Texas Water Development Board (TWDB) Groundwater Availability Modeling (GAM) Program

Natalie Ballew

Texas Water Development Board

Texas Water Development Board

GAM Program

Texas Water Development Board

Aim:

Produce groundwater flow models for the major and minor aquifers of Texas.

Purpose:

Develop various tools that can be used to aid in groundwater resources management by stakeholders.

Public process: Stakeholder involvement during model development process and during associated aquifer related projects-as applicable.

Models: Freely available, standardized, thoroughly documented. Reports available over the internet.

Living tools: Periodically updated.

How we use groundwater models

Per statute:

- TWDB provides groundwater conservation districts with water budget data for their management plans.
- Groundwater management areas can use to assist in determining desired future conditions.
- TWDB uses when calculating estimated Modeled Available Groundwater.
- TWDB uses when calculating Total Estimated Recoverable Storage.

Why Stakeholder Advisory Forums?

- Keep you updated about model-related project progress

- Provide the opportunity to provide input and data to assist with model-related project development

- Discuss project limitations and applications

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Web information:

www.twdb.texas.gov/groundwater/models/gam/czwx_n/czwx_n.asp

Accepting comments on Draft Numerical Model Report through September 10, 2020

GROUNDWATER AVAILABILITY MODEL FOR THE NORTHERN PORTION OF THE QUEEN CITY, SPARTA, AND CARRIZO-WILCOX AQUIFERS

For the Texas Water Development Board

GSI ENVIRONMENTAL

Texas Water Development Board

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PROJECT TEAM

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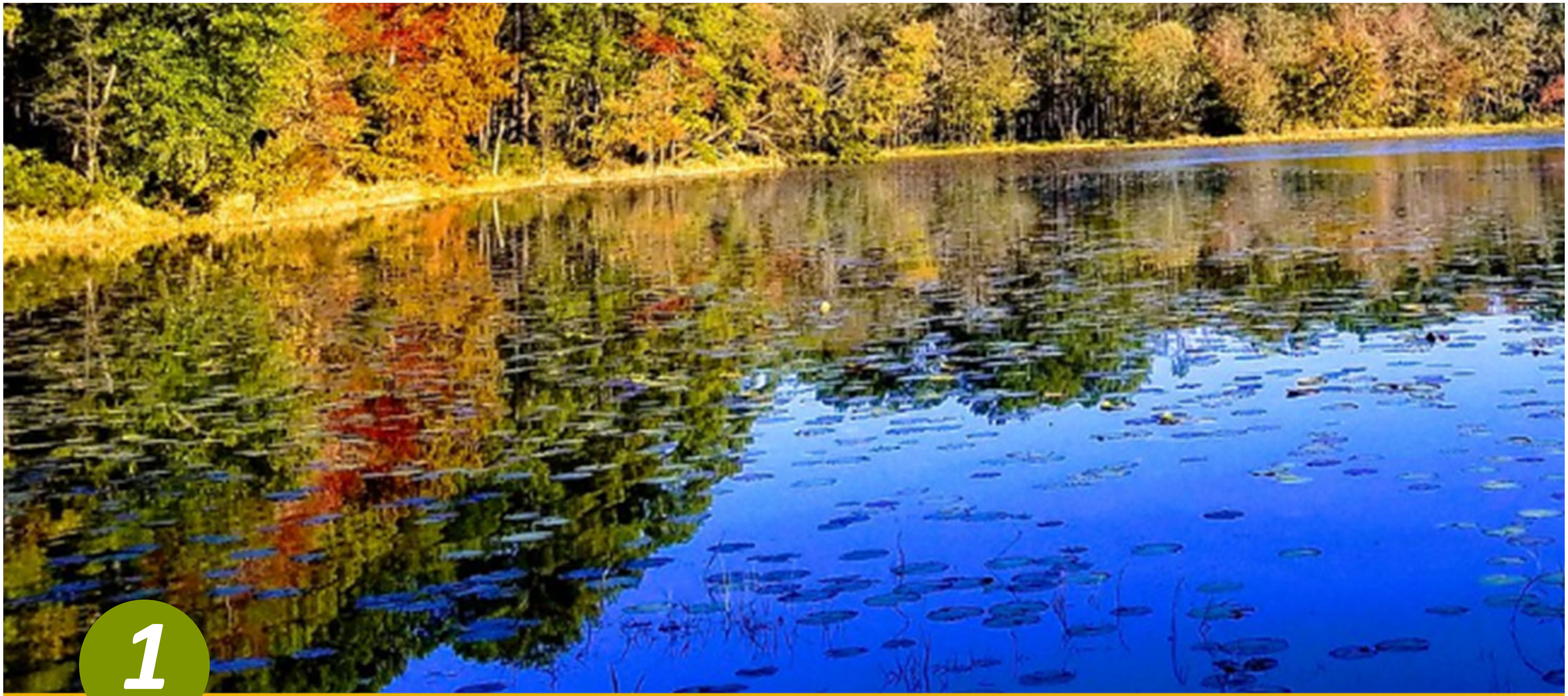
Independent Groundwater Consultant

Contents of Presentation

- Introduction and Purpose of Model
- Model Overview and Packages
- Model Calibration and Results
- Model Sensitivity
- Model Limitations
- Summary and Conclusions



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INTRODUCTION AND PURPOSE OF MODEL

GROUNDWATER MODEL BACKGROUND

Groundwater Availability Modeling (GAM) Program (since 1999)

Goal: To provide useful and timely information for determining groundwater availability for the citizens of Texas.

Reasons:

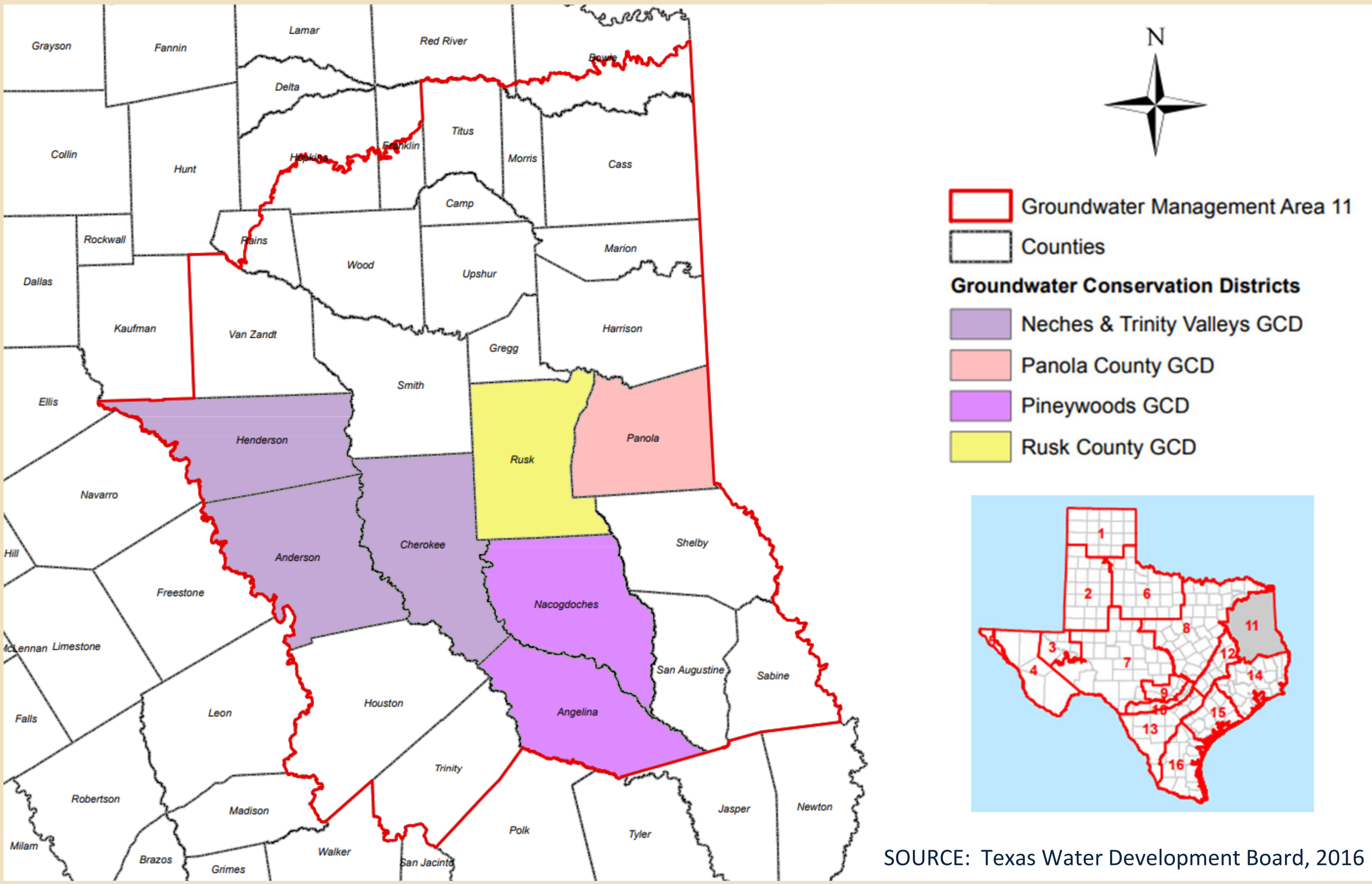
- **Projected 70% state-wide population increase by 2070;**
- **Possible future drought conditions;**
- **Groundwater is vital to state resources, health, and economy;**
- **Groundwater is difficult to observe and measure.**

Implementation:

- **Analyze groundwater management policies for Texas aquifers;**
- **Produce data for major and minor aquifers in Texas;**
- **Include stakeholder input;**
- **Provide results publicly (estimated available groundwater).**

GROUNDWATER MODEL BACKGROUND

The groundwater model update is for Groundwater Management Area 11.

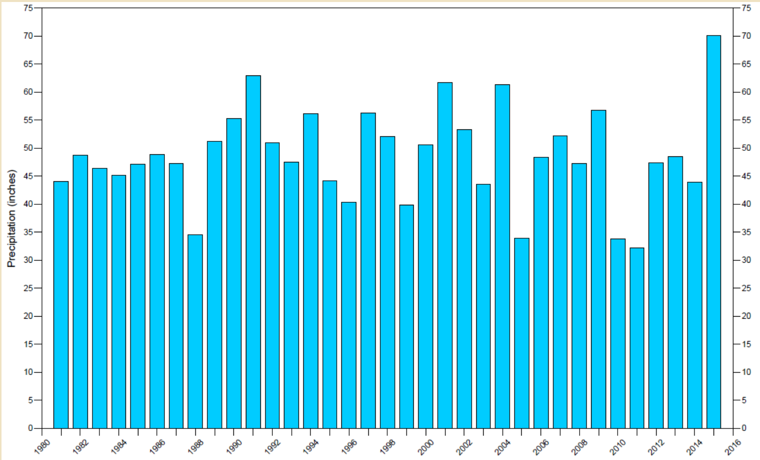


SOURCE: Texas Water Development Board, 2016

GROUNDWATER MODEL BACKGROUND

GMA 11 had a conceptual model update in 2018 and included the following:

- **Groundwater levels**
- **Groundwater movement**
- **Surface water features (rivers, creeks, etc.)**
- **Well pumping**
- **Precipitation**
- **Hydrostratigraphy**
- **Geologic unit properties (hydraulic conductivity, sand %, etc.)**



Example of Updated Parameter:
Annual Rainfall Across Study Area

SOURCE: Montgomery & Associates, 2018.

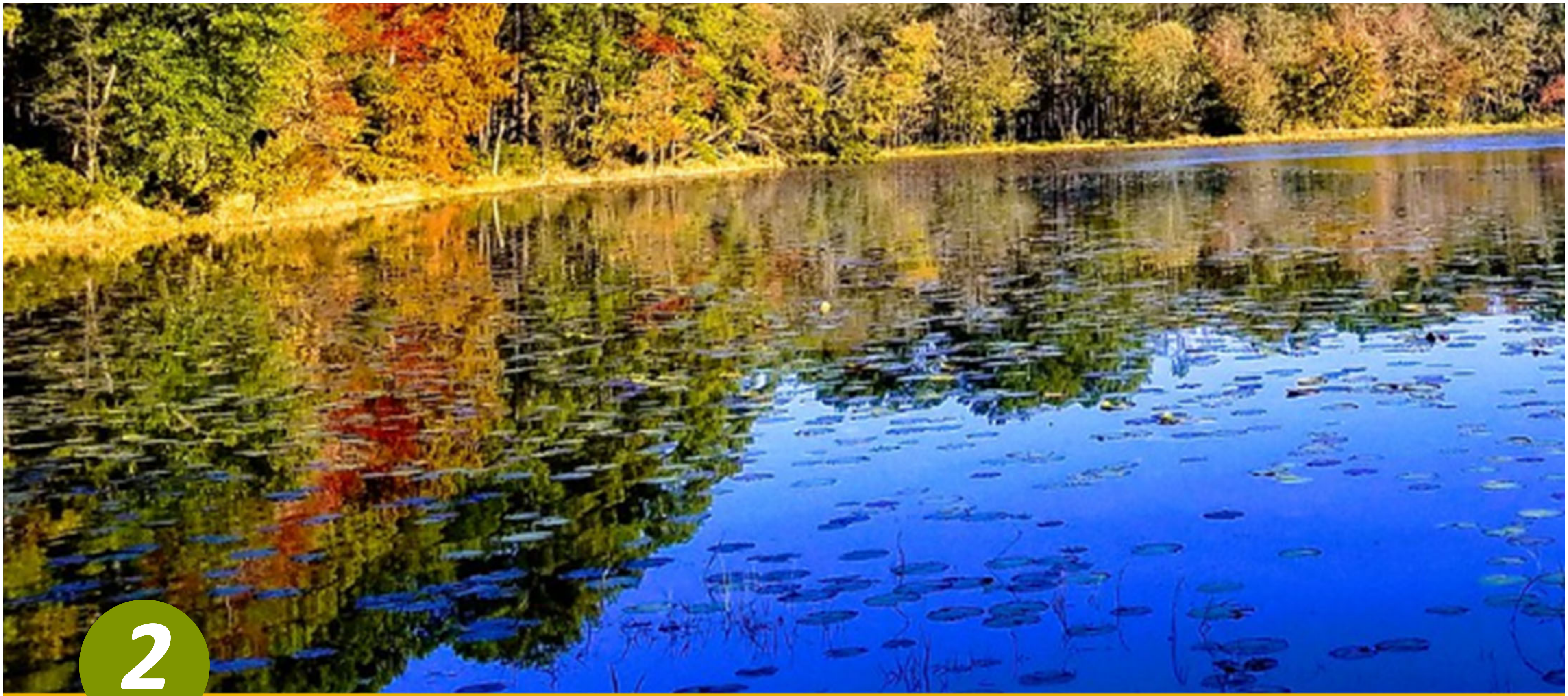
- **The conceptual model served as the basis for the 2020 GMA 11 groundwater model update.**

GROUNDWATER MODEL BACKGROUND

The model update was completed, and Draft report submitted July 2020.

Texas Water Development Board
Contract Number # 1648302063

Numerical Model Report:
Groundwater Availability Model for the Northern Portion of the Queen City, Sparta, and Carrizo-Wilcox Aquifers



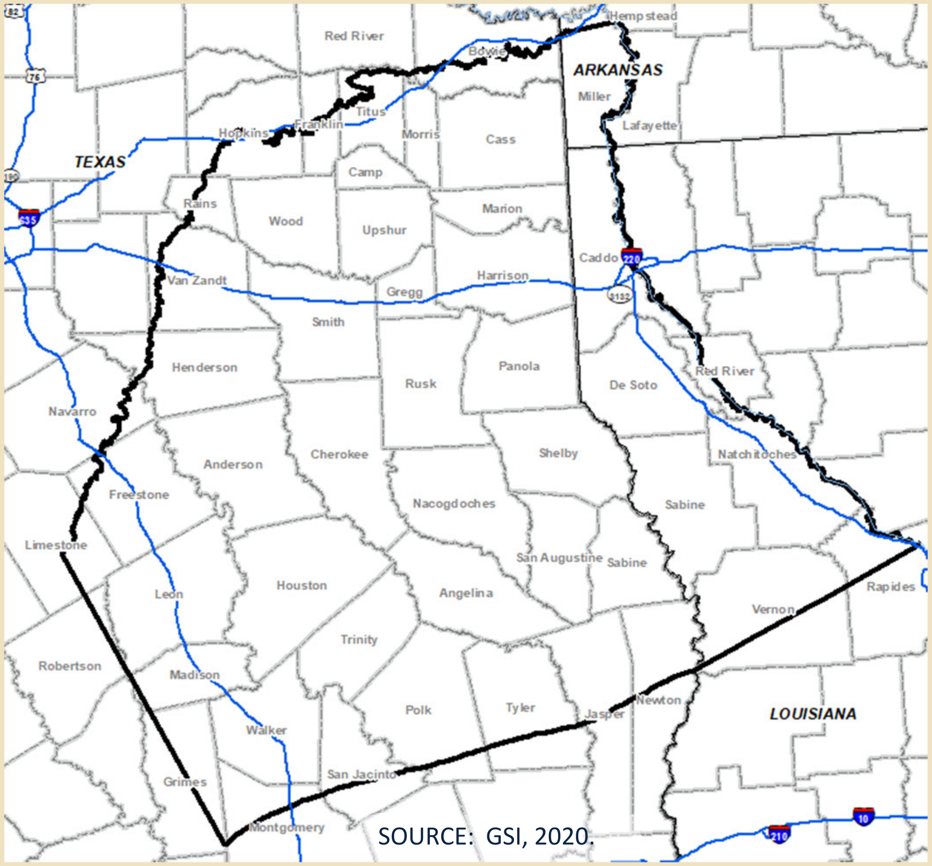
2 MODEL OVERVIEW AND PACKAGES

MODEL AREA

The model area includes the GMA 11 area in eastern Texas and overlaps parts of Louisiana and Arkansas.

Model Area

Closeup of Model Area



MODEL INPUTS

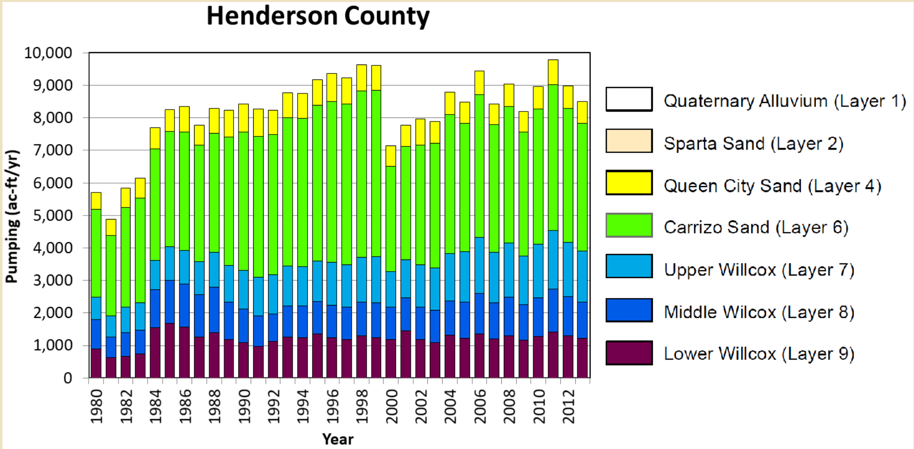
Model inputs consider:

- layering representing the geologic units, along with unit attributes relating to flow – sand fraction, hydraulic conductivity;
- pumping well locations and rates;
- a separate alluvium layer beneath rivers and creeks;
- precipitation infiltration to groundwater (recharge);
- lateral boundary inflows and outflows;
- evapotranspiration;
- monitoring wells;

Model time period: 1980 to 2013

(34 years)

Inputs that vary with time were entered as annual values except monitoring well data.



Example of Annual Values for Pumping, Summed for all Wells in Henderson County

AQUIFER UNITS

- **Groundwater = water present in pore spaces in the subsurface.**
- **Aquifer = water-bearing geologic units, used for groundwater wells.**
- **Aquitard = geologic unit that does not readily transmit water (for example, clay units).**

Ground Surface

Subsurface

(Increasing Depth)

MODEL LAYERS	AQUIFER UNITS	
Layer 1	Quaternary Alluvium	**(aquifer)**
Layer 2	Sparta Sand	**(aquifer)**
Layer 3	Weches Formation	(aquitard)
Layer 4	Queen City Sand	**(aquifer)**
Layer 5	Reklaw Formation	(aquitard)
Layer 6	Carrizo Sand	**(aquifer)**
Layer 7	Upper Wilcox	**(aquifer)**
Layer 8	Middle Wilcox	**(aquifer)**
Layer 9	Lower Wilcox	**(aquifer)**

AQUIFER UNITS

- Groundwater = water present in pore spaces in the subsurface.
- Aquifer = water-bearing geologic units, used for groundwater wells.
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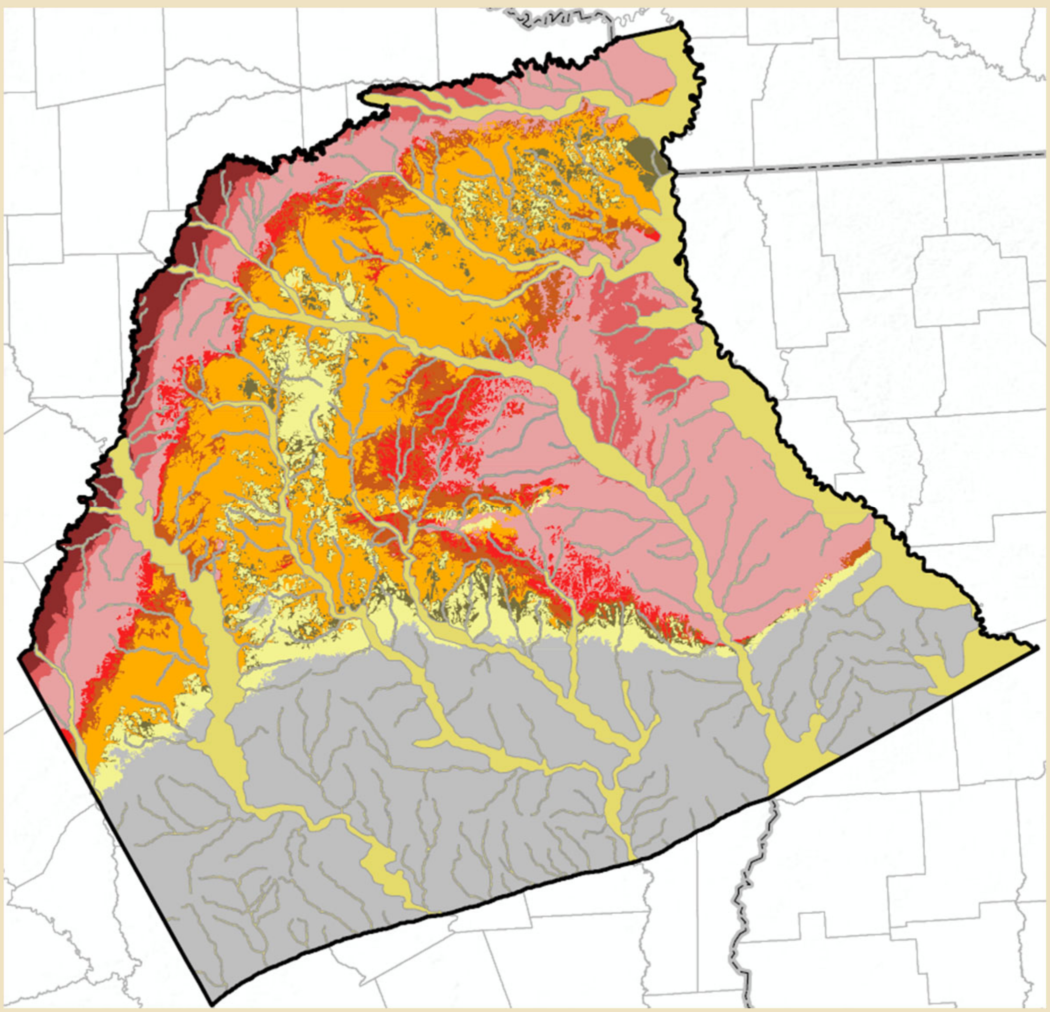
Major aquifers within GMA 11

OUTCROP MAP

The 9 aquifer and aquitard units in the model area, shown in plan view.

