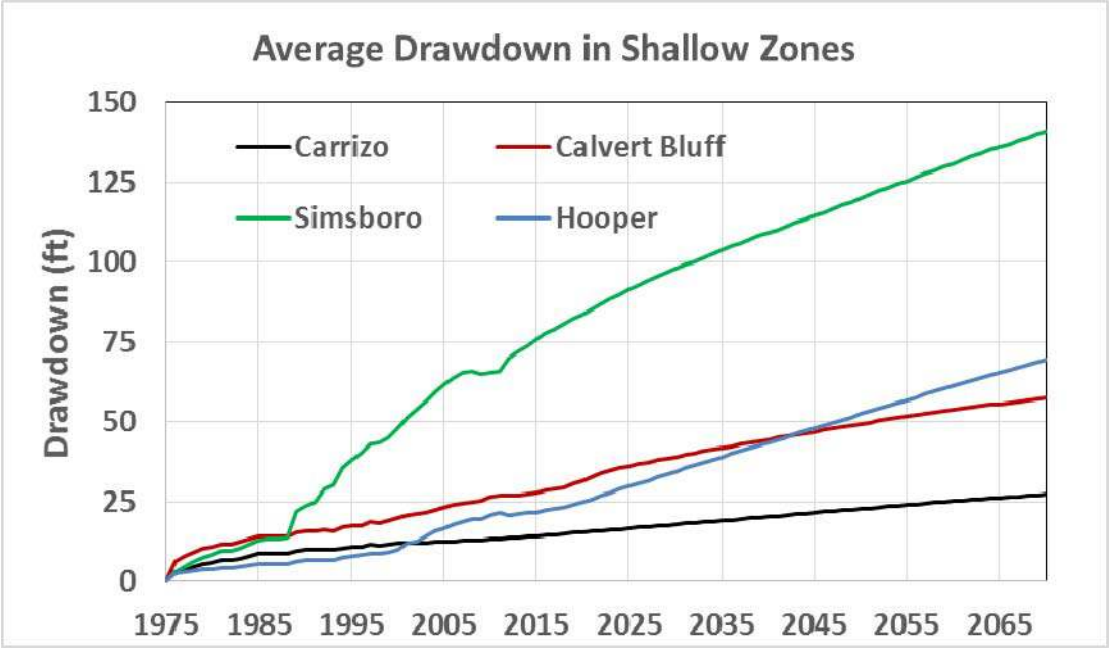


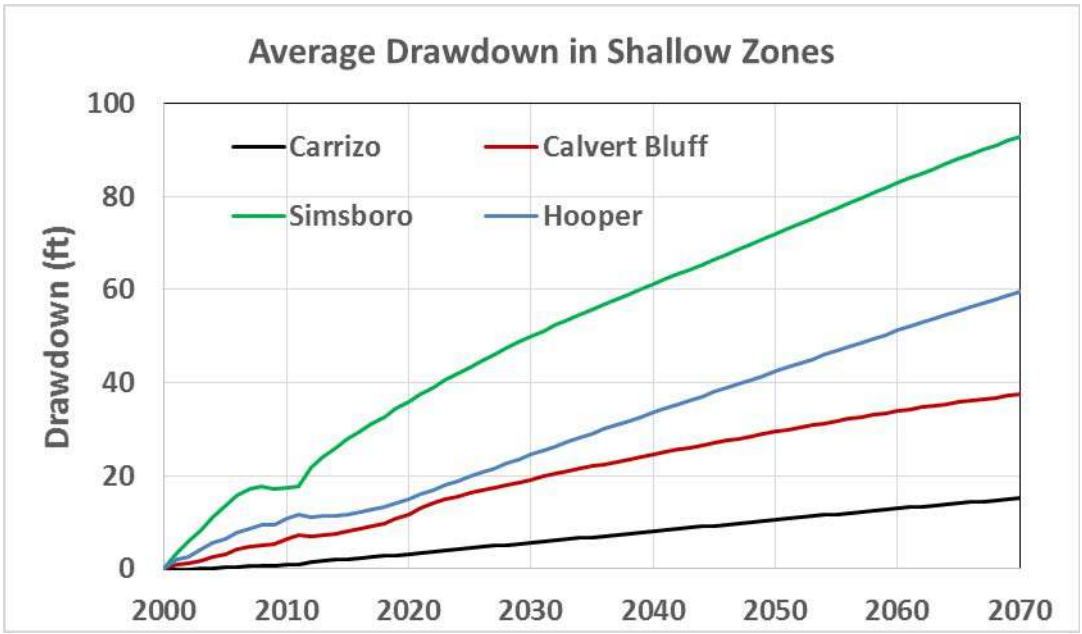






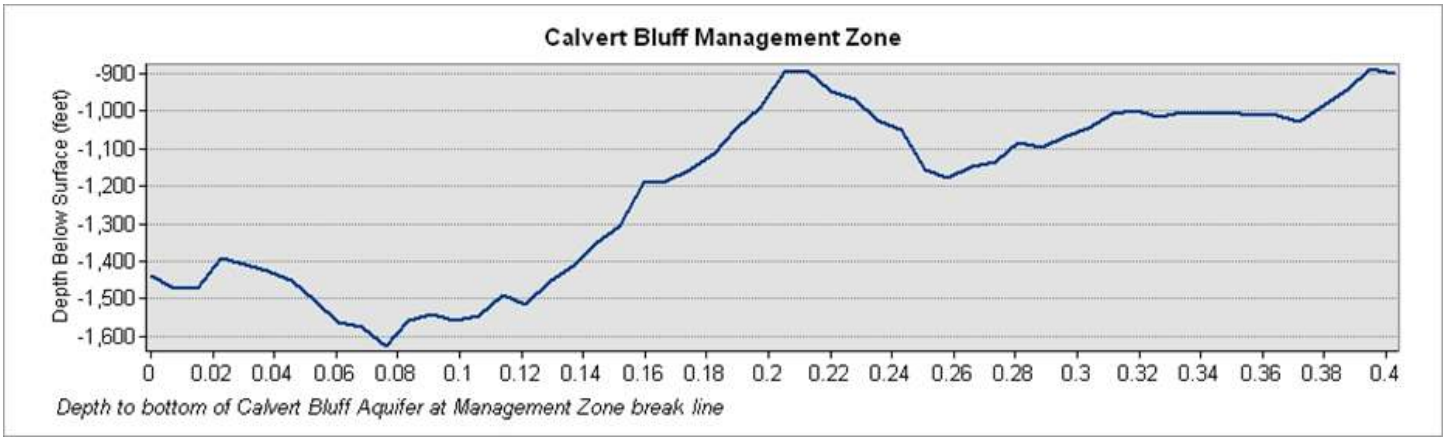
PS5 Predictions of Average Drawdown in POSGCD Shallow Zones





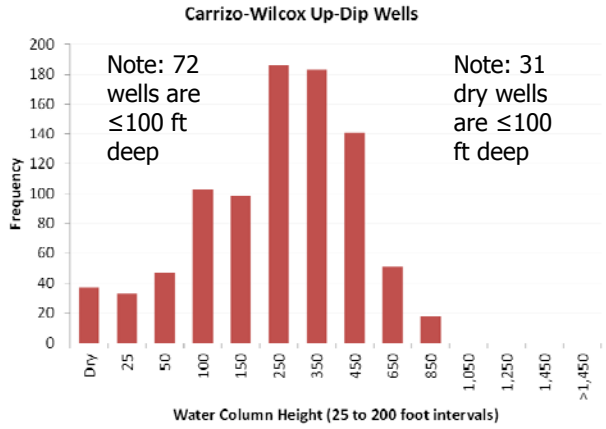
Bottom of Shallow Zone

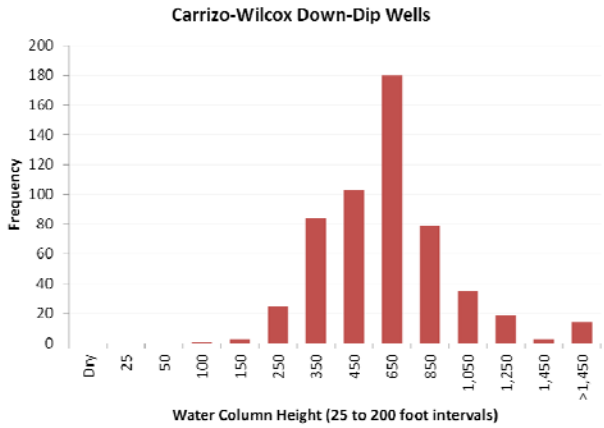
		Depth (ft) to Base of Aquifer					
		Sparta	Queen City	Carrizo	Calvert Bluff	Simsboro	Hooper
At Downdip Extent of Shallow Zone	Average	474	627	425	1221	735	747
	Median	467	658	351	1146	729	772
	Minimum	619	823	693	1639	1174	1185
	Maximum	338	441	206	858	515	493
	Range	281	383	487	780	658	693
At Downdip Extent of Unconfined Zone	Average	294	450	295	972	532	507
	Median	291	468	272	959	535	510
	Minimum	463	688	682	1359	834	924
	Maximum	156	145	3	689	140	51
	Range	307	543	679	670	695	873

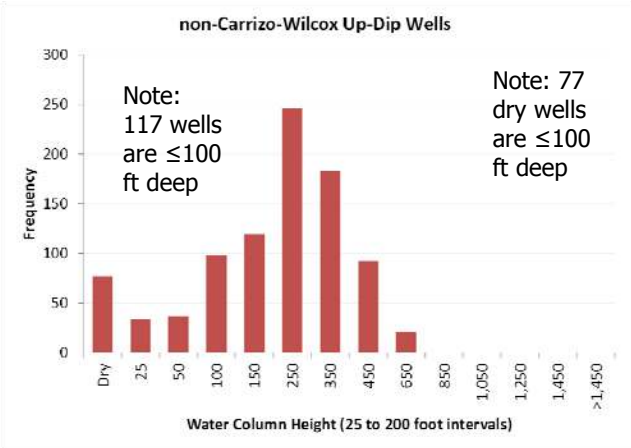


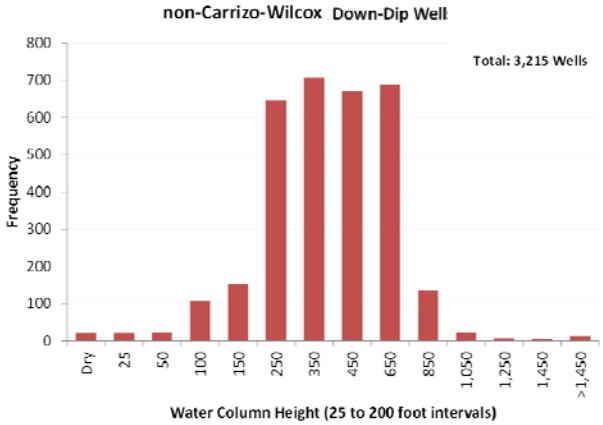
Water Column in Wells Located in Shallow and Depth Zones

Height of Water Above the Base of the Aquifer Based on GAM Simulated Water Levels in 2000









Monitoring

Aquifer	Management Zone	Desired Future Condition Average[1]	Number of Wells with Three-year Average				Average Based on Measured Water Levels in Same Wells in POSGCD from 2000 to 2012				Average Based on Interpolated Points		DFC Compliant[4]	Percent of Average Drawdown of DFC[5]
			2000		2012									
			POSGCD	All	POSGCD	All	Number of Wells	Straight Average	Group by Cluster	Four Zones in Shallow	All 2000 Wells and All 2012 Wells	Only Wells Common to 2000 and 2012[2]		
Sparta	Shallow	10	0		0		0	na	na	na	22.2	**3.6**	yes	36.0%
	Entire	30	3	12	6	27	3	4.6	4.6		33.6	**3.5**	yes	11.7%
Queen City	Shallow	10	4		5		4	2.5	3.0	3	12	**3.1**	yes	31.0%
	Entire	30	5	12	9	24	5	2.8	3.2		17.3	**3.1**	yes	10.3%
Carrizo	Shallow	20	0		1		0	na	na	na	7.7	**6.5**	yes	32.5%
	Entire	65	1	7	4	11	1	10.1	10.1		33.9	**6.7**	yes	10.3%
Calvert Bluff (Upper Wilcox)	Shallow	20	8		17		7	9.2	9.1	11.2	-11.1	**0**	yes	0.0%
	Entire	140	11	18	20	33	11	-1.7	-7.5		-6	**-11.4**	yes	-8.1%
Simsboro (Middle Wilcox)	Shallow	20	12		19		12	8.9	7.8	6	12	**9.6**	yes	48.0%
	Entire	300	14	31	29	71	14	3.5	-0.4		20.3	**11.1**	yes	3.7%
Hooper (Lower Wilcox)	Shallow	20	4		9		4	5.9	5.9	5.6	40	**6.2**	yes	31.0%
	Entire	180	5	6	11	25	5	7.4	7.4		84.5	**7.1**	yes	3.9%
Yegua Jackson	Shallow	15	0		0		0	na	na	na	na	**na**	unknown	unknown
	Entire	100	1	9	4	27	1	7.3	7.3		12.3	**16.4**	yes	16.4%
Brazos River Alluvium	Milam	5					0	na					unknown	unknown
	Burleson[3]	6					7	4.5	5.0	5.1			yes	81.1%

[1] all DFCs are from Jan. 2000 to Dec. 2059 except the BRAA DFC, which is from Jan. 2010 to Dec. 2059

[2] best estimate of calculated average drawdown from 2000 to 2012

[3] number of wells from 2010 to 2014

[4] likely is based on review of all available data; insuff. data requires additional information

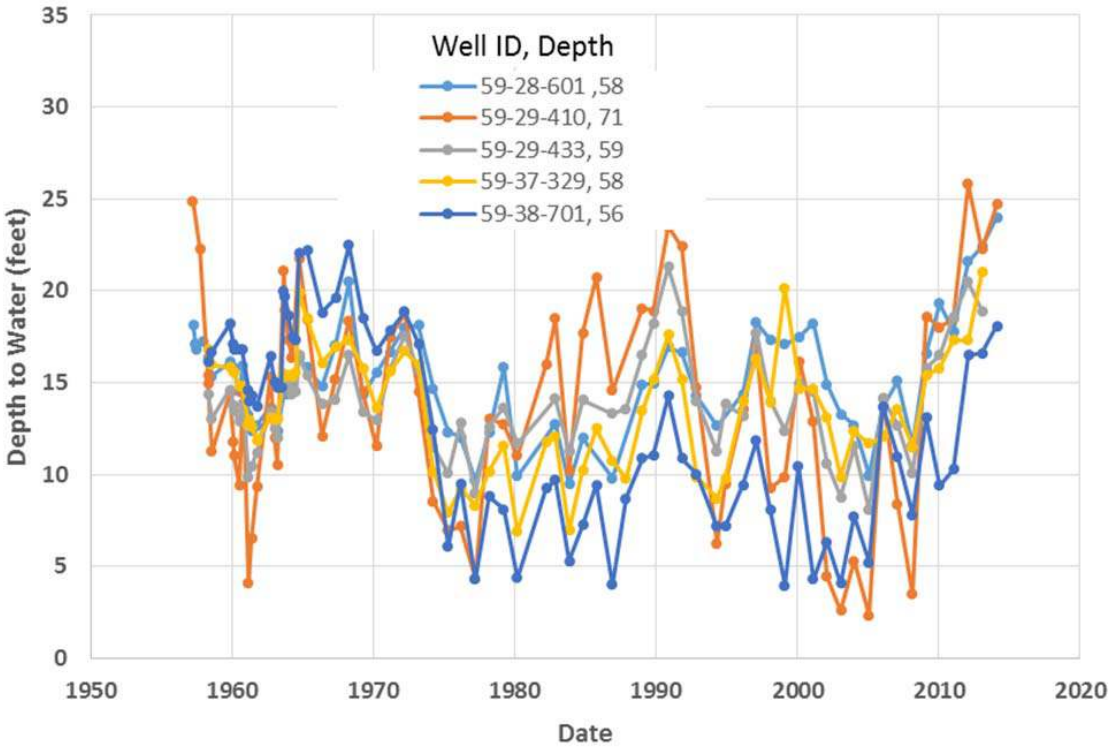
[5] Threshold Level 1 criteria is 60%

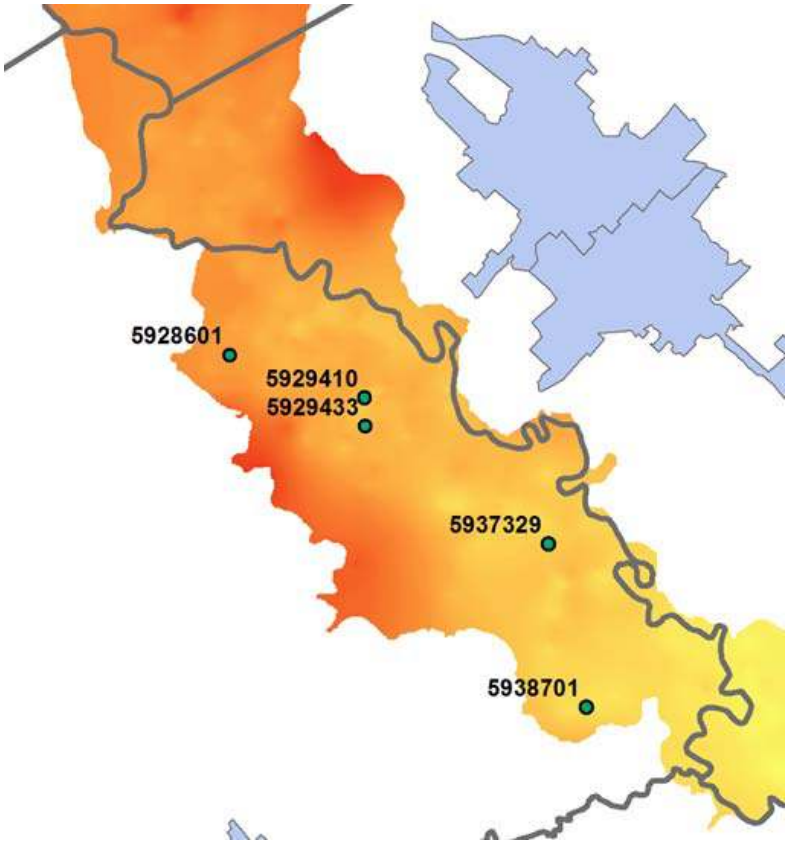
Discussion Topics

Brazos River Alluvium Threshold

TWDB Communications

Monitoring


Well ID, Depth
59-28-601 ,58
59-29-410, 71
59-29-433, 59
59-37-329, 58
59-38-701, 56
Depth to Water (feet)
35
30
25
20
15
10
5
0
1950
1960
1970
1980
1990
2000
2010
2020
Date


5928601
5929410
5929433
5937329
5938701

Discussion Items

- GMA 12 DFCs
  - Results from Pumping Scenario 5 (PS5)
  - 2010 Joint Planning Values for 2060

- Pumping Scenario 5
  - GCD Permit Amounts
  - POSGCD Current Pumping
  - Entire Aquifer Drawdown Since 1975
  - Shallow Zone Drawdowns

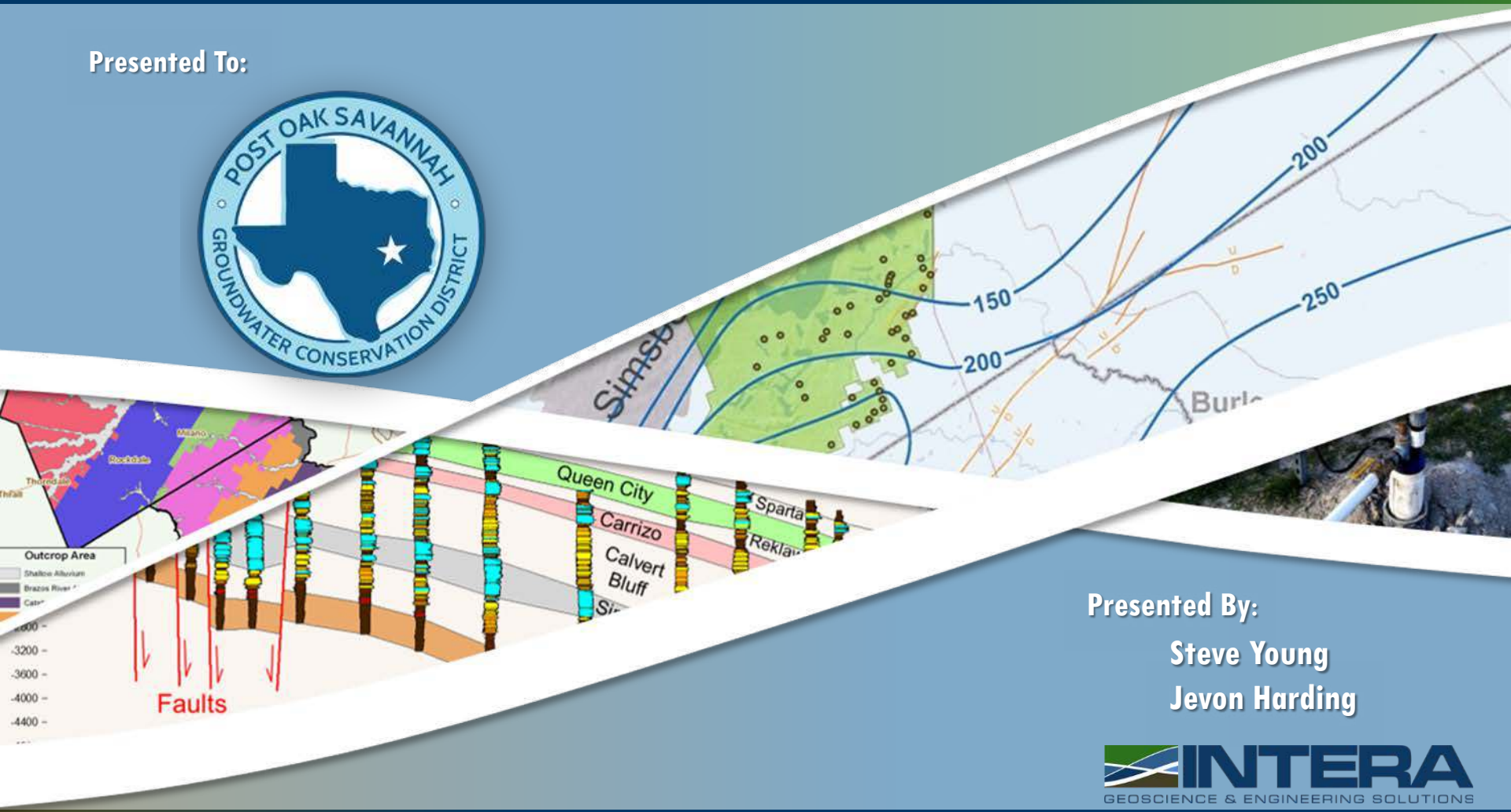
- Monitoring Program
  - Review Results from INTERA October 12 presentation
  - TWDB Discussions
  - Next Steps

ATTACHMENT C:
GROUNDWATER MODELING UPDATE AND INVESTIGATION INTO ALTERNATIVE DEFINITIONS FOR SHALLOW MONITORING ZONE
MARCH 8, 2016

Groundwater Monitoring Update and Investigation into Alternative Definitions for Shallow Monitoring Zone

Presented To:

POST OAK SAVANNAH GROUNDWATER CONSERVATION DISTRICT



Presented By:

Steve Young

Jevon Harding

INTERA
GEOSCIENCE & ENGINEERING SOLUTIONS

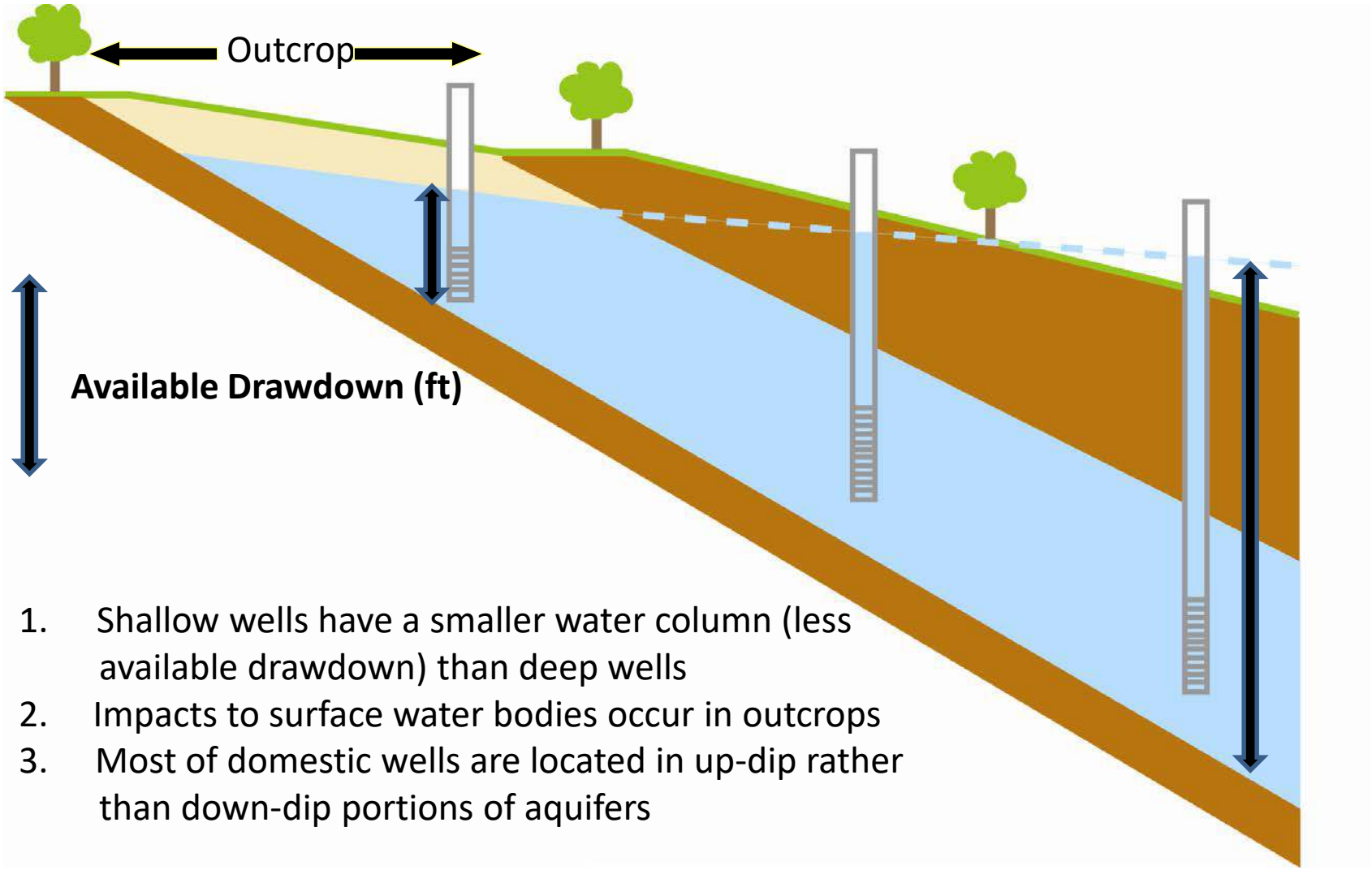
March 8, 2016

Outline

- Rationale for Monitoring Shallow Zone
- Analysis of Monitoring Data for DFC Compliance
  - Recap November 2015 presentation (2000 – 2012)
  - Calculations for 2000 – 2014
- Shallow Zone
  - Lateral and Vertical Extent
  - Water Level Measurements
- Recommended Options

INTERA
GEOSCIENCE & ENGINEERING SOLUTIONS

Rationale for Shallow Monitoring Zone

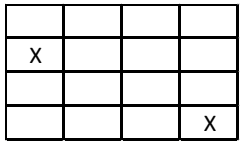


1. Shallow wells have a smaller water column (less available drawdown) than deep wells
2. Impacts to surface water bodies occur in outcrops
3. Most of domestic wells are located in up-dip rather than down-dip portions of aquifers

INTERA
GEOSCIENCE & ENGINEERING SOLUTIONS

November 2015 Presentation

- Investigated Different Spatial Analyses
  - Point Locations: Drawdowns at individual wells
  - Areas: Average drawdowns across a region based on interpolation of drawdowns at well locations



- Investigated Different Temporal Analyses
  - Three-year period
  - Five-year period
  - Seven-year period

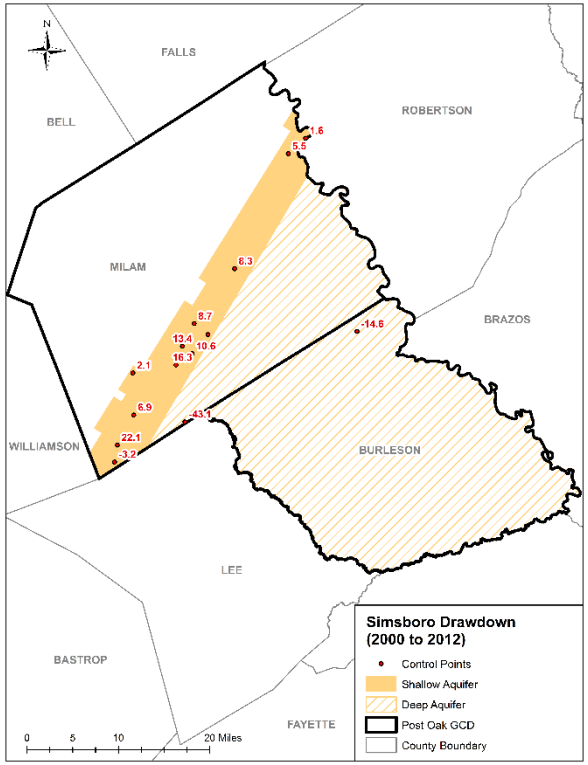
Average Period	Year 2012
3-year	2011, 2012, 2013
5-year	2010,2011, 2012, 2013,2014
7-year	2009,2010,2011, 2012, 2013,2014,2015

- Investigated Different Criteria for Selecting Wells Used in Analyses
  - Only wells with water levels for 2000 and 2012 (same set of wells used to calculate average water levels for two times)
  - All wells with water level in 2000 and all wells with water levels in in 2012 (different set of wells used to calculate average water levels for two times)

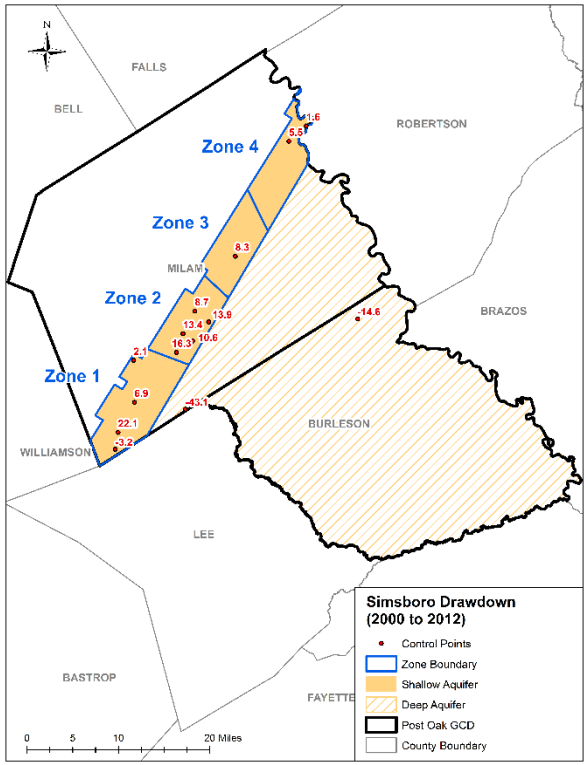
INTERA GEOSCIENCE & ENGINEERING SOLUTIONS