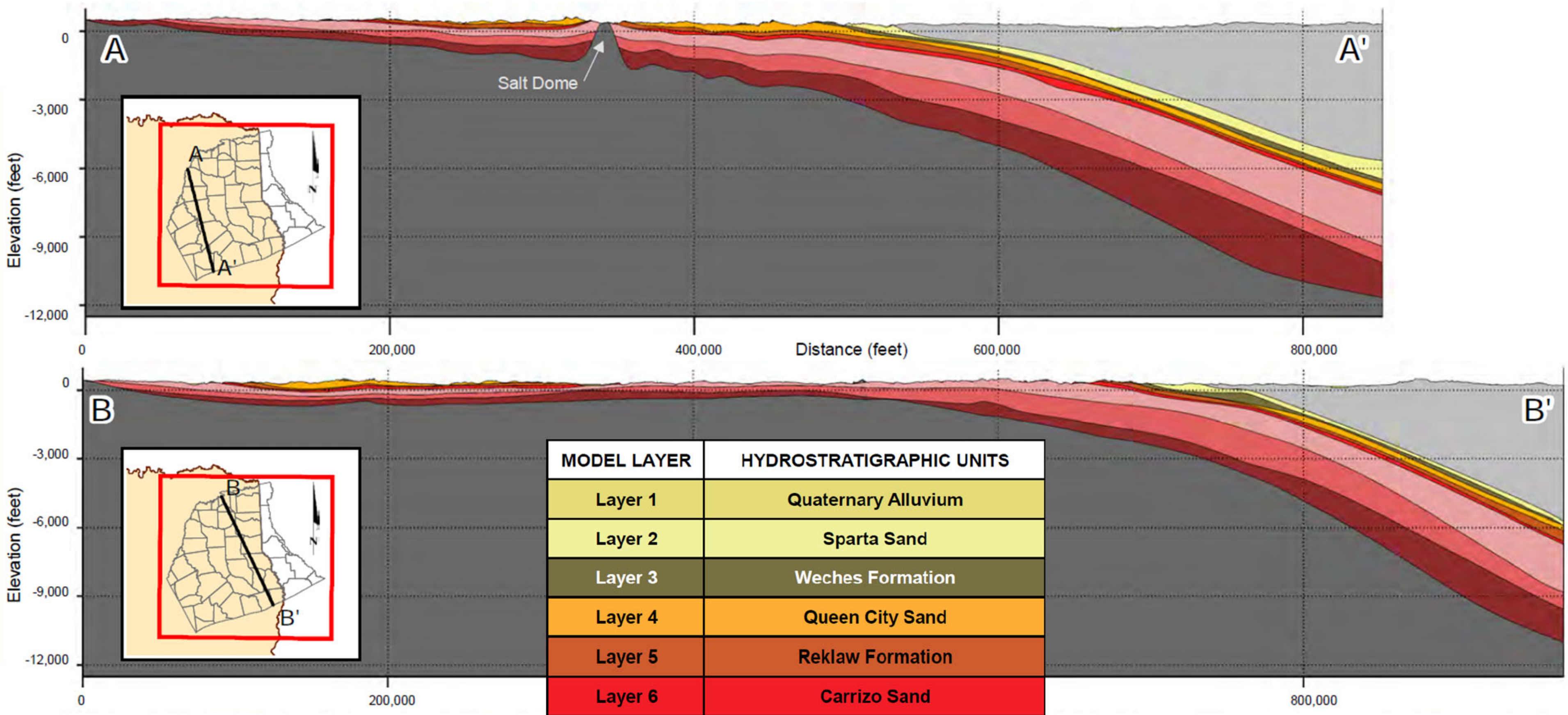


Hydrostratigraphy developed from electronic logs provided by previous GAM and Groundwater Conservation Districts (GCDs).

MODEL LAYER	HYDROSTRATIGRAPHIC UNITS
Layer 1	Quaternary Alluvium
Layer 2	Sparta Sand
Layer 3	Weches Formation
Layer 4	Queen City Sand
Layer 5	Reklaw Formation
Layer 6	Carrizo Sand
Layer 7	Upper Wilcox
Layer 8	Middle Wilcox
Layer 9	Lower Wilcox

AQUIFER UNITS

The 9 aquifer and aquitard units in the model area, shown in the subsurface. Depths and thicknesses of each unit vary.



MODEL LAYER	HYDROSTRATIGRAPHIC UNITS
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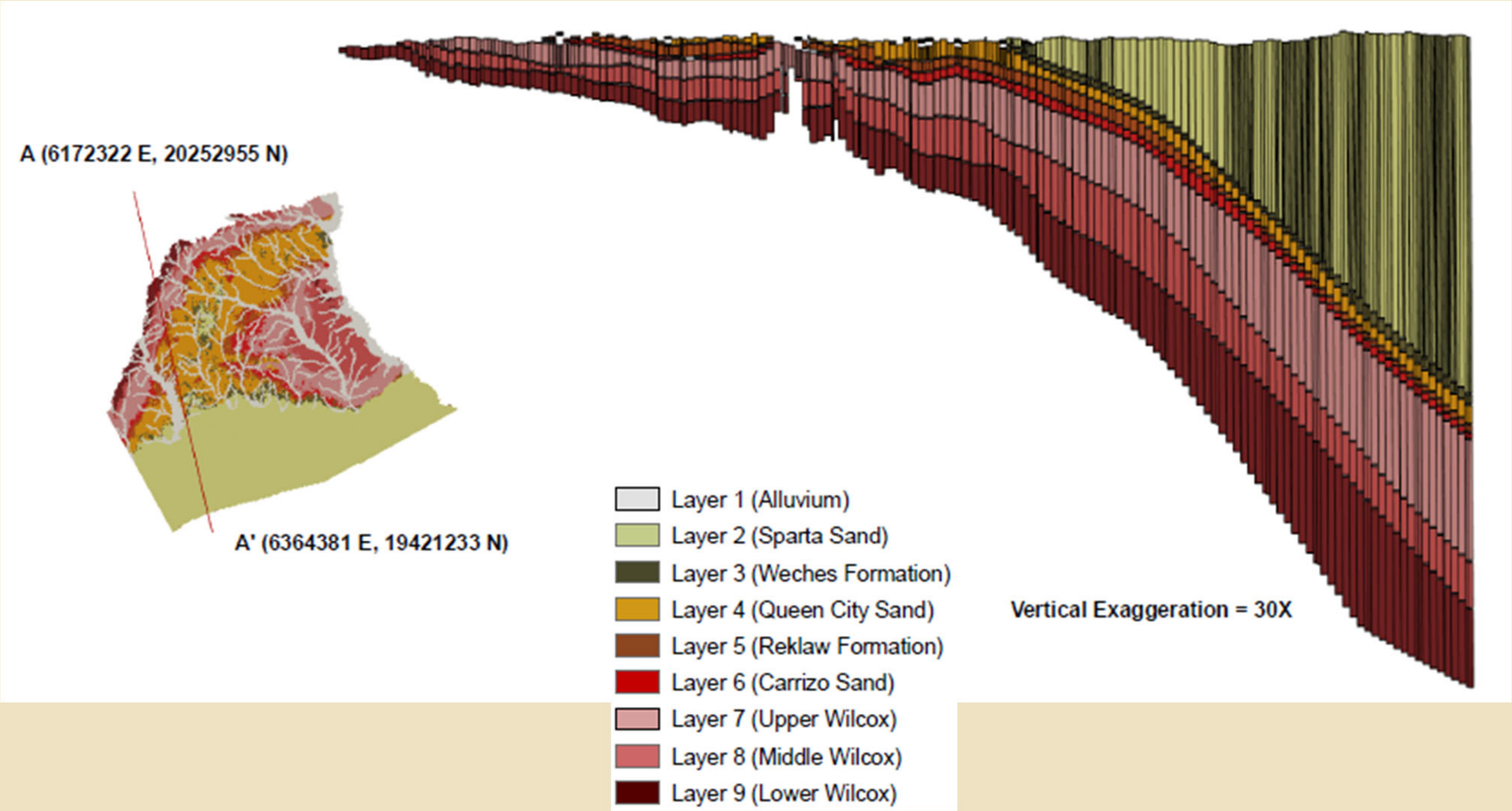
AQUIFER UNITS – IN THE MODEL

The groundwater model uses the 2018 conceptual layering.



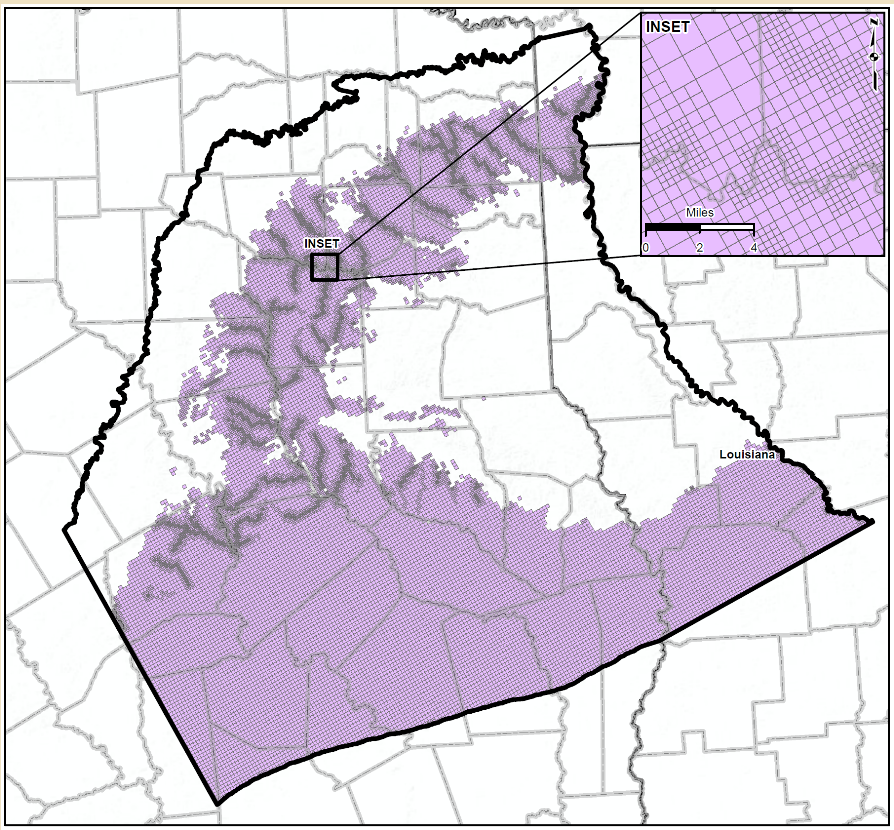
MODEL PACKAGES – MODFLOW6

- Name File
- Initial Conditions (IC)
- Model Domain Discretization (DIS)
- Node Property Flow (NPF)
- Storage (STO)
- General Head Boundary (GHB)
- River (RIV)
- Recharge (RCH)
- Evapotranspiration (EVT)
- Well (WEL)
- Output Control (OC)
- Solver (IMS)

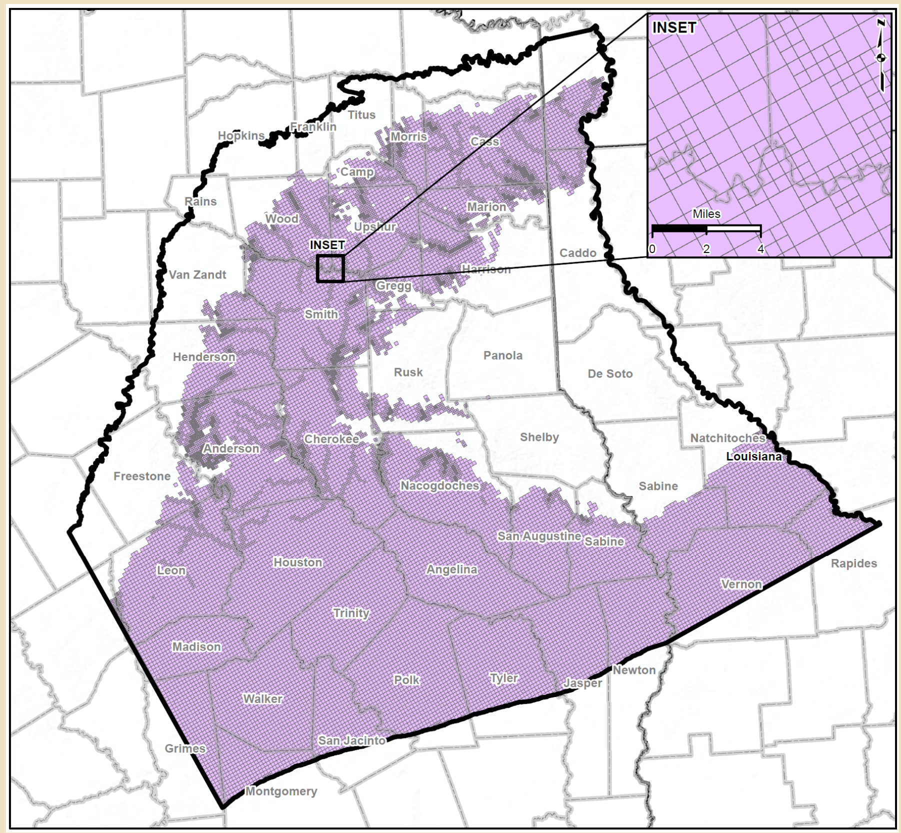
MODEL PACKAGES – DOMAIN DISCRETIZATION (DIS)

Grid refinement is finest near surface water features – horizontally and vertically

Layer 4



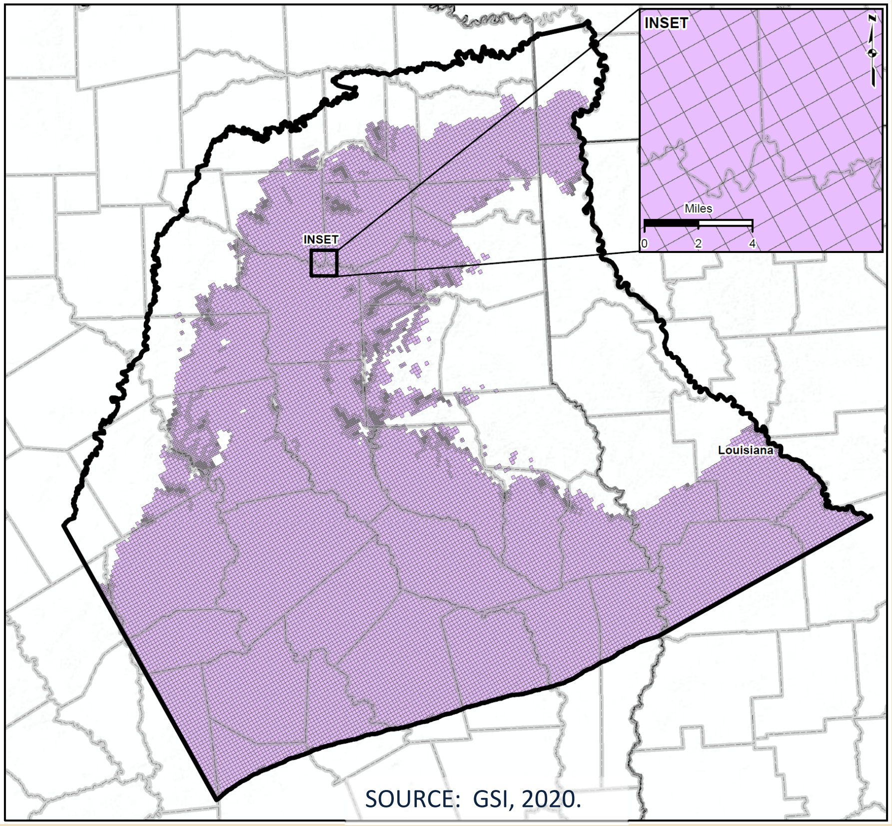
Layer 5



MODEL PACKAGES – DOMAIN DISCRETIZATION (DIS)

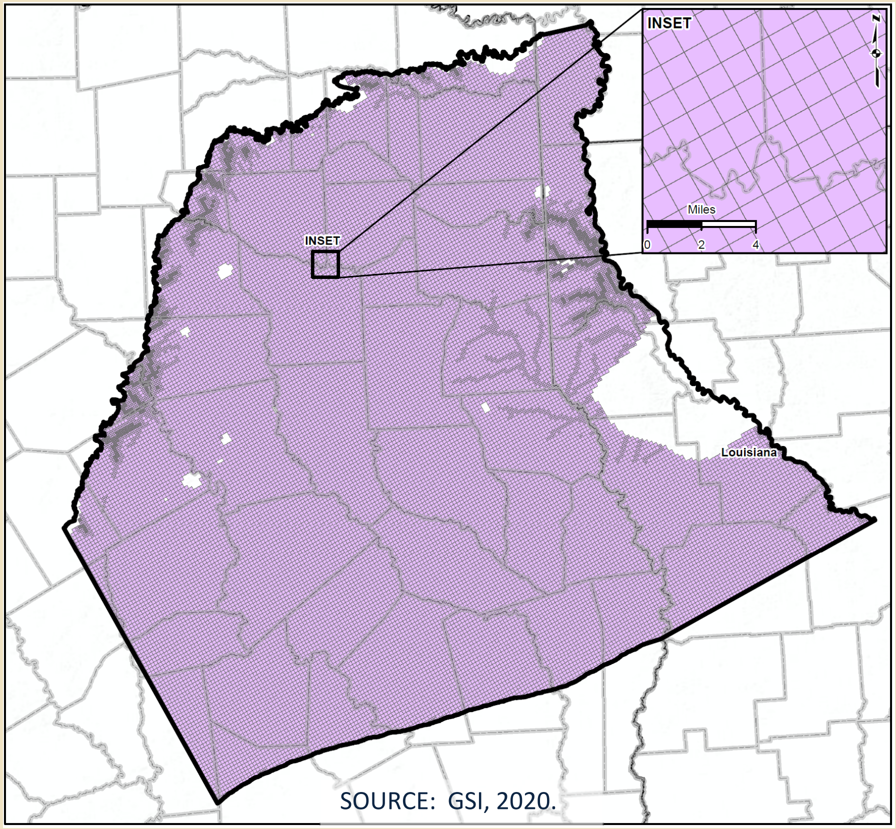
The model area grid: 193 miles by 201 miles; greater than 600,000 cells.

Layer 6



SOURCE: GSI, 2020.

Layer 9

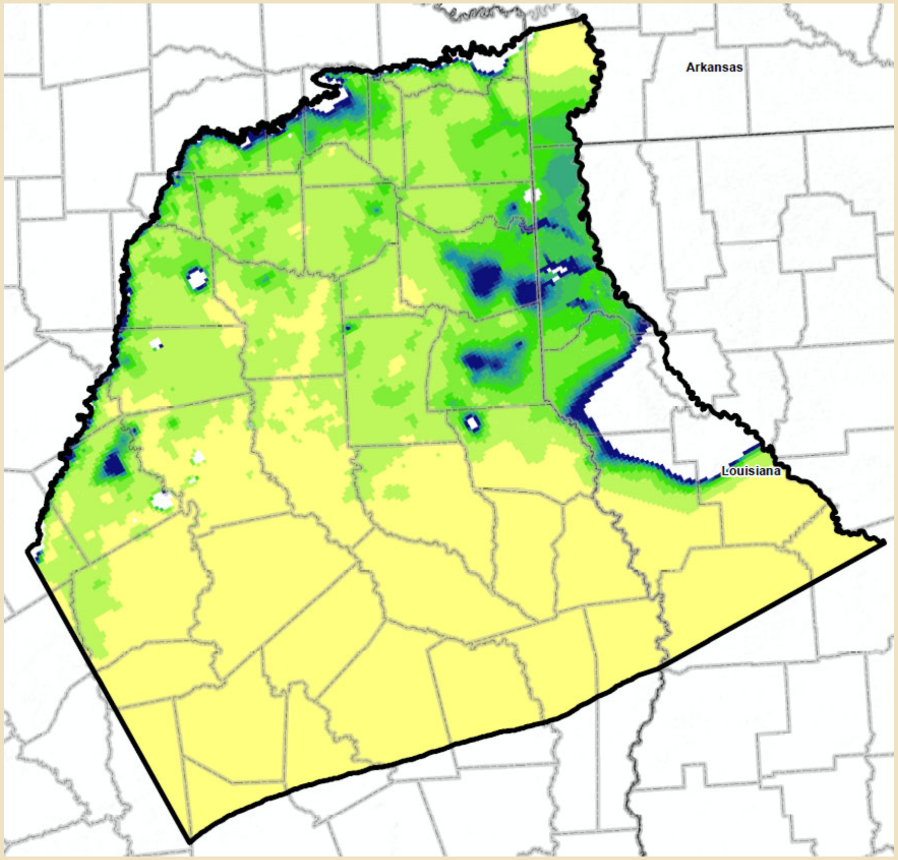


SOURCE: GSI, 2020.

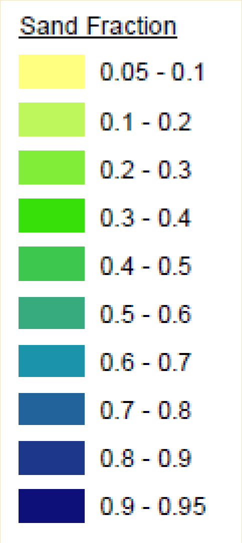
MODEL PACKAGES - NODE PROPERTY FLOW (NPF)

This package simulates hydraulic conductivity using sand fractions within each model layer.

Sand Fraction in Lower Wilcox (Layer 9)



Sand fractions same as in previous GMA.

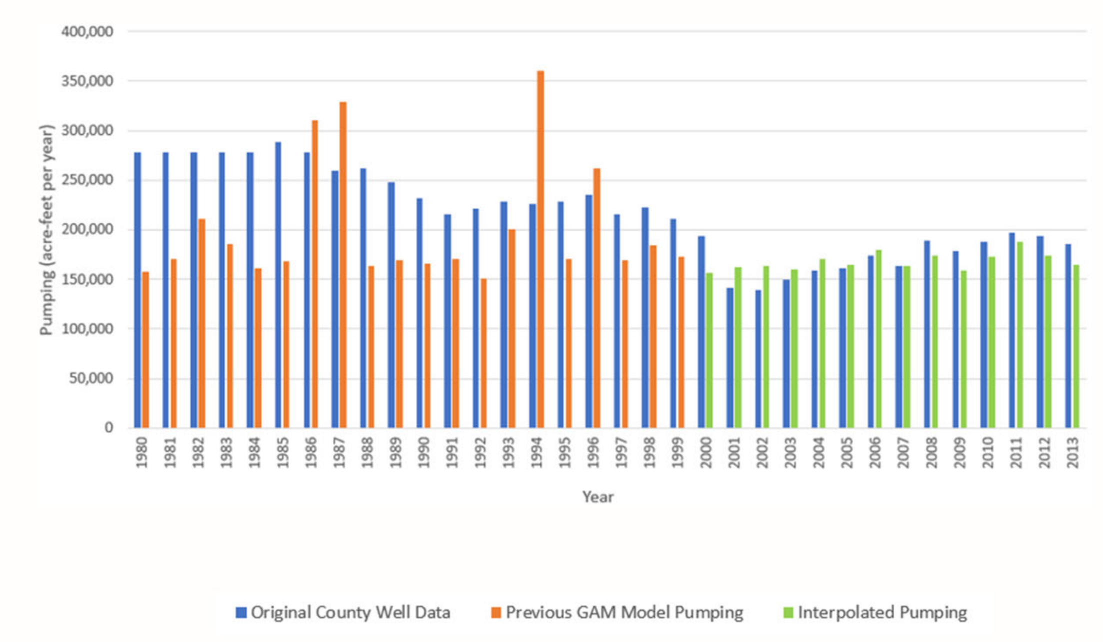


MODEL PACKAGES - WELL (WEL)

This package simulates the pumping wells in the model.