Averaging of Single Points: Simsboro

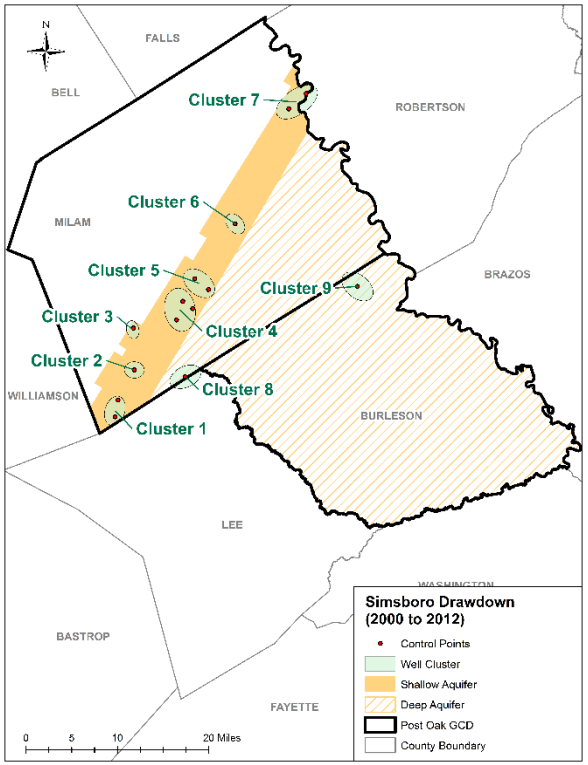
Straight Average
(shallow: 8.9 ft, entire: 3.5 ft)



Four Zones in Shallow
(shallow: 6 ft)



Group by Cluster
(shallow: 7.8 ft, entire: -0.4)



Note: 1) three-year averages for used to assign water levels for 2000 and 2012
2) negative values indicate rebound

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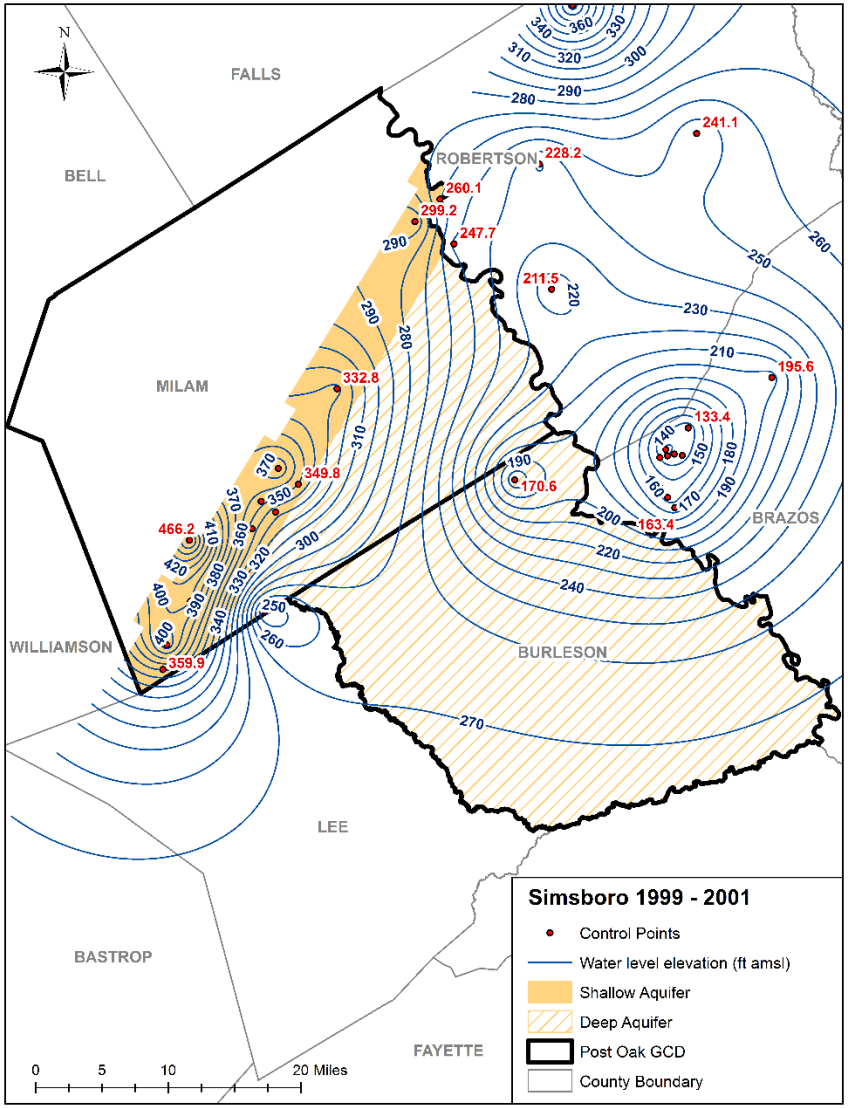
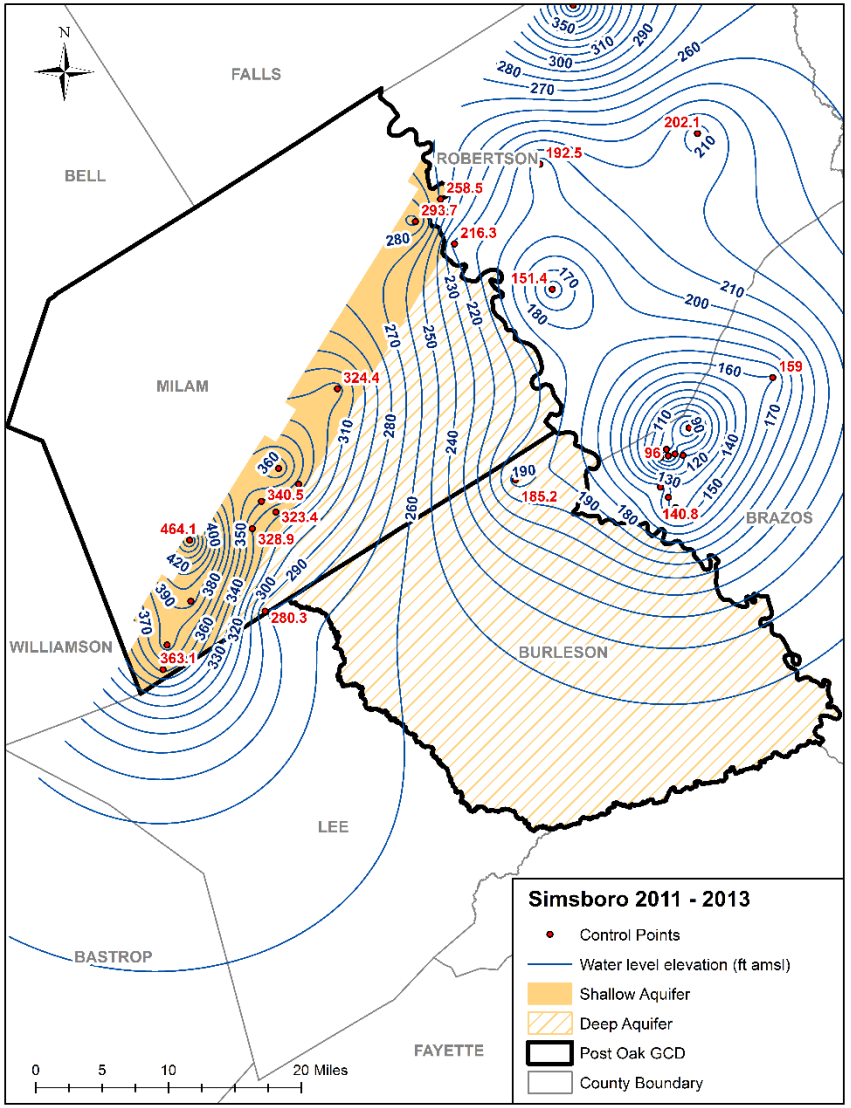
Interpolating Values Across Areas: Simsboro (same wells in 2012 and in 2000)





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Comparison Between DFC and Calculated Average Drawdown from 2000 to 2012

Selected Method

1) Area Averages
2) 3-year Period
3) 2000 & 2012 Water Levels

Aquifer	Management Zone	Desired Future Condition Average[1]	Number of Wells with Three-year Average				Average Based on Measured Water Levels in Same Wells in POSGCD from 2000 to 2012				Average Based on Interpolated Points		DFC Compliant[4]	Percent of Average Drawdown of DFC[5]
			2000		2012									
			POSGCD	All	POSGCD	All	Number of Wells	Straight Average	Group by Cluster	Four Zones in Shallow	All 2000 Wells and All 2012 Wells	Only Wells Common to 2000 and 2012[2]		
Sparta	Shallow	10	0		0		0	na	na	na	22.2	**3.6**	yes	36.0%
	Entire	30	3	12	6	27	3	4.6	4.6		33.6	**3.5**	yes	11.7%
Queen City	Shallow	10	4		5		4	2.5	3.0	3	12	**3.1**	yes	31.0%
	Entire	30	5	12	9	24	5	2.8	3.2		17.3	**3.1**	yes	10.3%
Carrizo	Shallow	20	0		1		0	na	na	na	7.7	**6.5**	yes	32.5%
	Entire	65	1	7	4	11	1	10.1	10.1		33.9	**6.7**	yes	10.3%
Calvert Bluff (Upper Wilcox)	Shallow	20	8		17		7	9.2	9.1	11.2	-11.1	**0**	yes	0.0%
	Entire	140	11	18	20	33	11	-1.7	-7.5		-6	**-11.4**	yes	-8.1%
Simsboro (Middle Wilcox)	Shallow	20	12		19		12	8.9	7.8	6	12	**9.6**	yes	48.0%
	Entire	300	14	31	29	71	14	3.5	-0.4		20.3	**11.1**	yes	3.7%
Hooper (Lower Wilcox)	Shallow	20	4		9		4	5.9	5.9	5.6	40	**6.2**	yes	31.0%
	Entire	180	5	6	11	25	5	7.4	7.4		84.5	**7.1**	yes	3.9%
Yegua Jackson	Shallow	15	0		0		0	na	na	na	na	**na**	unknown	unknown
	Entire	100	1	9	4	27	1	7.3	7.3		12.3	**16.4**	yes	16.4%
Brazos River Alluvium	Milam	5					0	na					unknown	unknown
	Burleson[3]	6					7	4.5	5.0	5.1			yes	81.1%

[1] all DFCs are from Jan. 2000 to Dec. 2059 except the BRAA DFC, which is from Jan. 2010 to Dec. 2059

[2] best estimate of calculated average drawdown from 2000 to 2012

[3] number of wells from 2010 to 2014

[4] likely is based on review of all available data; insuff. data requires additional information

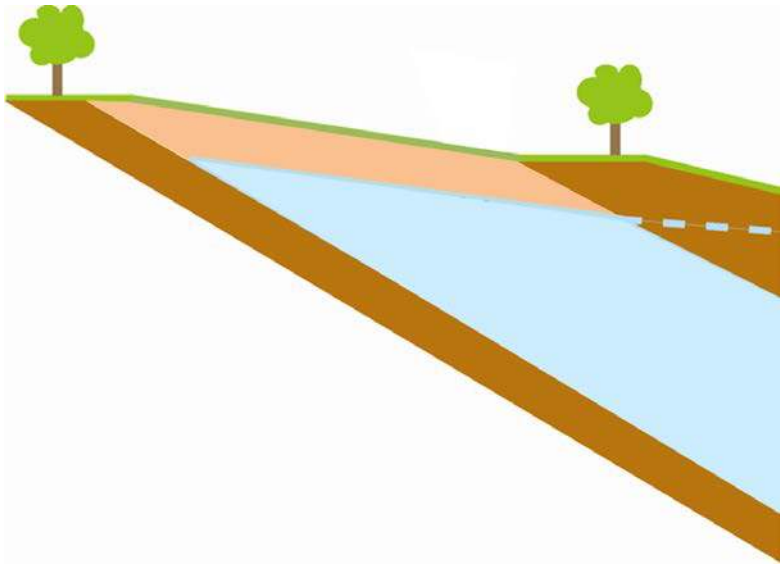
[5] Threshold Level 1 criteria is 60%

Comparison Between DFC and Calculated Average Drawdown from 2000 to 2014

Aquifer	Management Zone	Desired Future Condition Average	Average Based on Interpolated Points				DFC Compliant (2014)	Percent of Average Drawdown of DFC (2014)
			All Wells		Only Wells Common with 2000			
			2012	2014	2012	2014		
Calvert Bluff (Upper Wilcox)	Unconfined	20	---	-4.1	---	**2.9**	Yes	14.6
	Shallow	20	-11.1	-11.0	**0**	**1.3**	Yes	6.7
	Entire	140	-6	-2.7	**-11.4**	**-11.5**	Yes	-8.2
Simsboro (Middle Wilcox)	Unconfined	20	---	9.8	---	**11.5**	Yes	57.3
	Shallow	20	12	10.8	**9.6**	**10.8**	Yes	54.0
	Entire	300	20.3	43.6	**11.1**	**14.0**	Yes	4.7
Hooper (Lower Wilcox)	Unconfined	20	---	39.0	---	**7.0**	Yes	34.8
	Shallow	20	40	42.4	**6.2**	**7.2**	Yes	36.1
	Entire	180	84.5	89.2	**7.1**	**8.0**	Yes	4.5

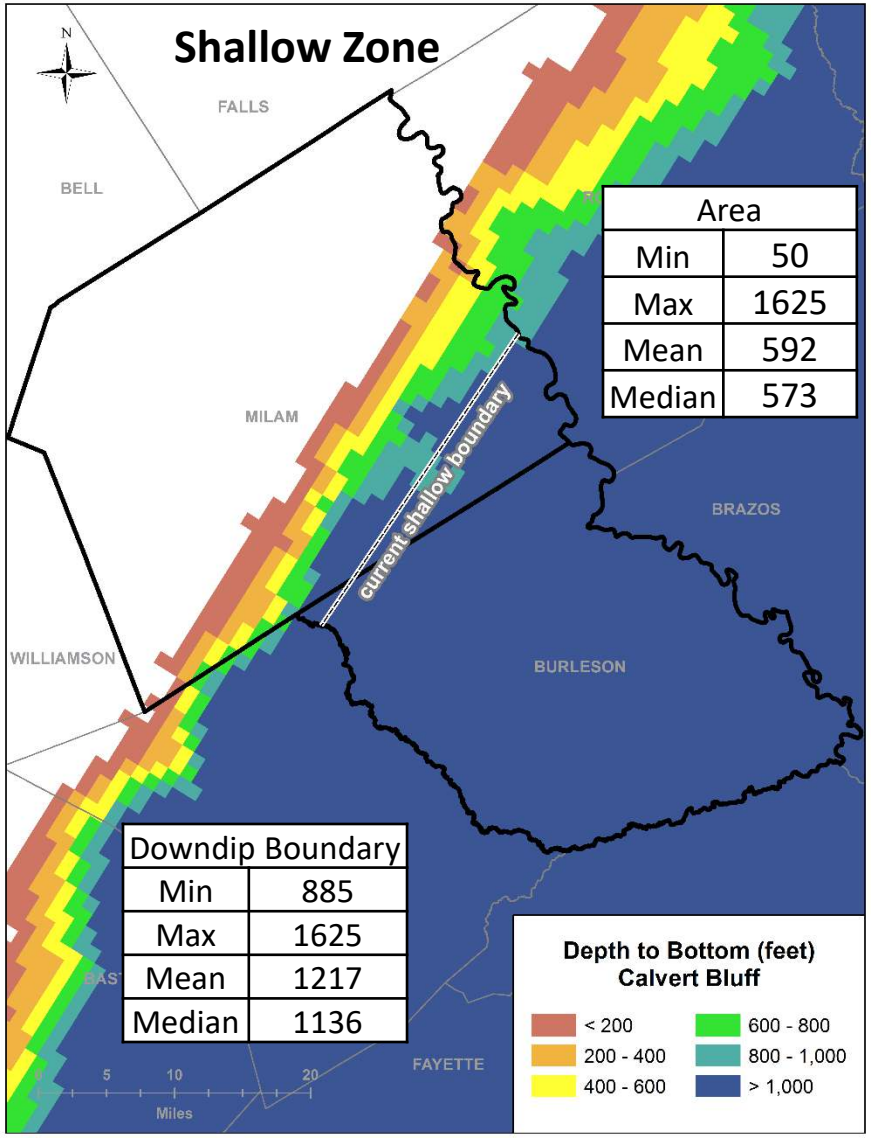
Options for Defining Shallow Monitoring Zone

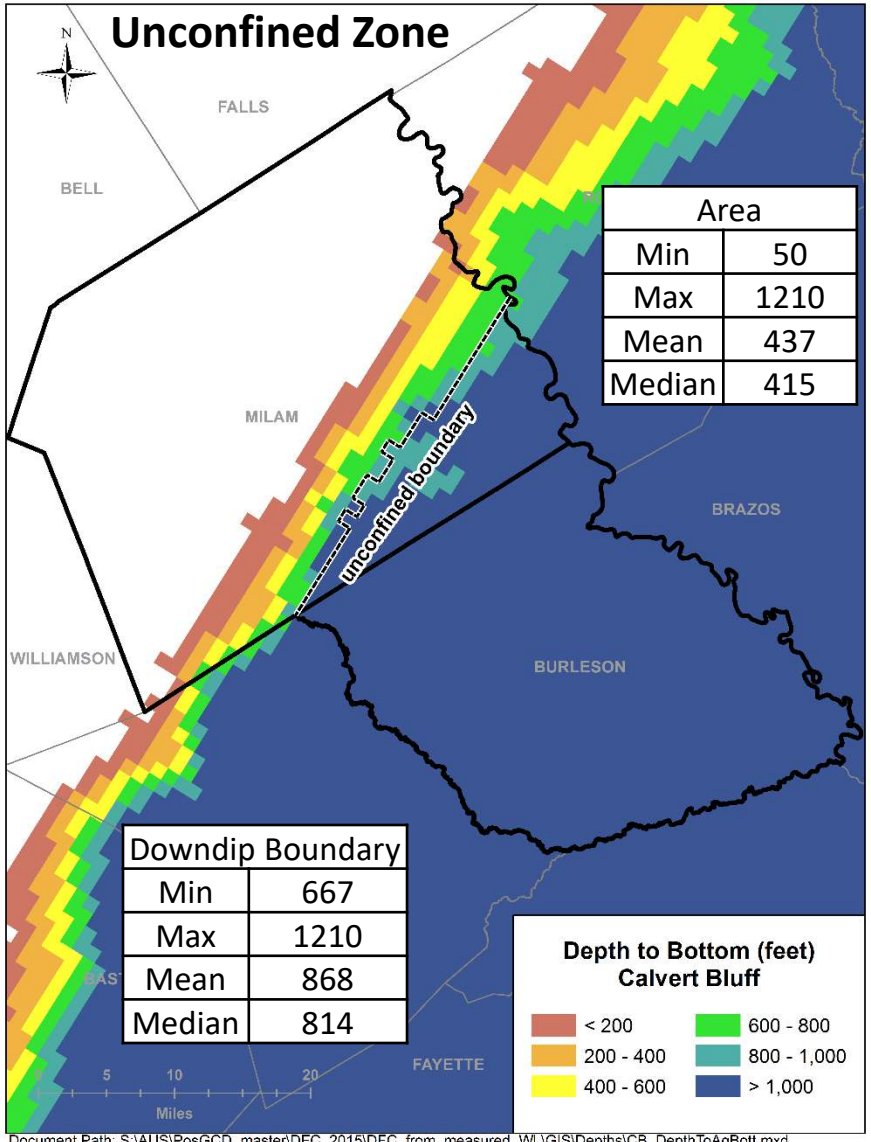
- Lateral Dimension
  - Outcrop: aquifer is at ground surface
  - Unconfined: water level is below top of aquifer
  - Fault zone: area where groundwater flow is impacted by faults
  - Other: political boundary, geographical feature



- Vertical Dimension
  - Maximum Depth below ground surface
  - Minimum Elevation

Depth to Base of Calvert Bluff





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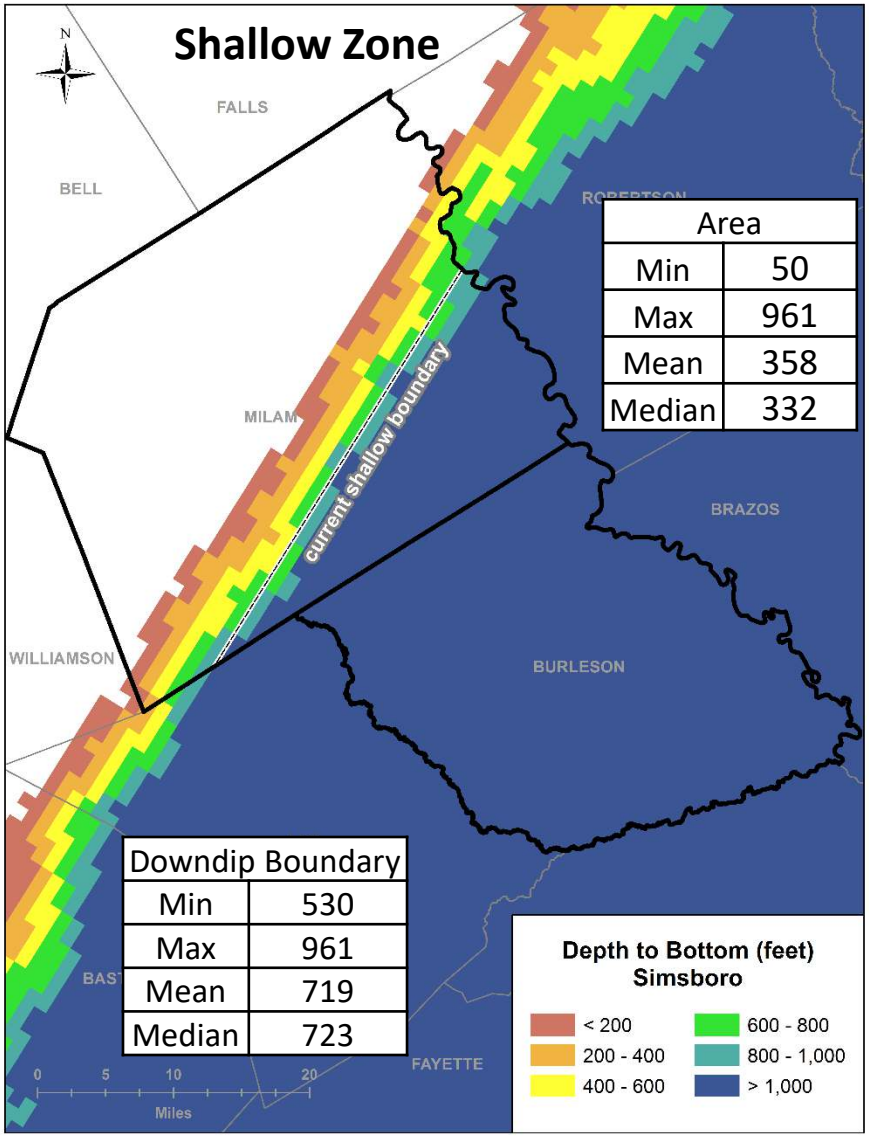
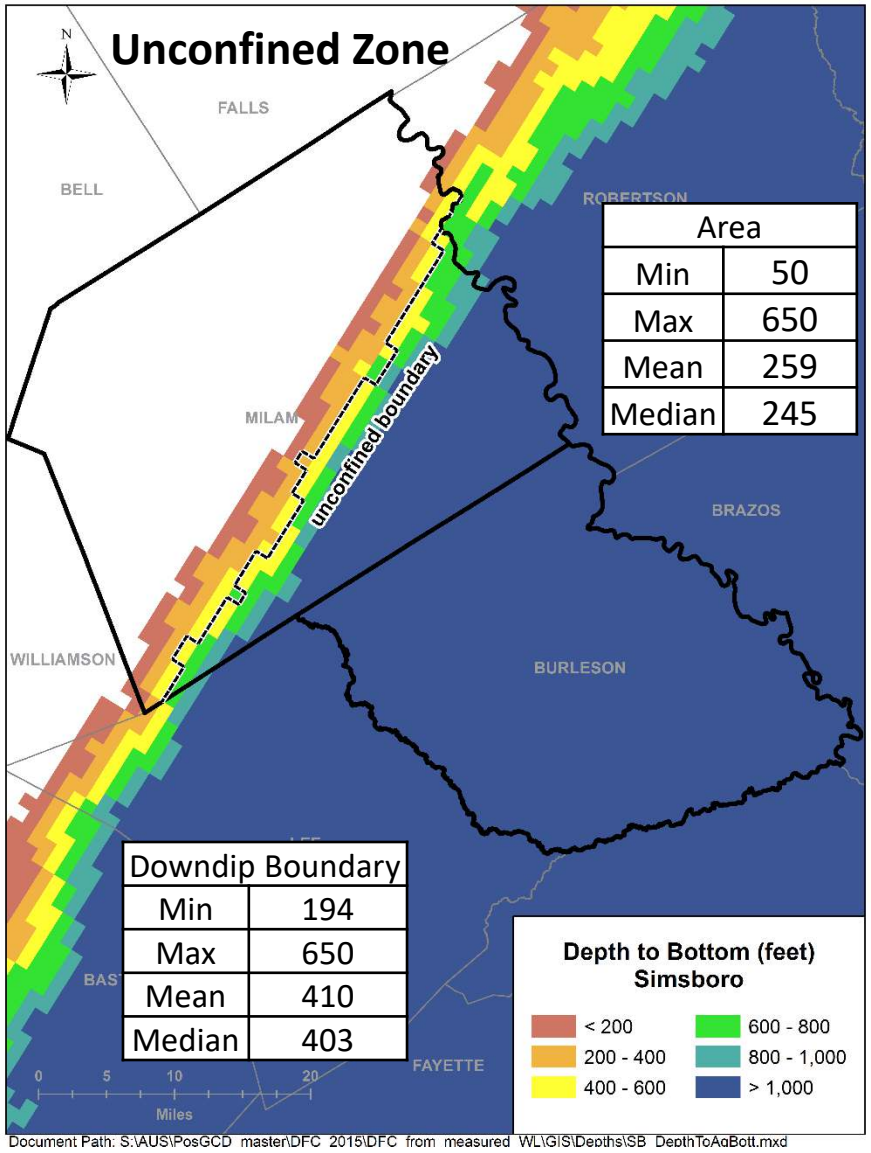
Depth to Bottom of Simsboro





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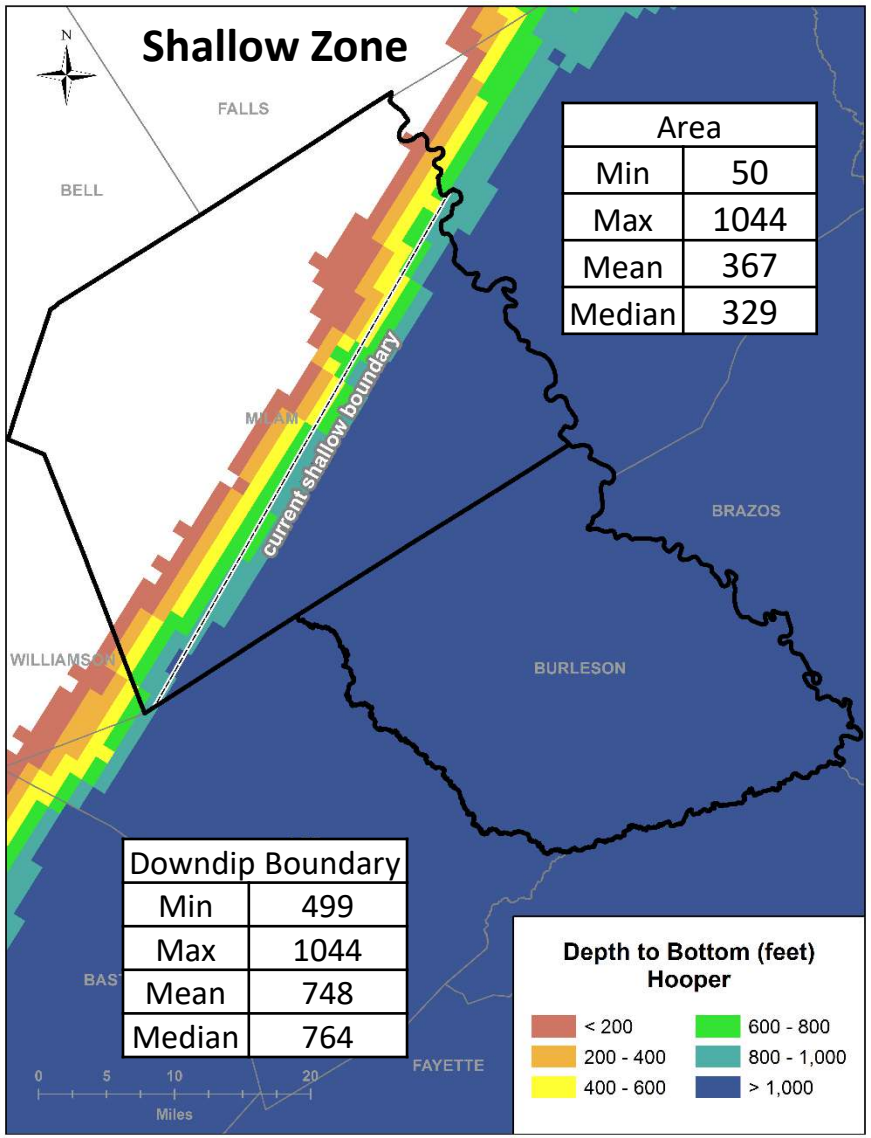
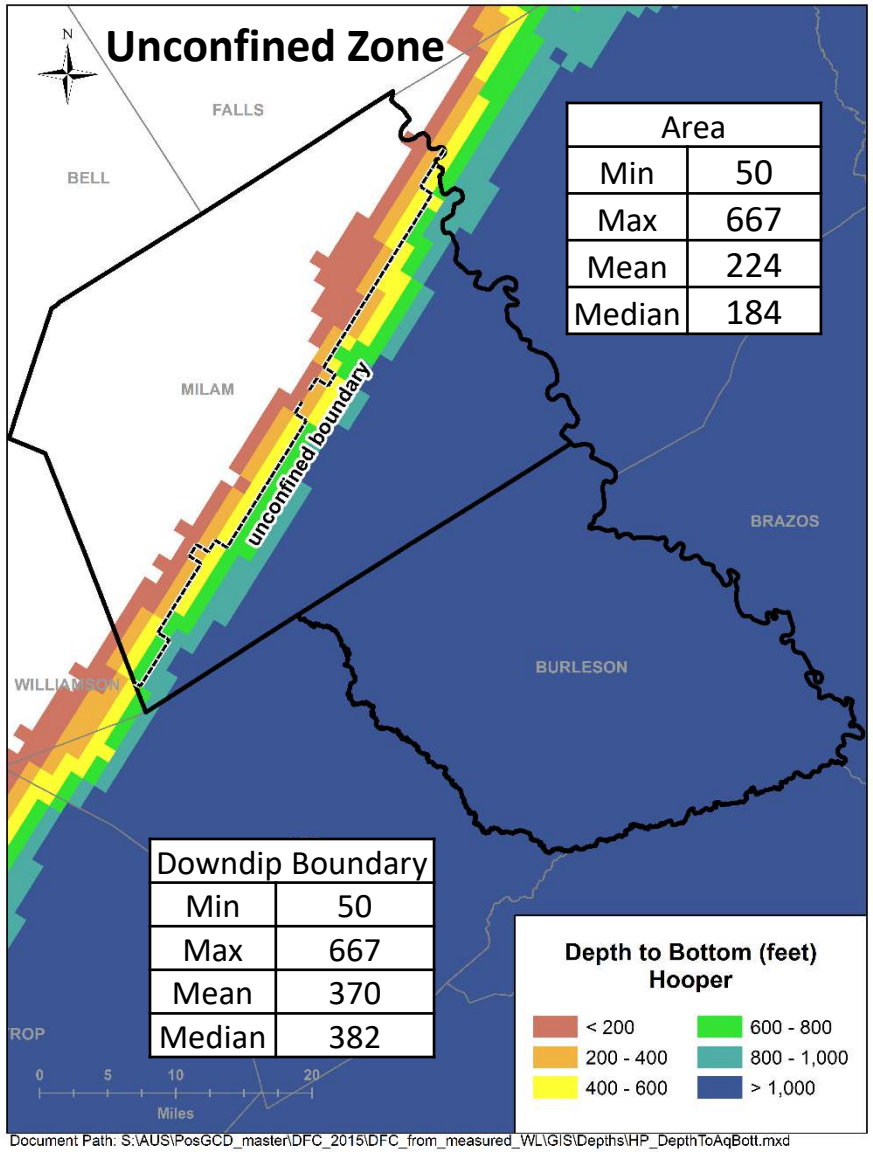
Depth to Bottom of Hooper





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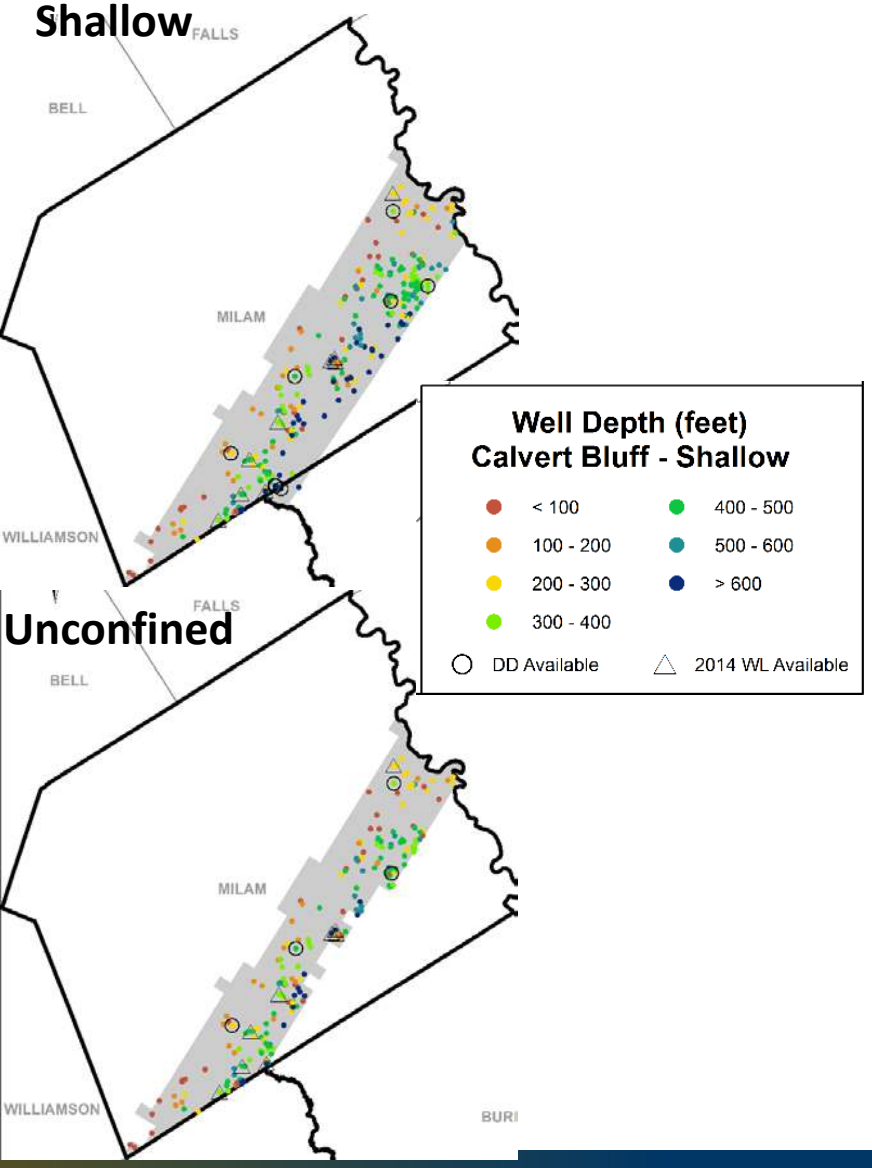
Depth to Bottom of Aquifers Within Shallow and Unconfined Areas – Wilcox

- Shallow Area
  - Maximum Depth across Area: 961 to 1625 ft
  - Maximum at Down Dip Boundary: 961 to 1625 ft
  - Average Depth across Area: 358 to 592 ft
  - Average Depth Down Dip Boundary: 719 to 1217 ft
- Unconfined Area
  - Maximum Depth across Area: 650 to 1210 ft
  - Maximum at Down Dip Boundary: 650 to 1210 ft
  - Average Depth across Area: 259 to 437 ft
  - Average Depth Down Dip Boundary: 370 to 868 ft

Possible Concerns

1. Wells Deeper than 1,000 feet included
2. Definition of "Shallow" varies with formation

Calvert Bluff: Distribution of Depths of Wells



Shallow

Depth	Total	Monitoring	Permit	Exempt
< 100	32	0	4	28
< 200	61	1	5	56
< 300	107	3	6	101
< 400	148	7	7	141
< 500	230	11	8	222
< 600	267	13	9	258

Depth	Total	Monitoring	Permit	Exempt
Deep (> 600)	38	5	4	34

Unconfined

Depth	Total	Monitoring	Permit	Exempt
< 100	32	0	4	28
< 200	58	1	5	53
< 300	94	3	6	88
< 400	126	6	7	119
< 500	180	10	8	172
< 600	202	10	8	194

Depth	Total	Monitoring	Permit	Exempt
Deep (> 600)	16	3	4	12

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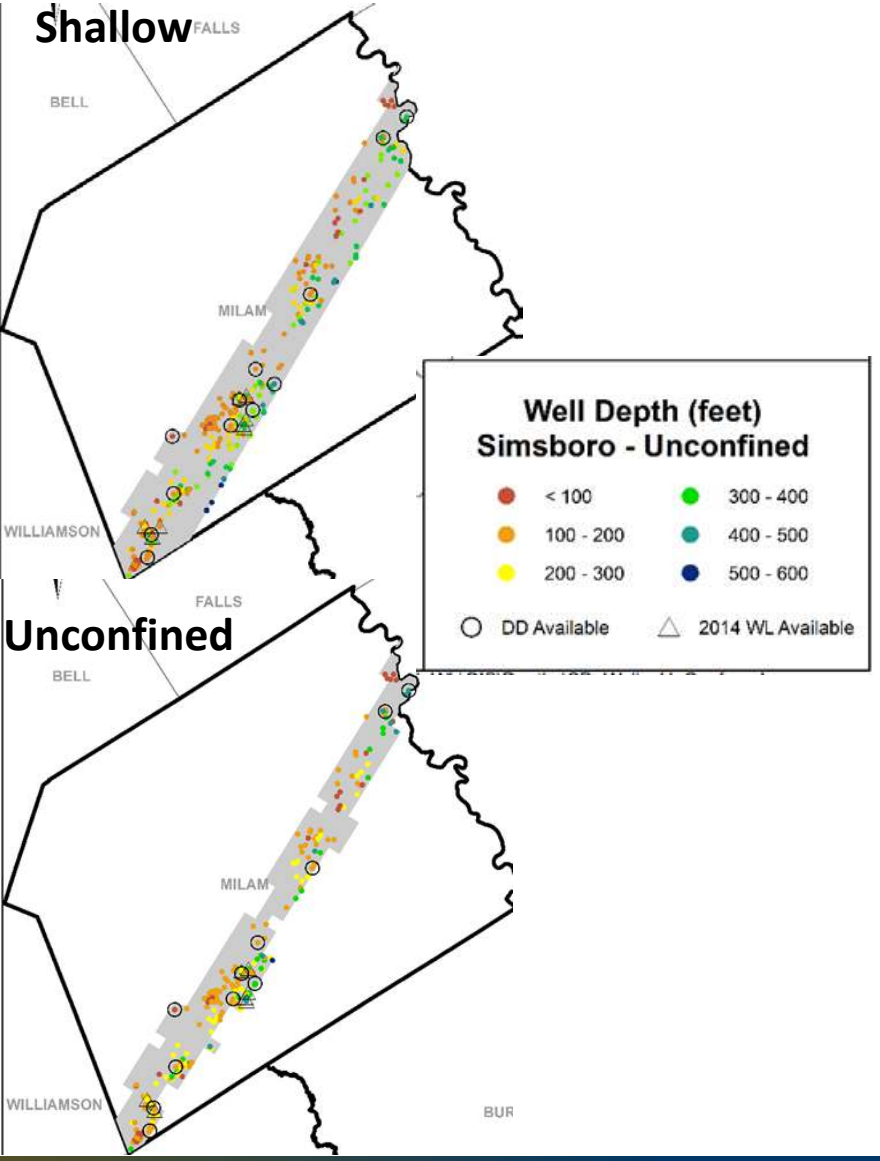
Simsboro: Distribution of Depths of Wells



Shallow

Depth	Total	Monitoring	Permit	Exempt
< 100	75	1	45	30
< 200	208	9	48	160
< 300	291	10	50	241
< 400	325	14	54	271
< 500	349	19	58	291
< 600	360	20	60	300

Depth	Total	Monitoring	Permit	Exempt
Deep (> 600)	4	0	1	3

Unconfined

Depth	Total	Monitoring	Permit	Exempt
< 100	37	1	7	30
< 200	162	8	10	152
< 300	221	9	12	209
< 400	247	13	15	232
< 500	261	18	18	243
< 600	263	18	18	245

Depth	Total	Monitoring	Permit	Exempt
Deep (> 600)	0	0	0	0

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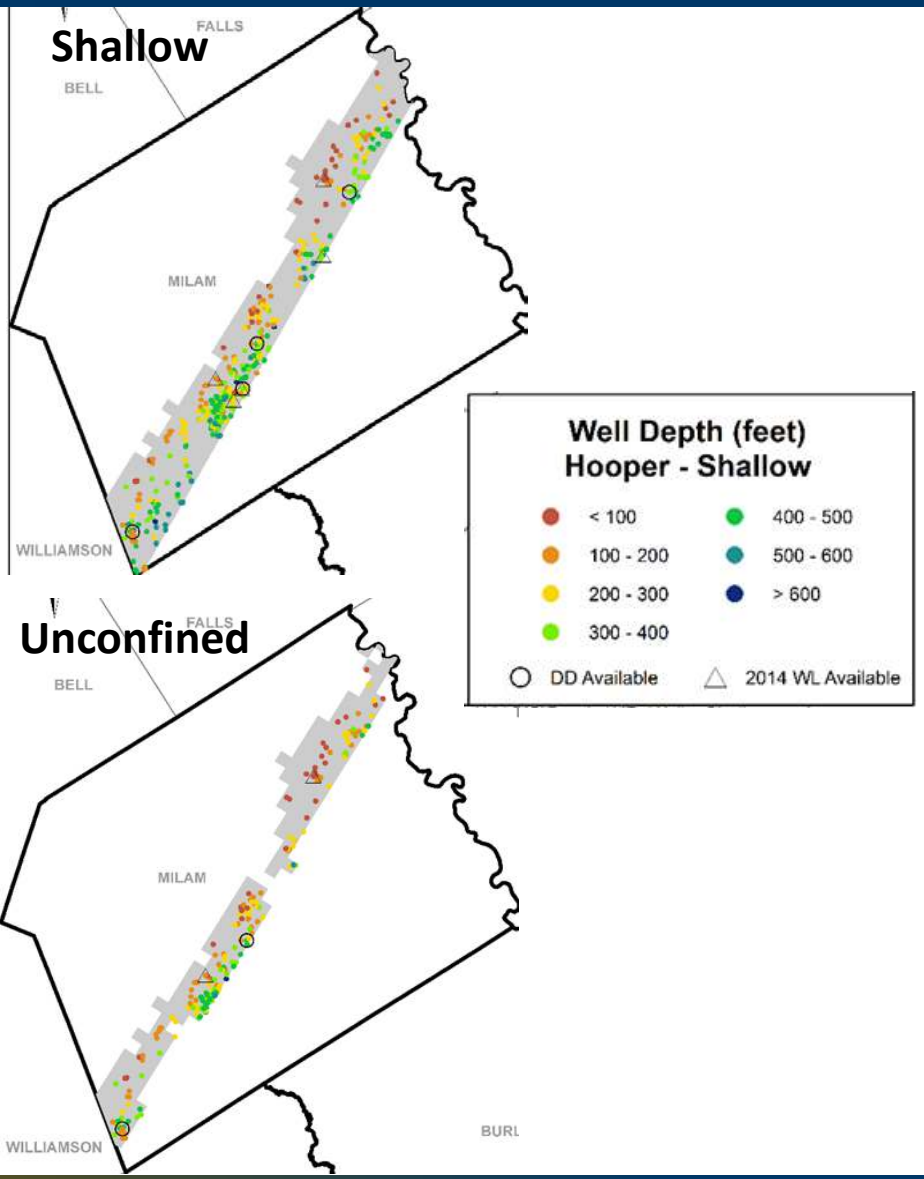
Hooper: Distribution of Depths of Wells



Shallow

Depth	Total	Monitoring	Permit	Exempt
< 100	37	1	2	35
< 200	108	3	4	104
< 300	204	4	9	195
< 400	307	7	13	294
< 500	401	9	18	383
< 600	418	10	18	400

Depth	Total	Monitoring	Permit	Exempt
Deep (> 600)	5	0	0	5

Unconfined

Depth	Total	Monitoring	Permit	Exempt
< 100	35	1	2	33
< 200	95	3	4	91
< 300	155	3	7	148
< 400	187	4	9	178
< 500	218	5	10	208
< 600	221	5	10	211

Depth	Total	Monitoring	Permit	Exempt
Deep (> 600)	1	0	0	1

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Distribution of Wells Based on Depth

Well Depth < 400 feet

Aquifer	Monitoring Wells	Total Wells
Calvert Bluff	7	148
Simsboro	14	325
Hooper	7	307

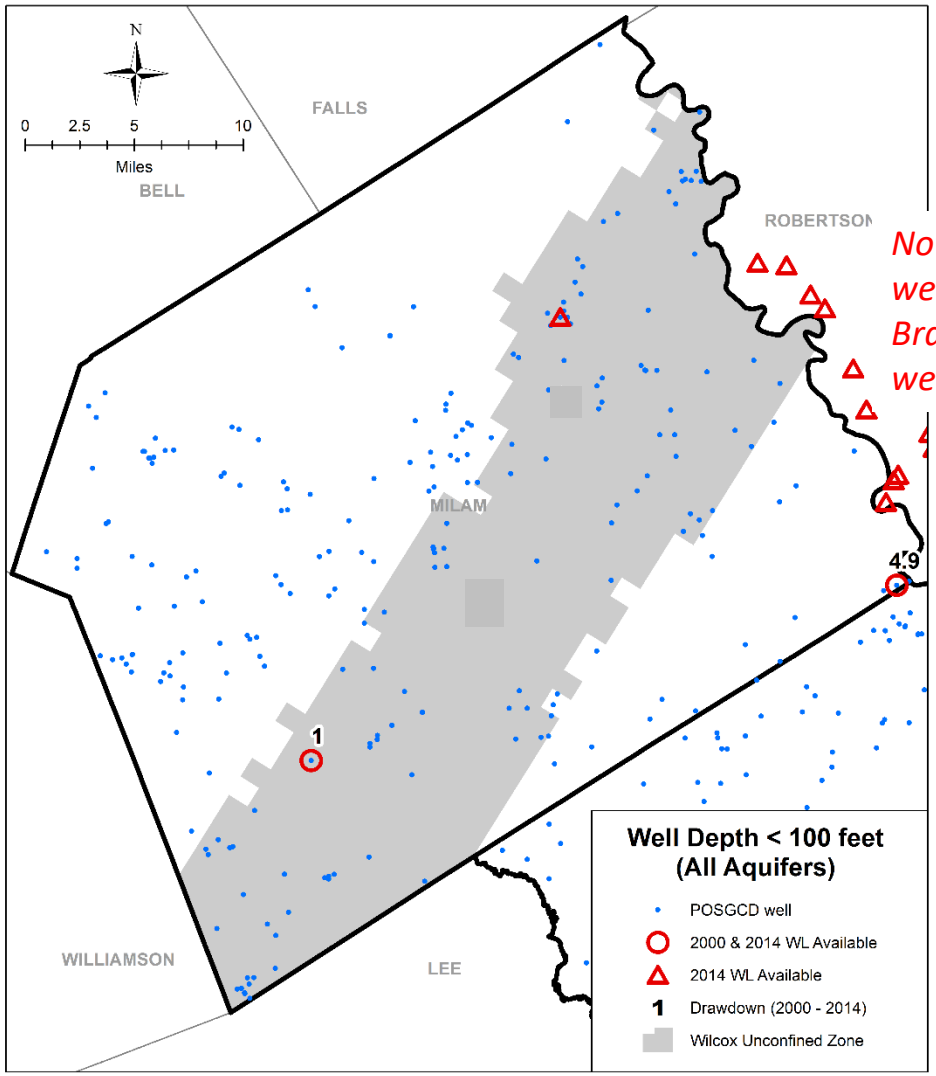
Well Depth < 500 feet

Aquifer	Monitoring Wells	Total Wells
Calvert Bluff	11	230
Simsboro	19	349
Hooper	9	401

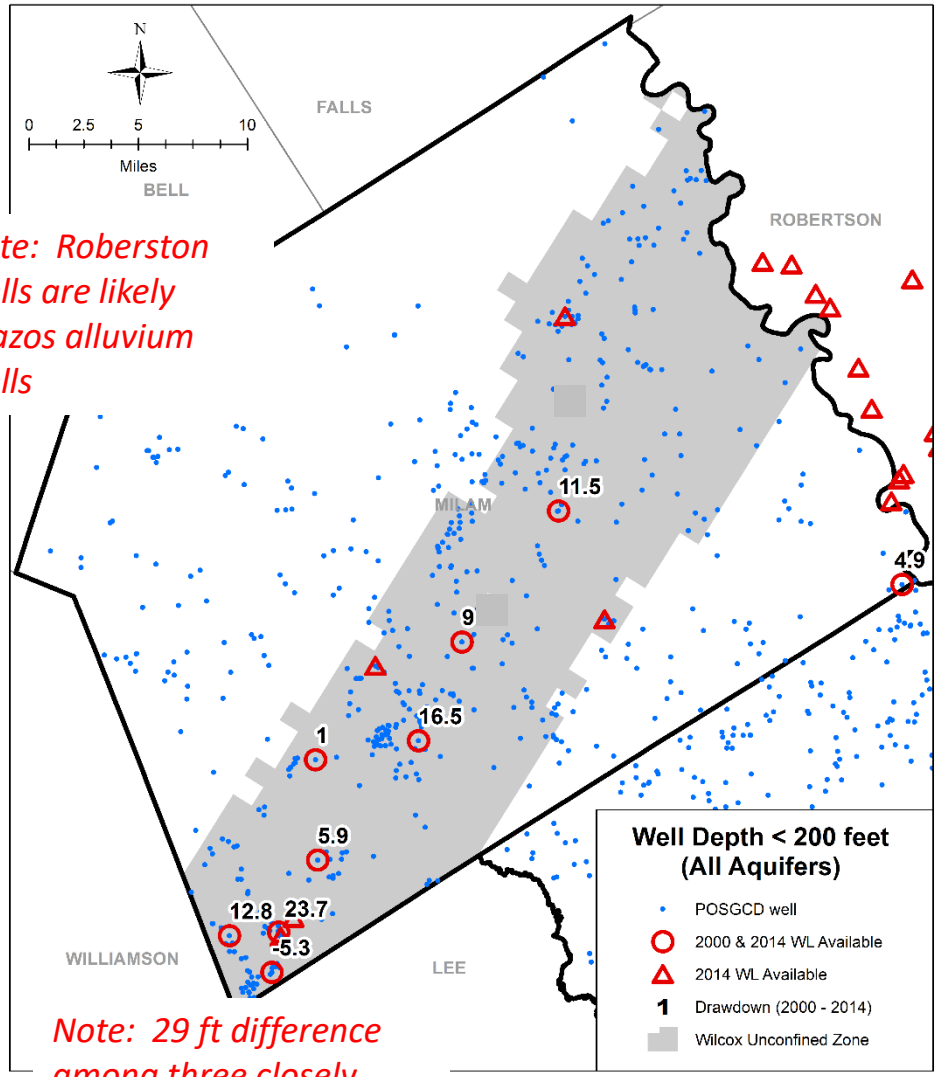
Well Depth < 600 feet

Aquifer	Monitoring Wells	Total Wells
Calvert Bluff	13	367
Simsboro	20	360
Hooper	10	418

All Aquifers: Shallow Wells



Note: Roberston wells are likely Brazos alluvium wells



Note: 29 ft difference among three closely spaced wells

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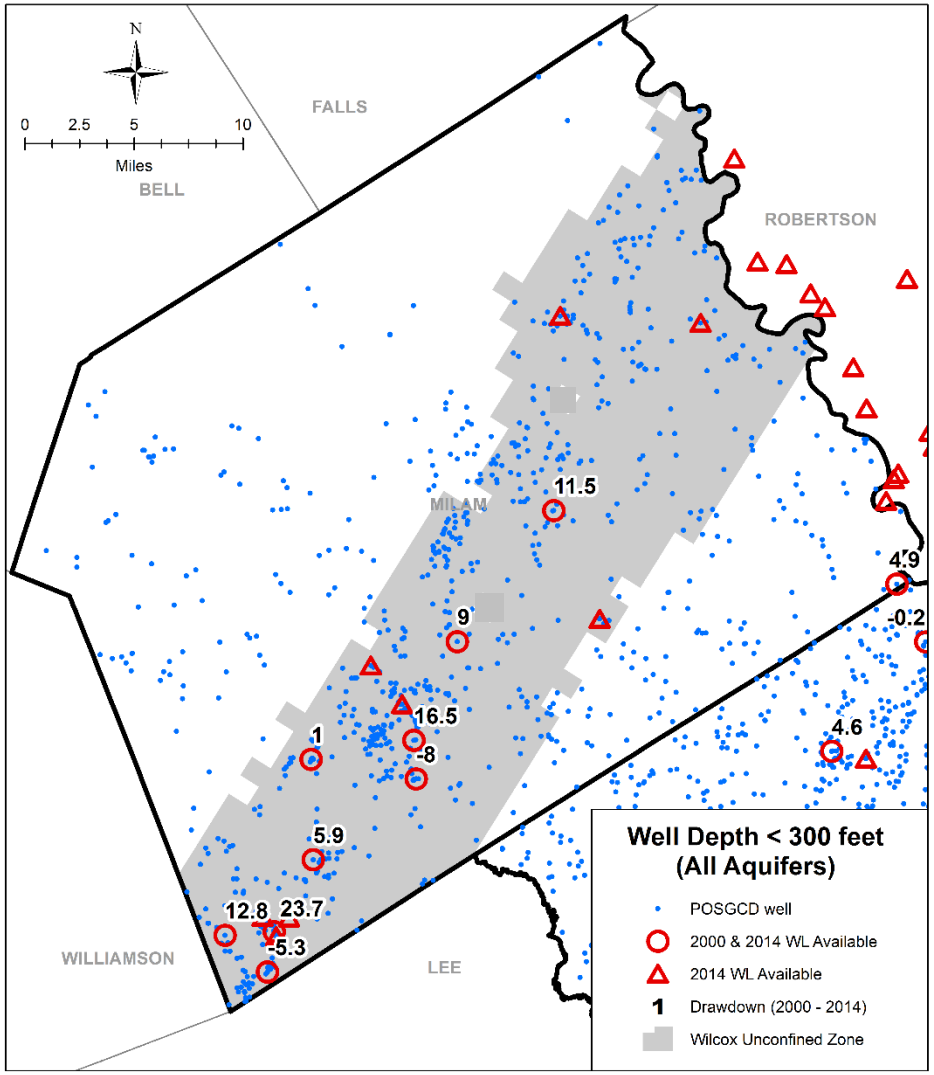
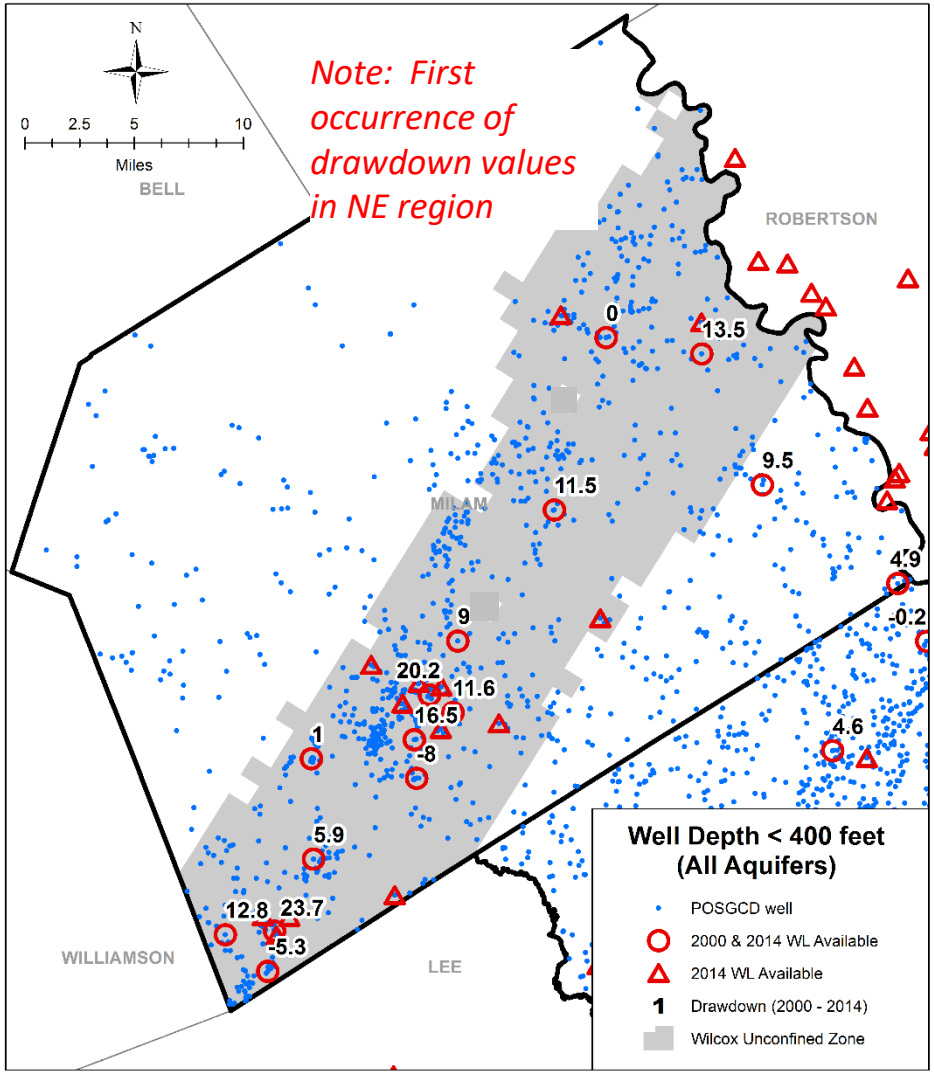
All Aquifers: Shallow Wells





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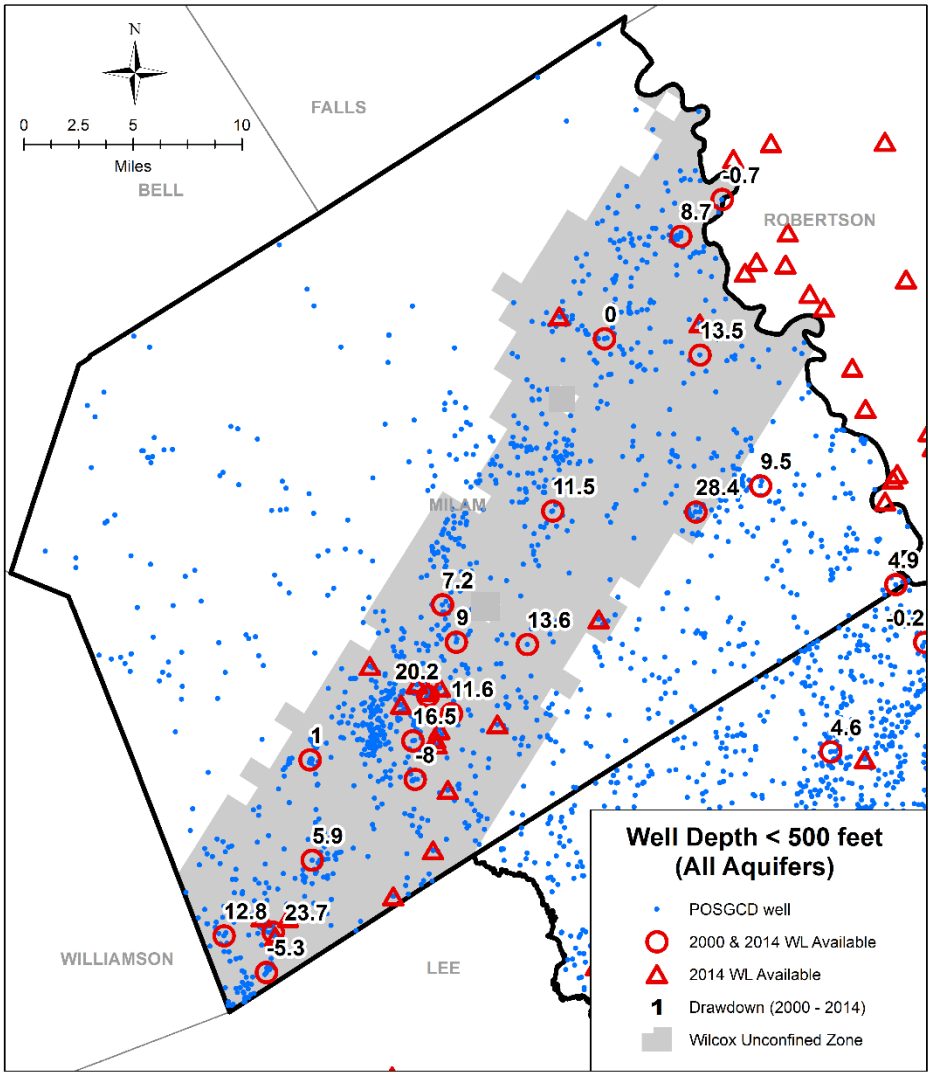
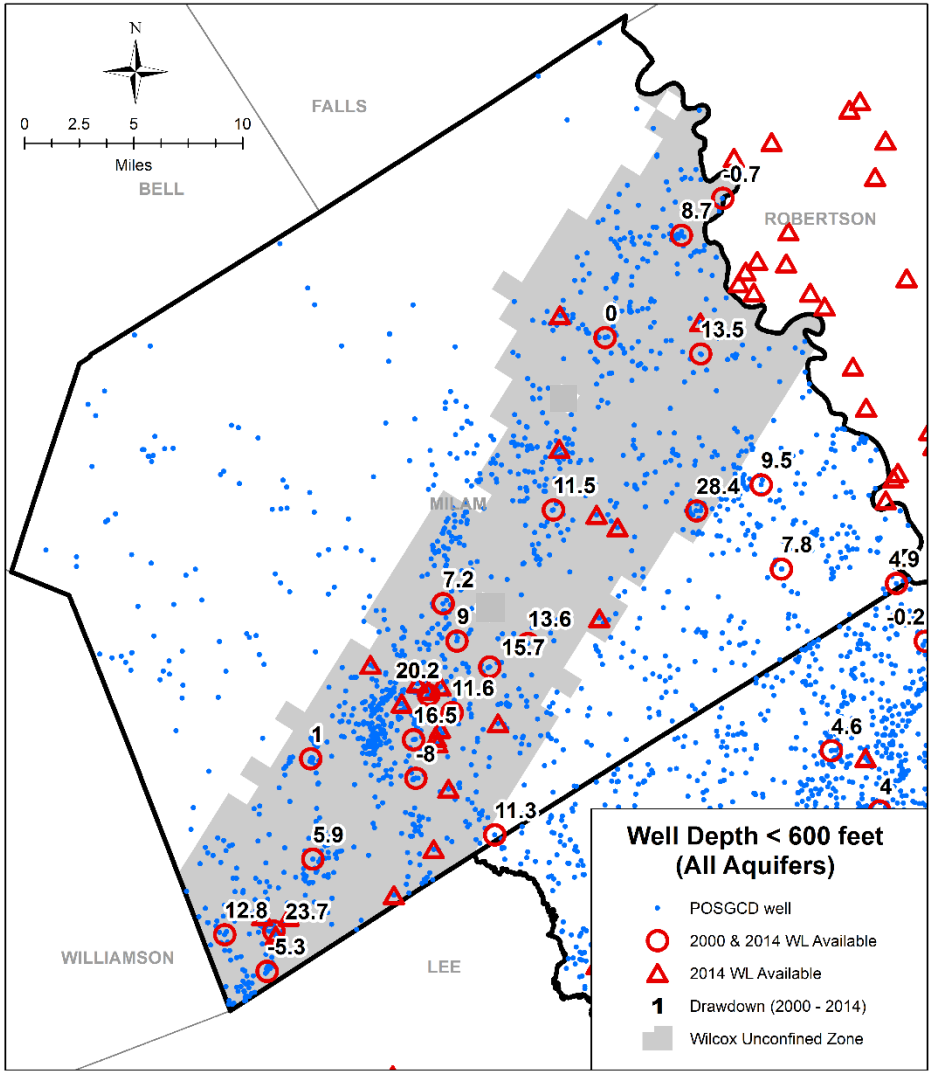
All Aquifers: Shallow Wells