Pumping dataset was developed using the following data sources:

- County-wide data from TWDB separated by water use types
- Updated with GCD data
- Updated with Railroad Commission data for mining

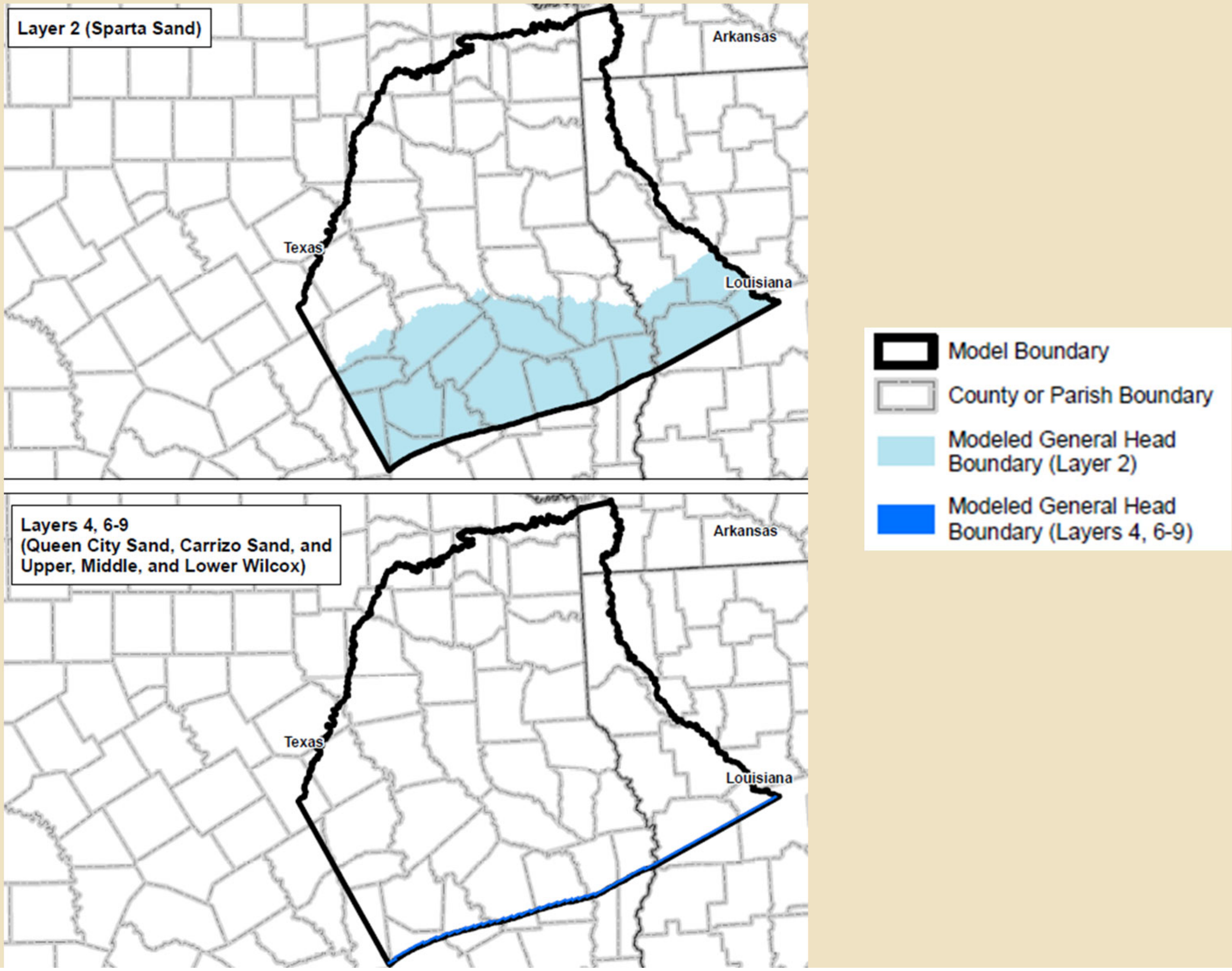


Note: Pumping interpolation for 2000 through 2013 was based on ratio with 1999 pumping.
Multiplication factors are shown in Table 2.7-2.

The old GAM is the basis for pumping estimates used in the numerical model.

MODEL PACKAGES - GENERAL HEAD BOUNDARY (GHB)

This package simulates flow in and out of the modeled area.



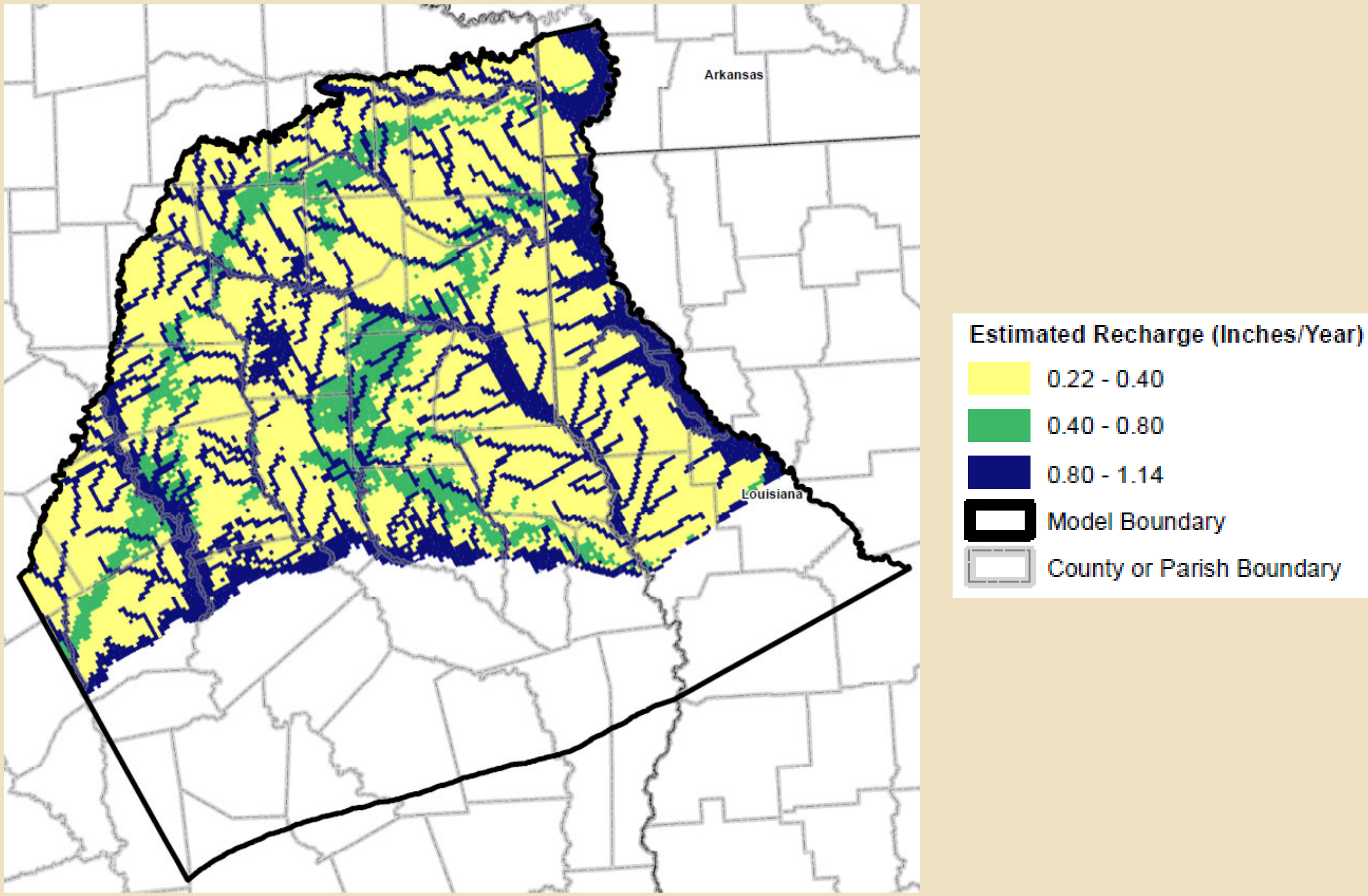
MODEL PACKAGES - RIVER (RIV)

This package simulates the rivers and streams in the model.

Stream network was generated based on the lowest elevations in the model domain based on the available DEM.

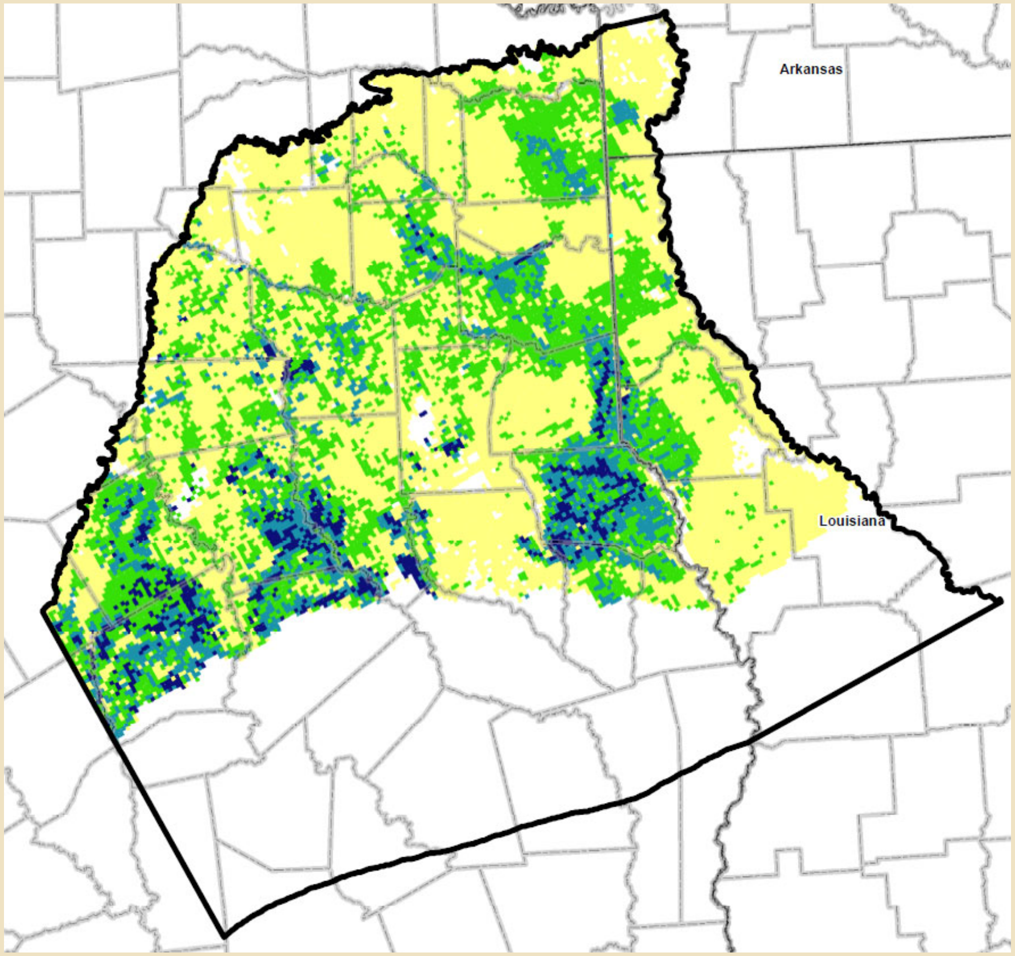
MODEL PACKAGES - RECHARGE (RCH)

This package simulates the amount of precipitation that reaches the subsurface units.

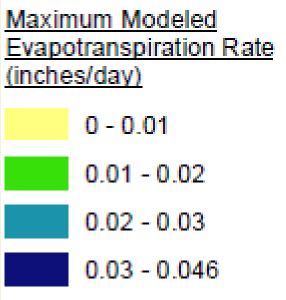


MODEL PACKAGES - EVAPOTRANSPIRATION (EVT)

This package simulates water lost from the subsurface units to evapotranspiration.



Evapotranspiration from previous SWAT modeling.



MODEL INPUTS – QUALITY CONTROL

Quality control of raw pumping data:

- Sudden change in pumping rates
- Outliers
- Pumping changes do not reflect observed water level elevation changes
- Data was unreliable
- Use of the old GAM pumping data for 1980-1999 provided a better fit to water levels in a calibrated model
- Pumping data for 2000-2013 was estimated by scaling of raw pumping data to match old GAM total estimates for 1999

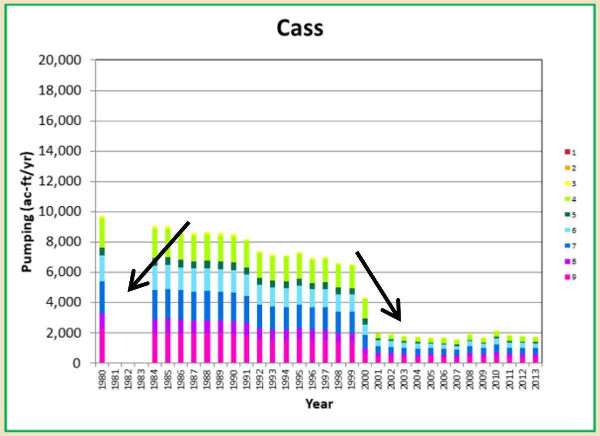
Quality control of water level elevation data:

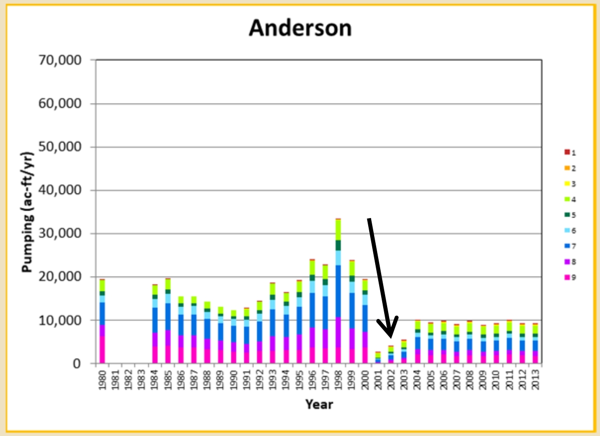
- Layer assignments provided were inconsistent with water level elevations
- Lack of well construction information
- Many data records with measurement problems

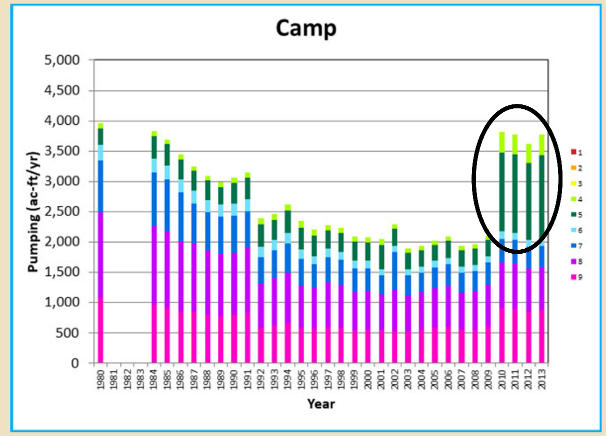
MODEL INPUTS – PUMPING DATA EVALUATIONS

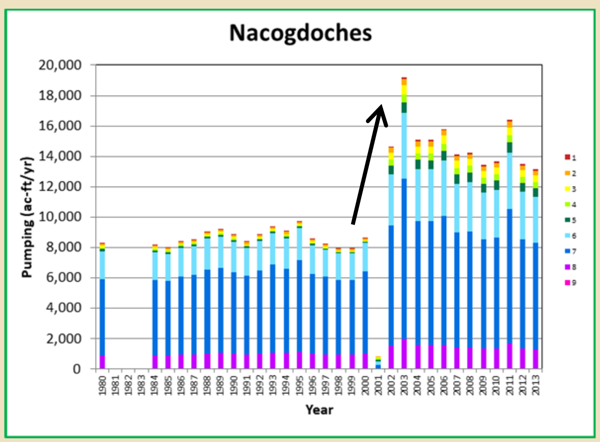
Sudden change in rates

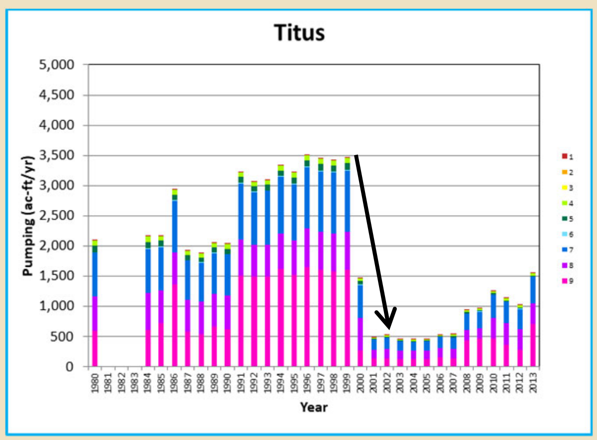
Outliers

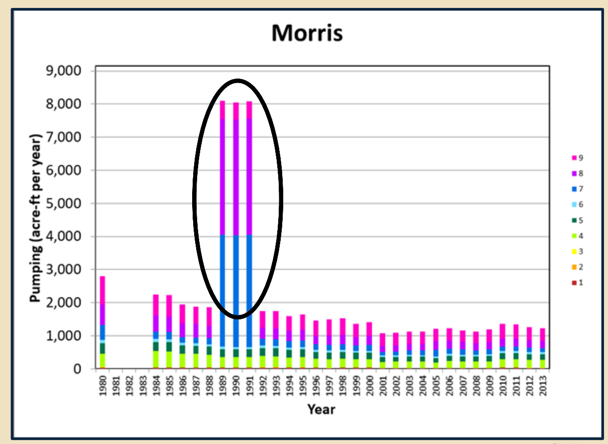












MODEL INPUTS – PUMPING DATA EVALUATIONS

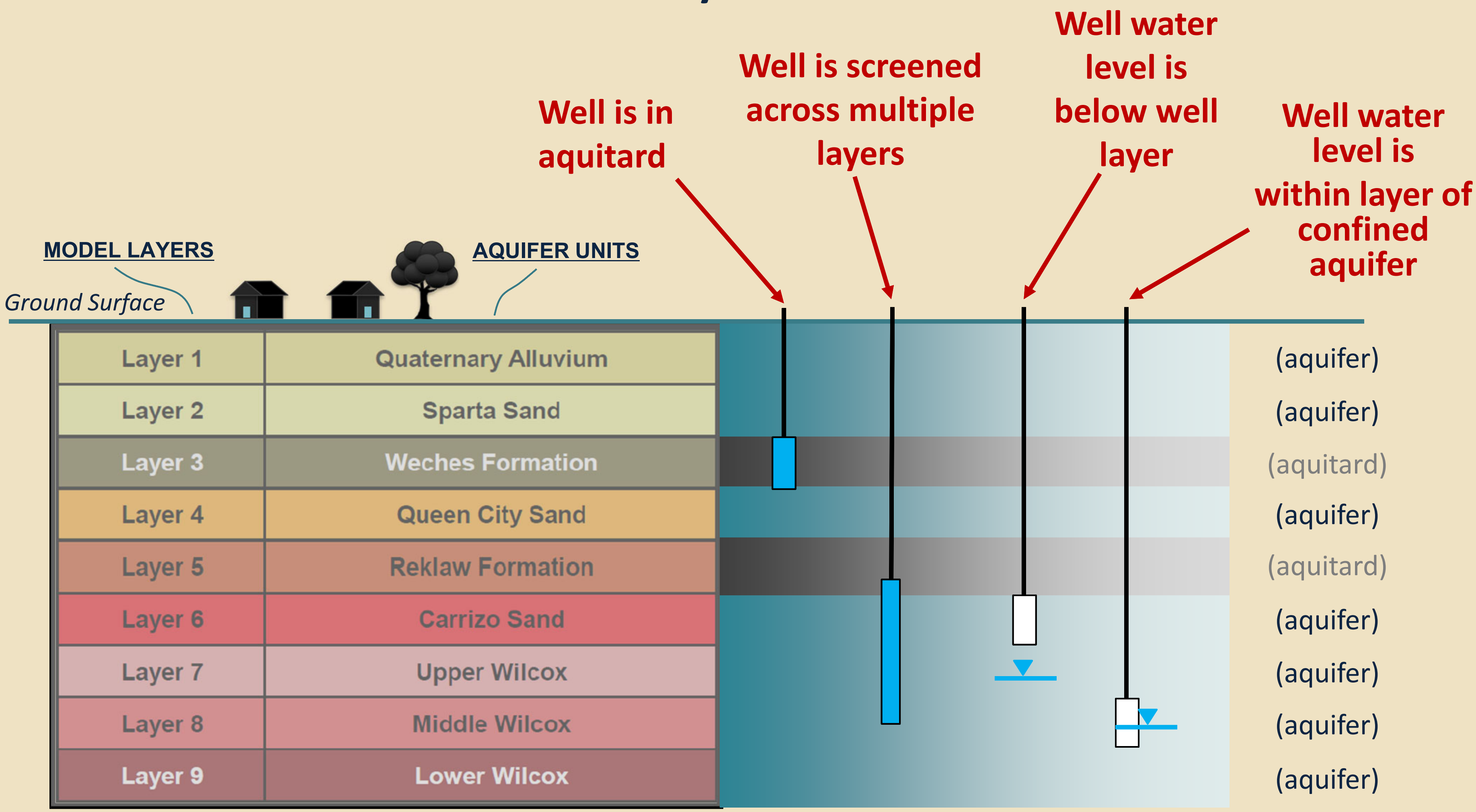
1. Attempted to calibrate model with developed pumping dataset using the raw data sources provided by TWDB and updated with GCD and Railroad Commission data
   a) Compiled pumping dataset was unreliable and contained errors
2. Attempted to calibrate model with pumping outliers corrected
3. Attempted to smooth the pumping data for each county by multiplying each stress period by a factor and filled in data gaps
   a) This proved time intensive
   b) This method did not significantly improve calibration or result in a more reliable data set
4. Attempted to use PEST to calibrate pumping for each county
   a) A program was written to use PEST to adjust pumping in each county by a pumping factor for every year
   b) Computationally intensive
   c) This method did not significantly improve calibration or result in a more reliable data set

Final Solution

5. Pumping data from the previous GAM (Intera, 2004) model was used
   a) Previous model pumping data was used for the period 1980 – 1999
   b) The pumping data for the period 2000 – 2013 used scaled 1999 data

MODEL INPUTS – MONITORING WELL EVALUATIONS

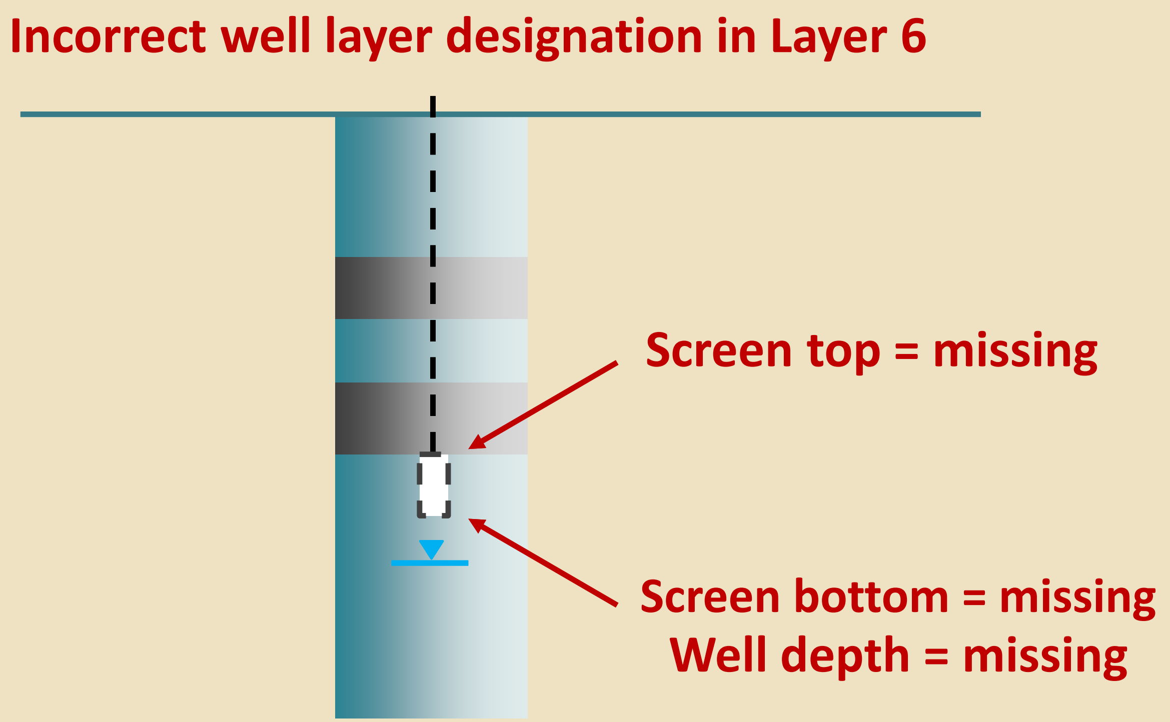
Difficulties encountered with county data:



MODEL INPUTS – MONITORING WELL WATER LEVEL DATA EVALUATIONS

Further difficulties encountered:

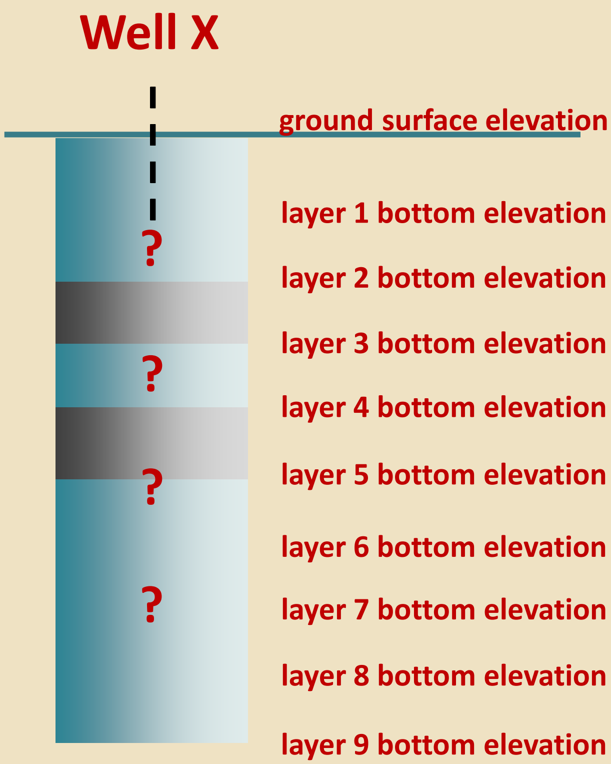
- few wells have available construction information
- locations are approximate for many wells (center of section)



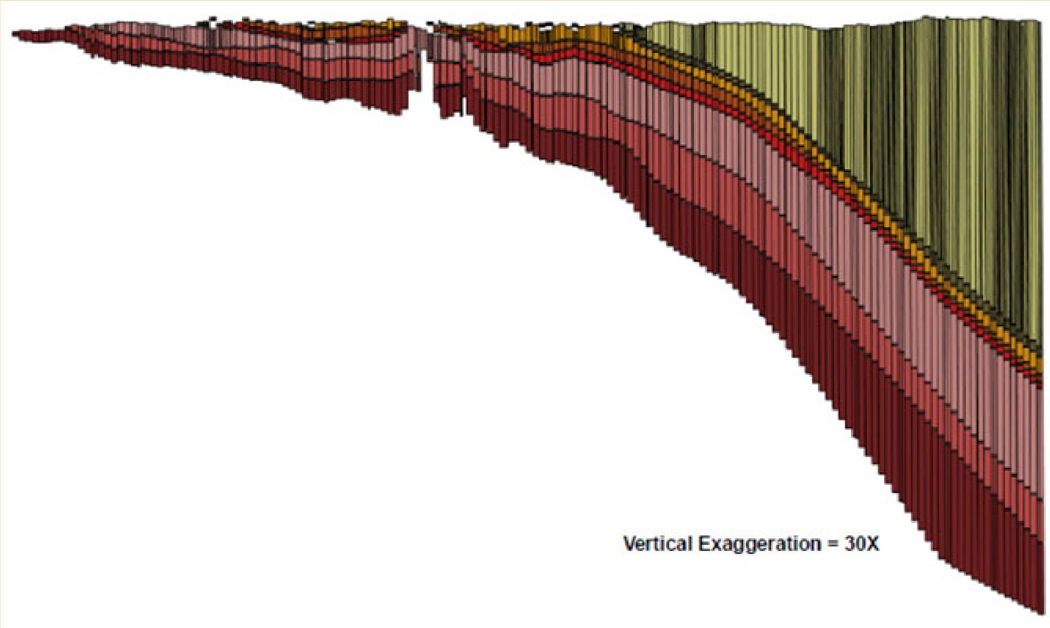
MODEL INPUTS – MONITORING WELL WATER LEVEL DATA EVALUATIONS

Data analysis for well layer placement:

1,859 wells and their minimum and maximum water levels were systematically compared to all layer top and bottom elevations at each of the 1,859 wells across the model area



Model Layers showing Variation in Elevations Across Model Area



MODEL INPUTS – MONITORING WELL WATER LEVEL DATA EVALUATIONS

The dataset contained 19,765 water level records from 1,859 wells.

Quality control evaluations with water level records

Unusable records due to:

- pumping-level measurement;
- presence of oil and grease in well;
- possible incorrect well identification;
- flooding/runoff into the well casing;
- air leak in the sampling line;
- re-completion in different zone;
- well bridged or caved;
- previously flagged as questionable; and
- well water levels previously marked for exclusion.

250 records removed

Records with quality issues due to:

- Reported recent pumping;
- nearby pumping;
- possible recharge activities nearby;
- measurements from ground surface prior to wellhead completion;
- wet or leaking casing; and
- tape does not fall freely in well;
- well screened across multiple model layers;
- and wells with a single water level measurement.

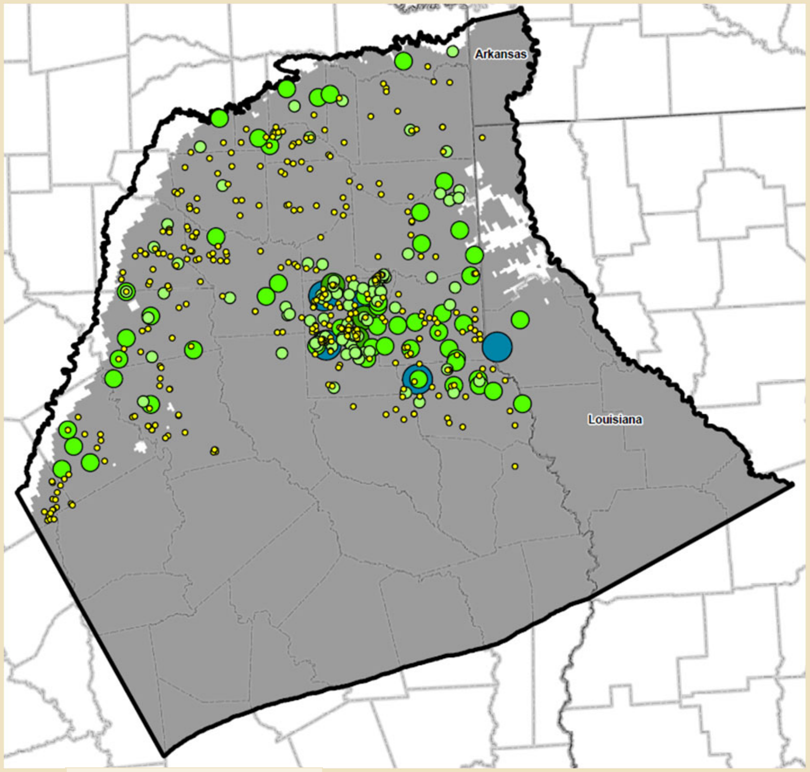
2,308 records used in model but weighted 0.5 or 0.7

Final dataset has 18,606 records from 1,797 wells.

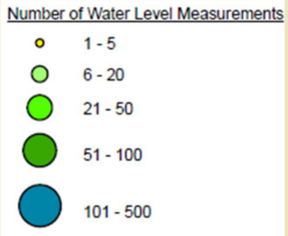
MODEL INPUTS – MONITORING WELL WATER LEVEL DATA EVALUATIONS

1,797 monitoring wells were placed in 7 water-bearing model layers.

Example Showing Monitoring Wells in Layer 8, Middle Wilcox, Displaying Number of Records at Each Well



SOURCE: GSI, 2020.



Summary of data evaluation:

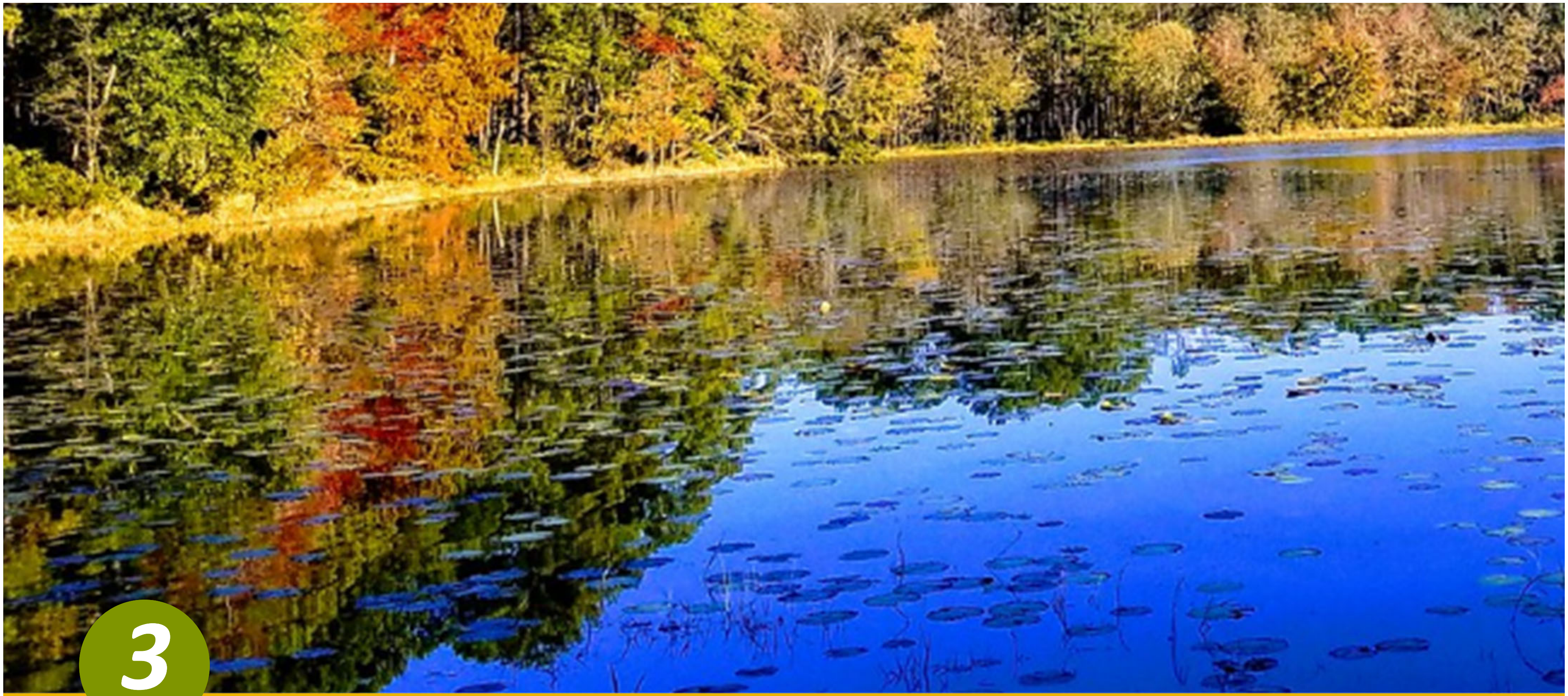
- **incorrect layer designations**
- **no construction information to verify layering**
- **uncertain well locations**
- **unusable data records**
- **data records with measurement quality problems**

MODEL INPUTS – MONITORING WELL WATER LEVEL DATA EVALUATIONS

1. Attempted to calibrate model with monitoring well data provided by TWDB using provided hydrostratigraphic unit designations and available well construction
   a) This resulted incorrect layer designations and poor PEST calibration
   b) Time intensive evaluations to categorize various water level and pumping errors

Final Solution

2. Compared the monitoring well water level with the hydrostratigraphic layers.
   a) Created a database with the minimum and maximum water levels for each of the 1,859 wells and the layer elevations for each layer for the well location cell
   b) Compared the minimum water level elevations and layer elevations at each well.
   c) Moved the well down if the minimum water level was below the designated layer elevation
   d) Moved the layer down if the water levels were within the designated layer elevation but it was not in the outcrop area (i.e., a saturated layer above exists)
   e) This proved time intensive
   f) This significantly improved calibration and resulted in a more reliable data set
3. Weighted each water level elevation
   a) This method improved calibration and resulted in a more reliable data set



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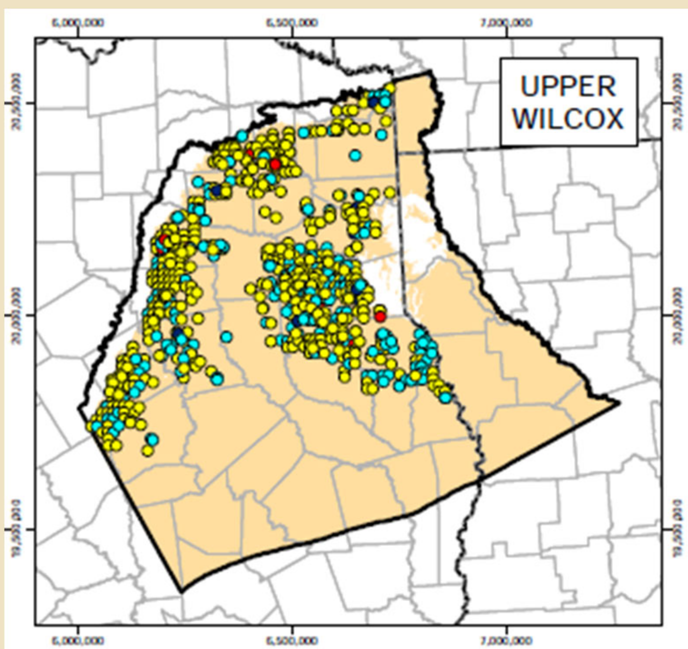
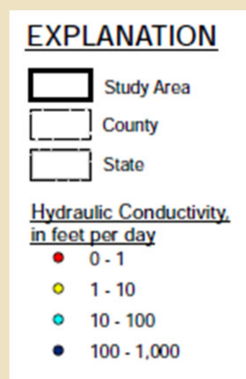
MODEL CALIBRATION AND RESULTS

MODEL CALIBRATION

Calibration is the process of adjusting model parameters that simulate real-world processes.

A groundwater model simulates flow processes in each cell within the model area (600,000+ cells). Therefore, estimates have to be made between the data points recorded.





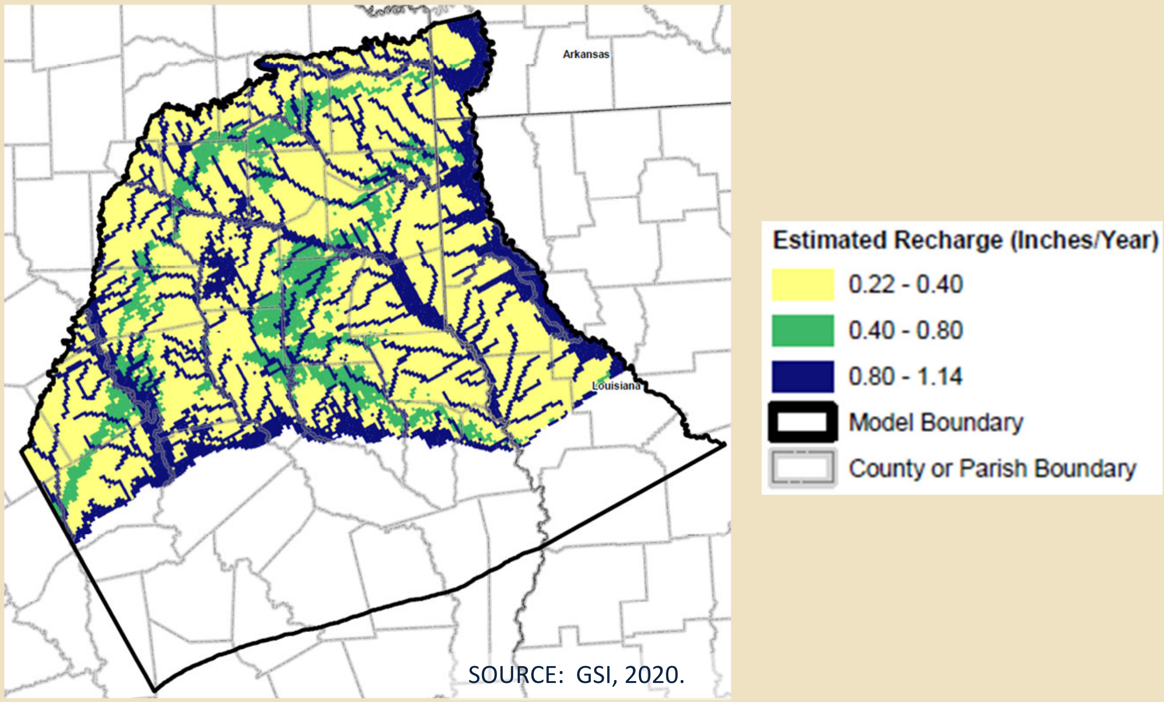
SOURCE: Montgomery & Associates, 2018.

Example of Measured Hydraulic Conductivity Values Within Aquifer Units

MODEL CALIBRATION

Calibration parameters were:

- recharge to groundwater from precipitation
- hydraulic conductivity of sand and clay
- groundwater flow in and out at the model boundaries

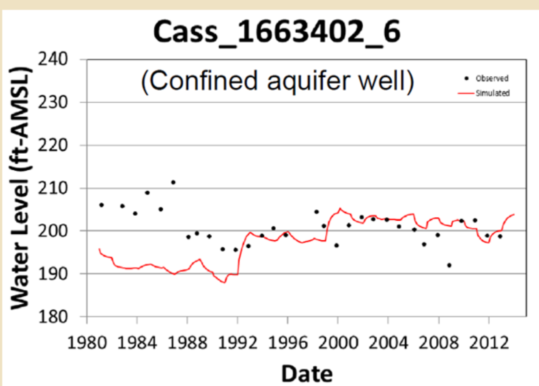


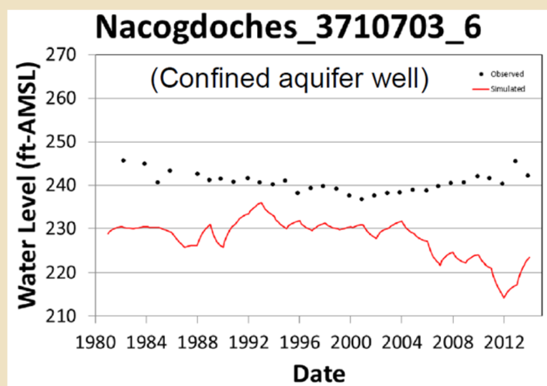
Example of Calibration Parameter: Distribution of Average Estimated Annual Recharge Rates for 1980

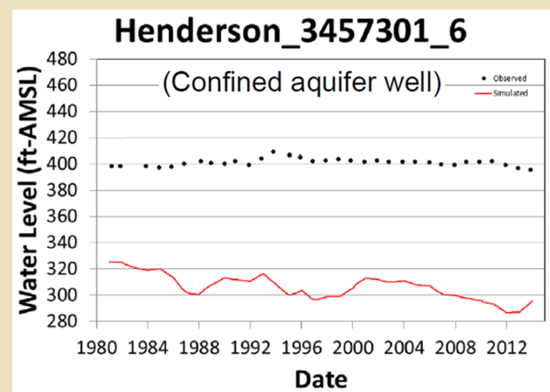
MODEL CALIBRATION

Calibration is verified by:

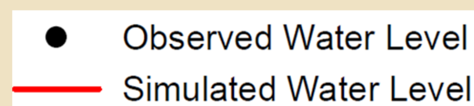
- **comparing the model's simulated water level elevations against measured water level elevations at monitoring wells**
- **comparing simulated and measured surface-water / groundwater interactions**







Example Comparisons at Individual Wells in Carrizo Sand Aquifer (Layer 6).



SOURCE: GSI, 2020.

MODEL CALIBRATION

Calibration was evaluated visually and statistically

- **Spatially, the model is well calibrated;**
- Simulated groundwater contours were similar to interpolated contours based on observed data;
- Simulated water level elevation errors were less than 10% which indicates a good calibration;
- Simulated water level elevations also showed good correlation to corresponding measured values; and
- Gaining and loosing reaches appropriately modeled.

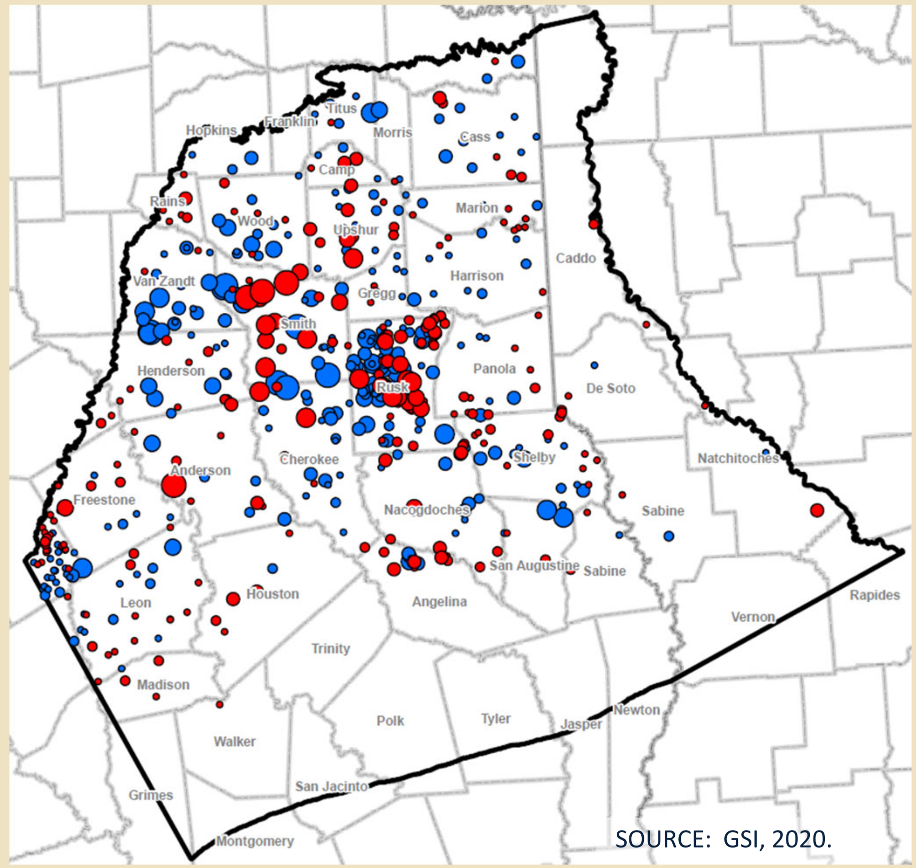
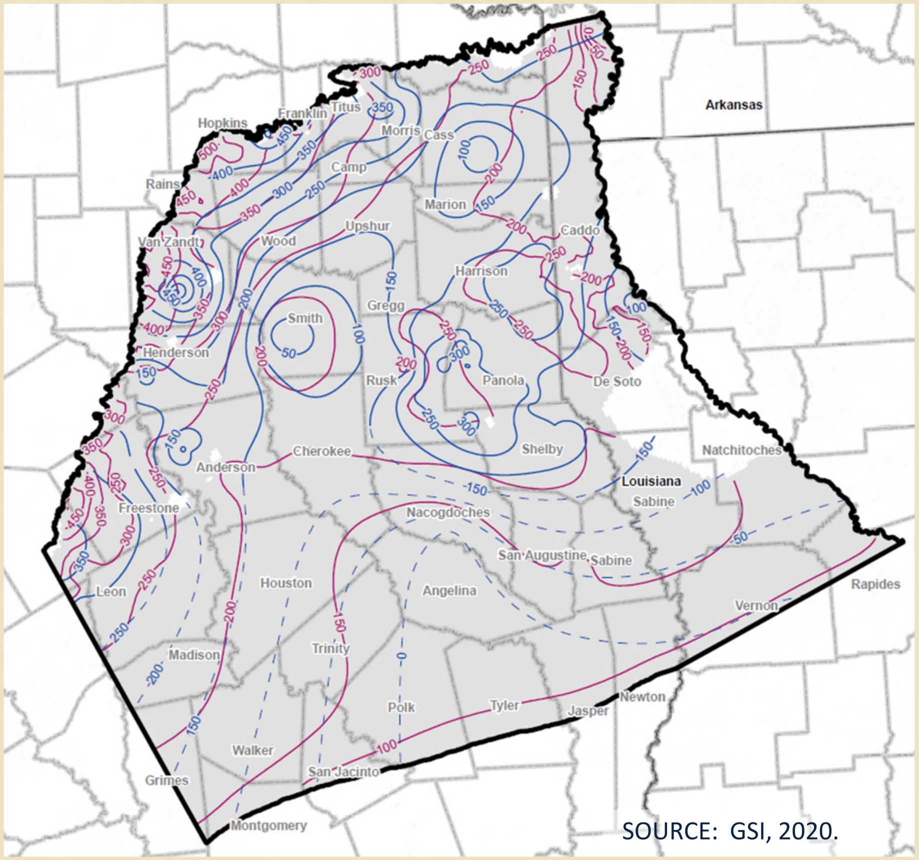


Figure Showing Average Error at Monitoring Wells from 1980 to 2013 (red: negative value; blue: positive value).