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Path Forward for Reevaluation of Shallow Monitoring Zone

- Considerations for Shallow Zone Delineation
  - Delineation by aquifer
  - Cut off at 400 to 600 feet maximum well depth
  - Use GAM surfaces to assign wells to aquifers
  - Areal extent should be more similar to unconfined boundary than current shallow boundary

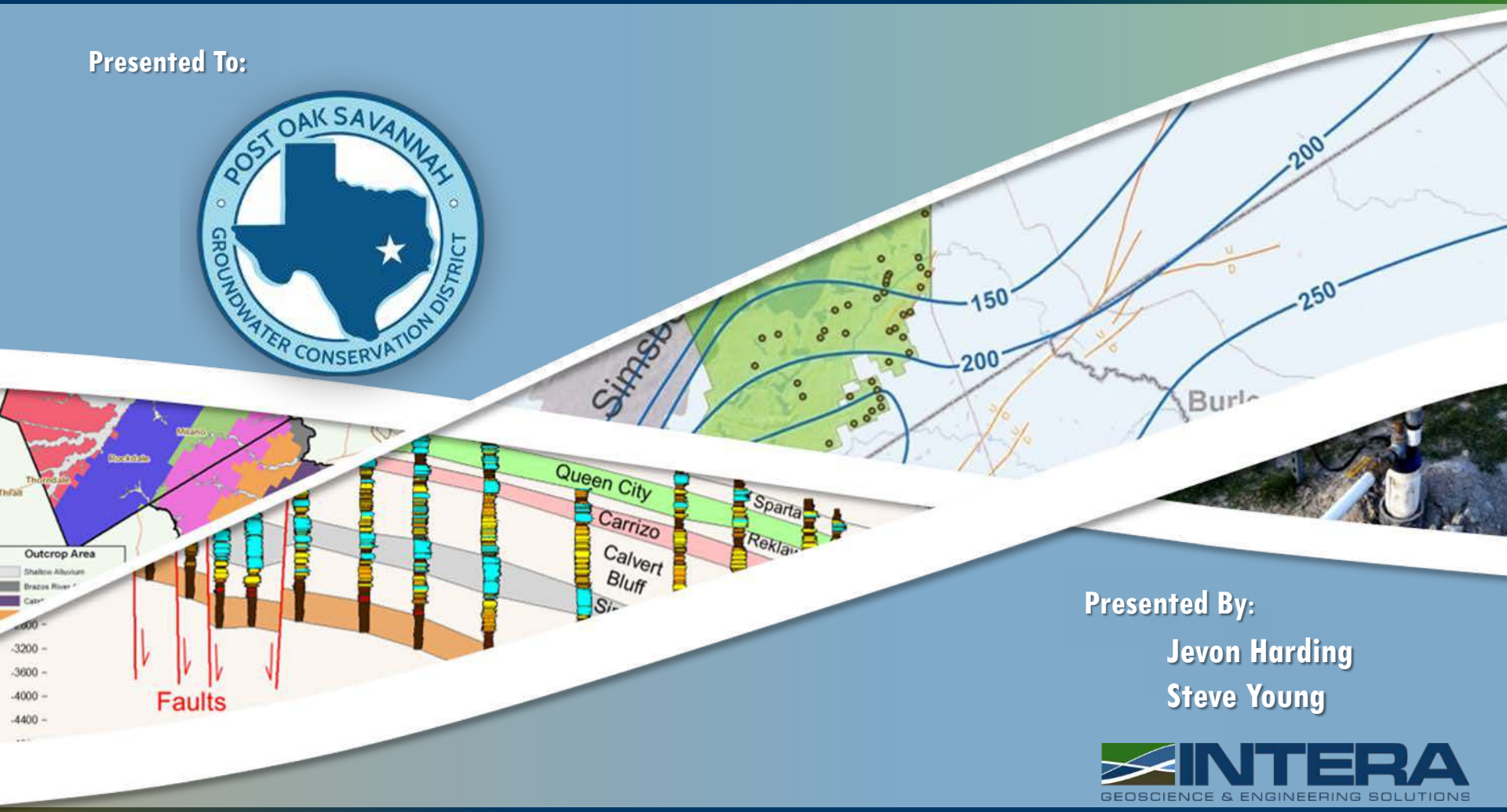
- Consideration for Drawdown Criteria
  - Mitigation Program for Shallow Wheels
  - Estimated Heights of water column in a well
    - above top of screen (most wells should have 200 to 300 feet of water above screen)
    - above bottom of well
    - above bottom of aquifer
    - above base of the Hooper (Hooper may be less than Simsboro)
  - Historical drawdowns (varies between about 5 feet and 100 feet in Simsboro)
  - Total depth to water level in wells (about 100 feet in Simsboro)
  - Predicted drawdowns from Pumping Scenario 6 Simulations

ATTACHMENT D:
GROUNDWATER MONITORING UPDATE AND INVESTIGATION INTO ALTERNATIVE DEFINITIONS FOR SHALLOW MONITORING ZONE
MAY 10, 2016

Groundwater Monitoring Update and Investigation into Alternative Definitions for Shallow Monitoring Zone

Presented To:

POST OAK SAVANNAH GROUNDWATER CONSERVATION DISTRICT



Presented By:

Jevon Harding

Steve Young

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May 10, 2016

Outline

- Rationale for Monitoring Shallow Zone
- Analysis of Monitoring Data for DFC Compliance
  - Calculations for 2000 – 2014
- Shallow Zone
  - wells < 400 or < 500 feet deep
  - Include wells in ALL aquifers

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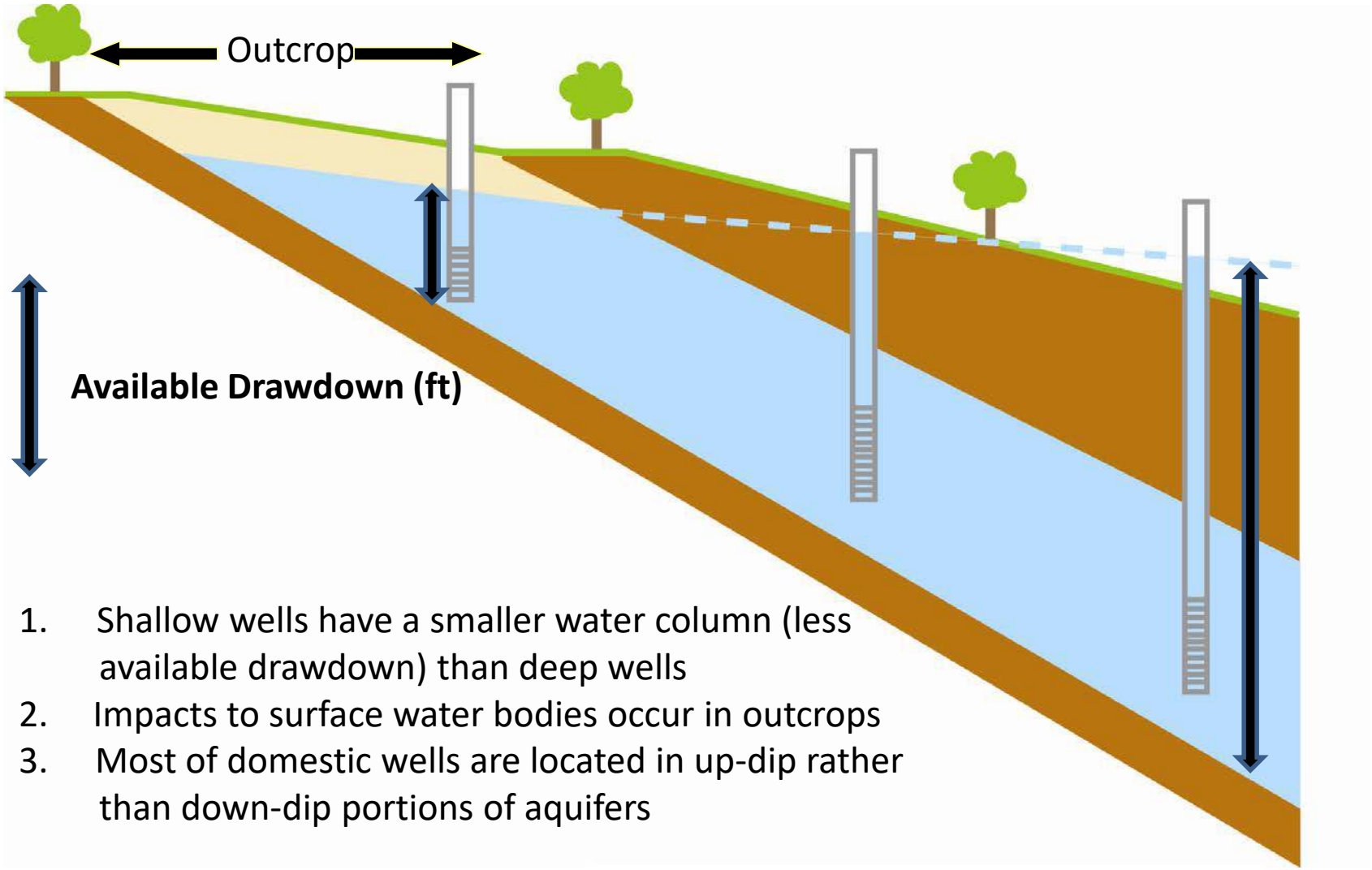
Rationale for Shallow Monitoring Zone



1. Shallow wells have a smaller water column (less available drawdown) than deep wells
2. Impacts to surface water bodies occur in outcrops
3. Most of domestic wells are located in up-dip rather than down-dip portions of aquifers

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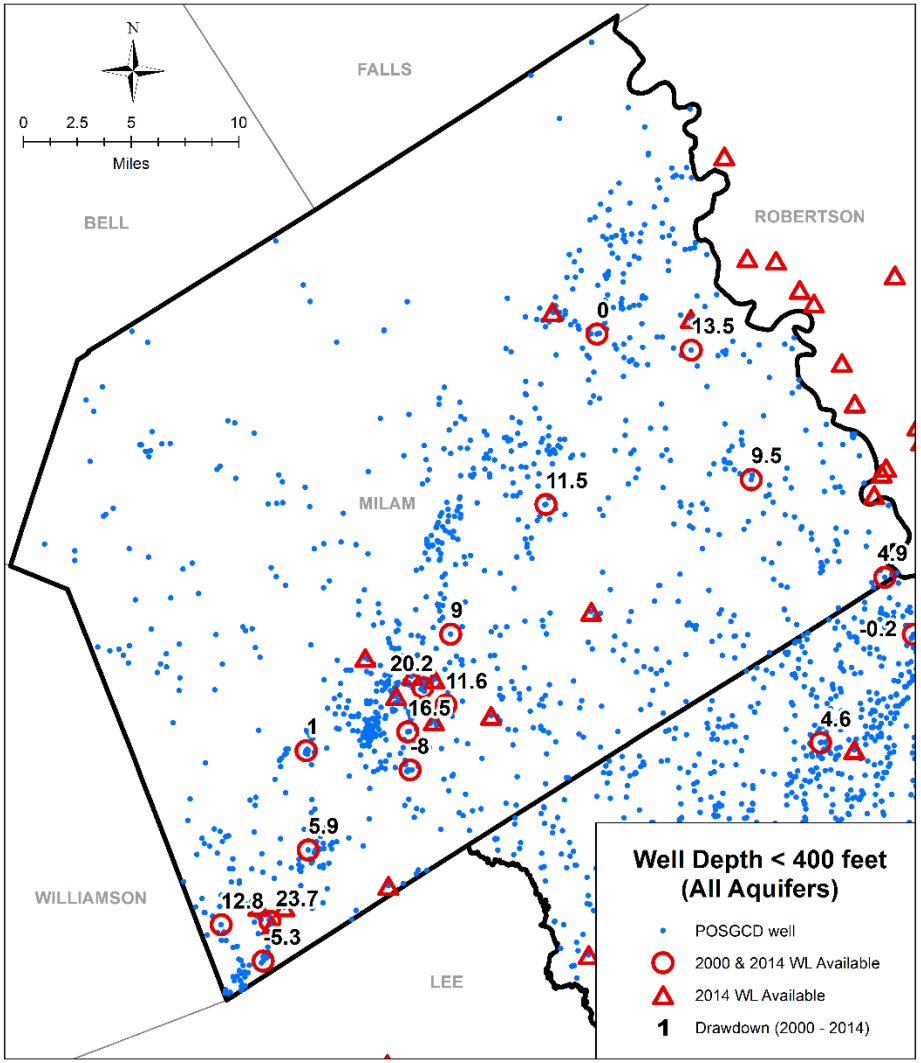
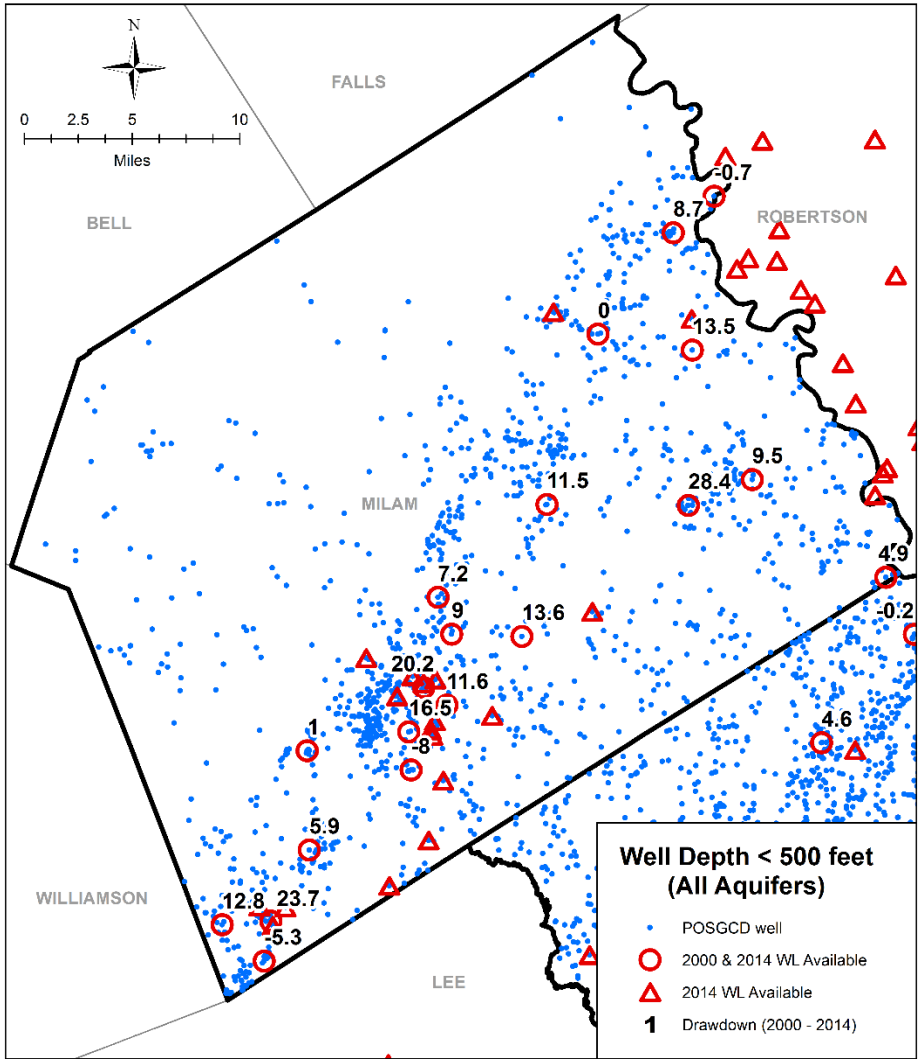
Reevaluation of Shallow Monitoring Zone

Cut off at 400 to 500 feet maximum well depth





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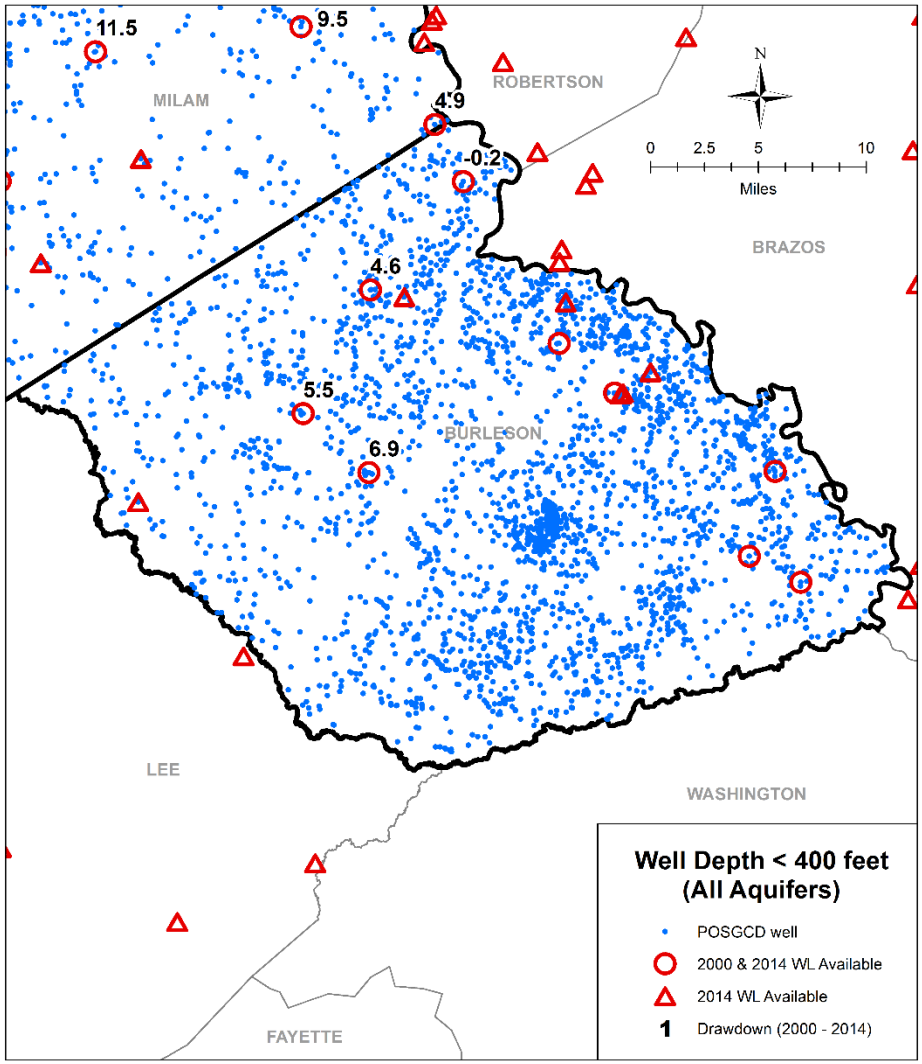
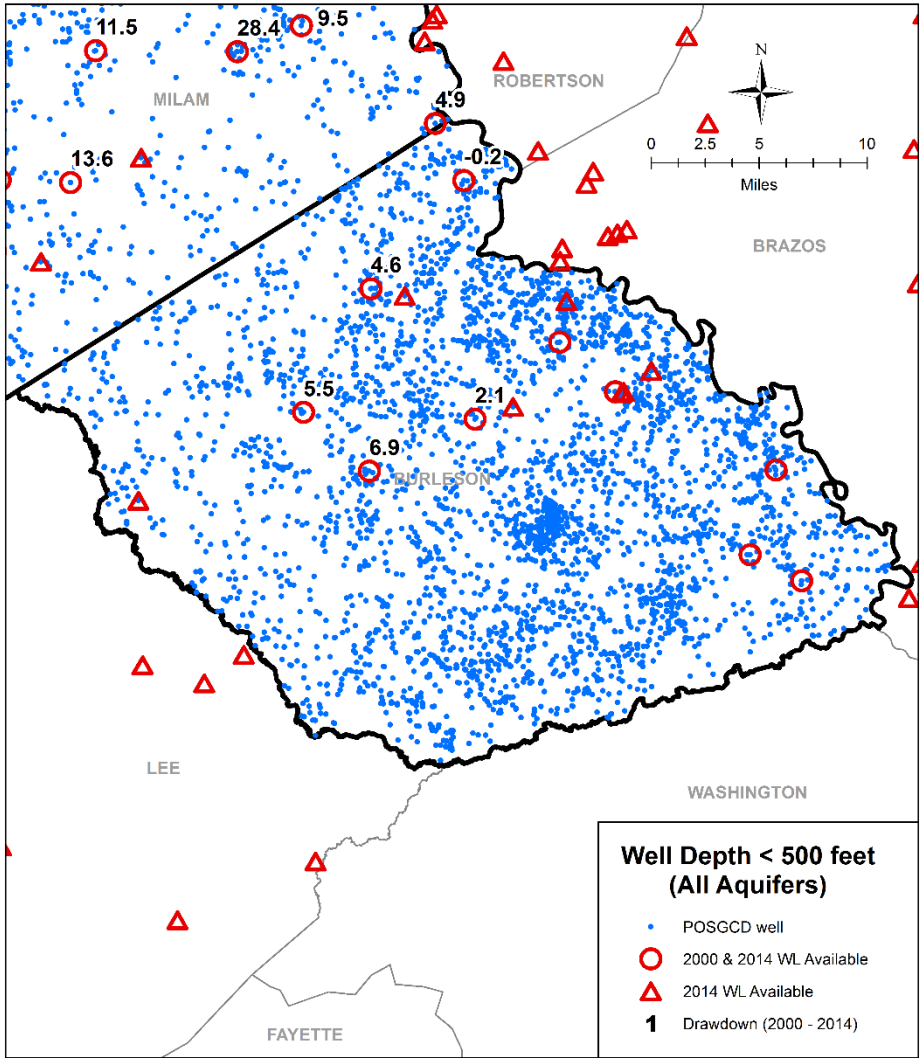
Reevaluation of Shallow Monitoring Zone

Cut off at 400 to 500 feet maximum well depth





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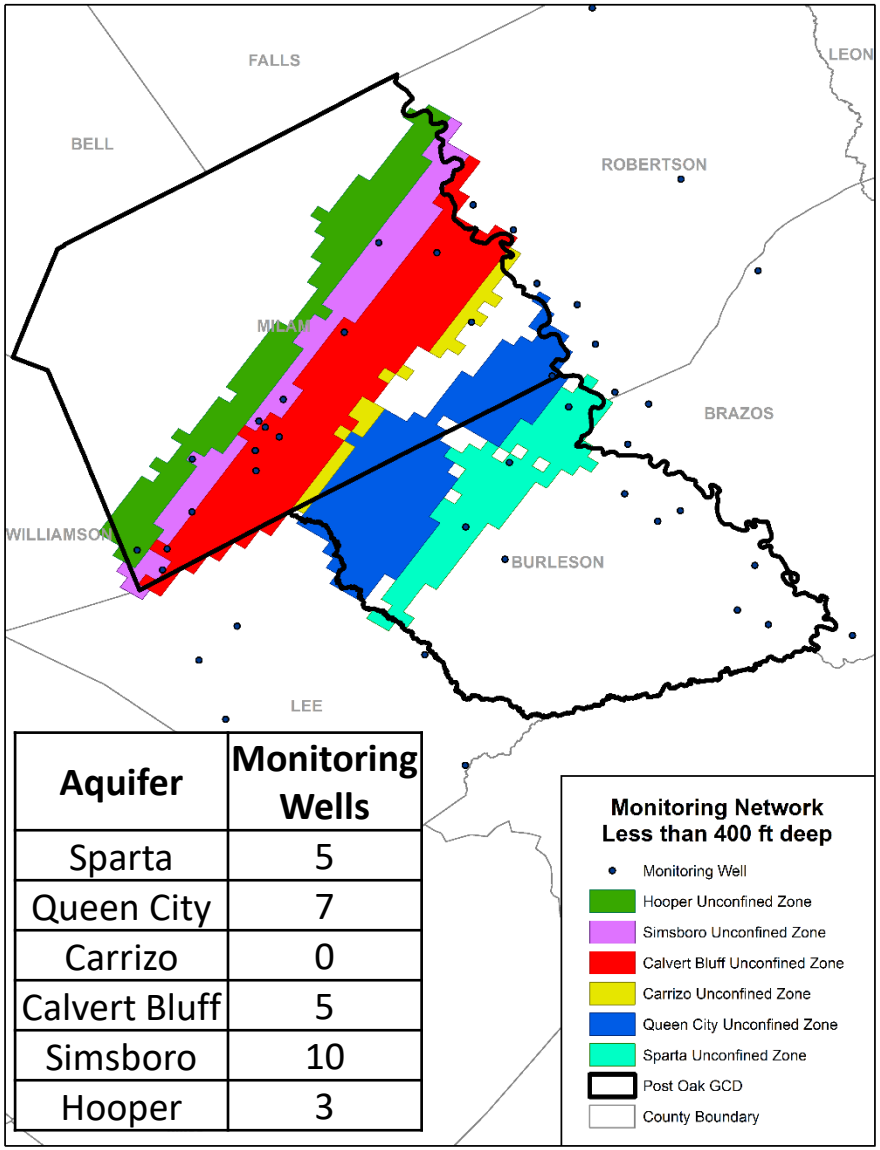
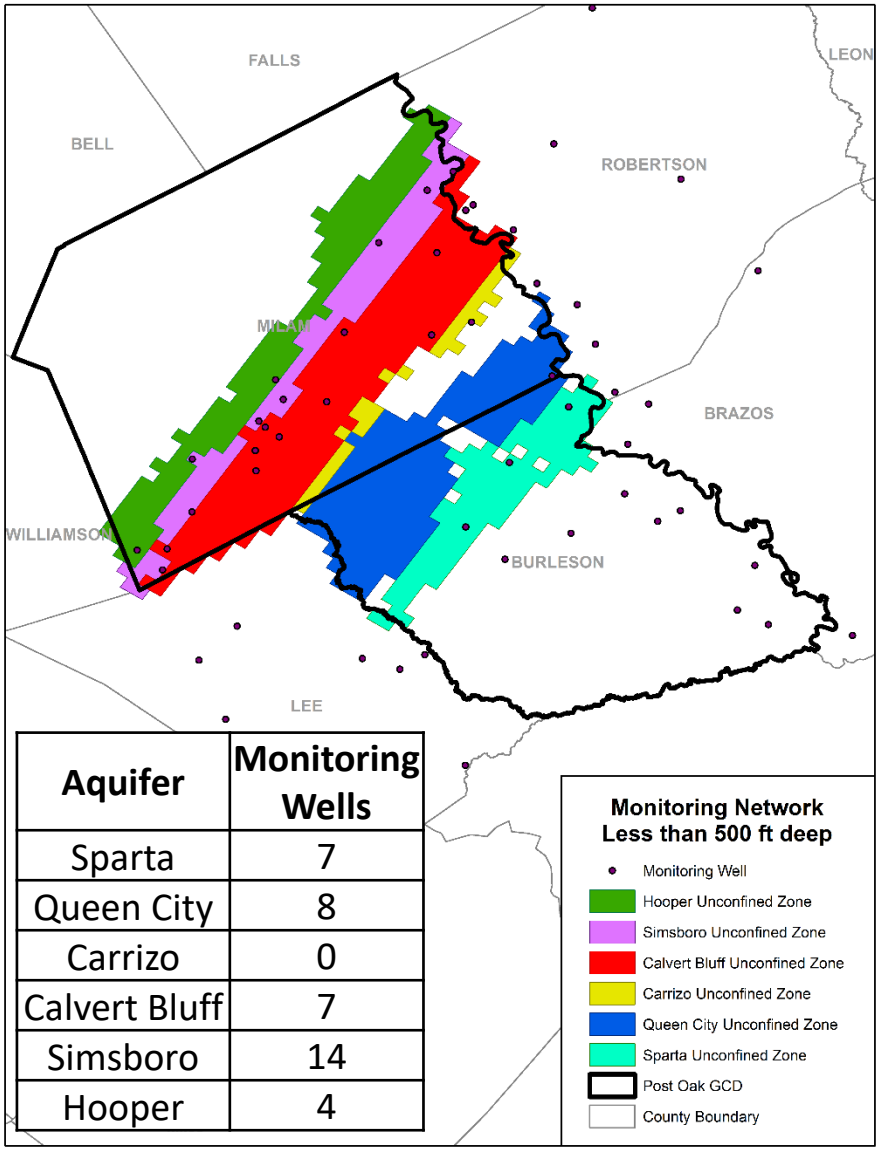
Monitoring Network Coverage



Aquifer	Monitoring Wells
Sparta	5
Queen City	7
Carrizo	0
Calvert Bluff	5
Simsboro	10
Hooper	3



Aquifer	Monitoring Wells
Sparta	7
Queen City	8
Carrizo	0
Calvert Bluff	7
Simsboro	14
Hooper	4