MODEL CALIBRATION

Calibration was evaluated visually and statistically

- Spatially, the model is well calibrated;
- **Simulated groundwater contours were similar to interpolated contours based on observed data;**
- Simulated water level elevation errors were less than 10% which indicates a good calibration;
- Simulated water level elevations also showed good correlation to corresponding measured values; and
- Gaining and loosing reaches appropriately modeled.



SOURCE: GSI, 2020.

Example Flow Field for Middle Wilcox Aquifer (Layer 8), showing Simulated (purple) and Measured (blue) for 2013.

MODEL CALIBRATION

Calibration was evaluated visually and statistically

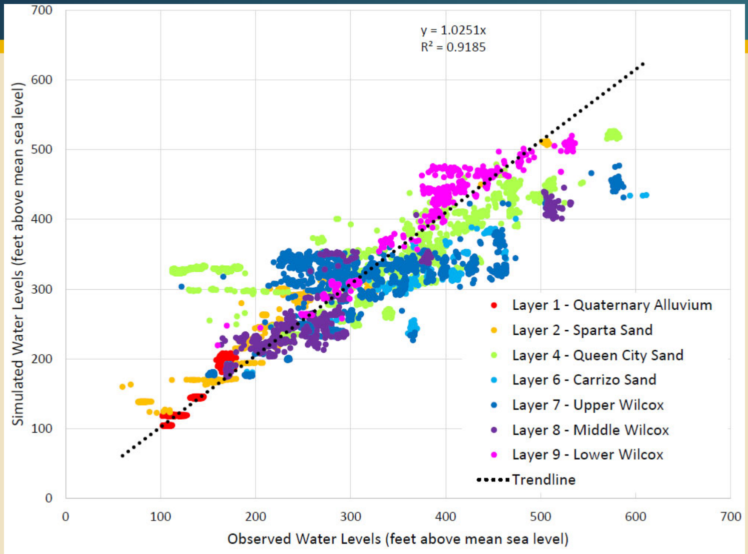
SOURCE: GSI, 2020.

Statistic	Layer 1 (Quaternary Alluvium)	Layer 2 (Sparta Sand)	Layer 4 (Queen City Sand)	Layer 6 (Carrizo Sand)	Layer 7 (Upper Wilcox)	Layer 8 (Middle Wilcox)	Layer 9 (Lower Wilcox)
Number of observations	707	626	3,072	3,581	3,458	4,147	2,830
Range in observed values	77.62	449.07	503.04	897.10	738.15	752.00	616.16
Residual mean	-8.73	-31.56	-70.38	26.11	4.87	-6.36	-3.33
Absolute residual mean	11.04	36.45	99.21	45.77	47.28	32.12	25.01
Standard deviation	13.16	26.96	106.91	54.30	61.00	46.60	35.27
RMS error	15.79	41.51	128.00	60.25	61.20	47.03	35.42
Scaled residual mean	-0.112	-0.070	-0.140	0.029	0.007	-0.008	-0.005
Scaled absolute residual mean	0.142	0.081	0.197	0.051	0.064	0.043	0.041
Scaled standard deviation	0.169	0.06	0.213	0.061	0.083	0.062	0.057
Scaled RMS error	0.203	0.092	0.254	0.067	0.083	0.063	0.057

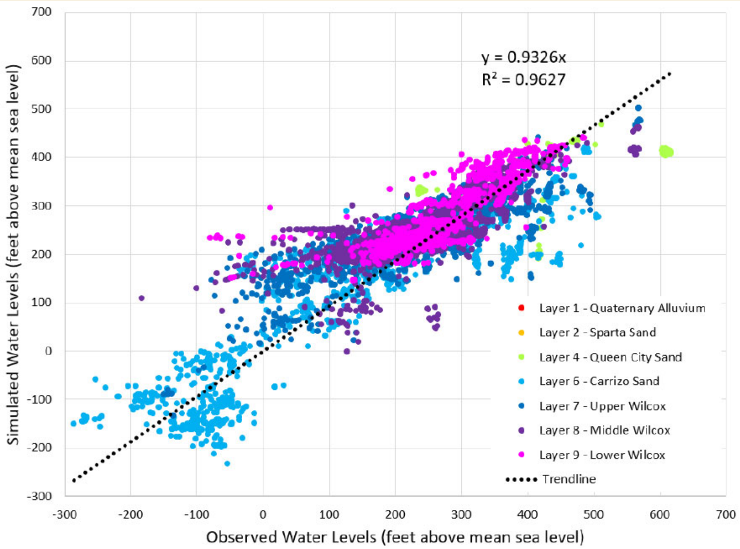
- **Simulated water level elevation errors were less than 10% which indicates a good calibration;**

Statistic	Value
Scaled residual mean	-0.010
Scaled absolute residual mean	0.052
Scaled standard deviation	0.077
Scaled RMS error	0.078

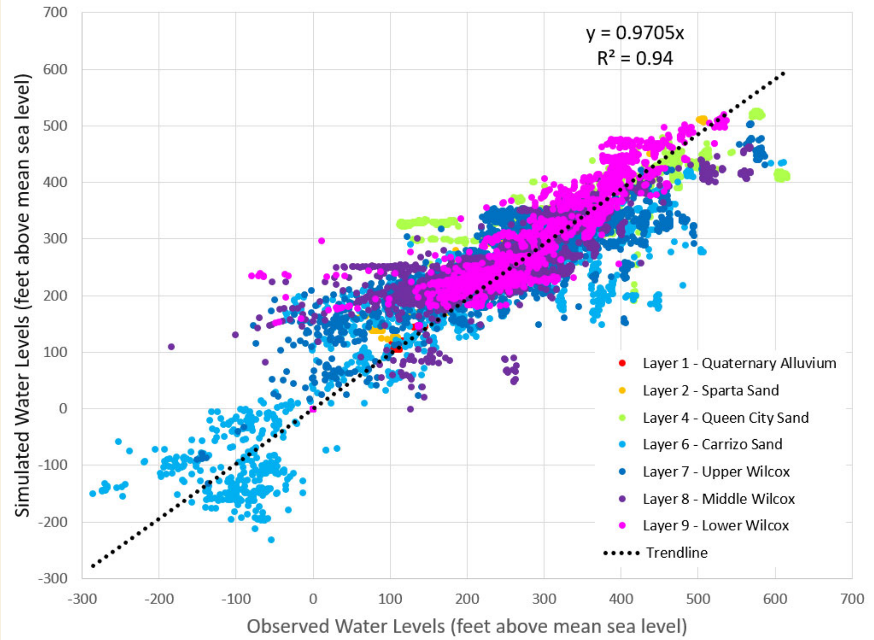
MODEL CALIBRATION



Unconfined (outcrop) wells: 1980 to 2013.



Confined (down-dip) wells: 1980 to 2013.



All Monitoring Well Datapoints from 1980 to 2013.

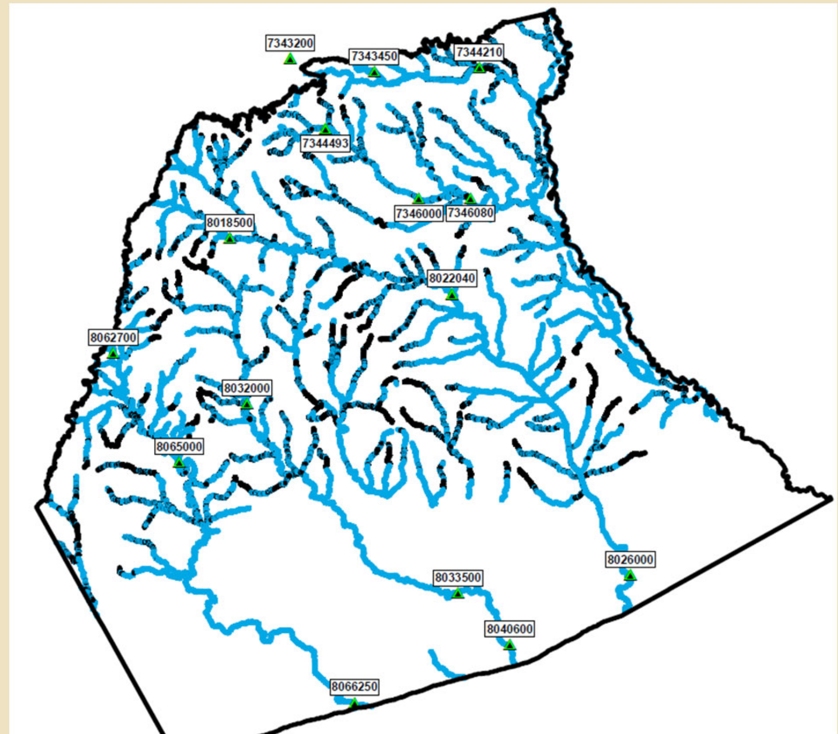
SOURCE: GSI, 2020.

- **Simulated water level elevations also showed good correlation to corresponding measured values**

MODEL CALIBRATION

Calibration was evaluated visually and statistically

- Spatially, the model is well calibrated;
- Simulated groundwater contours were similar to interpolated contours based on observed data;
- Simulated water level elevation errors were less than 10% which indicates a good calibration;
- Simulated water level elevations also showed good correlation to corresponding measured values; and
- **Gaining and loosing reaches appropriately modeled.**



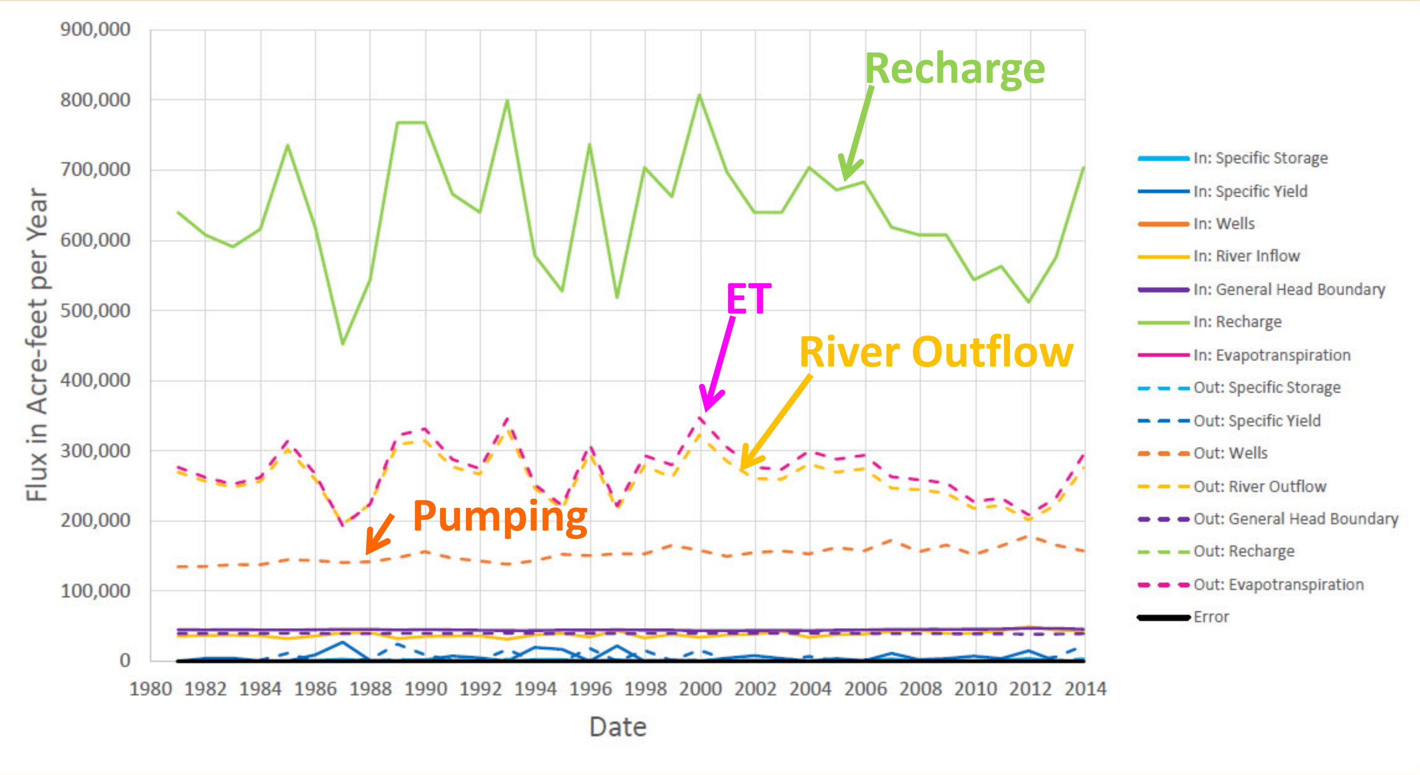
SOURCE: GSI, 2020.

Simulated Rivers Showing Gaining Conditions (blue), Consistent with Measured Conditions.

MODEL RESULTS – WATER BUDGET

The transient model water budget shows the following:

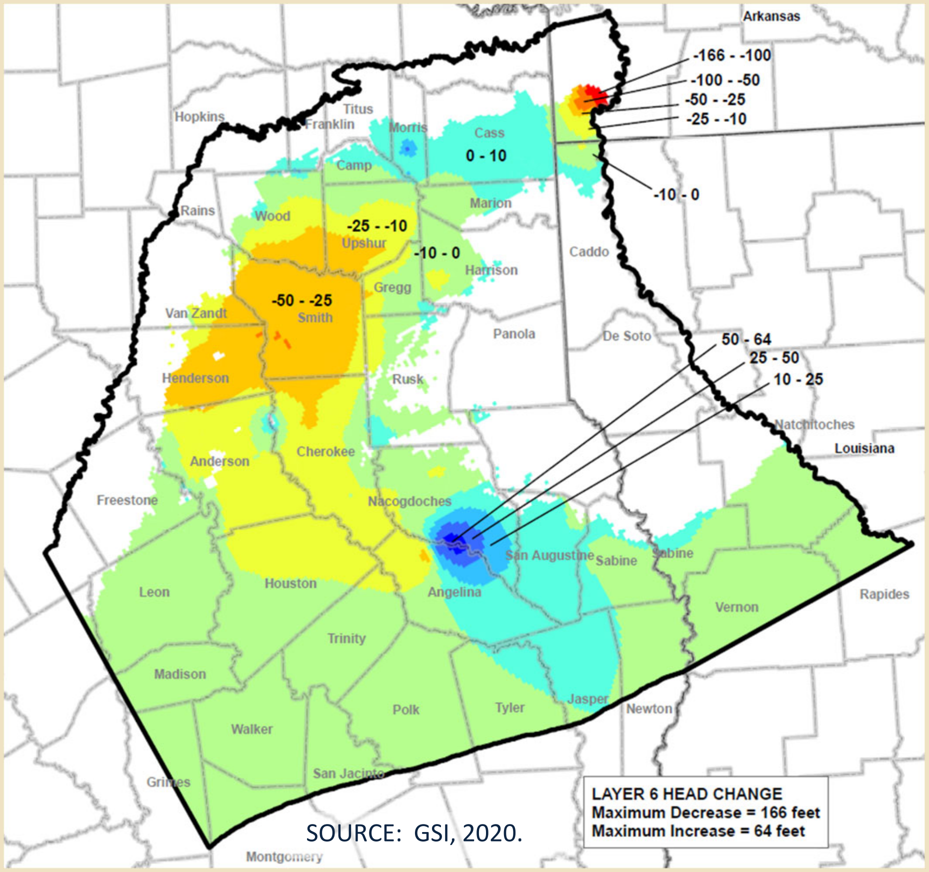
- **The largest inflow to the model is recharge;**
- **The largest outflows are evapotranspiration (ET), flow into the river, and groundwater pumping; and**
- **Most of the pumping in the model is in the Carrizo and Wilcox Aquifers.**



MODEL RESULTS – CHANGES IN WATER LEVEL

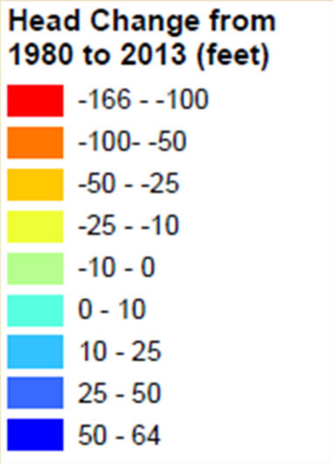
Carrizo Aquifer modeled drawdown from 1980 to 2013:

- General drawdown conditions through most of GMA 11 with maximum of 50 feet drawdown since 1980 around Smith and Henderson Counties.



SOURCE: GSI, 2020.

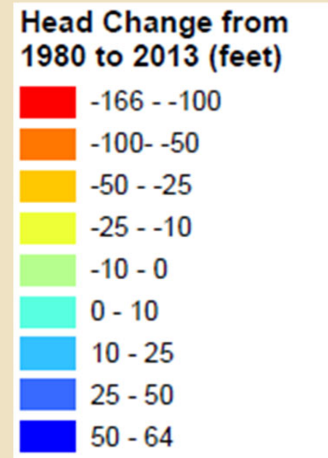
Modeled Change in Water Levels from 1980 to 2013.

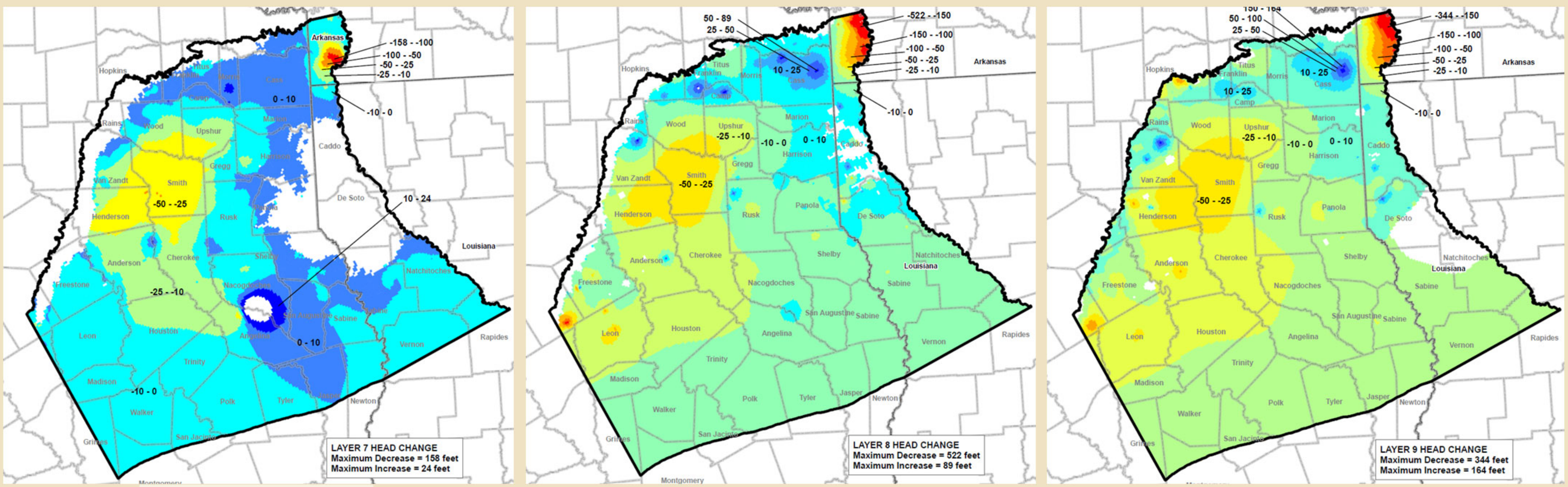


MODEL RESULTS – CHANGES IN WATER LEVEL

Wilcox Aquifer modeled drawdown:

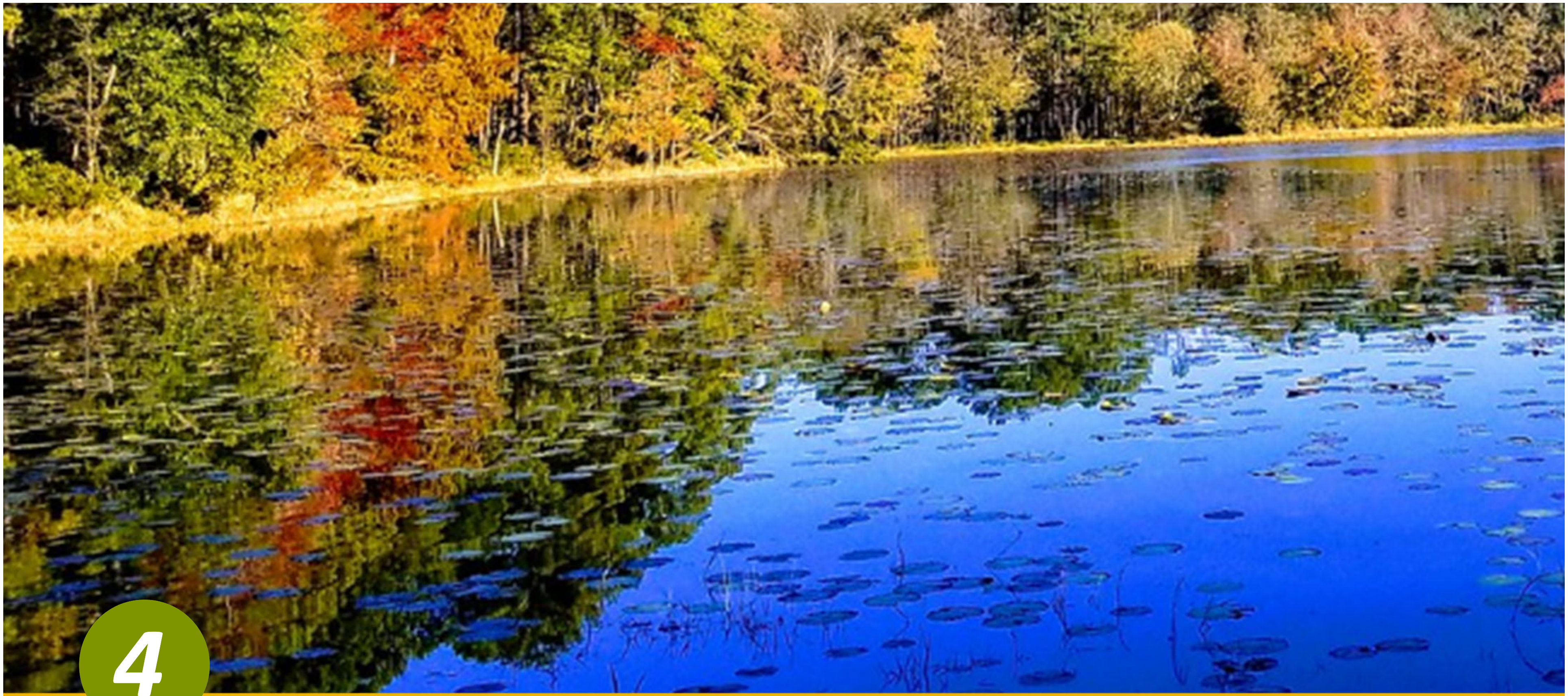
- General drawdown conditions through most of GMA 11 with maximum of 50 feet drawdown since 1980 around Smith and Henderson Counties.





SOURCE: GSI, 2020.

Upper, Middle, and Lower Wilcox Aquifers
Modeled Change in Water Levels from 1980 to 2013.



4 MODEL SENSITIVITY

MODEL SENSITIVITY

Once a model is calibrated, a series of sensitivity simulations are performed.

Each model constructed is unique. The specific design of a model may result in some inputs being very influential to model results, meaning that a small change to an input can create a disproportionately large change in the model results.

It is important to identify such parameters.

Sensitivities were performed for inputs important to the model:

Hydraulic Conductivity

Pumping

Recharge

Evapotranspiration

Specific Yield

MODEL SENSITIVITY - HYDRAULIC CONDUCTIVITY

Sensitivity to hydraulic conductivity is especially complex:

Each of the 9 model layers were evaluated.

Each layer contains both sand and clay fractions (aquifers contain more sand; aquitards contain more clay).