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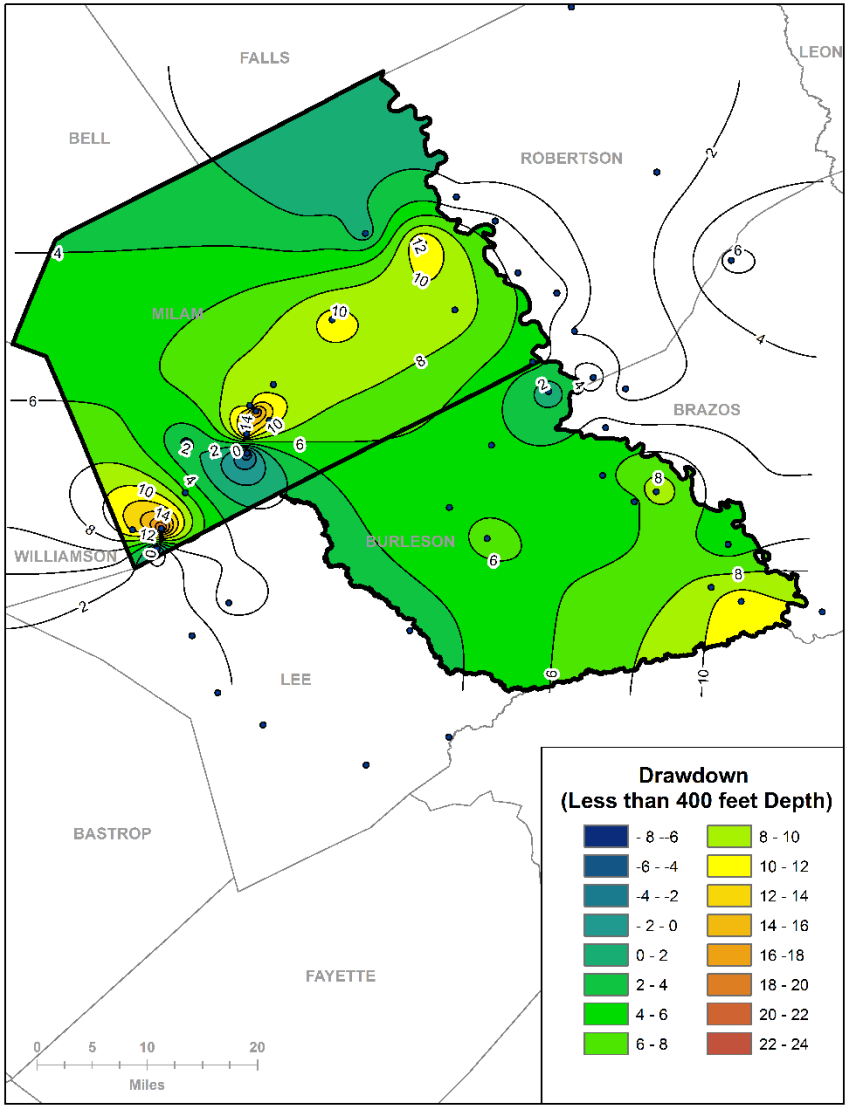
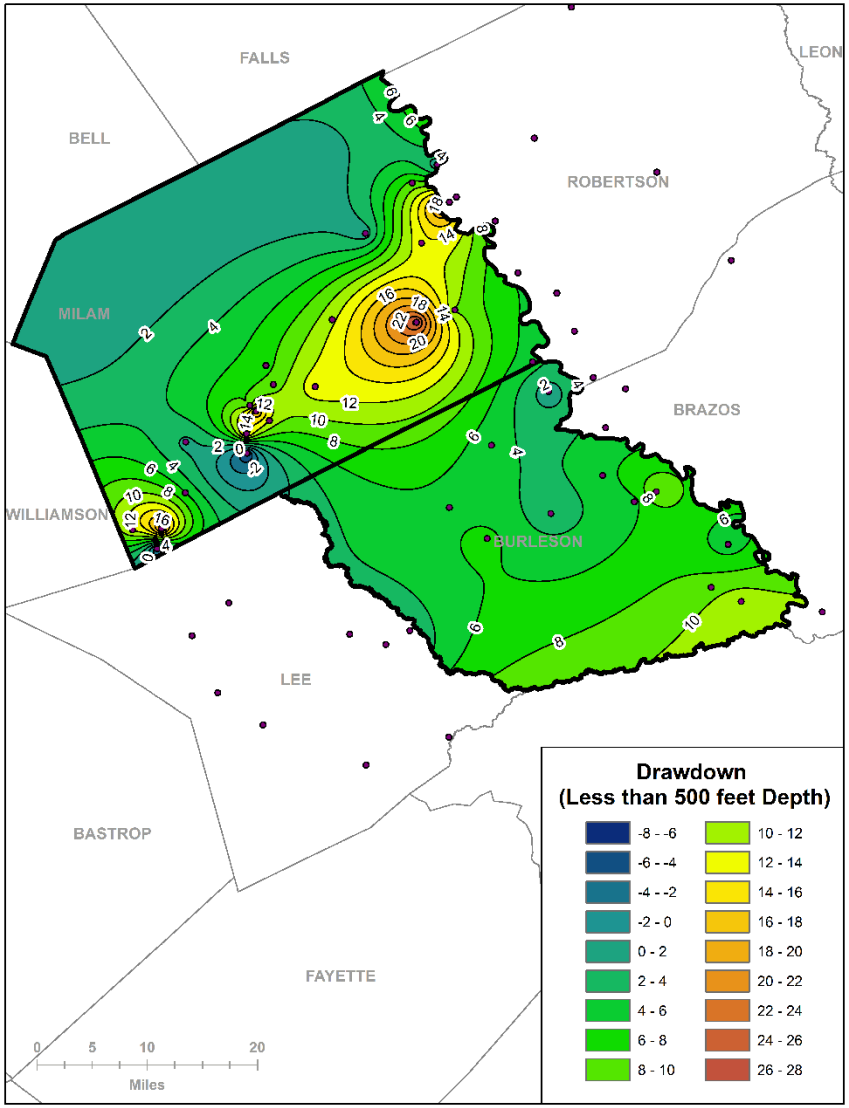
Drawdown in Shallow Wells





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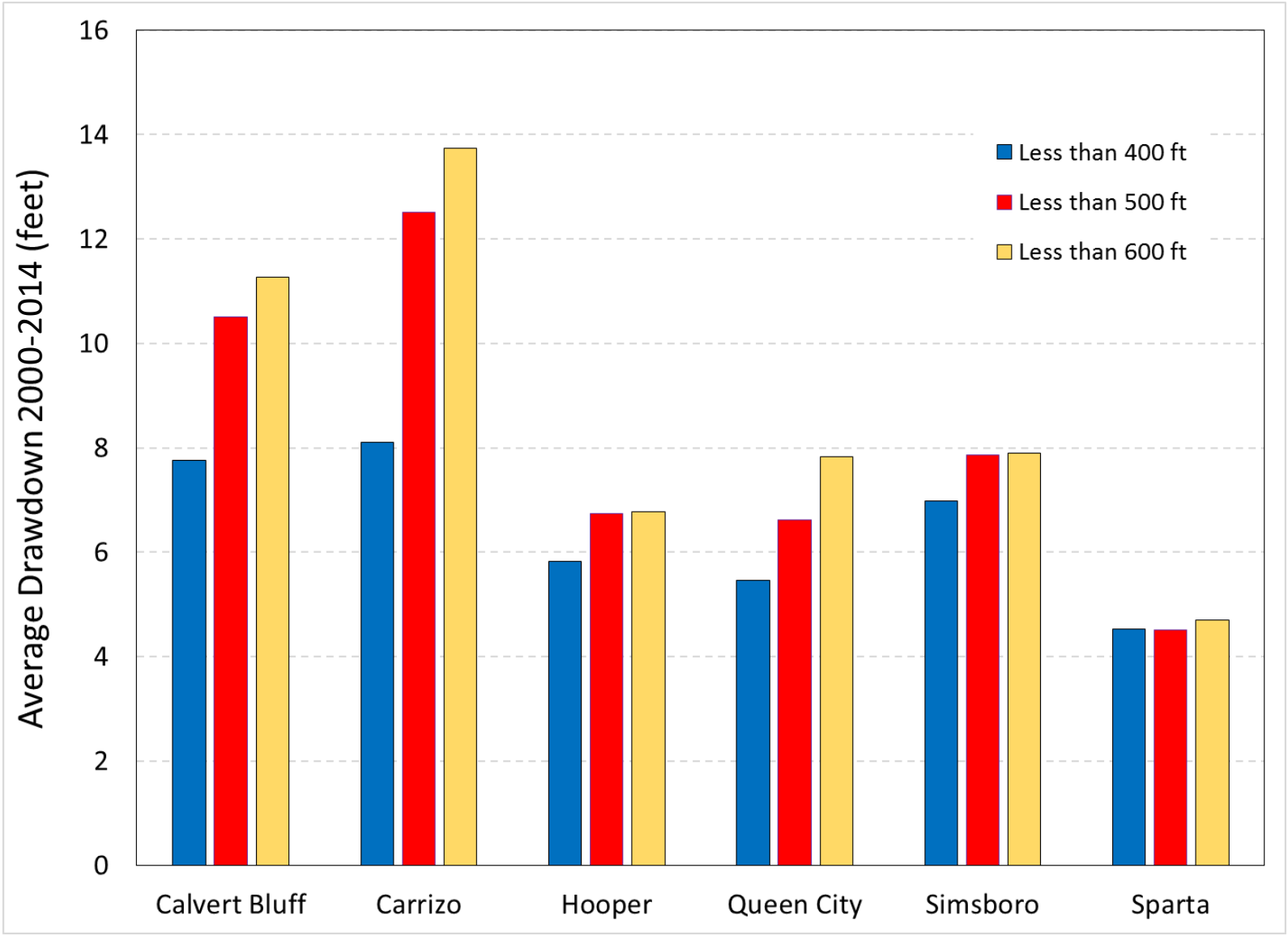
Average Drawdown Using Different Depth Cut-offs



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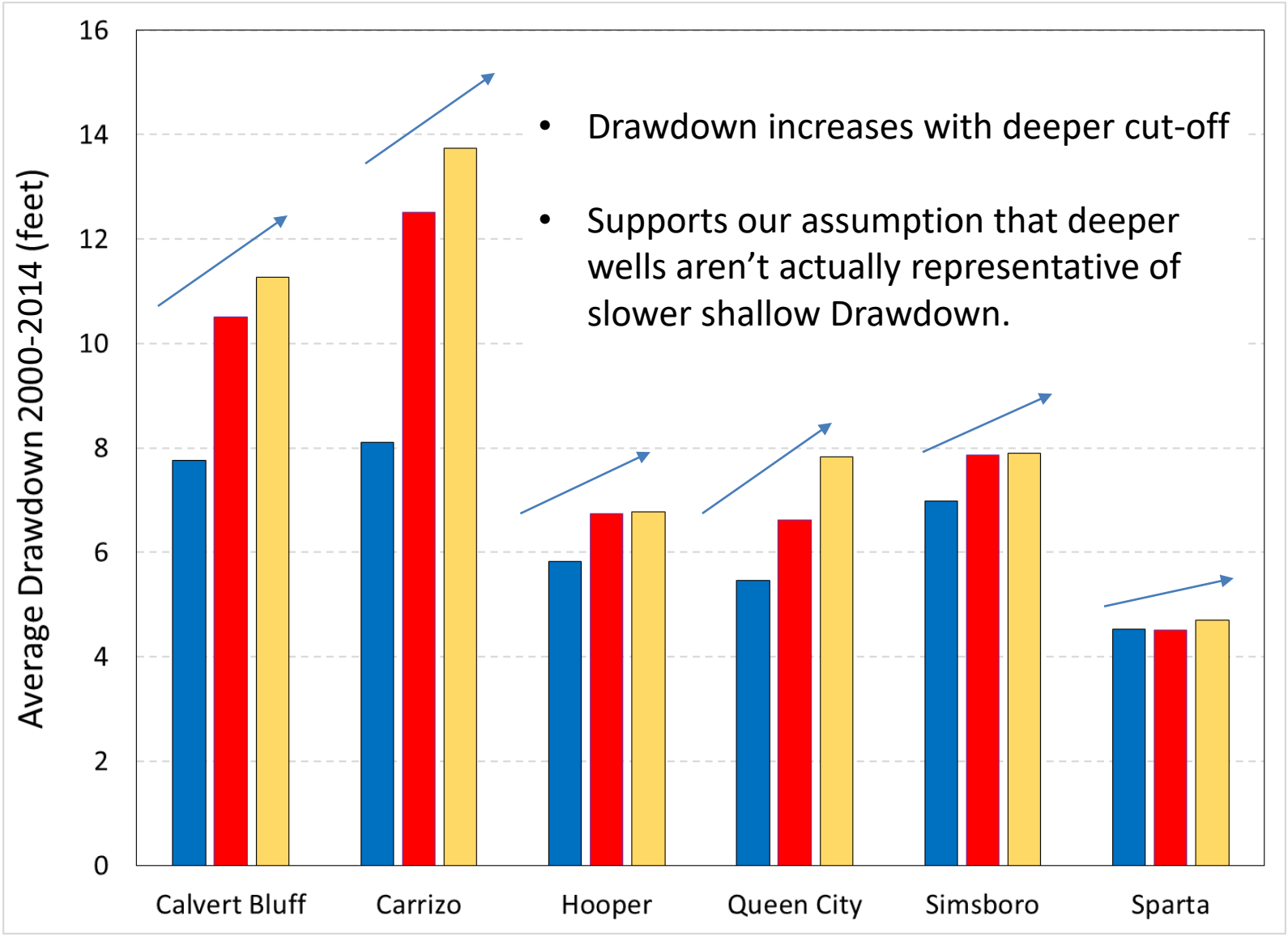
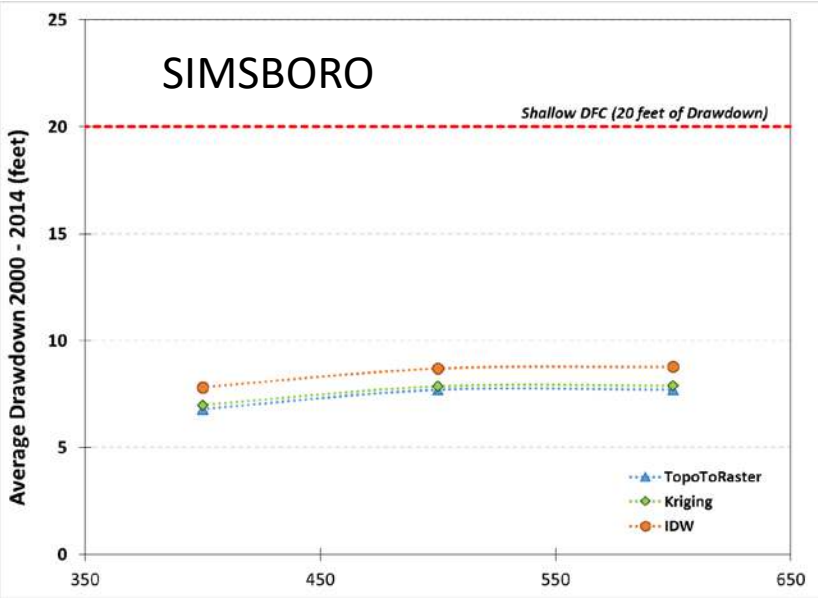
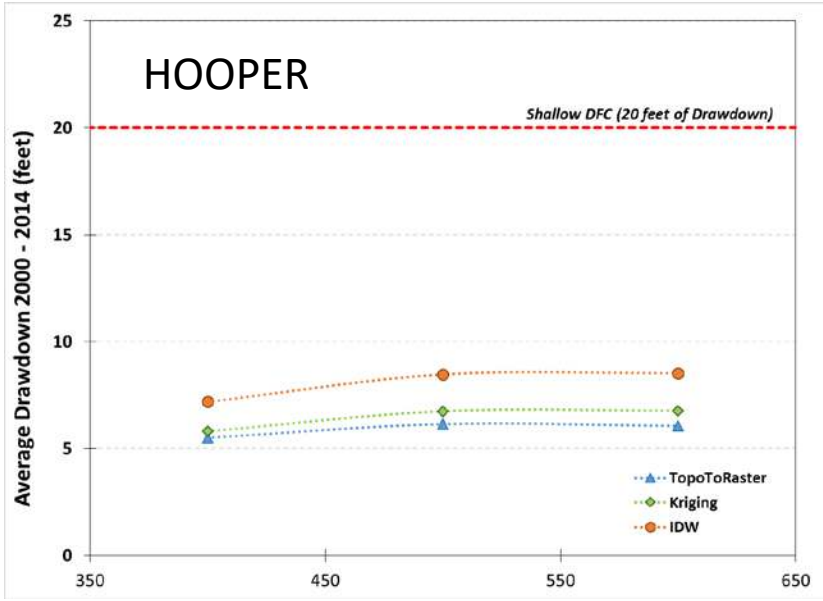
Average Drawdown Using Different Depth Cut-offs

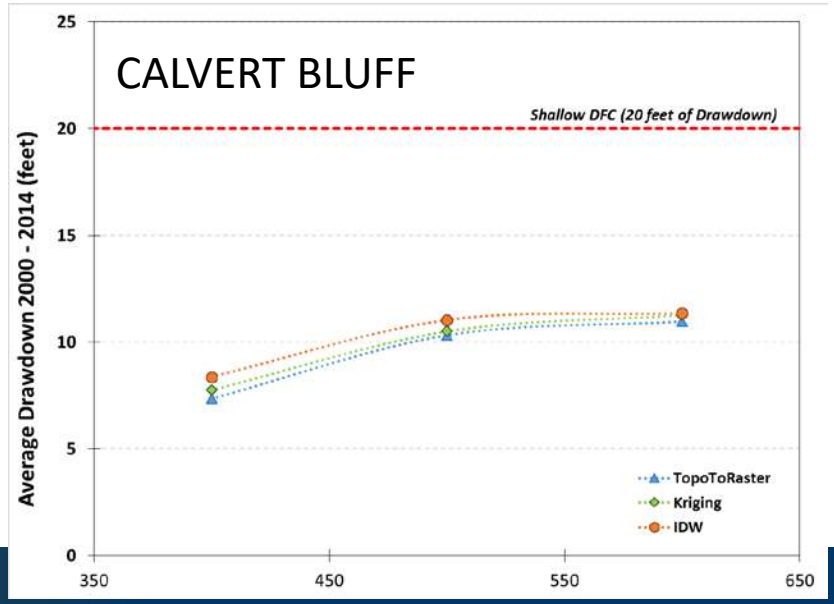


INTERA GEOSCIENCE & ENGINEERING SOLUTIONS

Average Drawdown Using Different Interpolation Methods







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Average Drawdown Using Different Interpolation Methods

Using 400 ft Cut-off

Aquifer	Average Drawdown
Sparta	4.5 *(4.3) (4.5)*
Queen City	5.5 *(5.1) (6.4)*
Carrizo	8.1 *(7.6) (8.4)*
Calvert Bluff	7.8 *(7.2) (8.4)*
Simsboro	7.0 *(6.7) (7.8)*
Hooper	5.8 *(5.5) (7.2)*

(IDW)

(Topo To Raster)

Kriging

Using 500 ft Cut-off

Aquifer	Average Drawdown
Sparta	4.5 *(4.6) (4.1)*
Queen City	6.6 *(7.1) (7.3)*
Carrizo	12.5 *(12.7) (13.2)*
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Using 600 ft Cut-off

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Hooper	6.8 *(6.1) (8.5)*

Original Shallow zones

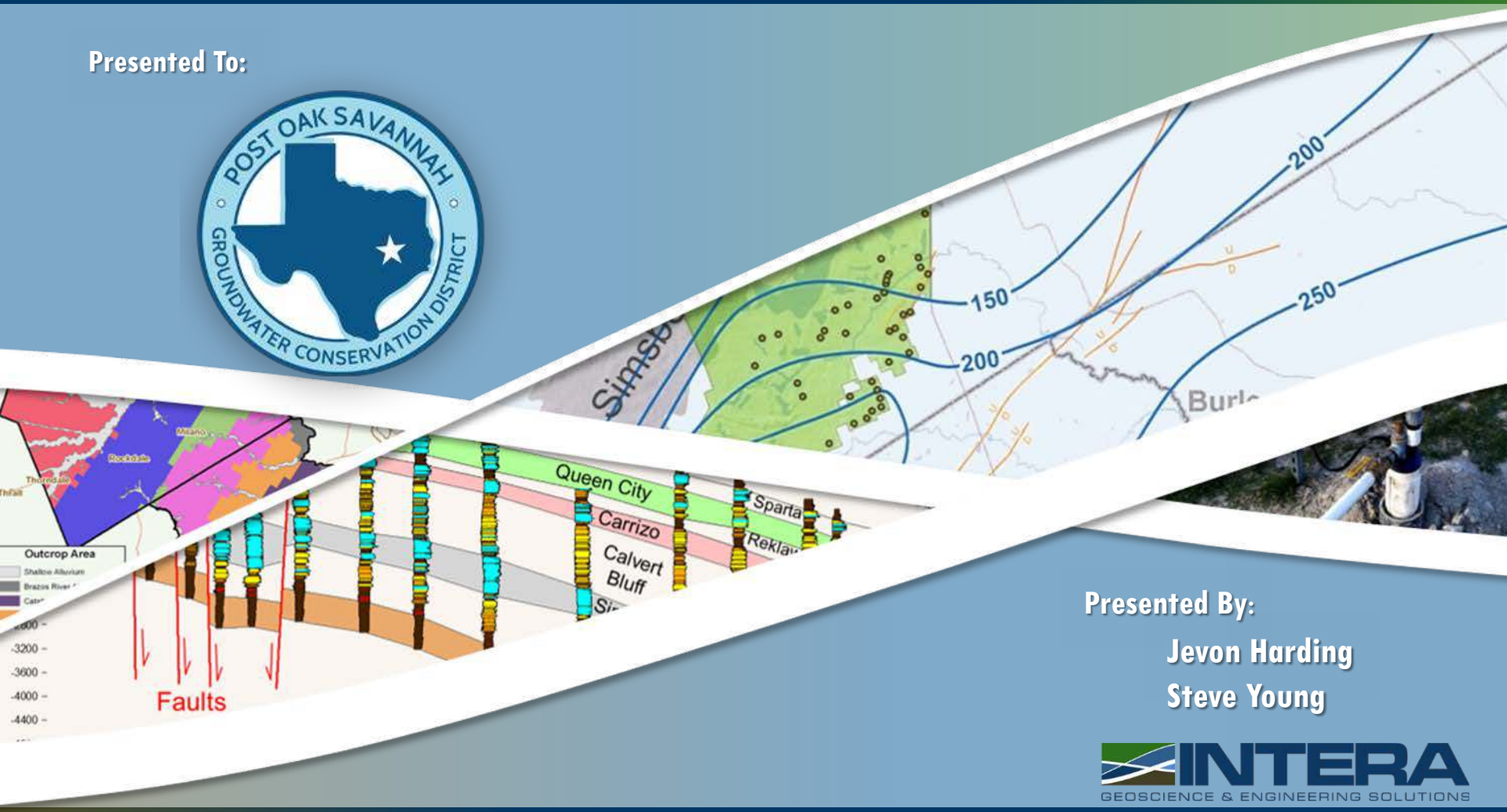
Aquifer	Average Drawdown
Sparta	--
Queen City	--
Carrizo	--
Calvert Bluff	1.3
Simsboro	10.8
Hooper	7.2

ATTACHMENT E:
GROUNDWATER MONITORING UPDATE AND INVESTIGATION INTO ALTERNATIVE DEFINITIONS FOR SHALLOW MONITORING ZONE
MAY 3, 2017

Groundwater Monitoring Update and Investigation into Alternative Definitions for Shallow Monitoring Zone

Presented To:

POST OAK SAVANNAH GROUNDWATER CONSERVATION DISTRICT



Presented By:

Jevon Harding

Steve Young

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May 3, 2017

Outline

- District-wide shallow water level surfaces for each year from 2012 - 2016 using most recent Monitoring Data
- Calculation of water level change for each year compared to 2000 water level
  - Compare water levels created using all wells VS filtered wells
- Shallow Drawdown in each aquifer (outcrop, shallow zone & average)

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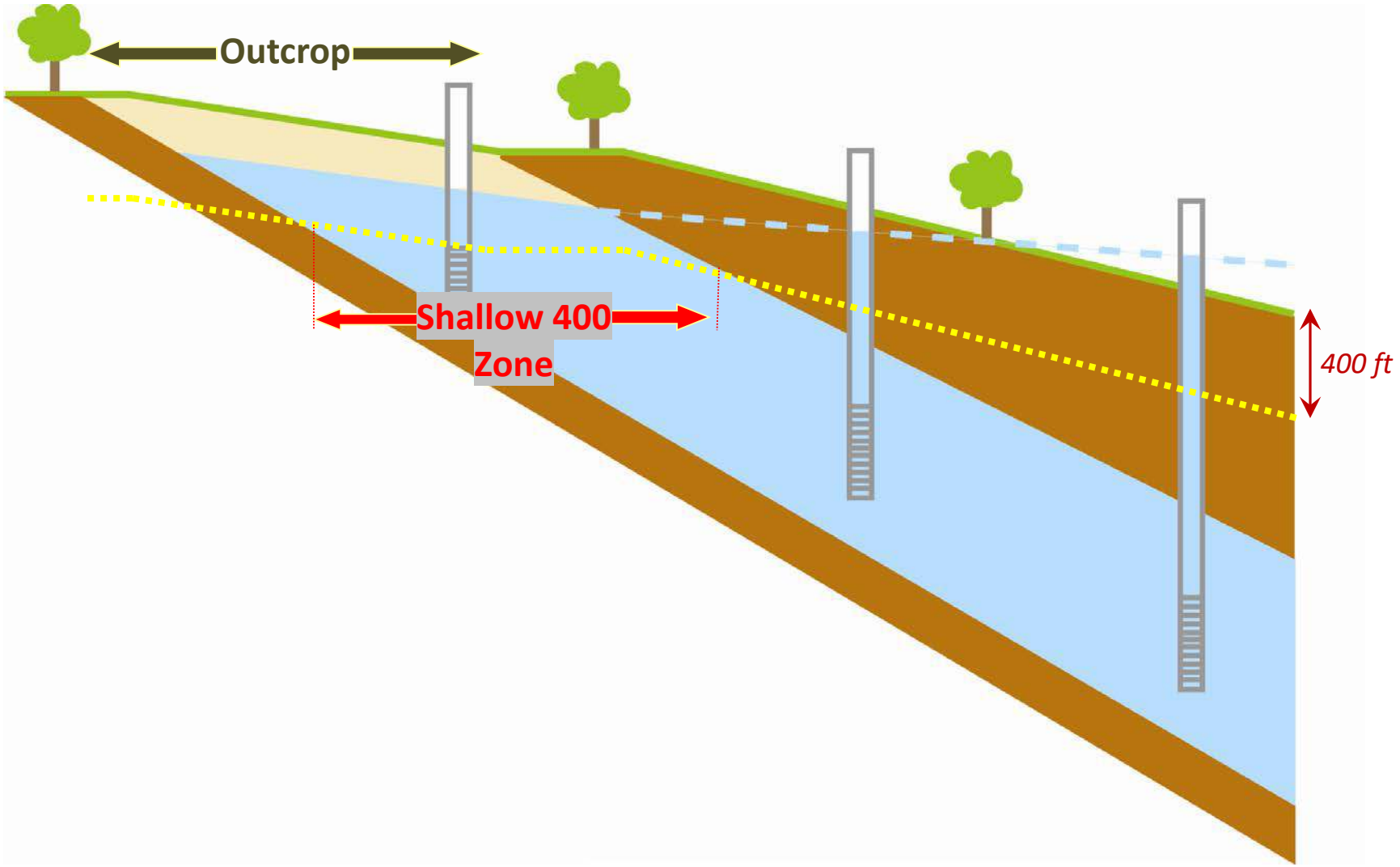
Defining the Shallow Monitoring Zone



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Recap

- Rationale for Monitoring Shallow Zone
- Analysis of Monitoring Data for DFC Compliance
- Shallow Zone
  - wells < 400
  - Include wells in ALL aquifers

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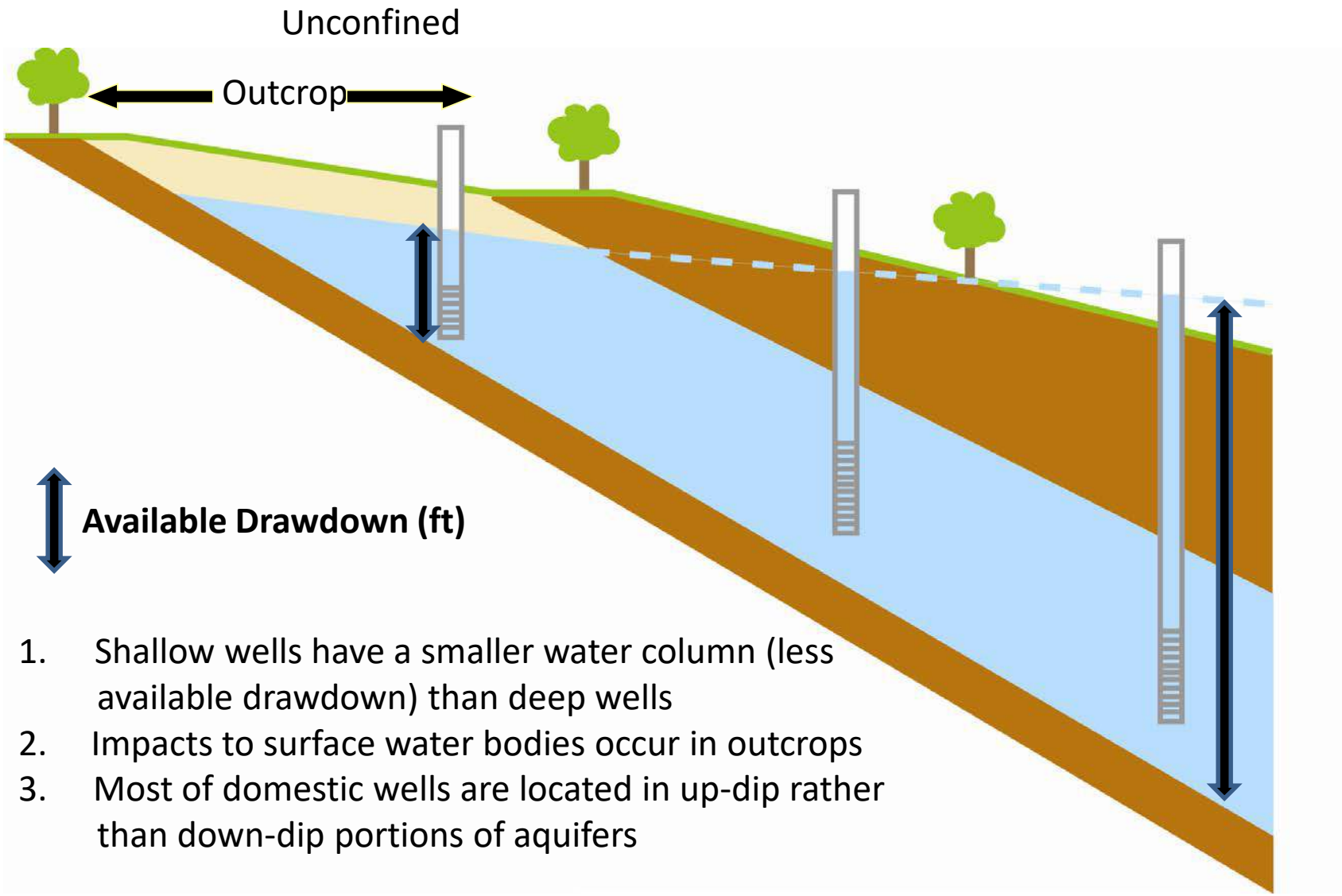
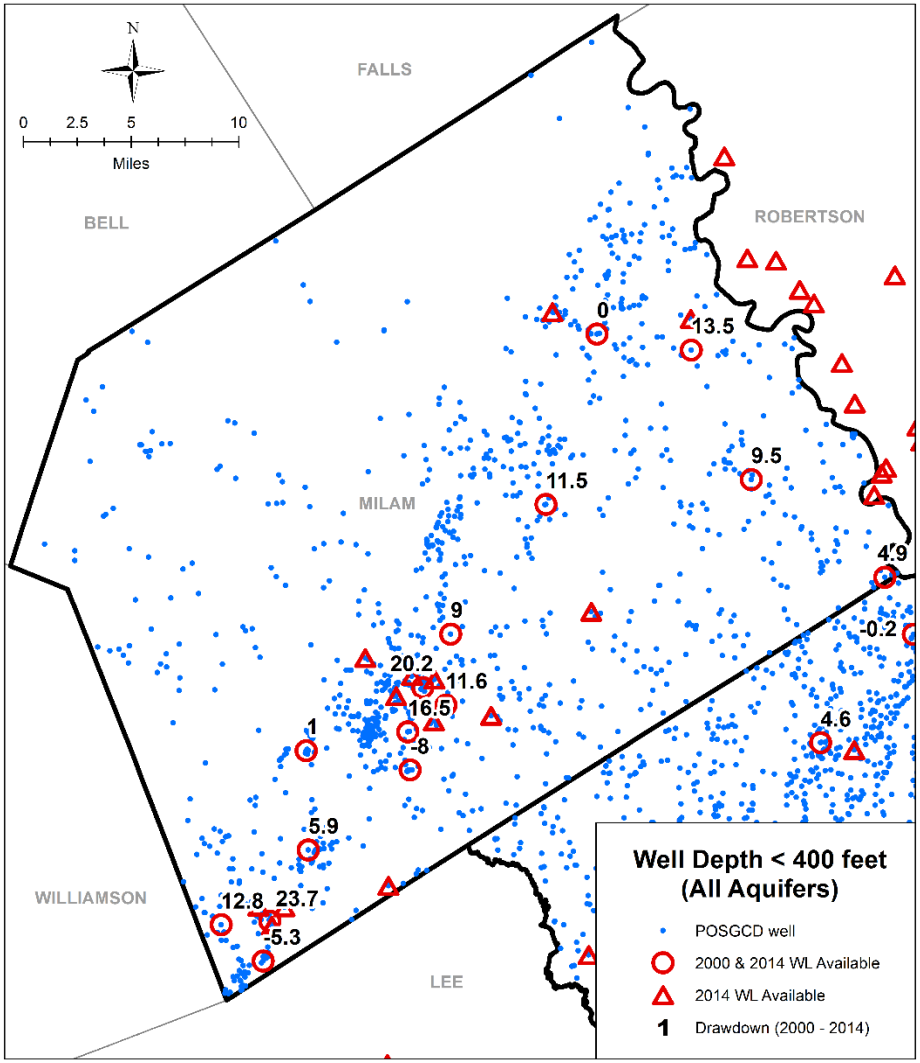
Recap: Rationale for Shallow Monitoring Zone