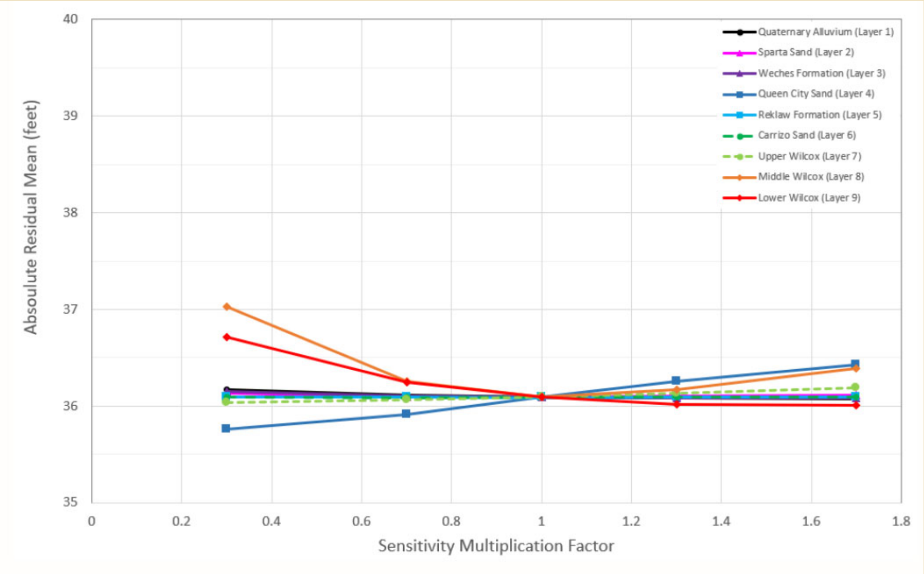
Within each layer, both sand and clay hydraulic conductivity were evaluated.

Hydraulic conductivity sensitivities were conducted on 1980 and 2013 steady-state conditions.

MODEL LAYER	HYDROSTRATIGRAPHIC UNITS AQUIFER UNITS
Layer 1	Quaternary Alluvium
Layer 2	Sparta Sand
Layer 3	Weches Formation
Layer 4	Queen City Sand
Layer 5	Reklaw Formation
Layer 6	Carrizo Sand
Layer 7	Upper Wilcox
Layer 8	Middle Wilcox
Layer 9	Lower Wilcox

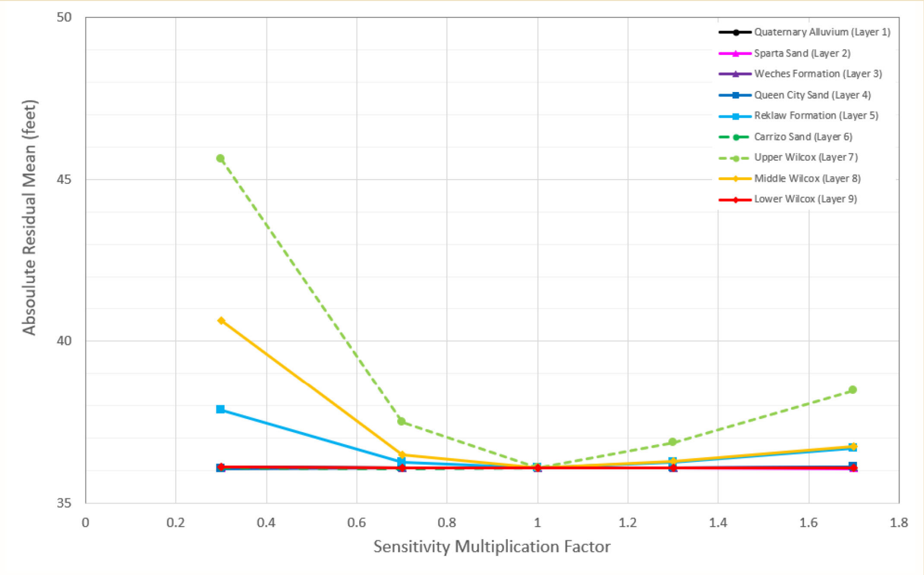
MODEL SENSITIVITY - HYDRAULIC CONDUCTIVITY

Sensitivity to the sand hydraulic conductivity value



- Sensitivity to sand value summary:
  - Queen City Sand (Layer 4) = low
  - Middle Wilcox (Layer 8) = medium
  - Lower Wilcox (Layer 9) = low
  - Remaining layers = no sensitivity

Sensitivity to the clay hydraulic conductivity value

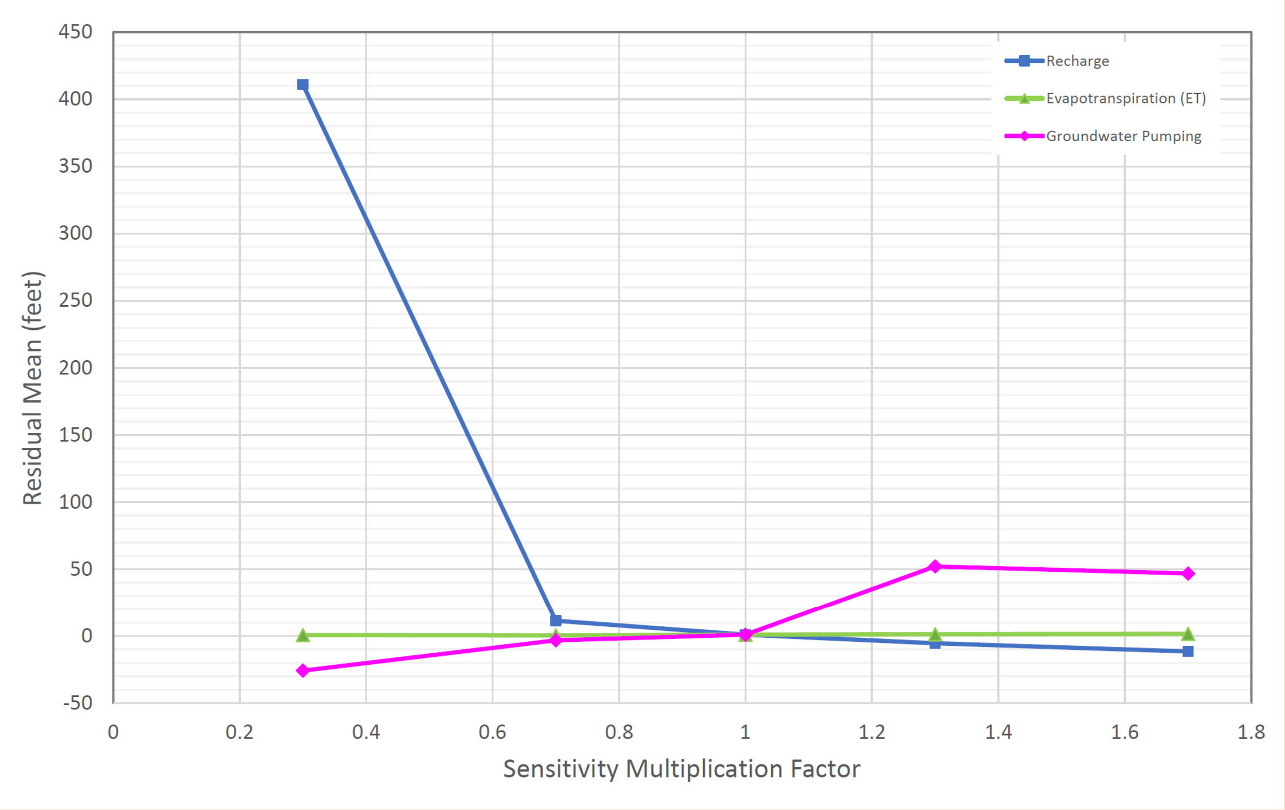


- Sensitivity to clay value summary:
  - Reklaw Formation (Layer 5) = low
  - Upper Wilcox (Layer 7) = high
  - Middle Wilcox (Layer 8) = medium
  - Remaining layers = no sensitivity

MODEL SENSITIVITY – MODEL STRESSES

Sensitivity to model parameters

- Recharge = high sensitivity
- Evapotranspiration = no sensitivity
- Groundwater Pumping = medium sensitivity

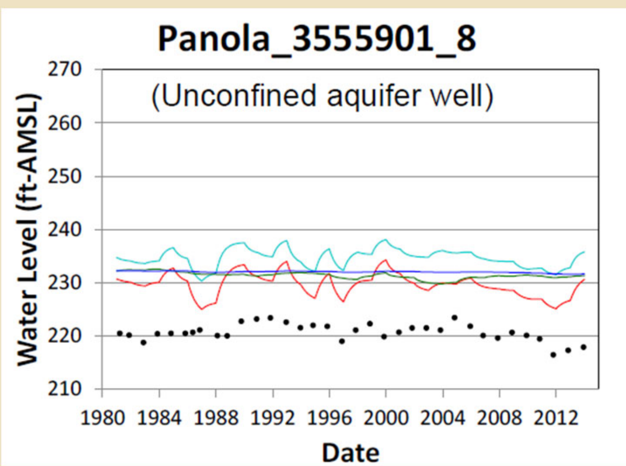


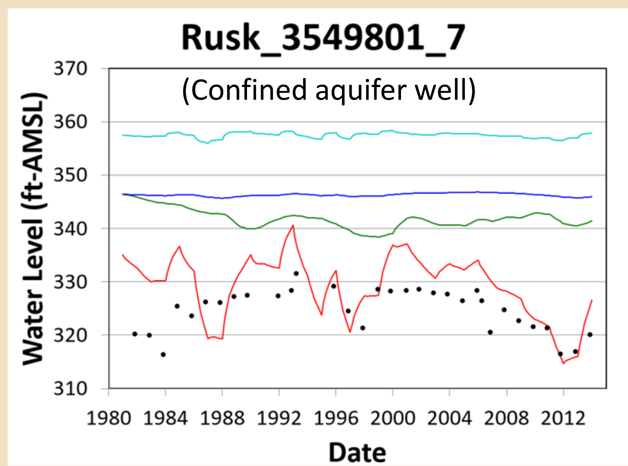
MODEL SENSITIVITY – MODEL STRESSES

Transient sensitivities were conducted on pumping, recharge, and storage.

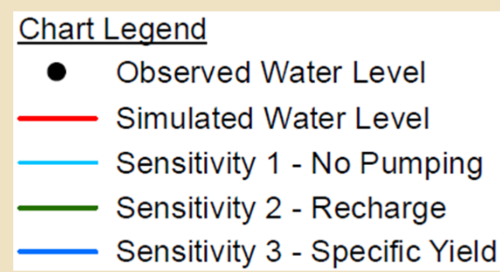
- **No pumping generally resulted in an increase in water levels**
- **Constant recharge generally resulted in dampened water level fluctuations**
- **Higher specific yield generally resulted in flat water levels**

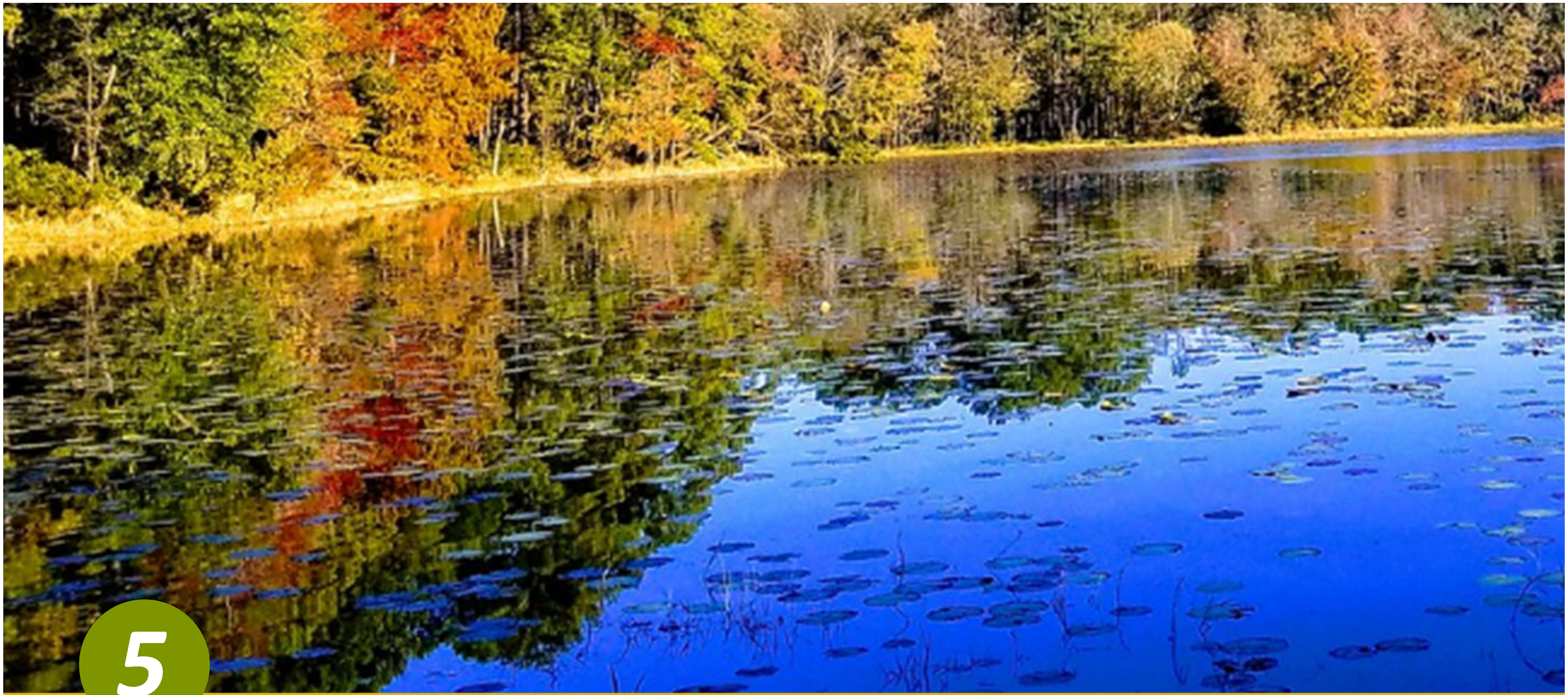
Provided insight for model calibration





Sensitivity:
No pumping = medium
Recharge = high
Specific Yield = none





5

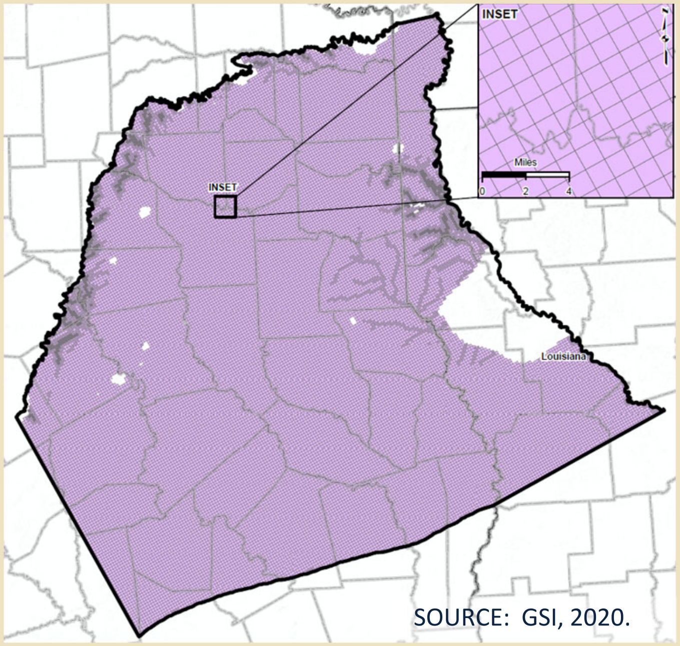
MODELING LIMITATIONS

MODEL LIMITATIONS AND ASSUMPTIONS

Modeled conditions diverge from actual conditions due to:

- **numerical equations representing flow processes**
- **grid design**
- **boundary geometry and properties**
- **errors in aquifer conceptualization**
- **averaging of model inputs values over time such as annual time frame**

Model Grid Representing Study Area as Discrete Cells



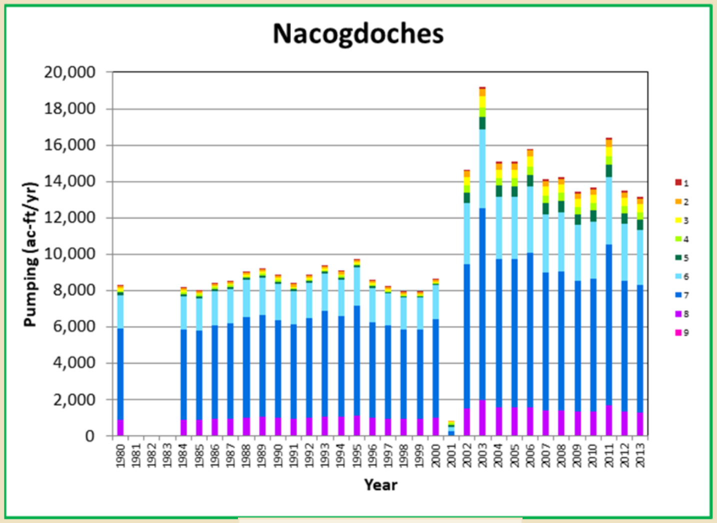
SOURCE: GSI, 2020.

MODEL LIMITATIONS AND ASSUMPTIONS

The 2020 GMA 11 model also has the following specific limitations:

- **Uncertainty in pumping estimates**
- **Errors in water level elevation locations**
- **Lack of well construction information**
- **Estimates of sand and clay fractions for each layer**
- **Equation used to convert clay and sand fraction to hydraulic conductivity**

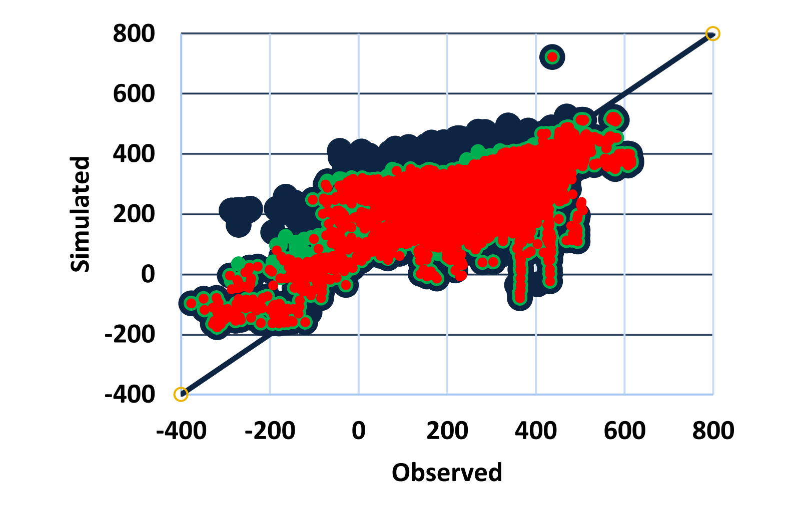
Example of Uncertain County Pumping Data



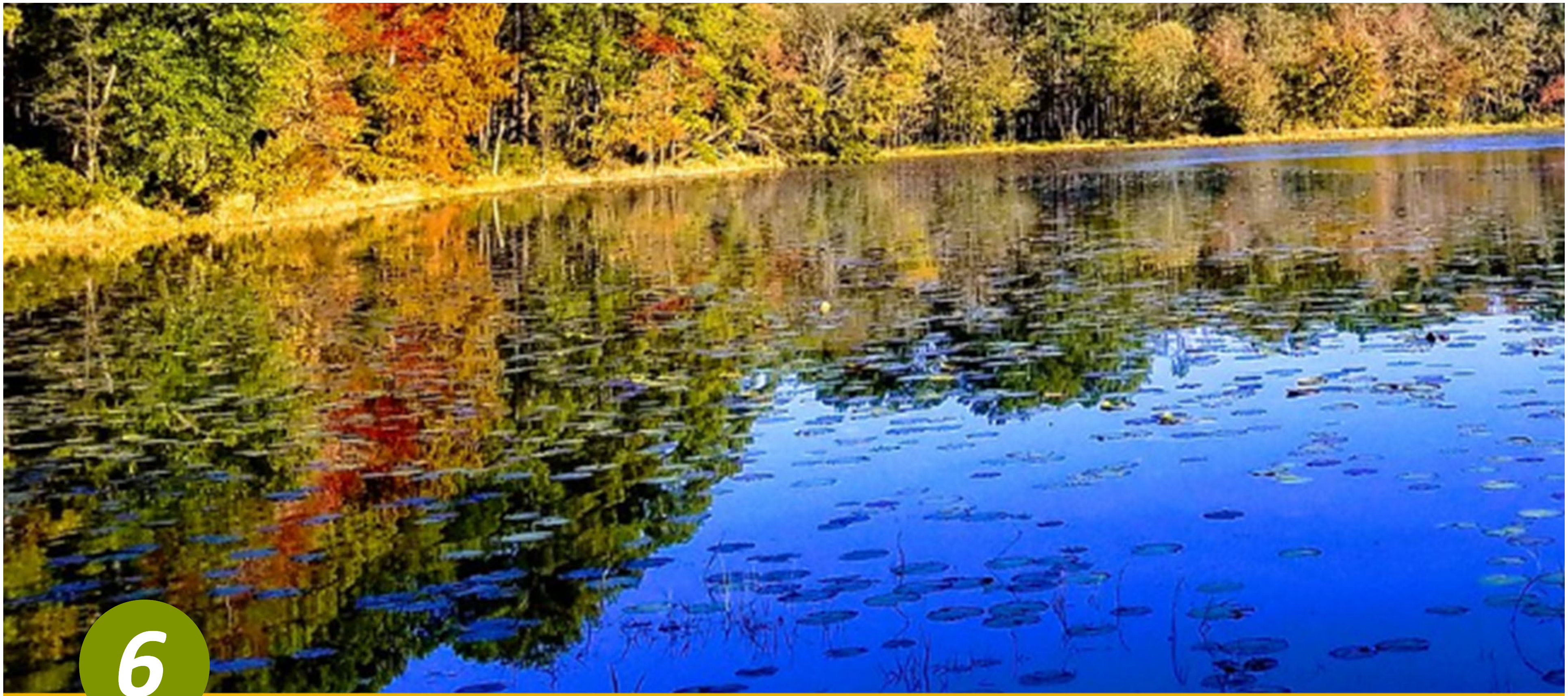
SOURCE: GSI, 2020.

MODEL LIMITATIONS

The 2020 GMA 11 model calibration statistics are sensitive to the monitoring well layer designations.