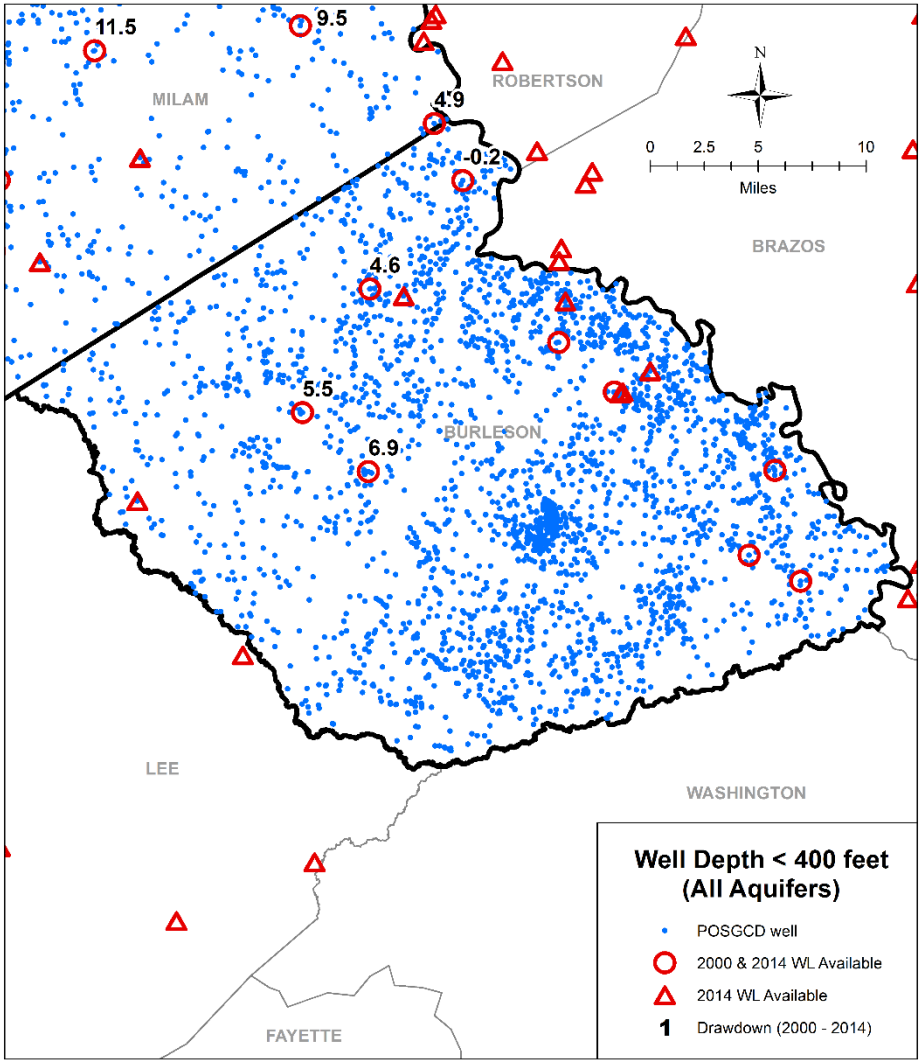


1. Shallow wells have a smaller water column (less available drawdown) than deep wells
2. Impacts to surface water bodies occur in outcrops
3. Most of domestic wells are located in up-dip rather than down-dip portions of aquifers

Recap: Re-evaluation of Shallow Monitoring Zone

Cut off at 400 feet maximum well depth





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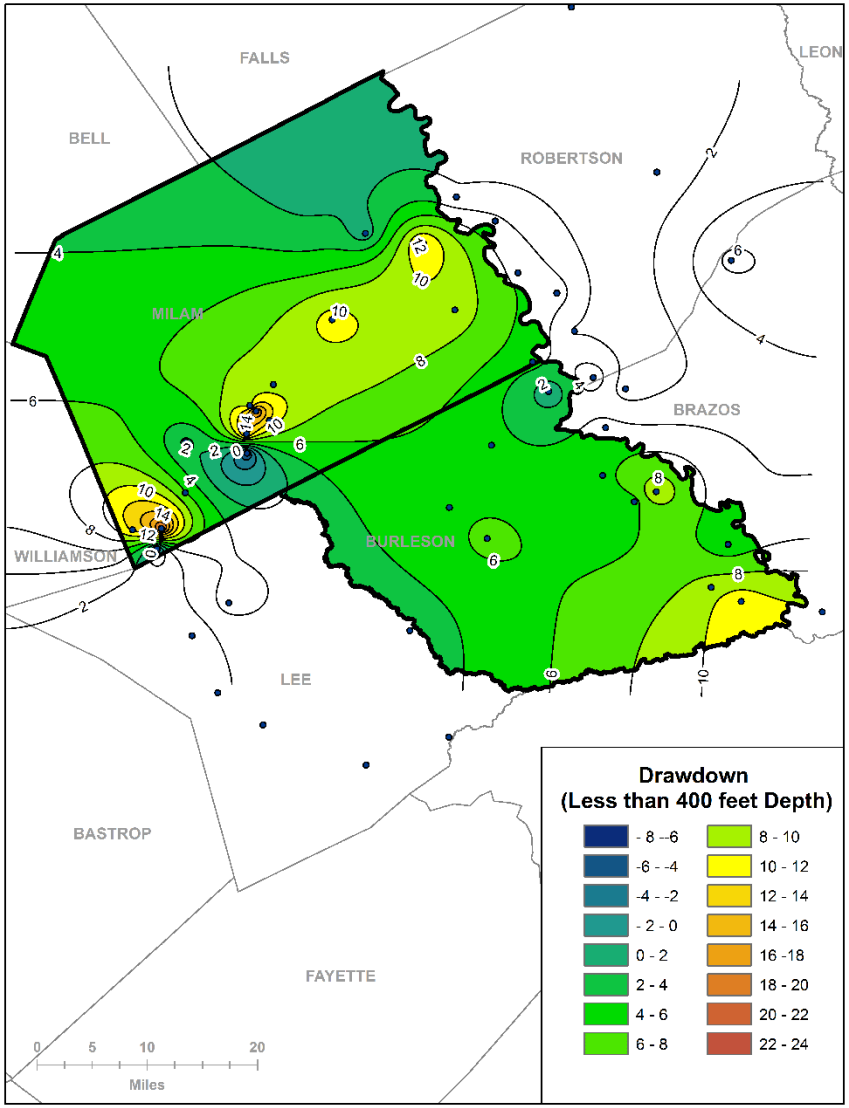
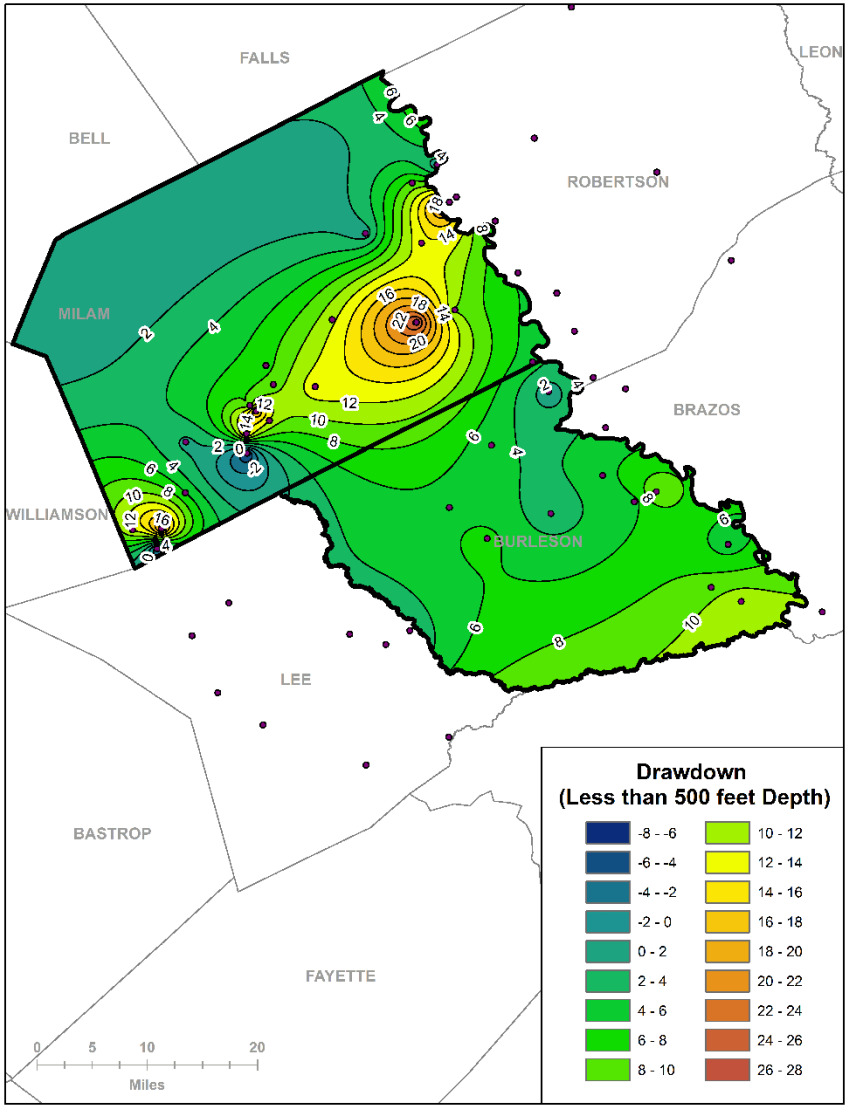
Recap: Drawdown in Shallow Wells





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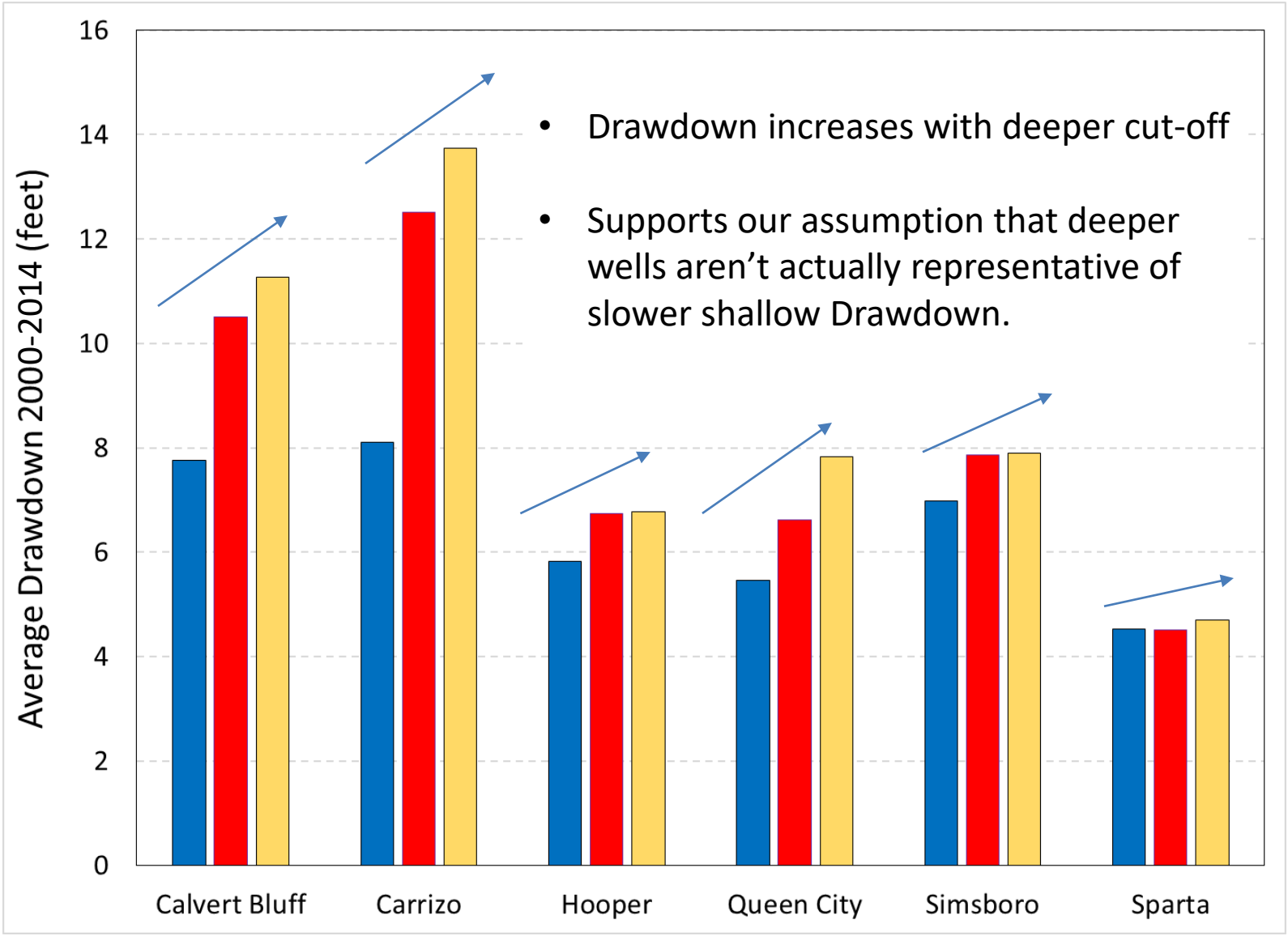
Recap: Average Drawdown Using Different Depth Cut-offs



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Recap: Average Drawdown Using Different Interpolation Methods

Using 400 ft Cut-off

Aquifer	Average Drawdown
Sparta	4.5 *(4.3) (4.5)*
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(IDW)

(Topo To Raster)

Kriging

Using 500 ft Cut-off

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Original Shallow zones

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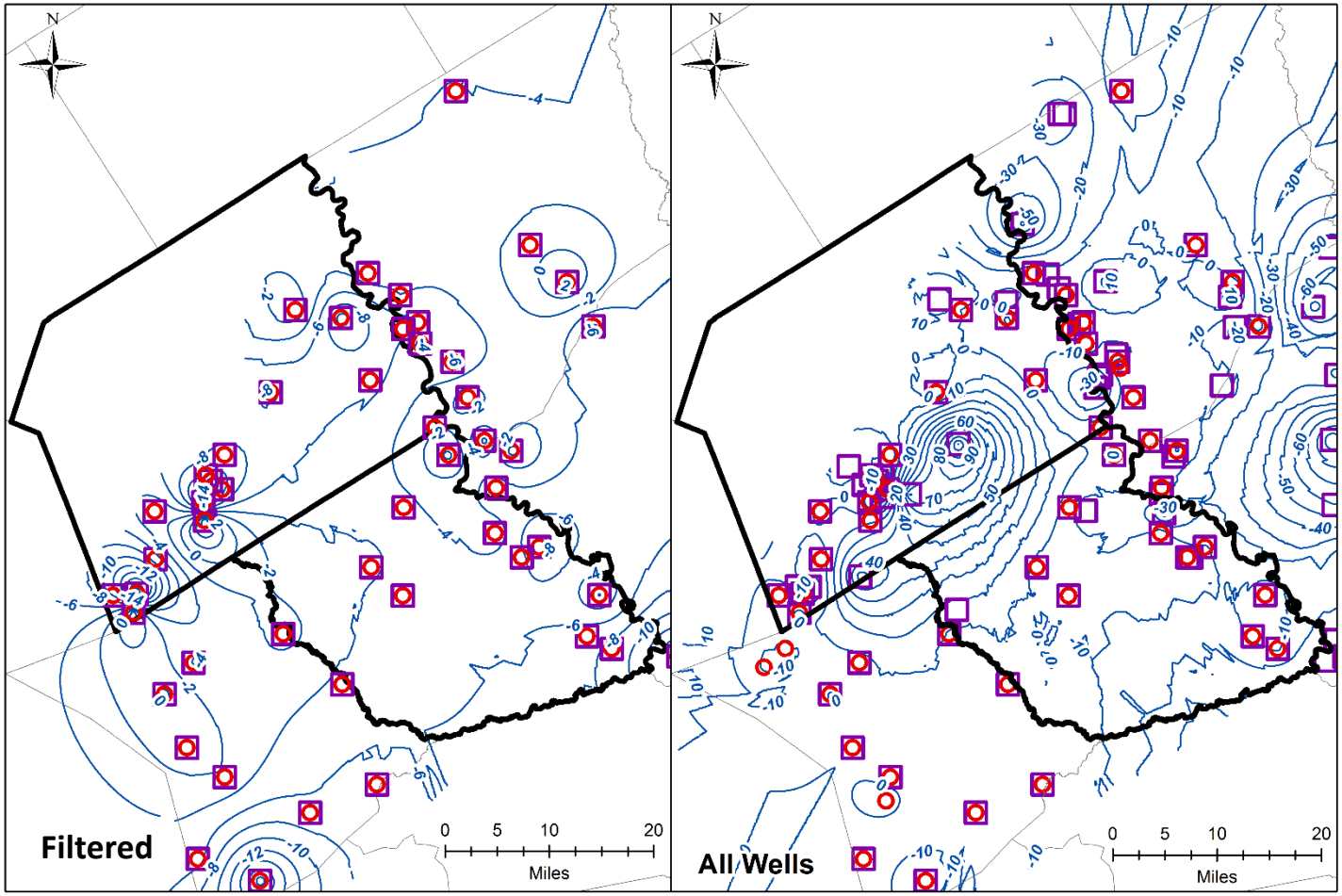
Filtered vs All Wells



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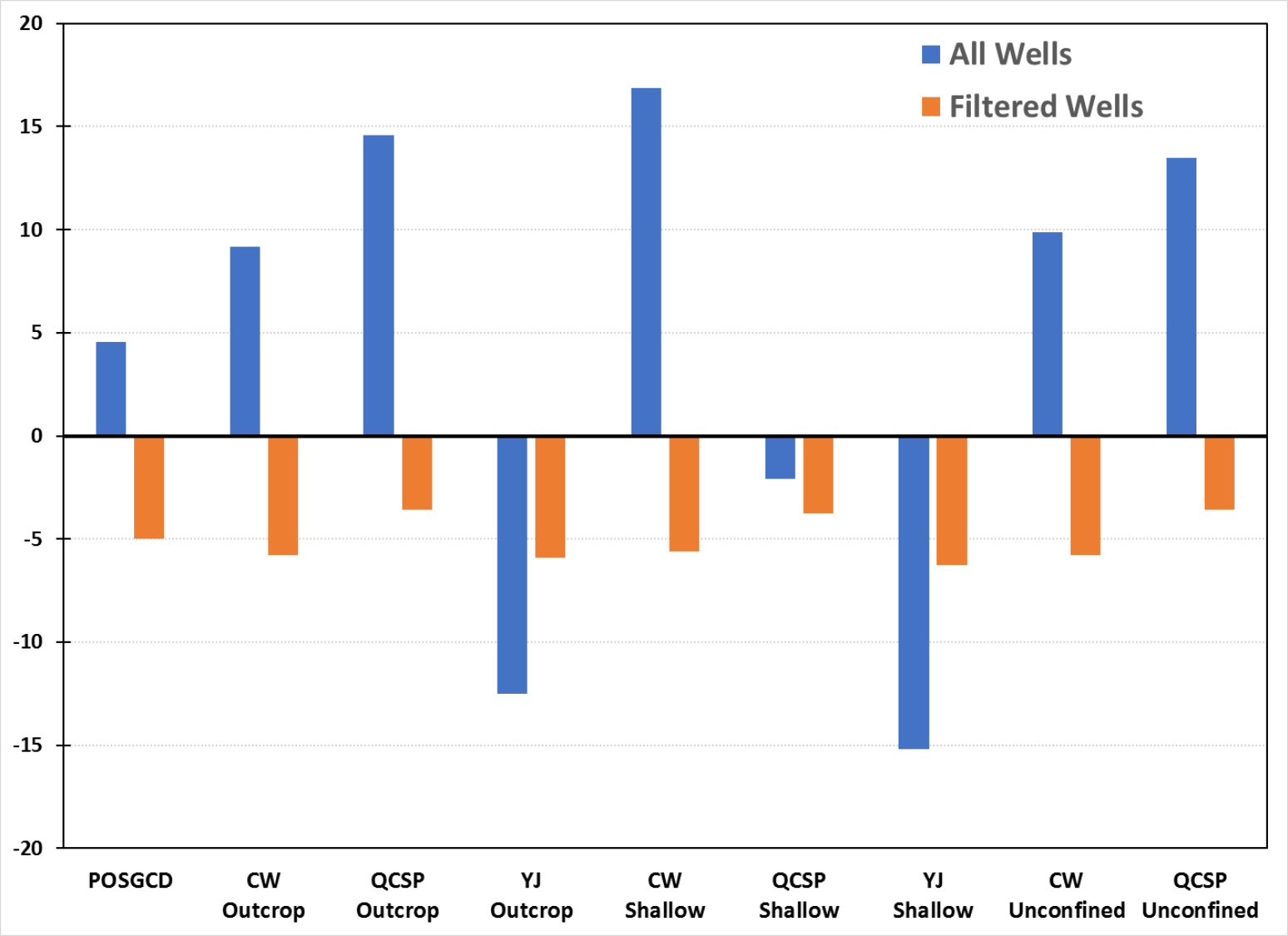
Filtered vs All Wells



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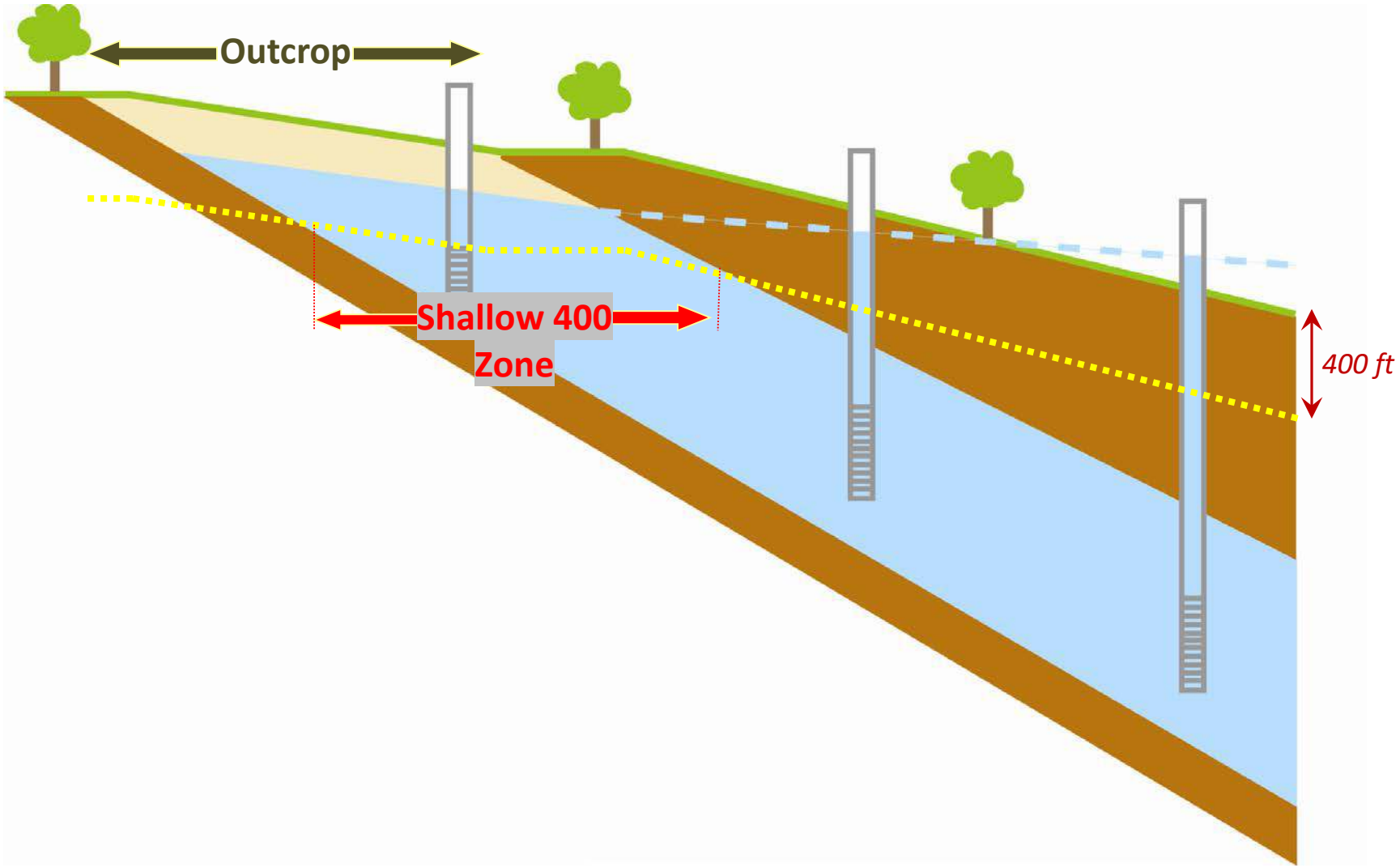
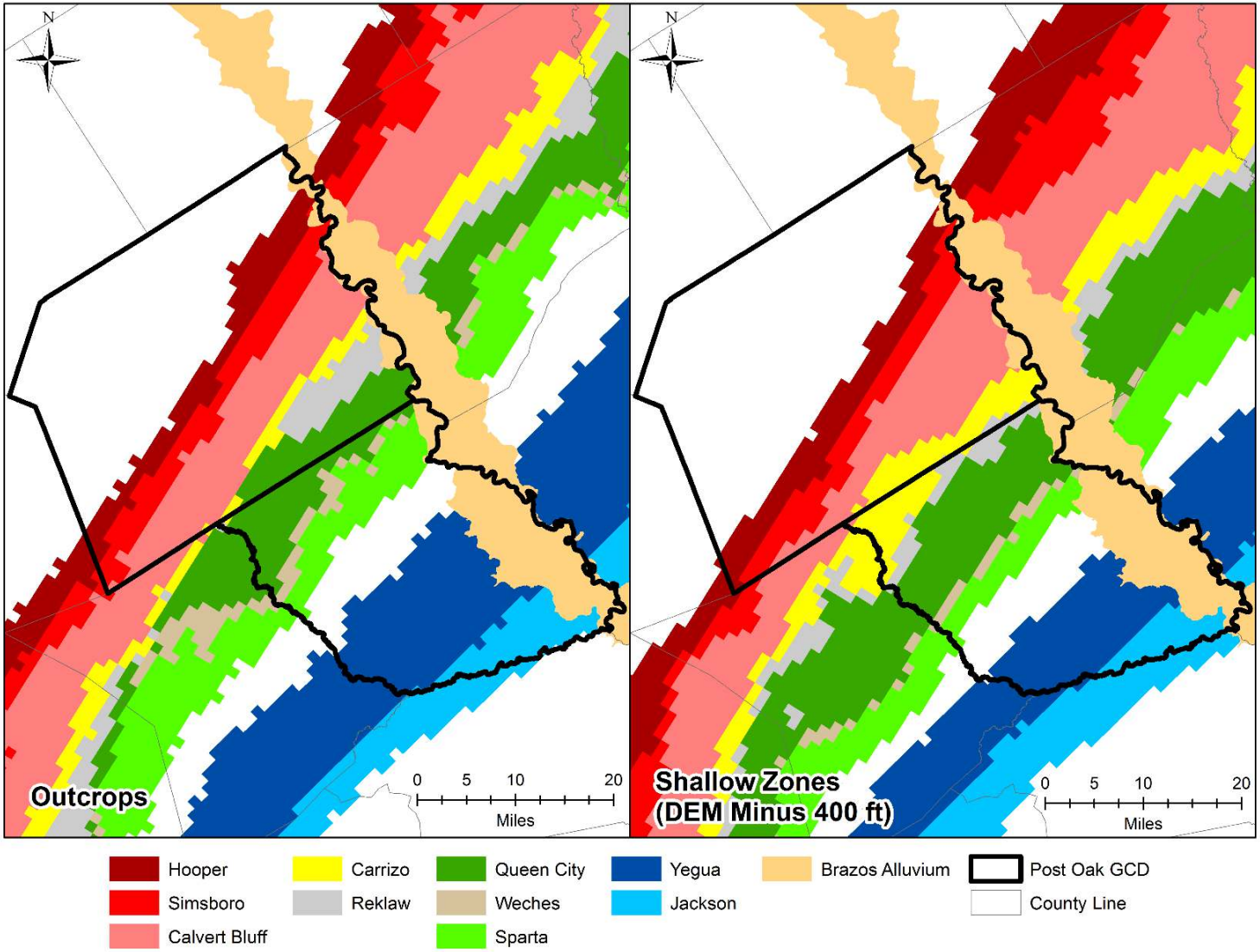
Defining the Shallow Monitoring Zone



Outcrops & Shallow Zones By Formation



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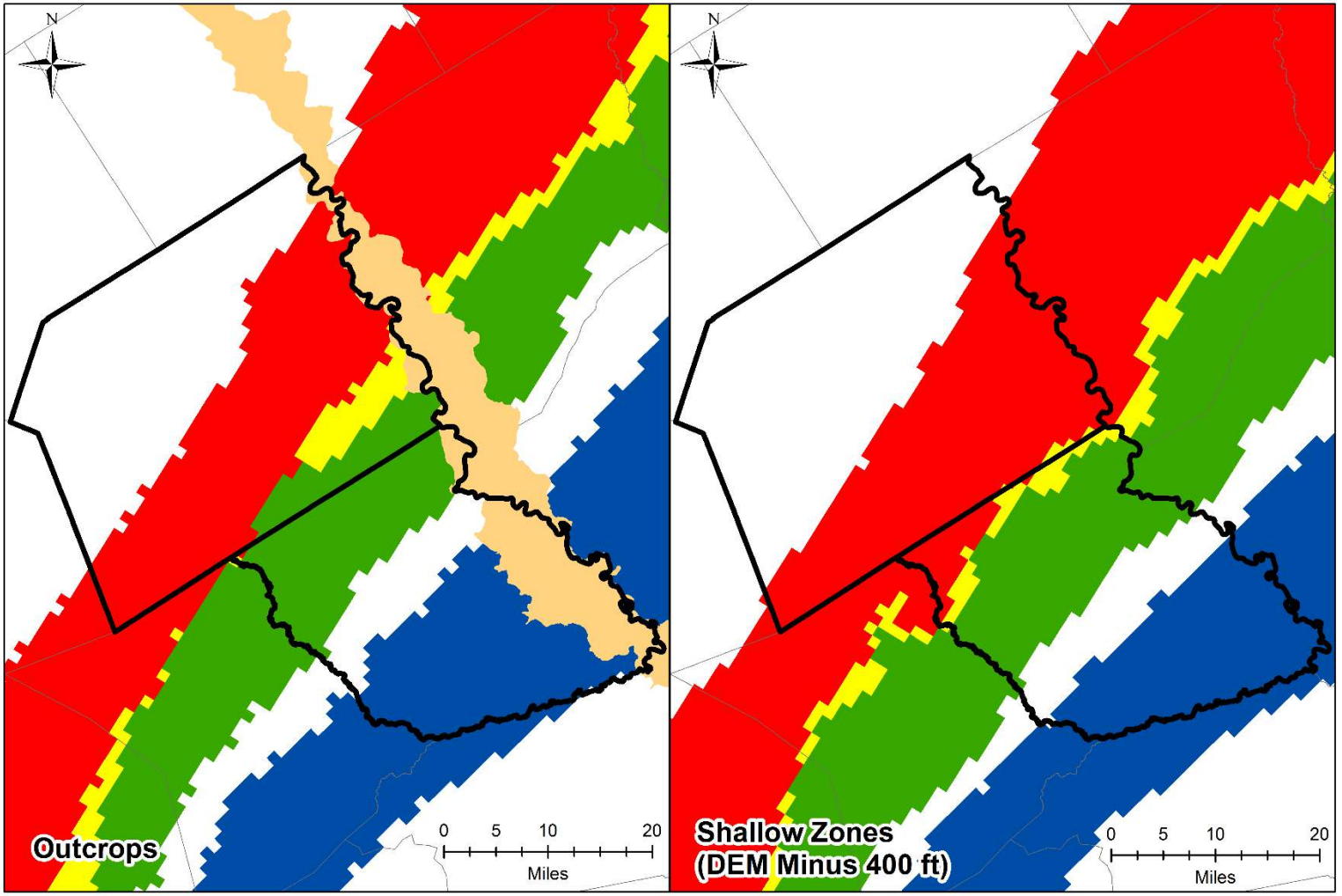
Outcrops & Shallow Zones By Aquifer



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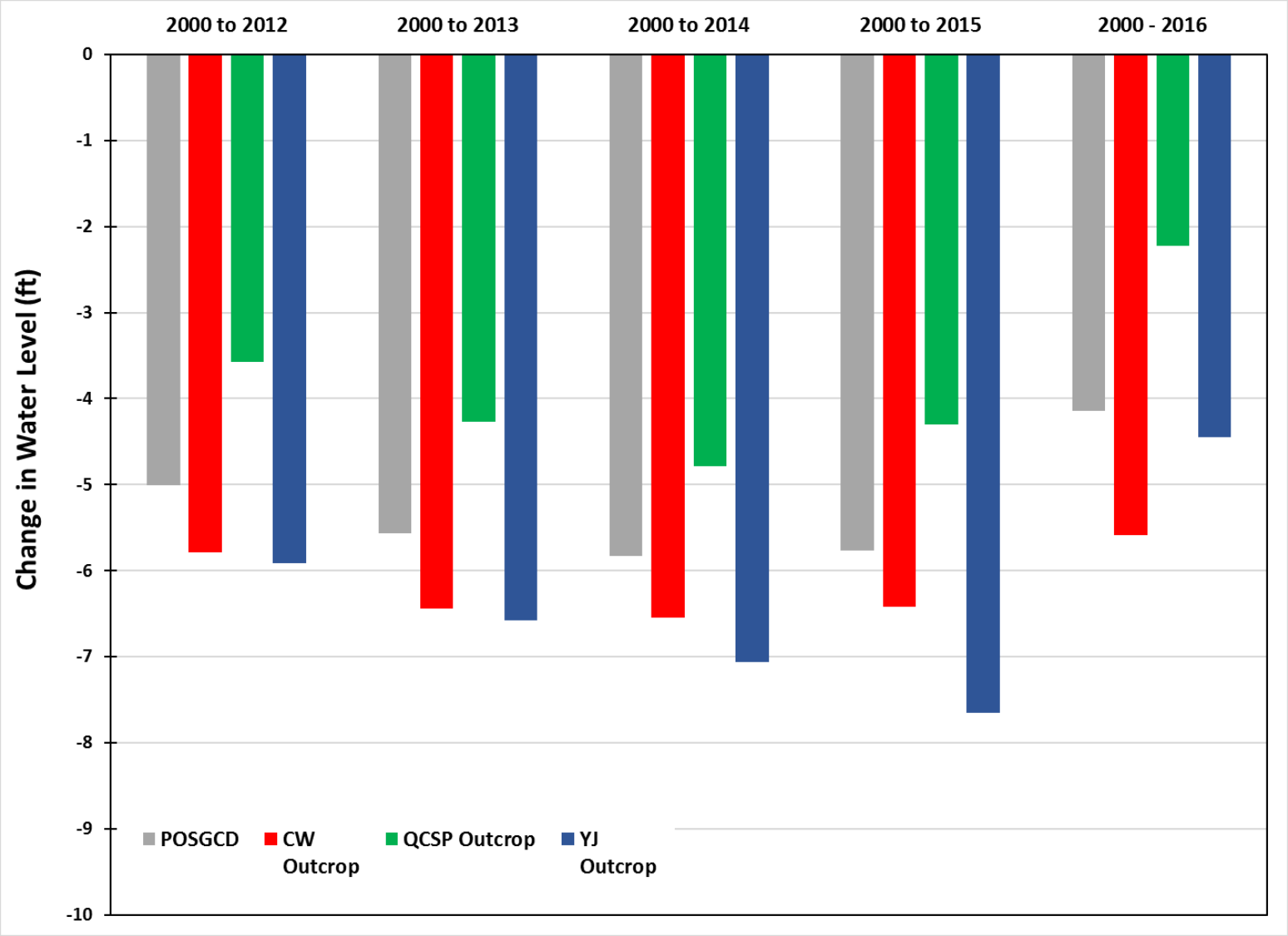
Drawdown in Outcrop



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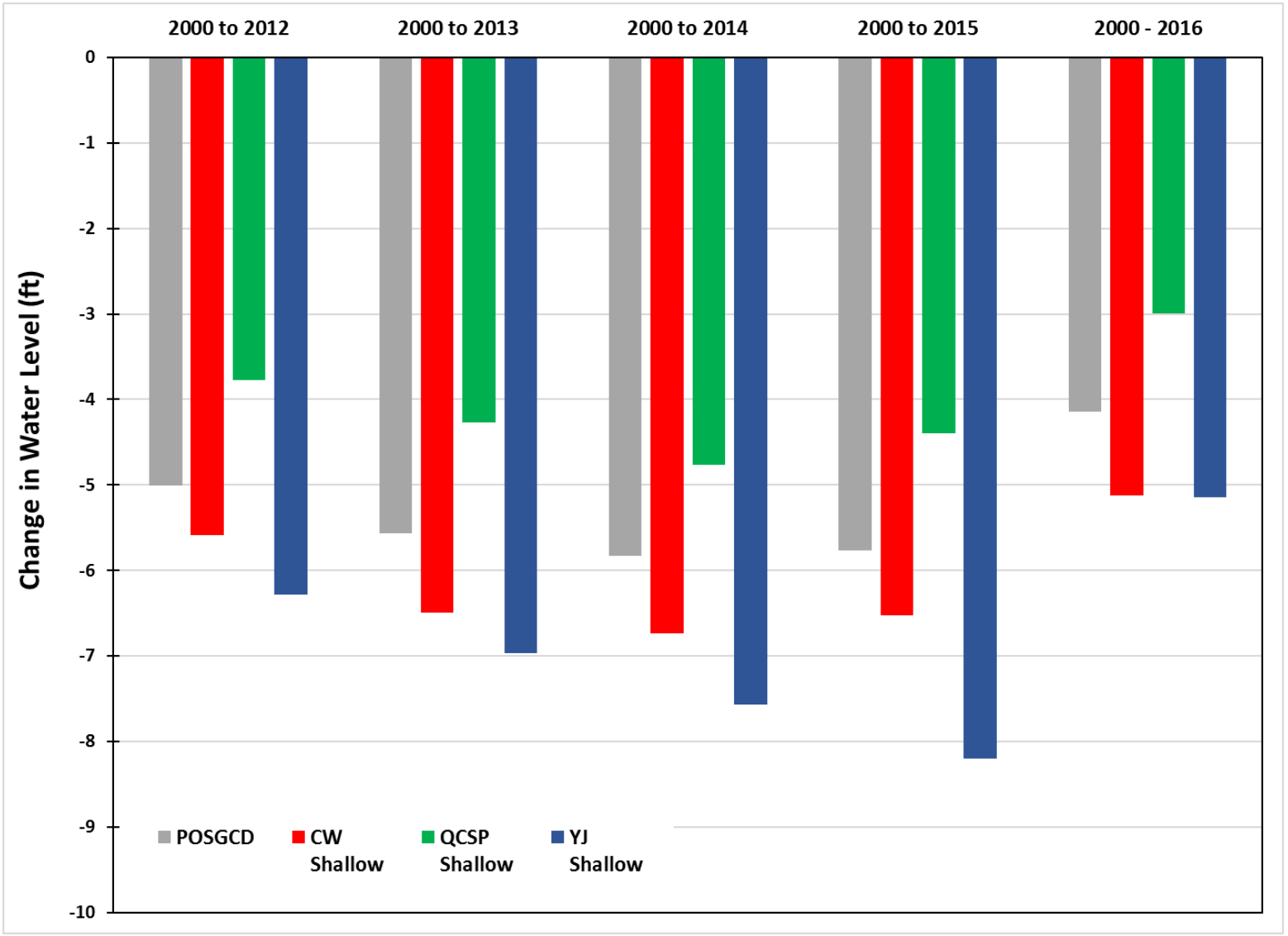
Drawdown in Shallow (<400)



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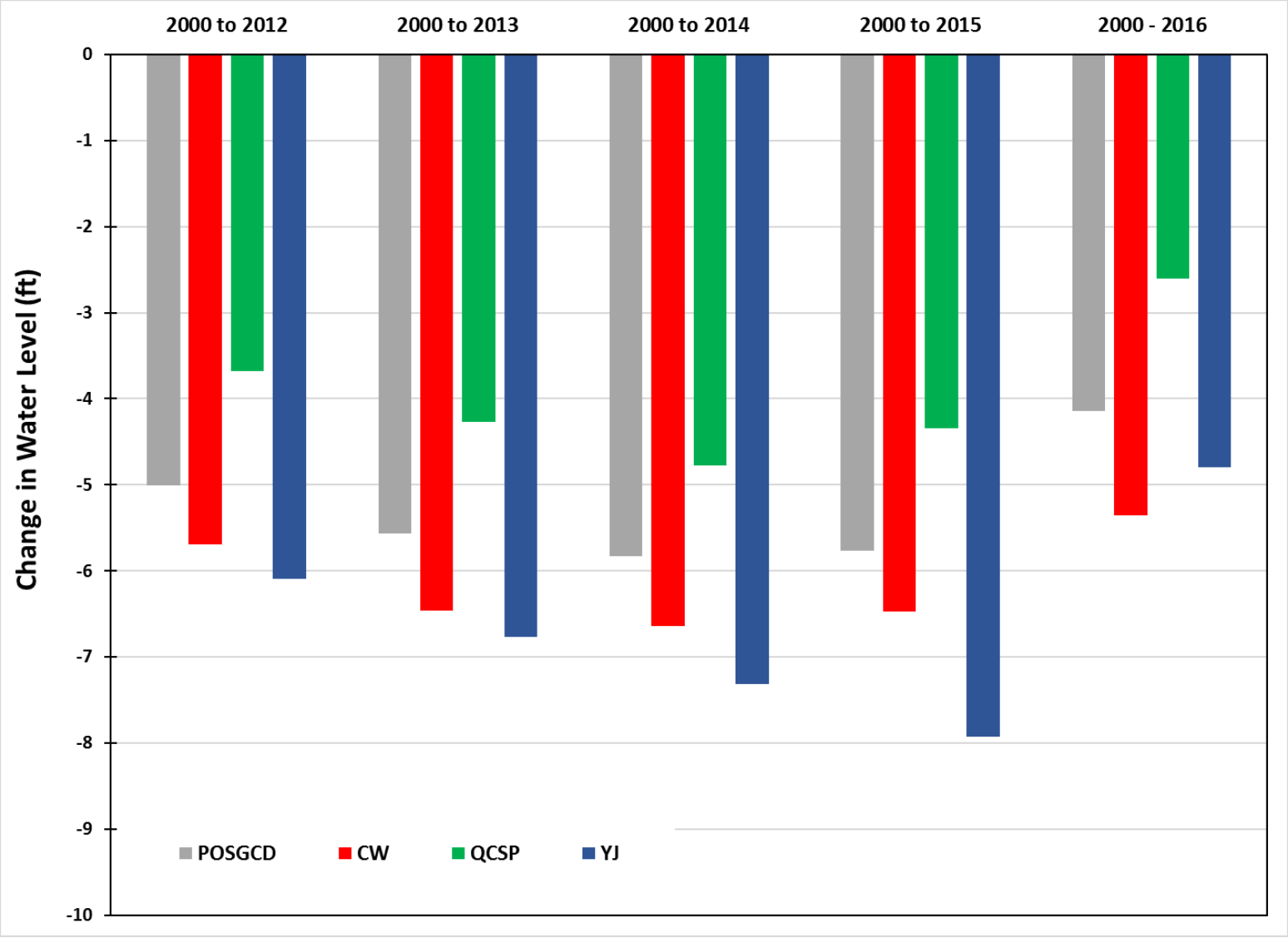
Avg Drawdown (Outcrop & Shallow)



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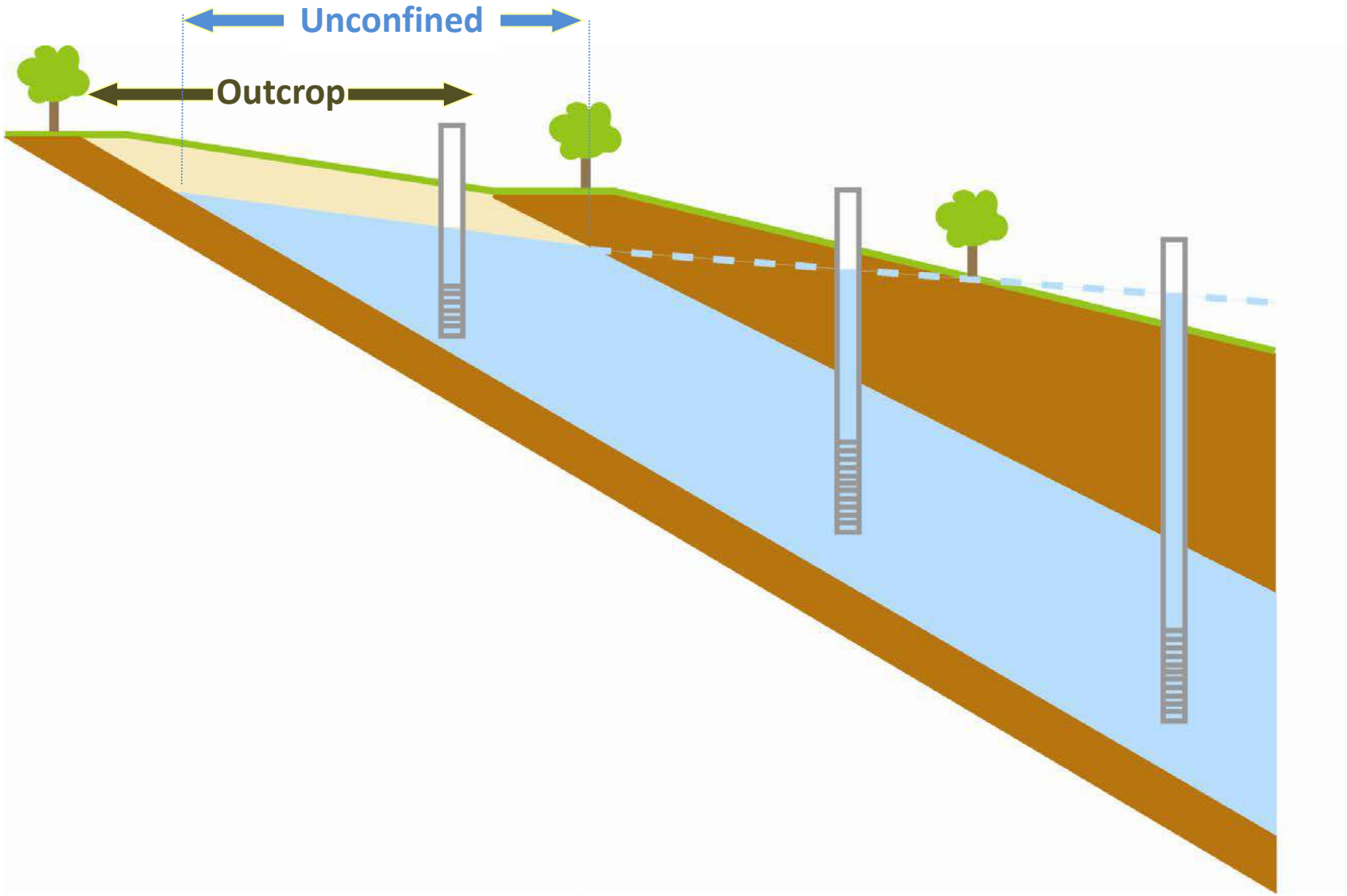
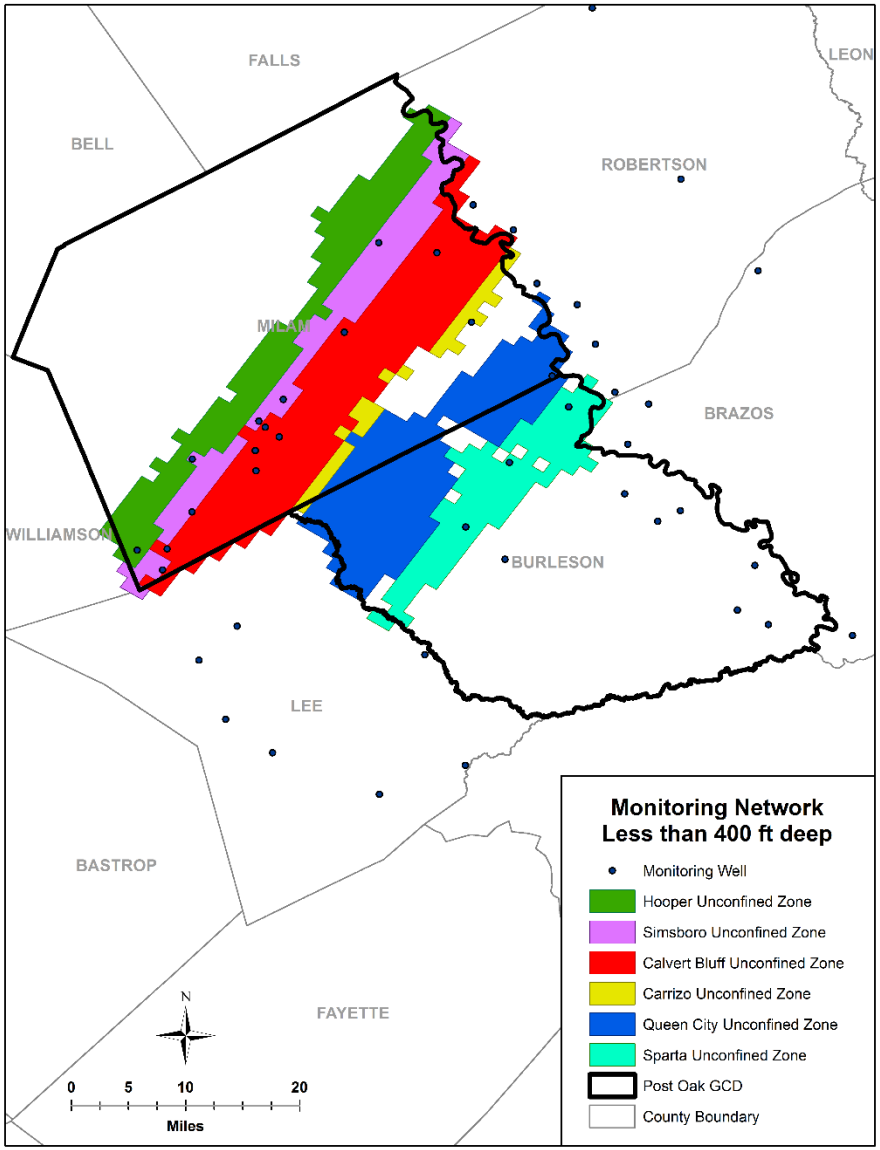
Unconfined Zone



Unconfined Zones



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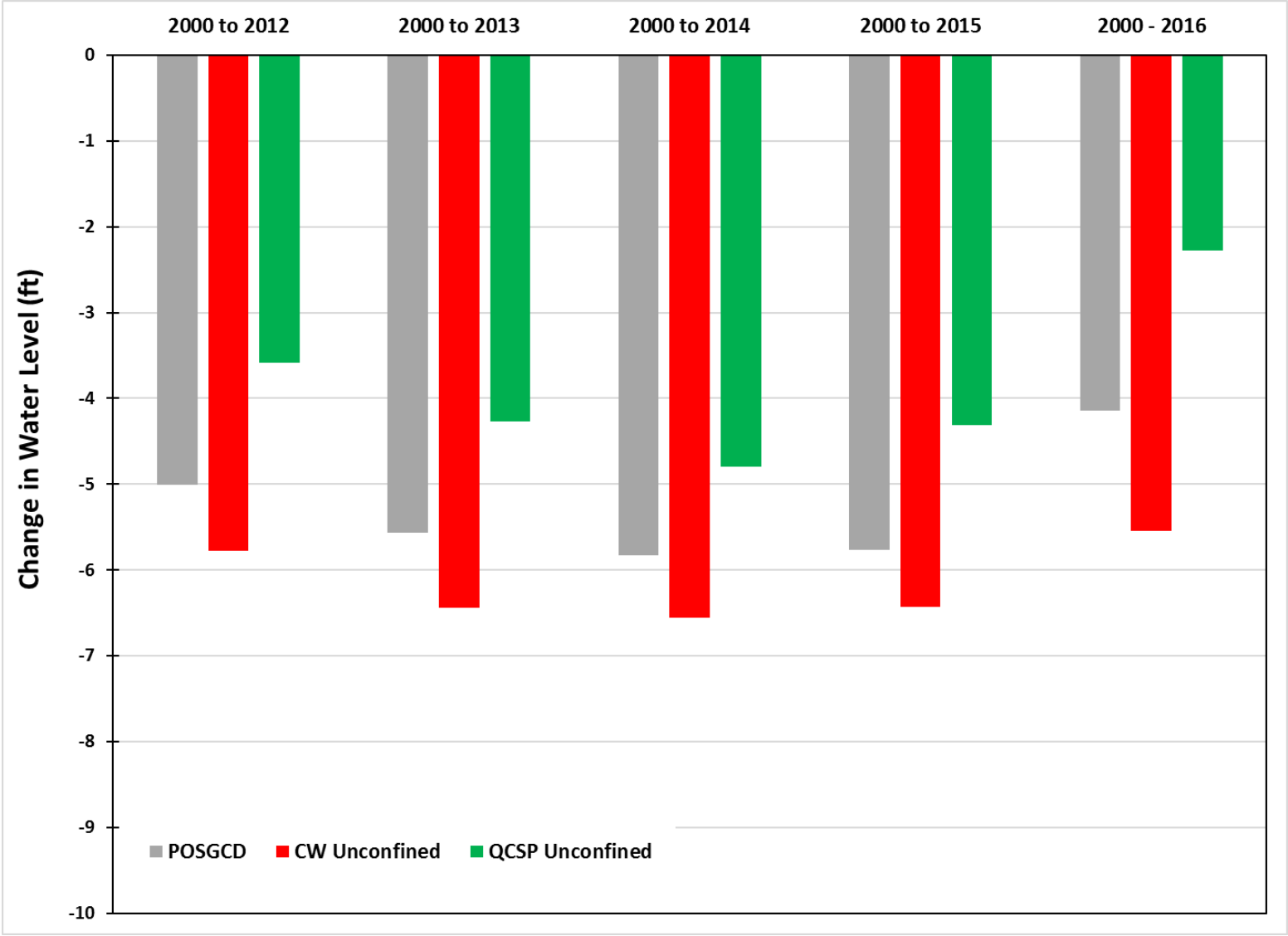
Drawdown in Unconfined Aquifer



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Sensitivity Analyses

- Difference between Interpolation techniques
- Outcrop vs. Shallow (400') Zone vs. Unconfined
- Drawdowns calculated from Filtered Wells vs. All Wells
- Drawdown based on 2012 instead of 2000

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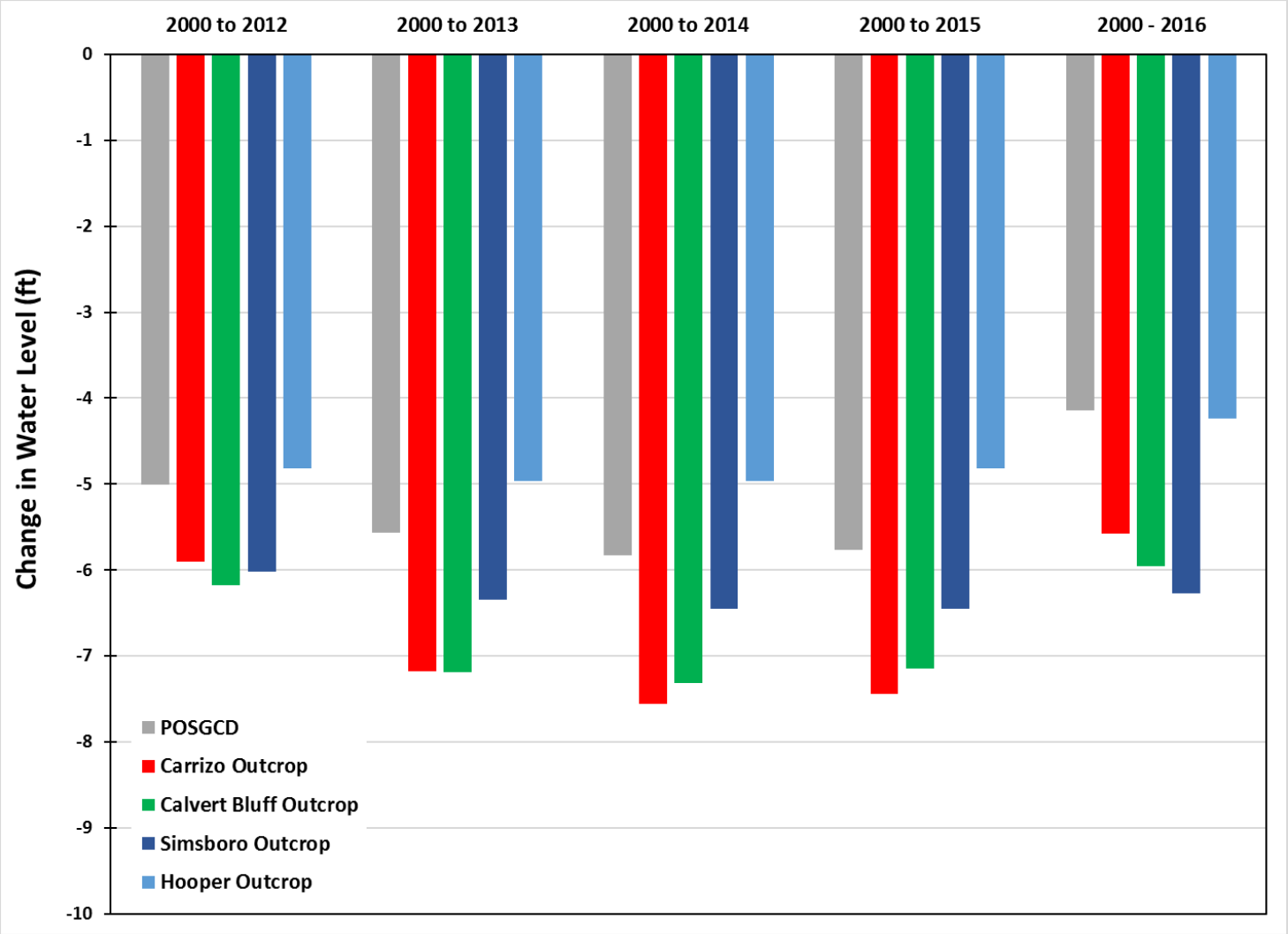
Supplemental Data

Outcrop Drawdown (CW only)



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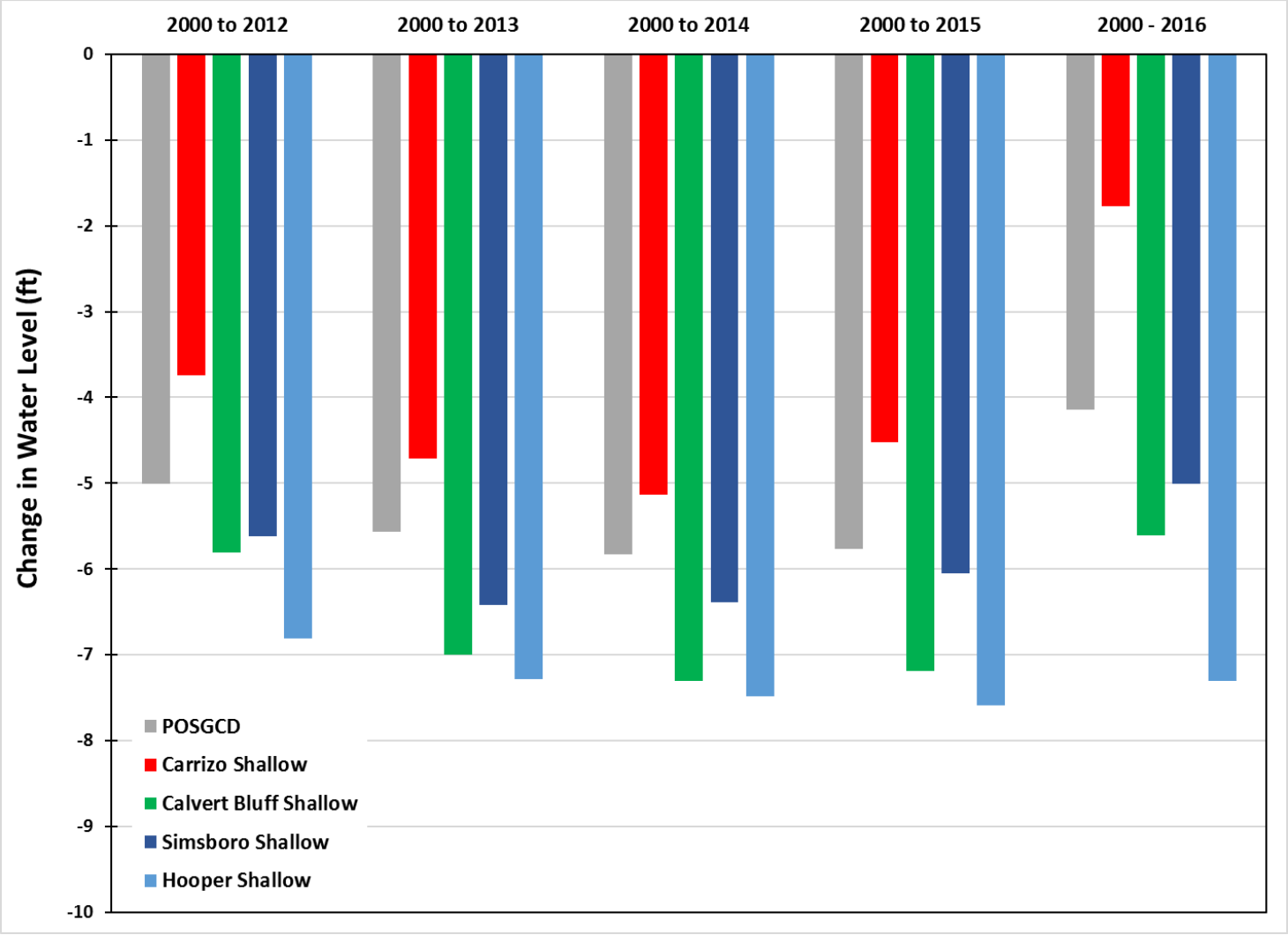
Shallow Drawdown (CW only)