	Calibrated Model	Trial 1	Trial 2
Target changes	None	37 wells moved from layer 4 to layer 6	37 wells moved to layer 6; 6 wells to layer 2; and 12 outliers removed
Layer 4 RMS	0.254	0.127	0.117
Layer 6 RMS	0.067	0.075	0.075
Layer 2 RMS	0.092	0.092	0.099
All model RMS	0.078	0.06	0.06



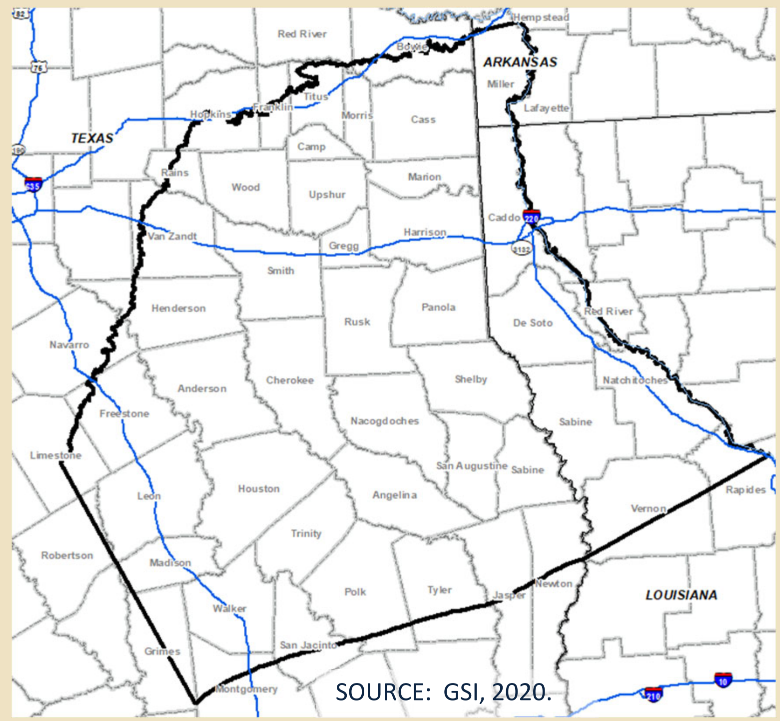
6 SUMMARY AND CONCLUSIONS

SUMMARY AND CONCLUSIONS

<u>The 2020 GMA 11 model update summary:</u>

- **Aquifer units – Quaternary Alluvium, Sparta Sand, Carrizo Sand, Wilcox**
- **Area simulated – 193 miles by 201 miles**
- **Model grid – 9 model layers, greater than 600,000 cells**
- **Time period – 34 years from 1980 to 2013**
- **Monitoring wells – 1,797 wells with 18,606 records**
- **Pumping – estimated using GAM 2004 model**
- **Updated precipitation recharge, evapotranspiration, boundaries, sand and clay fractions**

GMA 11 Model Area



SUMMARY AND CONCLUSIONS

The 2020 GMA 11 model calibration and sensitivity:

- **Statistically, the model is well calibrated**
- **Qualitatively, the model matches observed water levels and flows**
- **Model mass balance errors are negligible**
- **Water fluxes in and out of the model are consistent with the conceptual model**
- **Recharge and pumping are sensitive parameters.**

SUMMARY AND CONCLUSIONS

GMA 11 model – future improvement recommendations:

- **Further evaluation of sand fraction and hydraulic conductivity in units that lack sand fraction data (aquitards)**
- **Obtain more reliable pumping estimates (pumping rates and aquifer well screen information)**
- **Improved QA checks on well construction information for pumping and monitoring wells**
- **Use clustering techniques to correlate hydrographs to reduce data uncertainty and preprocess data for calibration**
- **Use data science approaches to evaluate consistency in pumping, recharge and water level data**
  - **Evaluate correlations for better understanding of the aquifer systems**
  - **Evaluate response functions for focused calibration**
  - **Assess aquifer fractures, connections, or displacement**

IMPROVEMENT FROM PREVIOUS MODEL

- **Current model predictive behavior is appropriate, while previous model was unusable for predictions.**
- **Current model provides realistic representation of outcrops, pinch-out, faulting, and hydrostratigraphy.**
- **Current model includes alluvium layer beneath streams**
- **Current model provides appropriate resolution around surface water features.**
- **A MODFLOW-NWT model provides similar calibration statistics but cannot include vertical and horizontal resolution; or represent pinchout, outcrop and displacement features.**

PREDICTIVE SIMULATIONS

Bill Hutchison

August 27, 2020

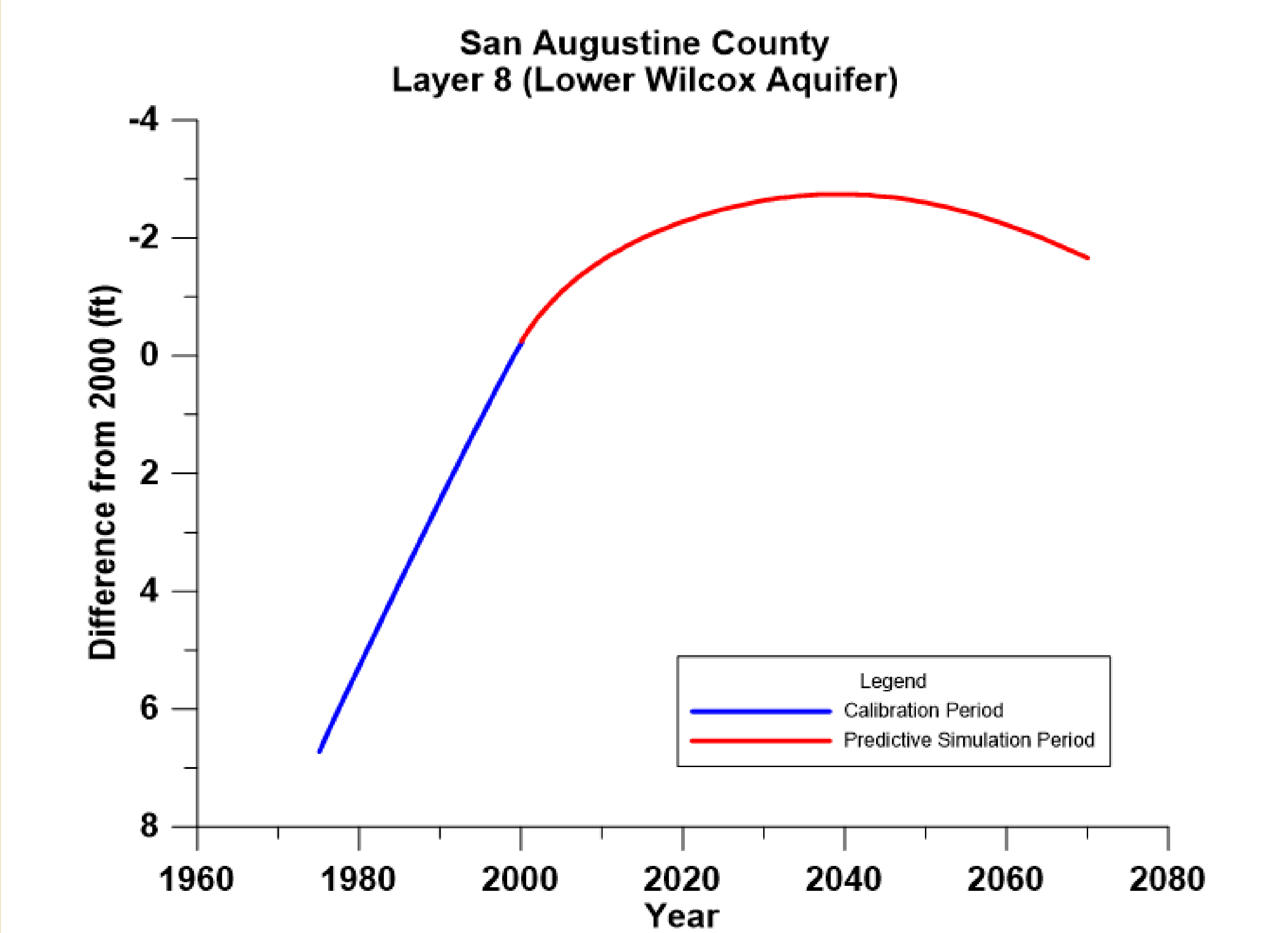
THREE SETS OF PREDICTIVE SIMULATIONS

- **Pumping Sensitivity (Tech Memo 1)**
- **Recharge Sensitivity (Tech Memo 2)**
- **Find drawdown with current MAG (Tech Memo 3)**

BACKGROUND

- **DFCs adopted January 11, 2017**
  - Based on simulations with GMA Scenario 4
- **Existing GAM had limitations**
  - Constant pumping in predictive period did not result in stabilization of groundwater levels
  - Rising groundwater levels (recharge and difficulty moving water from outcrop area to downdip area)
- **Objective of these predictive simulations was to evaluate new GAM for development and evaluation of DFCs**

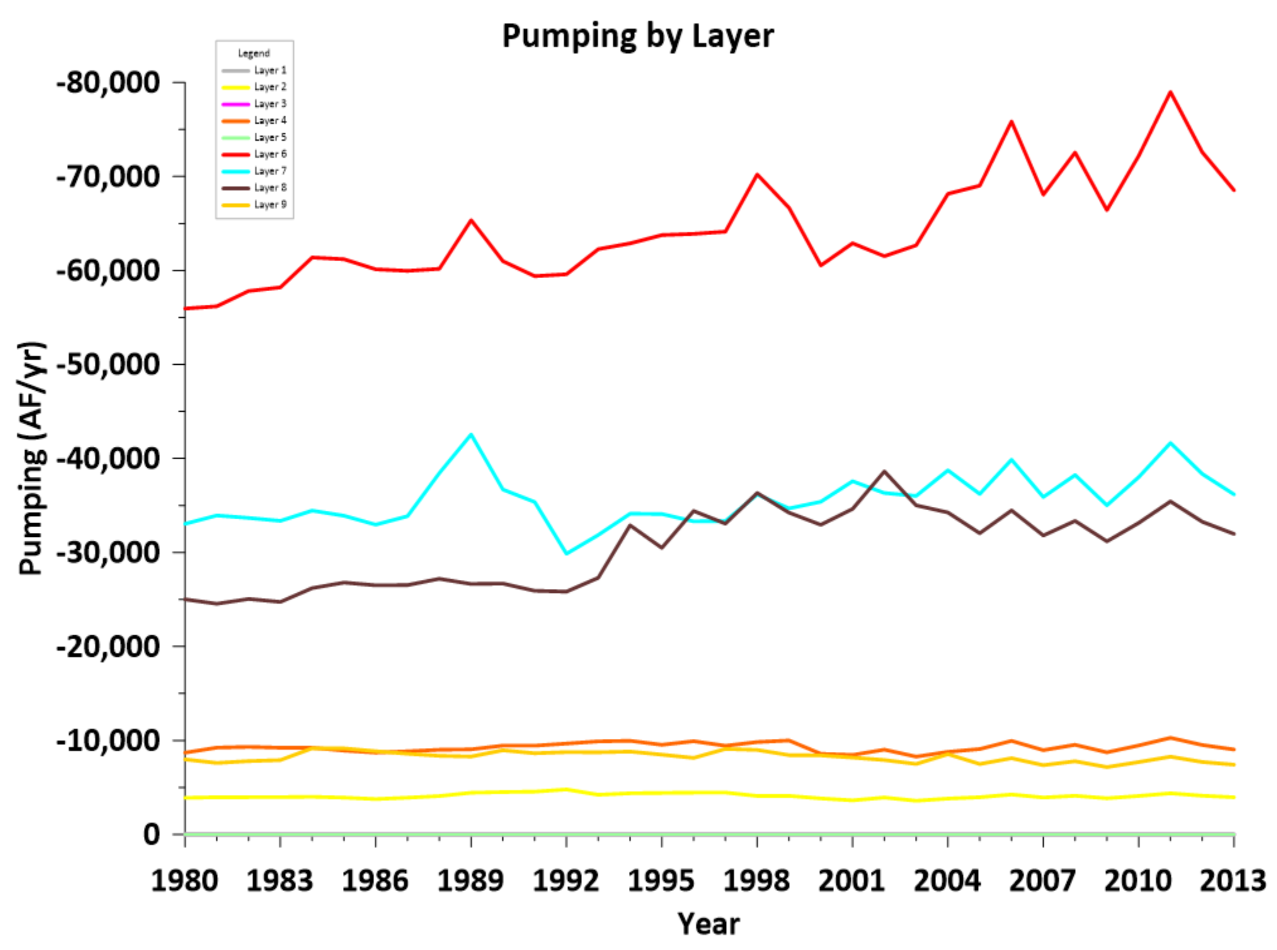
OLD GAM



San Augustine County
Layer 8 (Lower Wilcox Aquifer)
Difference from 2000 (ft)
-4
-2
0
2
4
6
8
1960
1980
2000
2020
2040
2060
2080
Year
Legend
Calibration Period
Predictive Simulation Period

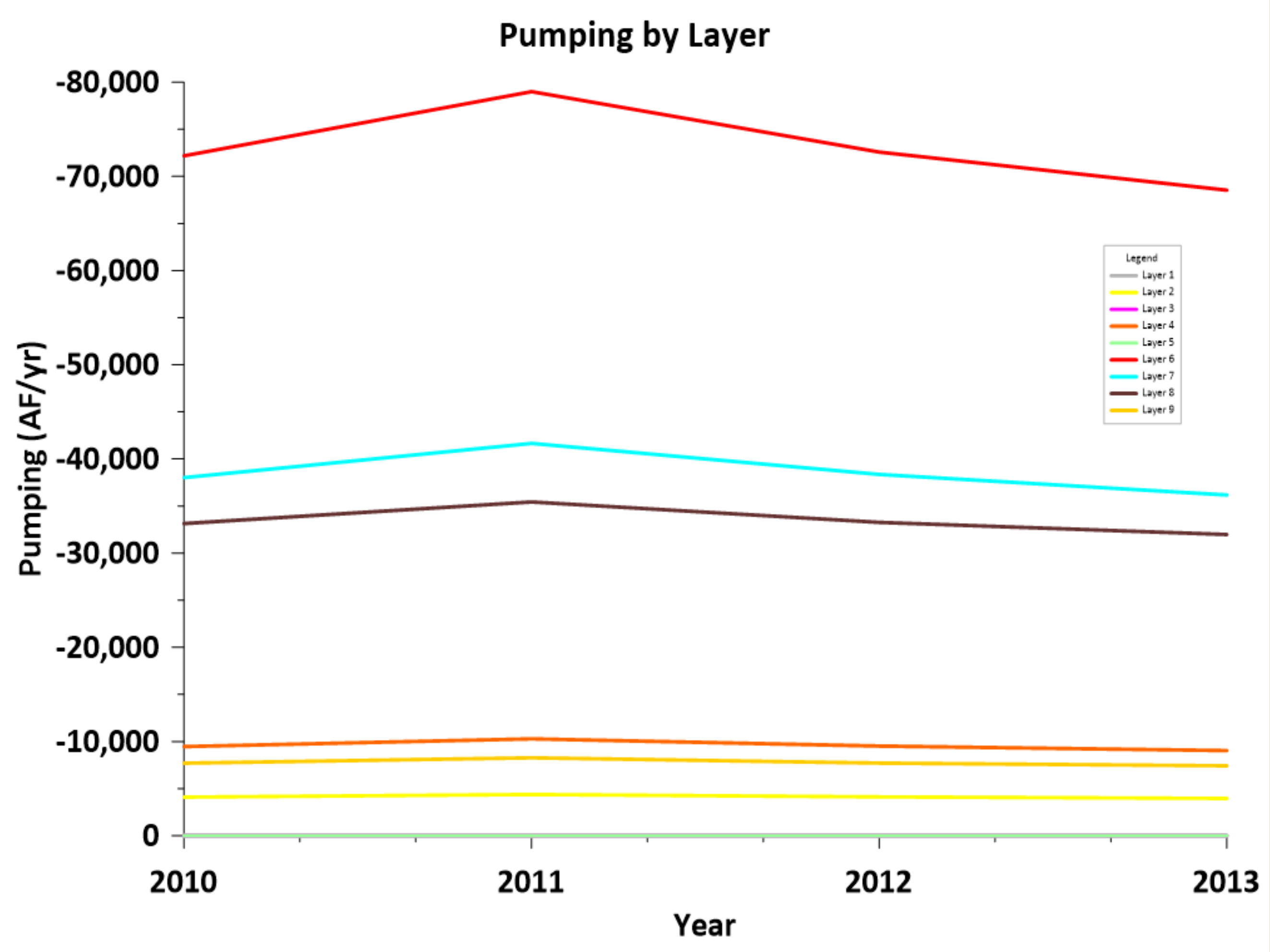
PUMPING SENSITIVITY (TM 1)

- **Calibration Period = 1980 to 2013**



PUMPING SENSITIVITY (TM 1)

- **Focus on 2010 to 2013 (4 years)**

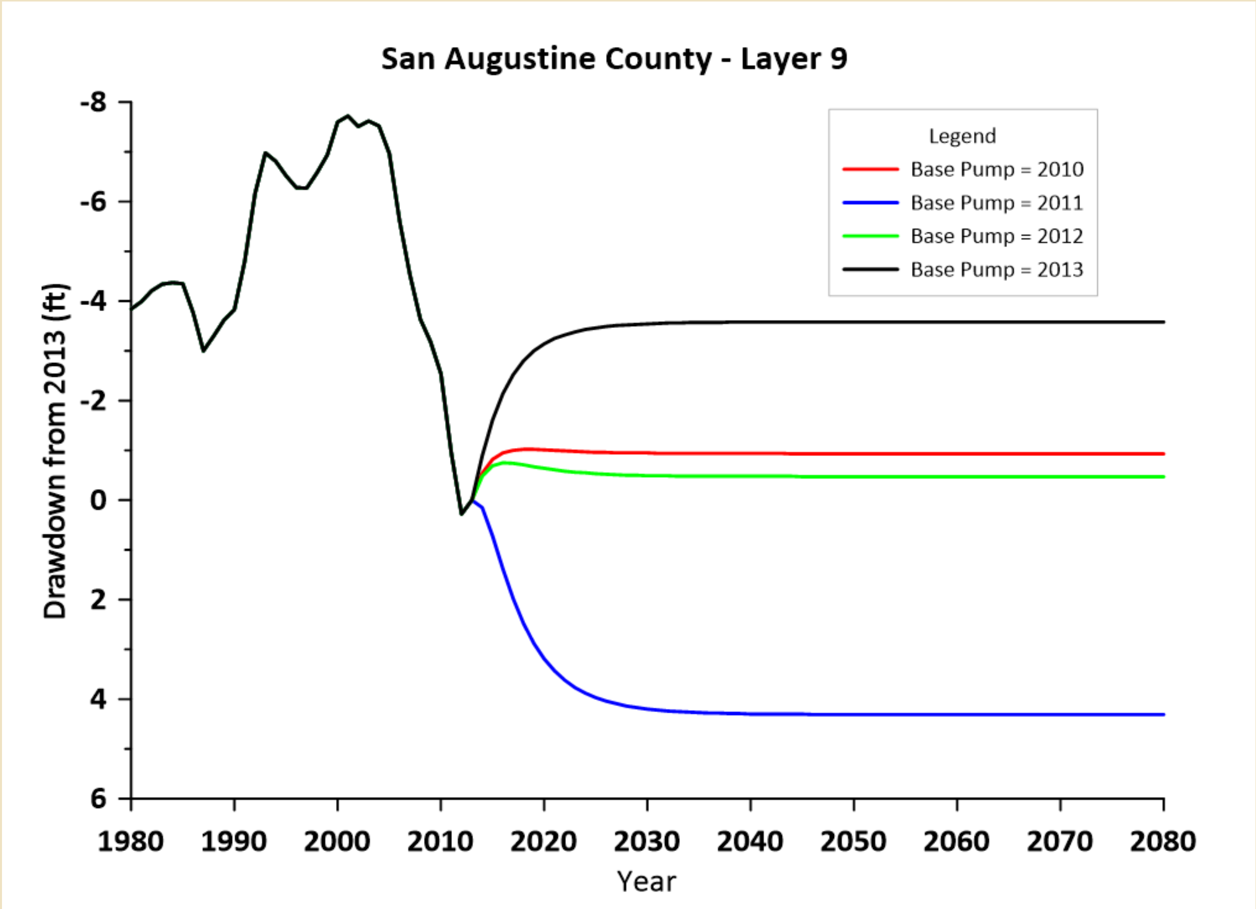


COMPLETED FOUR "SENSITIVITY" RUNS

- **Constant pumping (2014 to 2080) based on:**
  - **2010**
  - **2011 (high pumping – drought)**
  - **2012**
  - **2013**
- **Expect some initial increases/decreases depending on year then reach a new equilibrium level**
  - **Test to make sure limitations of old GMA have been addressed**

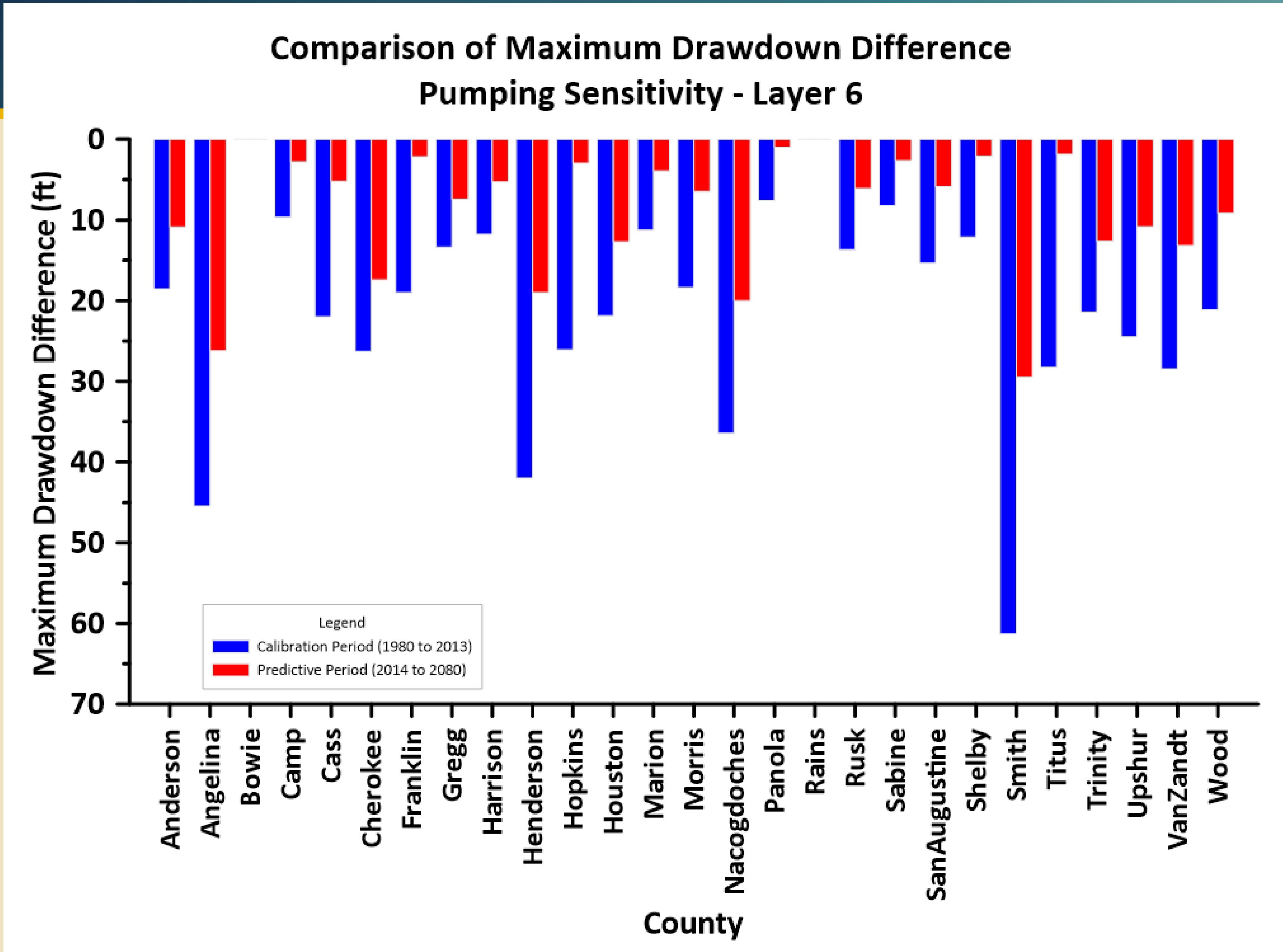
COUNTY-MODEL LAYER RESULTS

- **213 hydrographs (*PumpSensHydrographsDD.pdf*)**



APPENDIX A OF TM 1

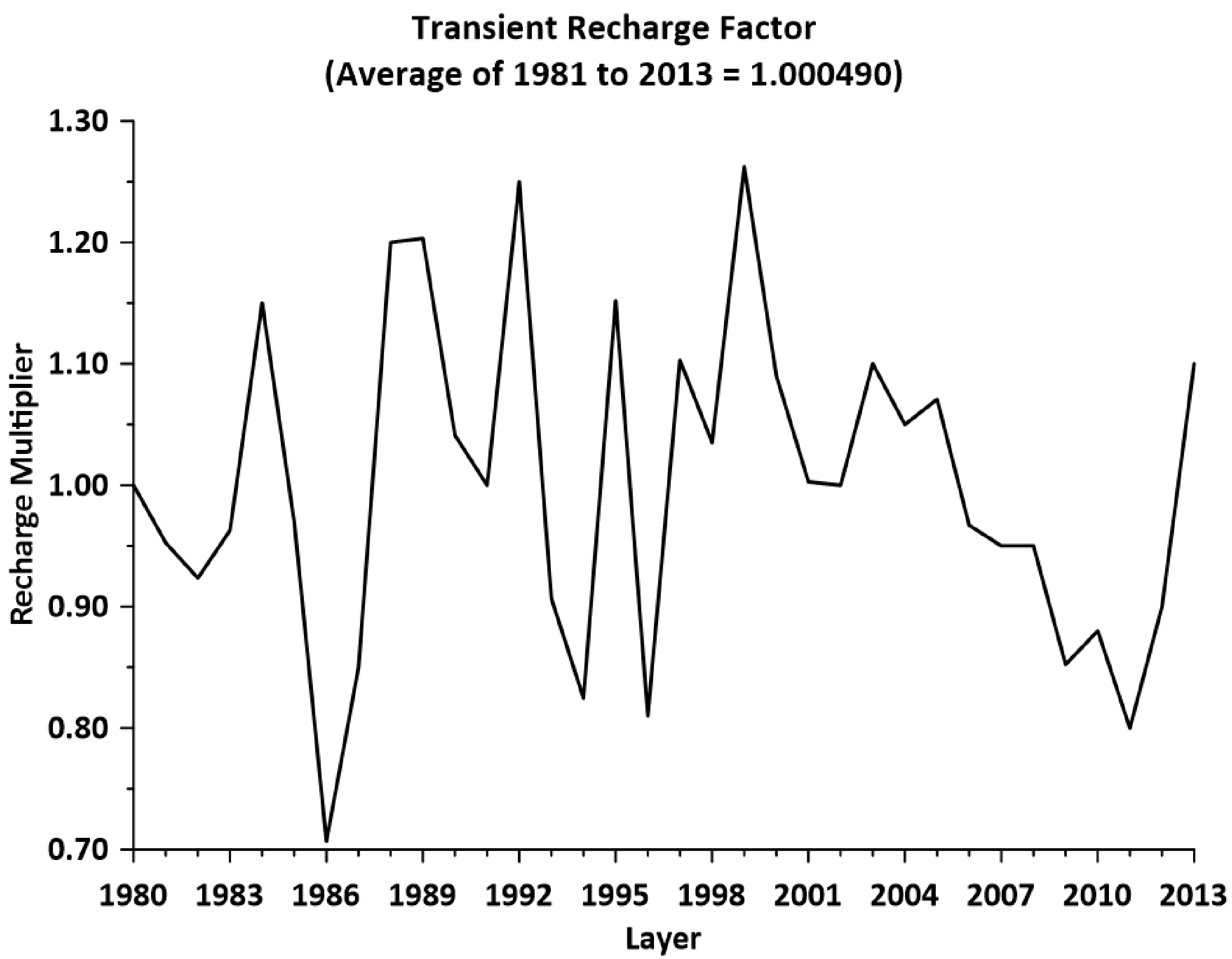
- **Bar graphs (one per layer) for each county in GMA 11**
- **Relative sensitivity of calibration period and predictive period**
  - **Does the sensitivity analysis of these four years represent a sufficient variation in pumping relative to the calibration period? (it does)**