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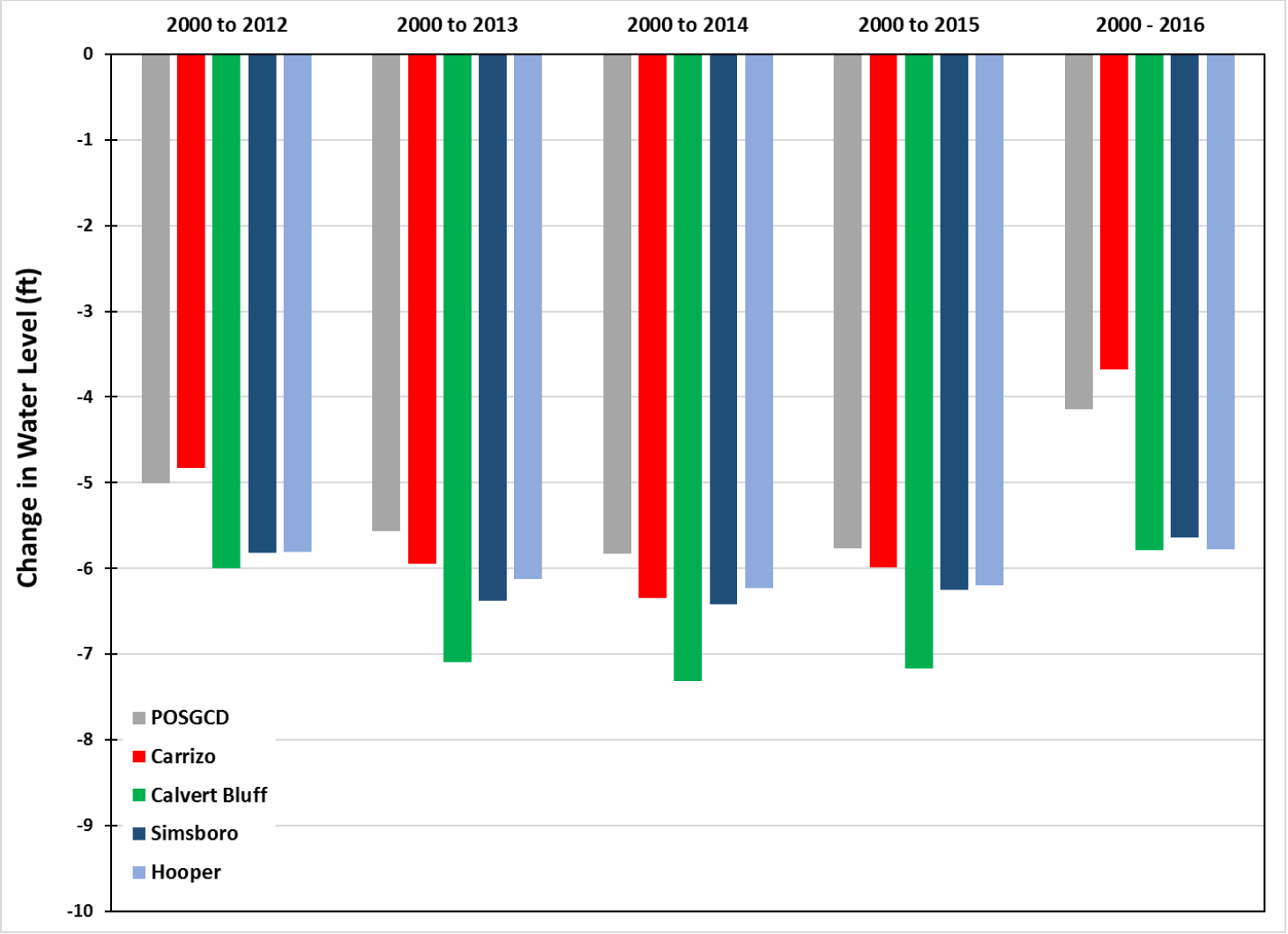
Avg Drawdown (Outcrop & Shallow) – CW



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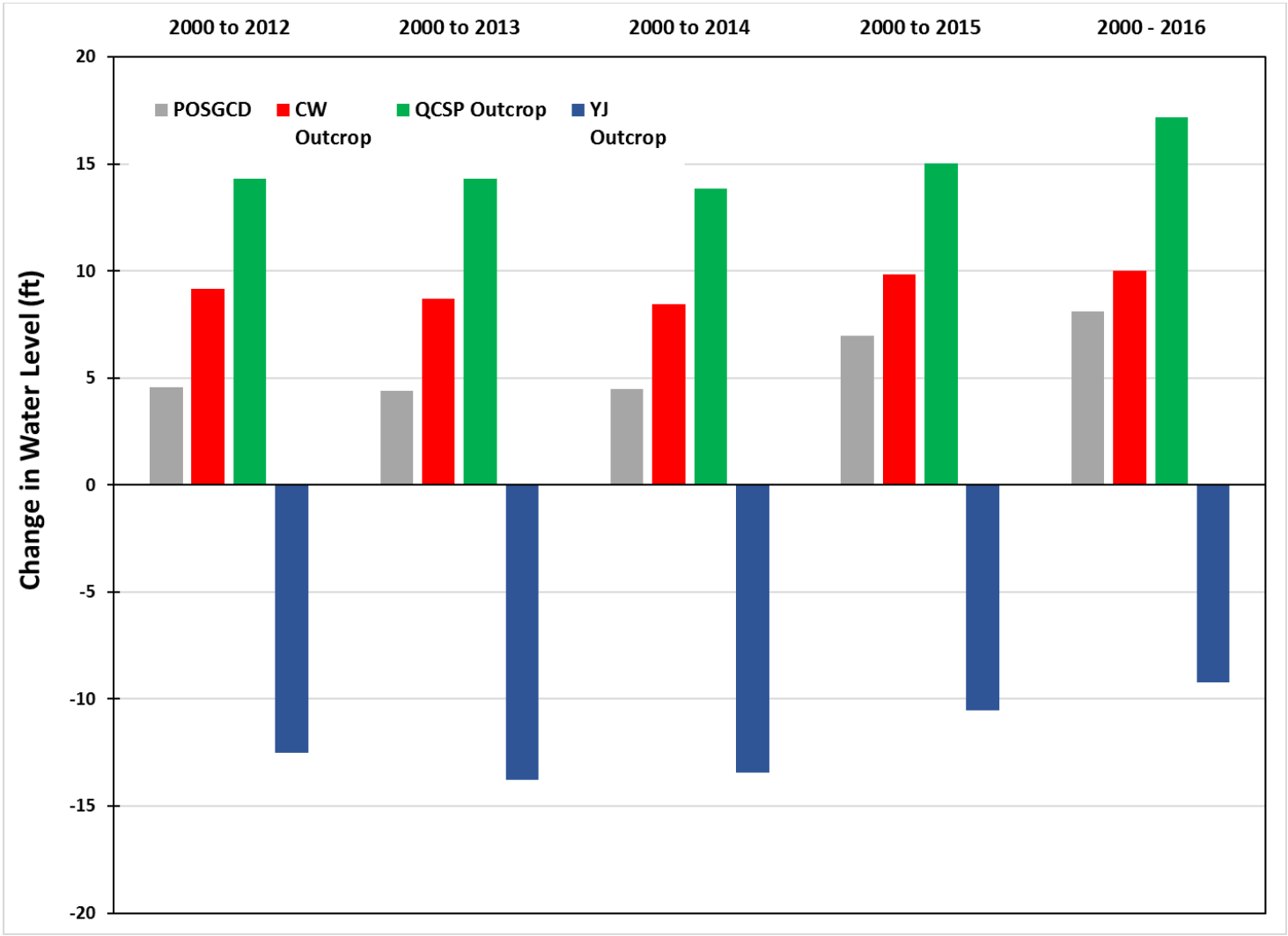
Outcrop Drawdowns using Unfiltered Wells



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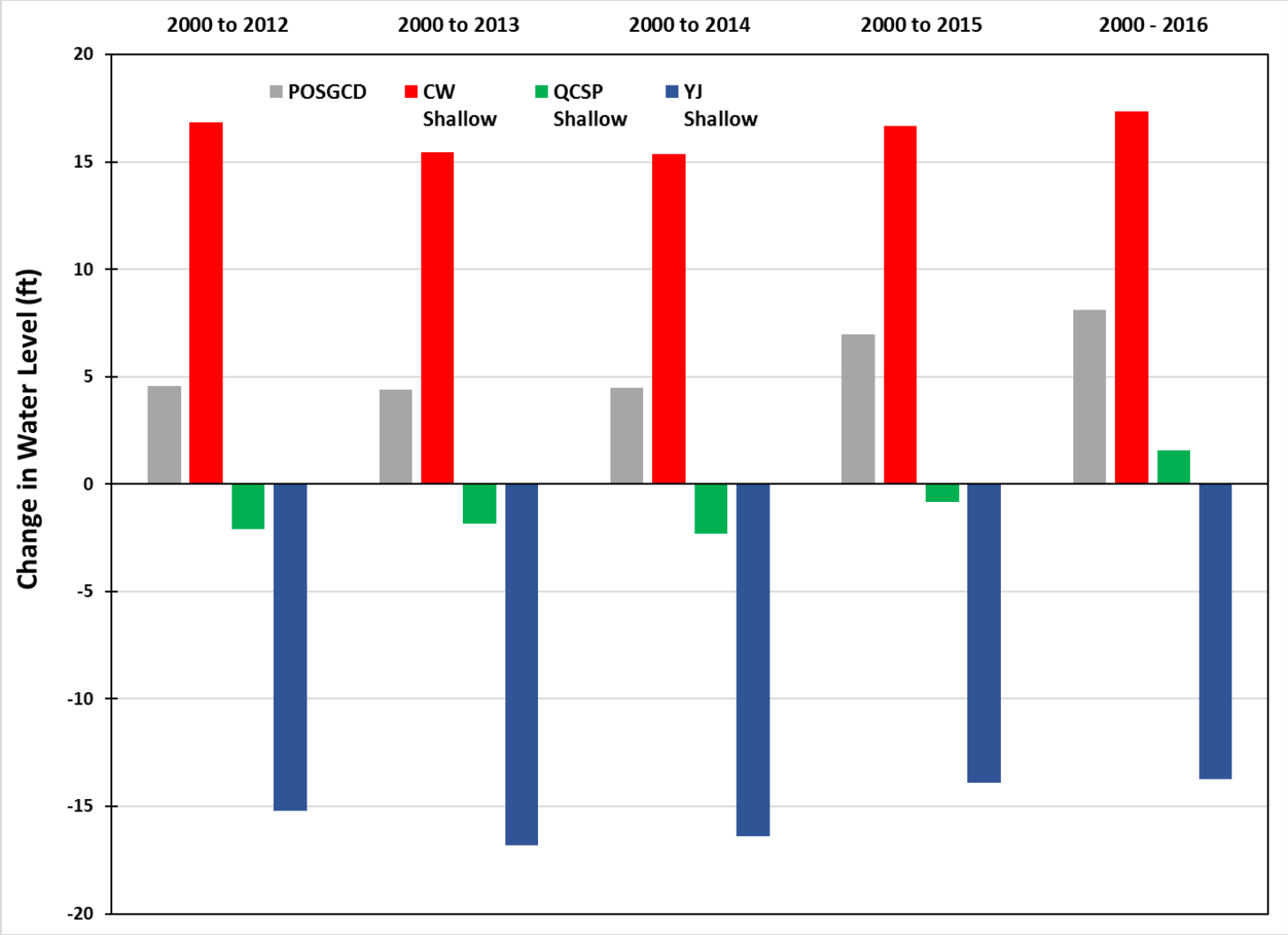
Shallow Drawdowns using Unfiltered Wells



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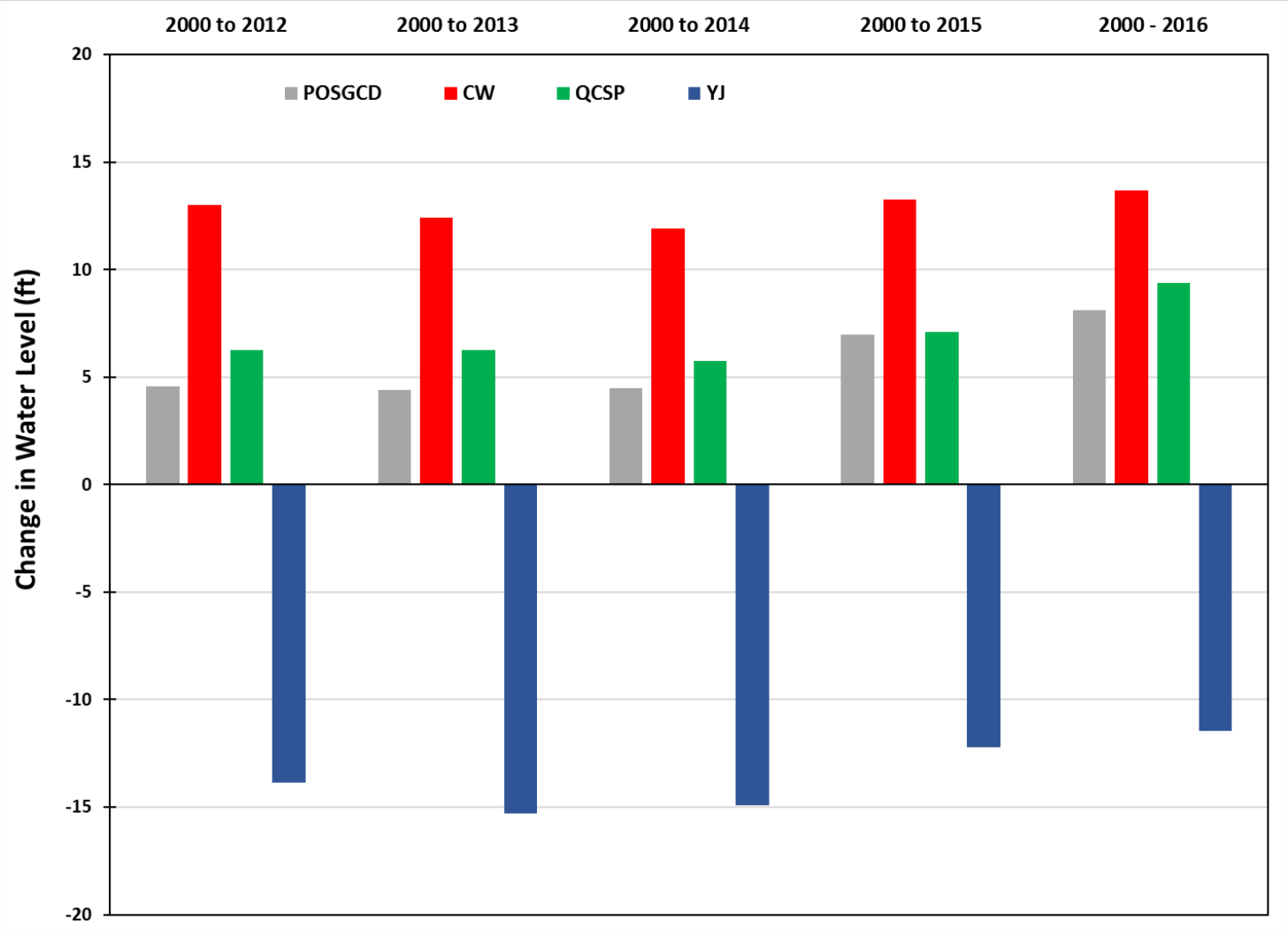
Average Drawdowns using Unfiltered Wells



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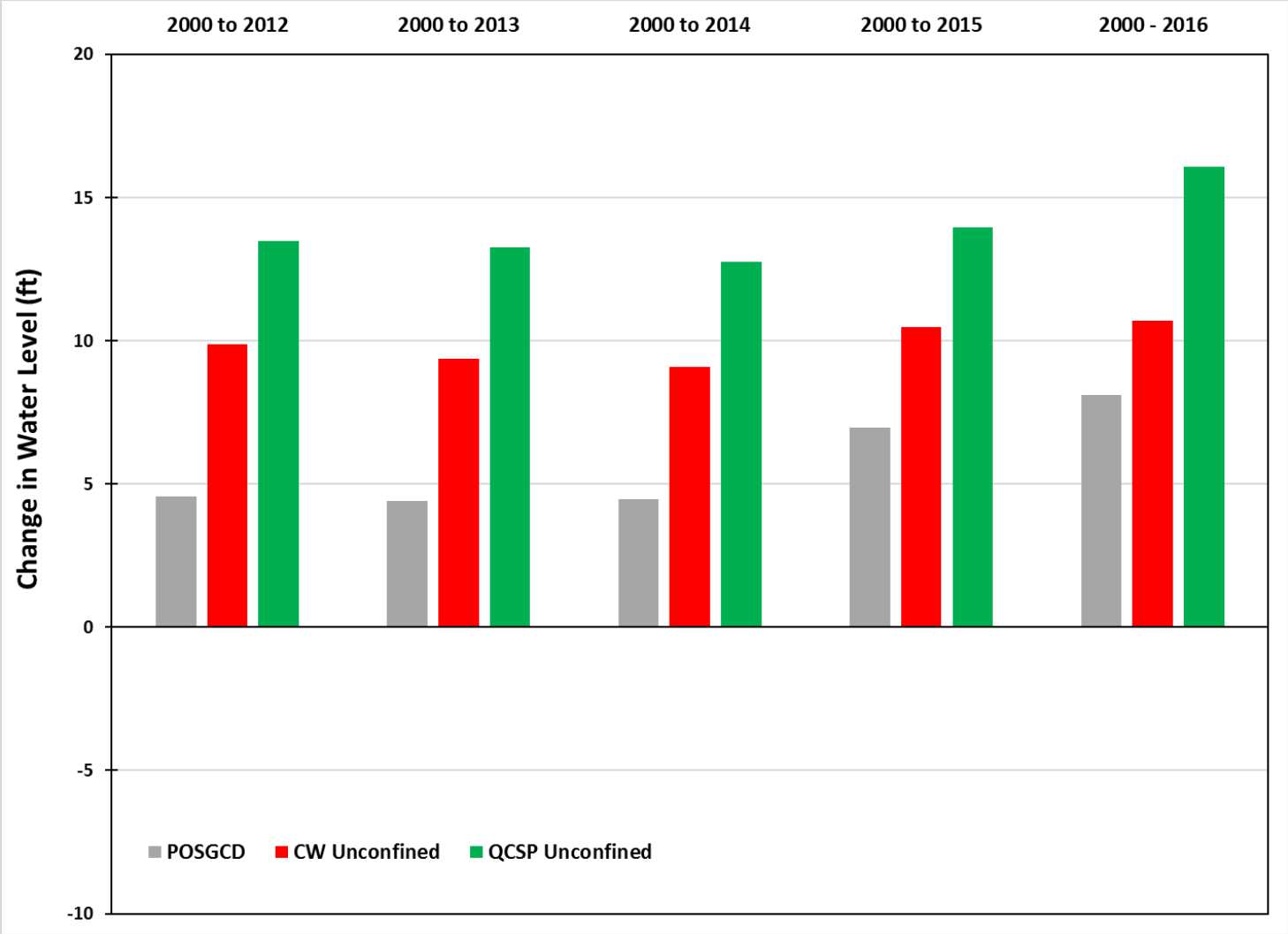
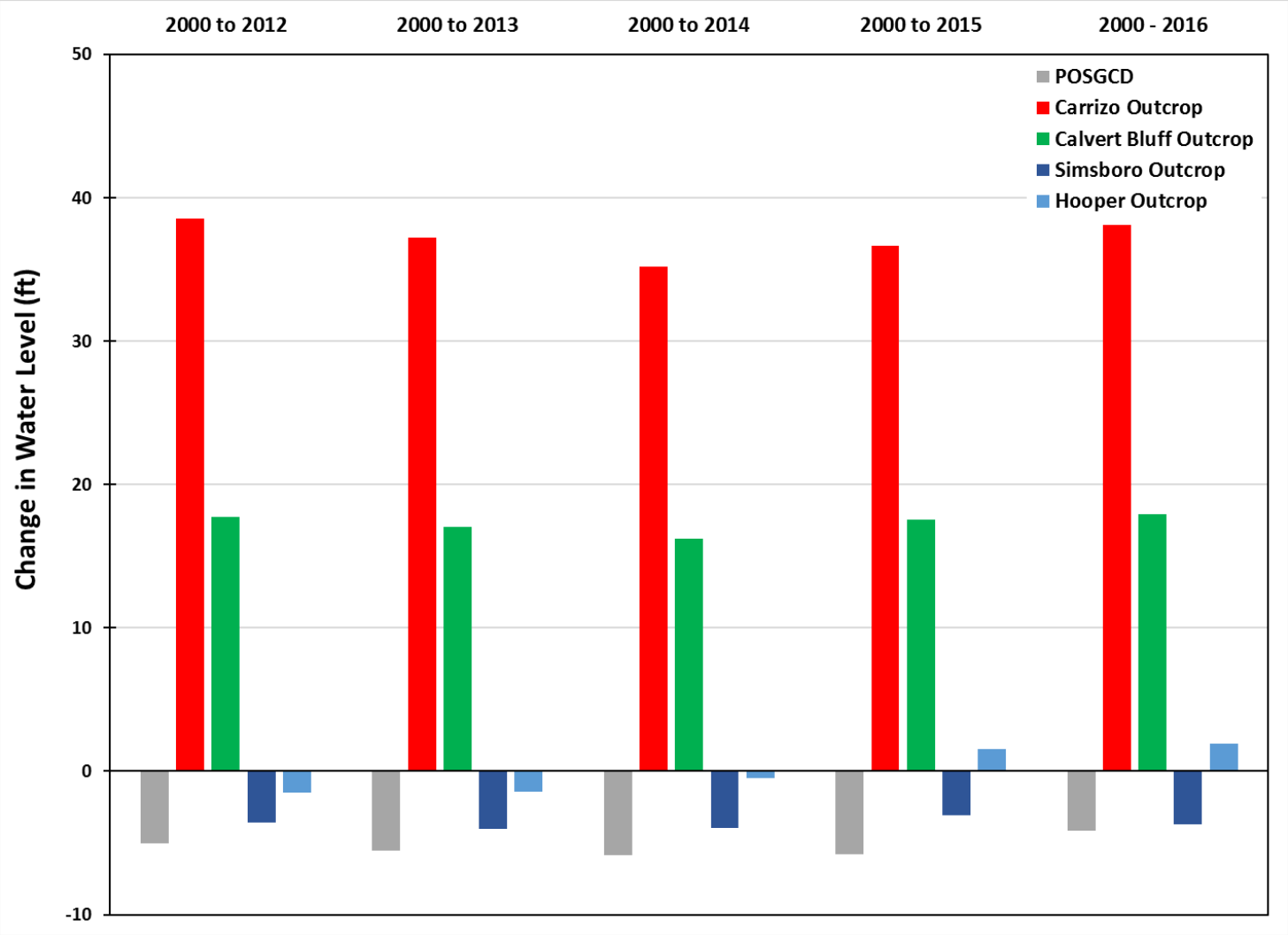
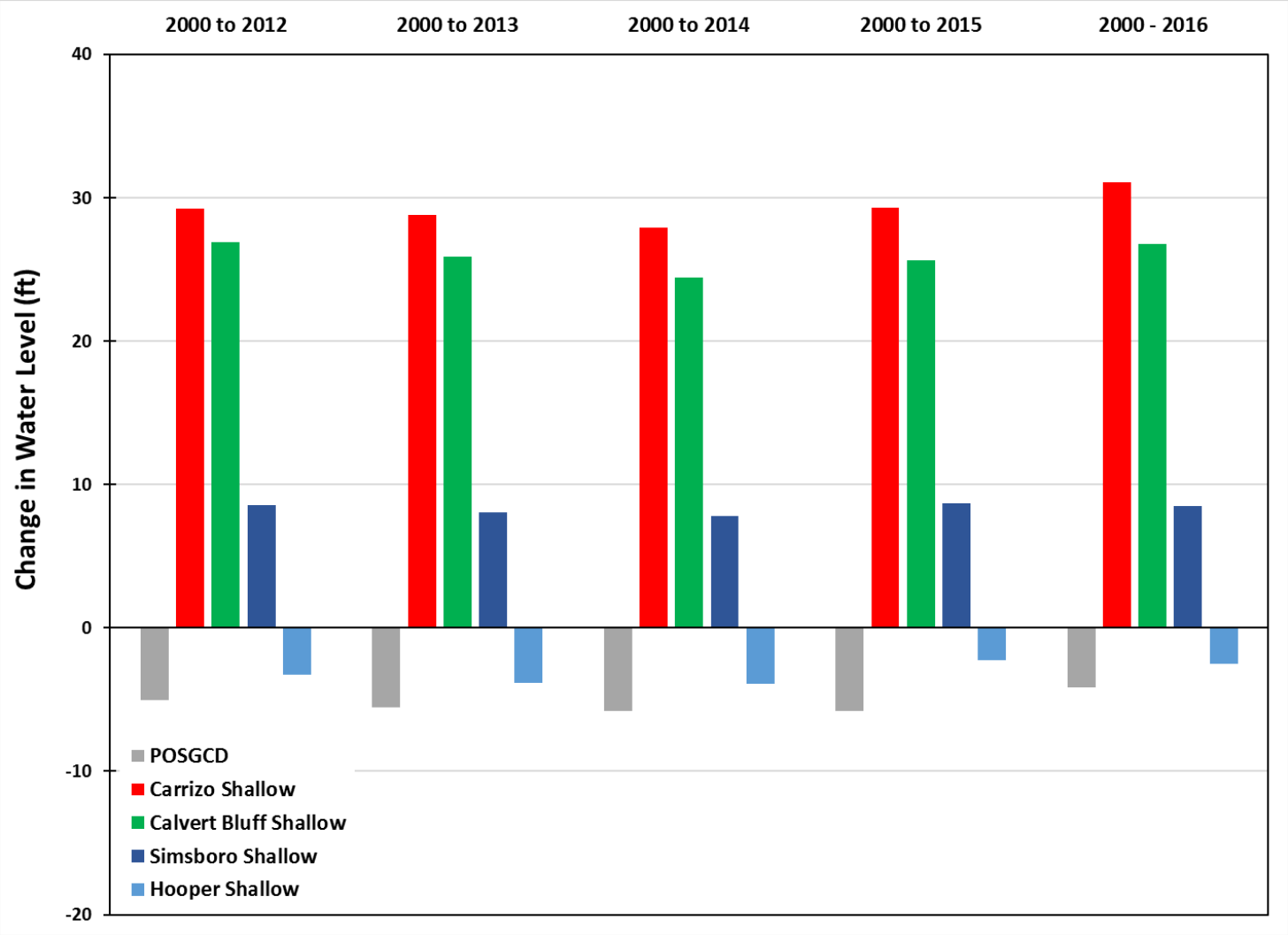
Unconfined Drawdowns using Unfiltered Wells



Outcrop DD using unfiltered Wells



Shallow DD using unfiltered wells



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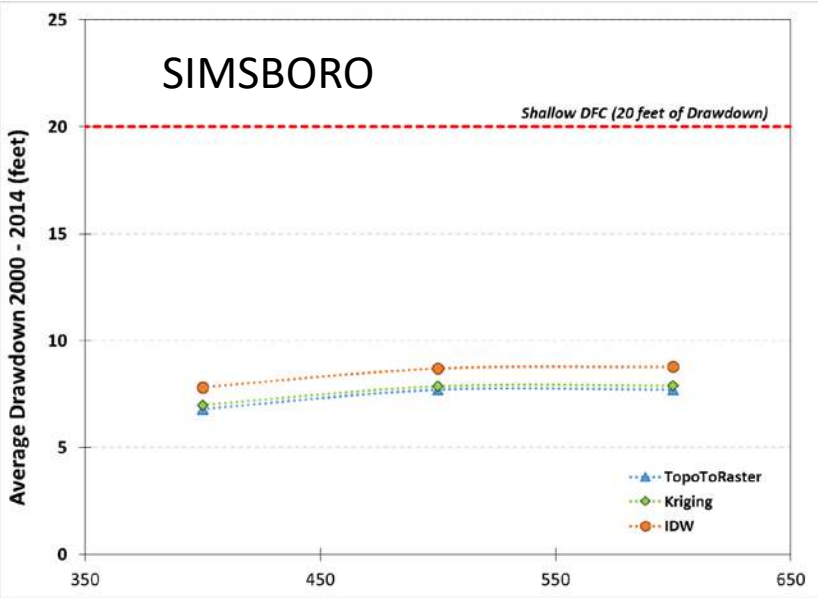
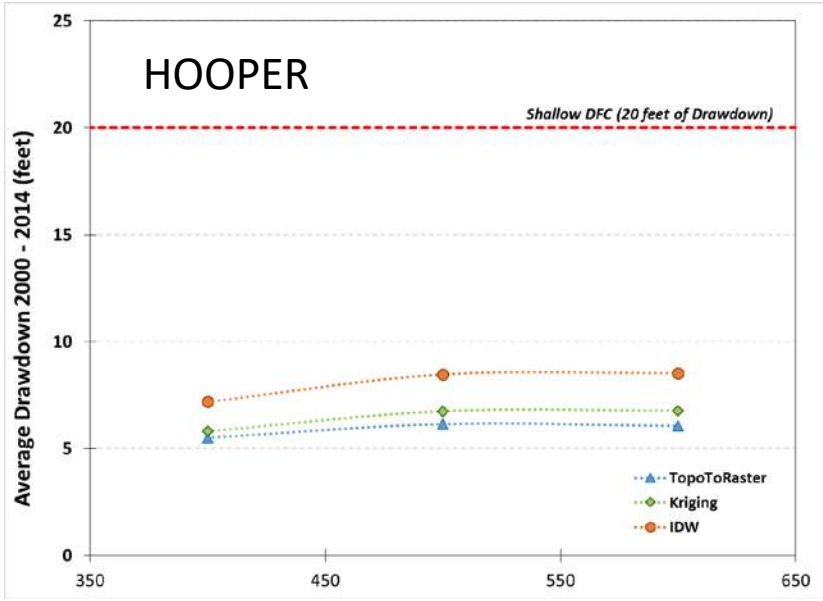
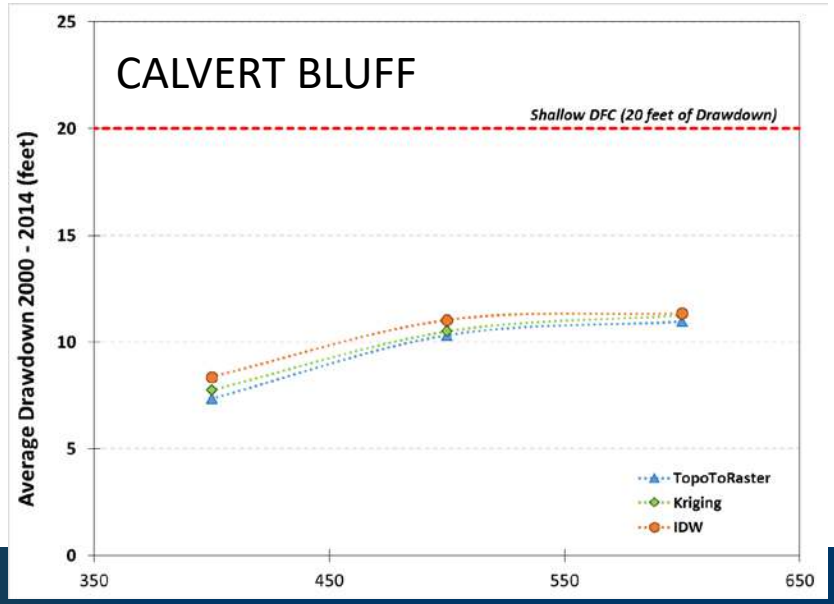
Average Drawdown Using Different Interpolation Methods







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