Comparison of Maximum Drawdown Difference
Pumping Sensitivity - Layer 6
Maximum Drawdown Difference (ft)
0
10
20
30
40
50
60
70
Legend
Calibration Period (1980 to 2013)
Predictive Period (2014 to 2080)
Anderson
Angelina
Bowie
Camp
Cass
Cherokee
Franklin
Gregg
Harrison
Henderson
Hopkins
Houston
Marion
Morris
Nacogdoches
Panola
Rains
Rusk
Sabine
SanAugustine
Shelby
Smith
Titus
Trinity
Upshur
VanZandt
Wood
County

RECHARGE SENSITIVITY (TM 2)

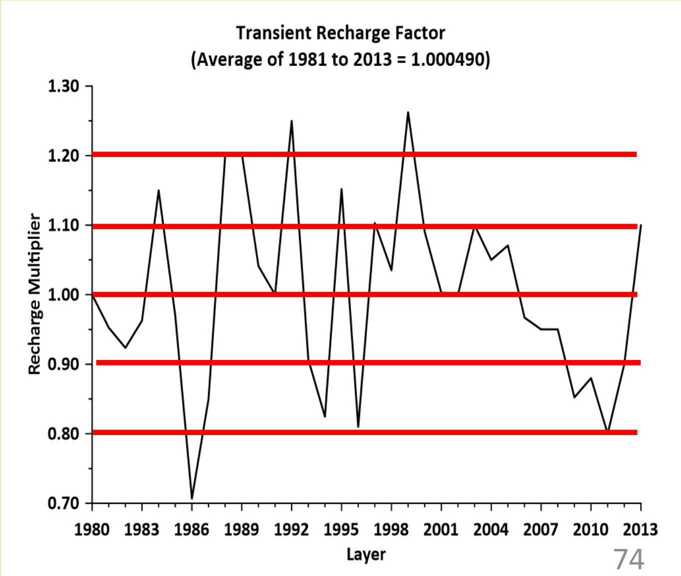
- **Calibration period = 1980 to 2013**
- **Recharge calibrated with a "Transient Recharge Factor"**
  - **Multiplier on estimated average recharge in each outcrop model cell**



Transient Recharge Factor
(Average of 1981 to 2013 = 1.000490)
Recharge Multiplier
1.30
1.20
1.10
1.00
0.90
0.80
0.70
1980
1983
1986
1989
1992
1995
1998
2001
2004
2007
2010
2013
Layer

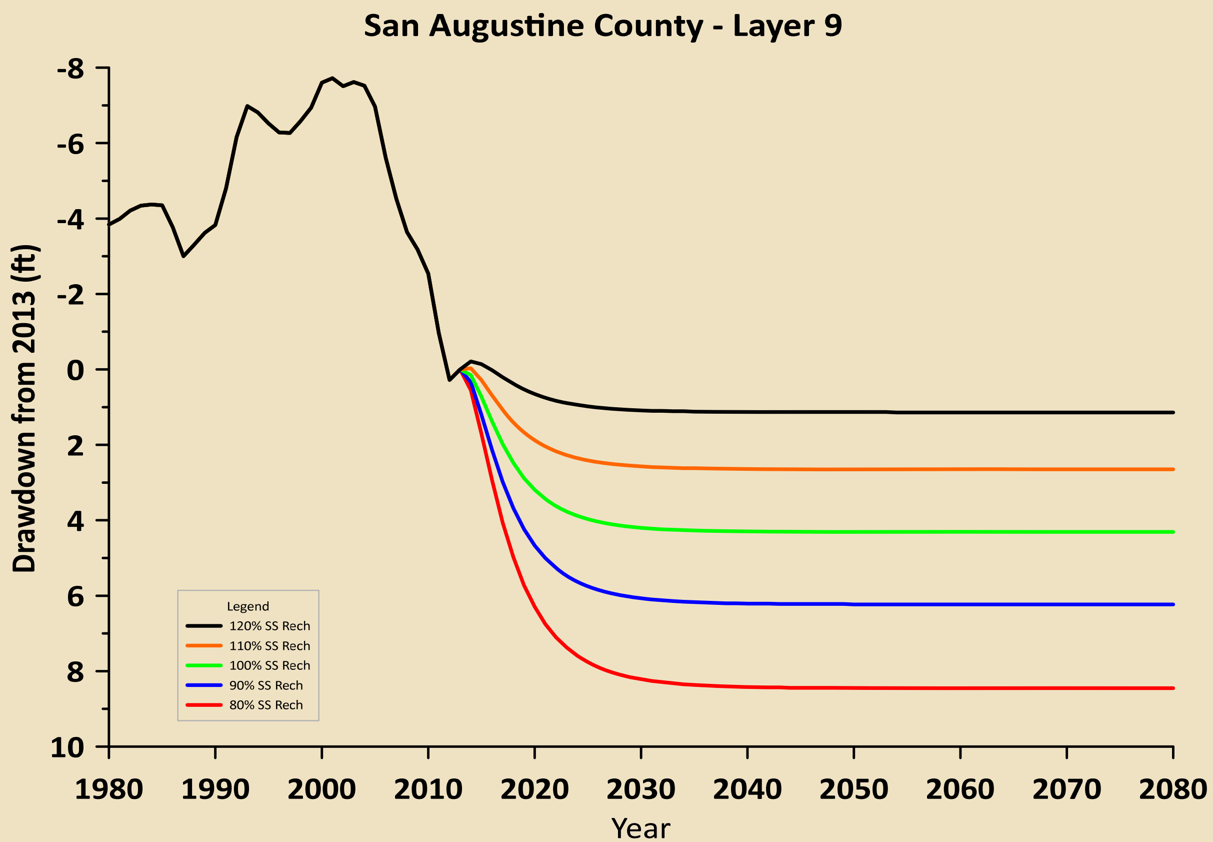
FIVE SIMULATIONS (2014 TO 2080)

- 80 % of steady state recharge
- 90 % of steady state recharge
- 100 % of steady state recharge
- 110 % of steady state recharge
- 120 % of steady state recharge



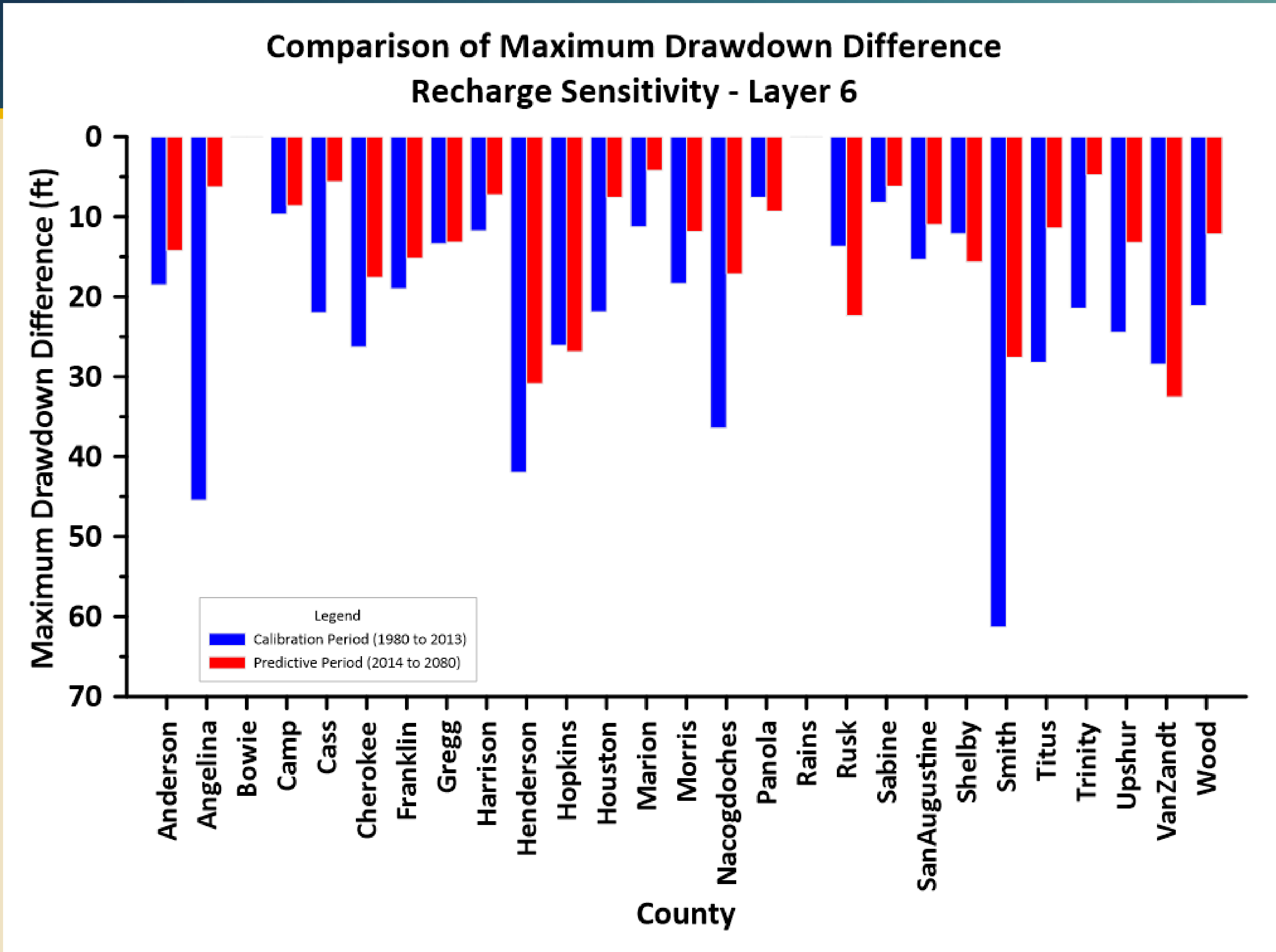
COUNTY-MODEL LAYER RESULTS

- **213 hydrographs (*RechSensHydrographsDD.pdf*)**



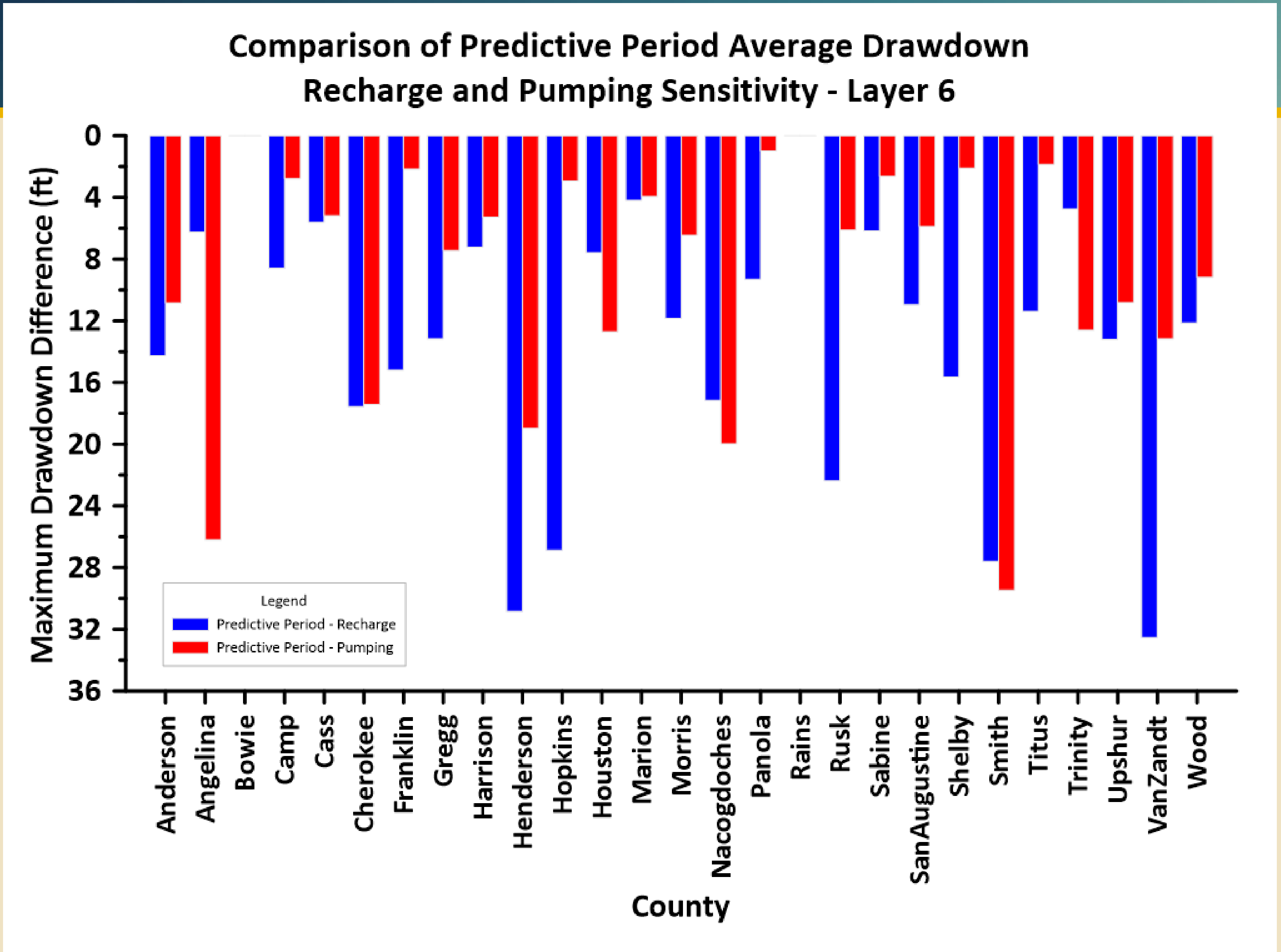
APPENDIX A OF TM 2

- **Bar graphs (one per layer) for each county in GMA 11**
- **Relative sensitivity of calibration period and predictive period**
  - **Does the sensitivity analysis of these five constant recharge scenarios represent a sufficient variation in recharge relative to the calibration period? (it does)**


Comparison of Maximum Drawdown Difference
Recharge Sensitivity - Layer 6
Maximum Drawdown Difference (ft)
0
10
20
30
40
50
60
70
Legend
Calibration Period (1980 to 2013)
Predictive Period (2014 to 2080)
Anderson
Angelina
Bowie
Camp
Cass
Cherokee
Franklin
Gregg
Harrison
Henderson
Hopkins
Houston
Marion
Morris
Nacogdoches
Panola
Rains
Rusk
Sabine
SanAugustine
Shelby
Smith
Titus
Trinity
Upshur
VanZandt
Wood
County

APPENDIX B OF TM 2

- **Bar graphs comparing pumping sensitivity and recharge sensitivity**
  - **One graph per model layer**
  - **Each county in GMA 11 depicted in graph**


Comparison of Predictive Period Average Drawdown
Recharge and Pumping Sensitivity - Layer 6
Maximum Drawdown Difference (ft)
0
4
8
12
16
20
24
28
32
36
Legend
Predictive Period - Recharge
Predictive Period - Pumping
Anderson
Angelina
Bowie
Camp
Cass
Cherokee
Franklin
Gregg
Harrison
Henderson
Hopkins
Houston
Marion
Morris
Nacogdoches
Panola
Rains
Rusk
Sabine
SanAugustine
Shelby
Smith
Titus
Trinity
Upshur
VanZandt
Wood
County

CALCULATE DRAWDOWN WITH CURRENT MAG (TM 3)

- **What is the "new" DFC with the new model given the current MAG (pumping)**
- **Evaluated:**
  - **MAG (pumping from Scenario 4 from DFC Run of old GAM)**
  - **Input pumping of new model**
  - **Output pumping of new model**
- **Developed pumping adjustment factors**
  - **Predictive pumping = 2011 pumping * factor**

County	Layer 1	Layer 2	Layer 3	Layer 4	Layer 5	Layer 6	Layer 7	Layer 8	Layer 9
Anderson	1.00	11.20	1.00	28.45	1.00	2.60	7.41	39.26	1.54
Angelina	1.00	2.02	1.00	11.36	1.00	1.24	1.75	1.00	1.00
Bowie	1.00	1.00	1.00	1.00	1.00	1.00	0.62	11.03	2.52
Camp	1.00	1.00	1.00	23.61	1.00	2.59	2.88	3.55	1.00
Cass	1.00	1.00	1.00	66.63	1.00	6.12	5.31	14.69	5.45
Cherokee	1.00	1.61	1.00	20.94	1.00	1.41	1.94	304.43	1.00
Franklin	1.00	1.00	1.00	1.00	1.00	12.22	6.41	30.13	2.01
Gregg	1.00	1.00	1.00	28.89	1.00	2.46	2.35	2.69	1.00
Harrison	1.00	1.00	1.00	25.87	1.00	2.55	2.57	4.08	1.46
Henderson	1.00	1.00	1.00	20.78	1.00	1.40	1.53	1.56	1.72
Hopkins	1.00	1.00	1.00	1.00	1.00	68.29	0.96	3.53	1.20
Houston	1.00	1.87	1.00	10.60	1.00	9.50	1379.00	1.00	1.00
Marion	1.00	1.00	1.00	89.86	1.00	2.03	2.14	2.16	1.33
Morris	1.00	1.00	1.00	65.88	1.00	2.22	1.89	1.81	1.25
Nacogdoches	1.00	1.53	1.00	15.13	1.00	1.10	2.33	2.37	1.00
Panola	1.00	1.00	1.00	1.00	1.00	1.53	2.58	2.80	1.20
Rains	1.00	1.00	1.00	1.00	1.00	1.00	1.23	6.29	0.89
Rusk	1.00	1.00	1.00	2.31	1.00	3.15	2.66	2.41	1.00
Sabine	1.00	5.36	1.00	1.00	1.00	8.07	7.79	7.69	7.69
SanAugustine	1.00	8.87	1.00	1.00	1.00	2.42	1.68	3.00	0.00
Shelby	1.00	1.00	1.00	1.00	1.00	1.16	3.50	2.63	3.15
Smith	1.00	1.00	1.00	48.01	1.00	2.19	2.21	2.28	1.00
Titus	1.00	1.00	1.00	1.00	1.00	2.98	4.57	4.84	2.54
Trinity	1.00	32.26	1.00	0.00	1.00	65.18	1.00	1.00	1.00
Upshur	1.00	1.00	1.00	18.73	1.00	1.26	1.22	1.36	1.00
VanZandt	1.00	1.00	1.00	18.40	1.00	1.75	1.51	1.77	2.14
Wood	1.00	1.00	1.00	5.64	1.00	3.52	3.58	3.73	0.75

Sparta

County	Layer 1	Layer 2	Layer 3	Layer 4	Layer 5	Layer 6	Layer 7	Layer 8	Layer 9
Anderson	1.00	11.20	1.00	28.45	1.00	2.60	7.41	39.26	1.54
Angelina	1.00	2.02	1.00	11.36	1.00	1.24	1.75	1.00	1.00
Bowie	1.00	1.00	1.00	1.00	1.00	1.00	0.62	11.03	2.52
Camp	1.00	1.00	1.00	23.61	1.00	2.59	2.88	3.55	1.00
Cass	1.00	1.00	1.00	66.63	1.00	6.12	5.31	14.69	5.45
Cherokee	1.00	1.61	1.00	20.94	1.00	1.41	1.94	304.43	1.00
Franklin	1.00	1.00	1.00	1.00	1.00	12.22	6.41	30.13	2.01
Gregg	1.00	1.00	1.00	28.89	1.00	2.46	2.35	2.69	1.00
Harrison	1.00	1.00	1.00	25.87	1.00	2.55	2.57	4.08	1.46
Henderson	1.00	1.00	1.00	20.78	1.00	1.40	1.53	1.56	1.72
Hopkins	1.00	1.00	1.00	1.00	1.00	68.29	0.96	3.53	1.20
Houston	1.00	1.87	1.00	10.60	1.00	9.50	1379.00	1.00	1.00
Marion	1.00	1.00	1.00	89.86	1.00	2.03	2.14	2.16	1.33
Morris	1.00	1.00	1.00	65.88	1.00	2.22	1.89	1.81	1.25
Nacogdoches	1.00	1.53	1.00	15.13	1.00	1.10	2.33	2.37	1.00
Panola	1.00	1.00	1.00	1.00	1.00	1.53	2.58	2.80	1.20
Rains	1.00	1.00	1.00	1.00	1.00	1.00	1.23	6.29	0.89
Rusk	1.00	1.00	1.00	2.31	1.00	3.15	2.66	2.41	1.00
Sabine	1.00	5.36	1.00	1.00	1.00	8.07	7.79	7.69	7.69
SanAugustine	1.00	8.87	1.00	1.00	1.00	2.42	1.68	3.00	0.00
Shelby	1.00	1.00	1.00	1.00	1.00	1.16	3.50	2.63	3.15
Smith	1.00	1.00	1.00	48.01	1.00	2.19	2.21	2.28	1.00
Titus	1.00	1.00	1.00	1.00	1.00	2.98	4.57	4.84	2.54
Trinity	1.00	32.26	1.00	0.00	1.00	65.18	1.00	1.00	1.00
Upshur	1.00	1.00	1.00	18.73	1.00	1.26	1.22	1.36	1.00
VanZandt	1.00	1.00	1.00	18.40	1.00	1.75	1.51	1.77	2.14
Wood	1.00	1.00	1.00	5.64	1.00	3.52	3.58	3.73	0.75

Queen City

County	Layer 1	Layer 2	Layer 3	Layer 4	Layer 5	Layer 6	Layer 7	Layer 8	Layer 9
Anderson	1.00	11.20	1.00	28.45	1.00	2.60	7.41	39.26	1.54
Angelina	1.00	2.02	1.00	11.36	1.00	1.24	1.75	1.00	1.00
Bowie	1.00	1.00	1.00	1.00	1.00	1.00	0.62	11.03	2.52
Camp	1.00	1.00	1.00	23.61	1.00	2.59	2.88	3.55	1.00
Cass	1.00	1.00	1.00	66.63	1.00	6.12	5.31	14.69	5.45
Cherokee	1.00	1.61	1.00	20.94	1.00	1.41	1.94	304.43	1.00
Franklin	1.00	1.00	1.00	1.00	1.00	12.22	6.41	30.13	2.01
Gregg	1.00	1.00	1.00	28.89	1.00	2.46	2.35	2.69	1.00
Harrison	1.00	1.00	1.00	25.87	1.00	2.55	2.57	4.08	1.46
Henderson	1.00	1.00	1.00	20.78	1.00	1.40	1.53	1.56	1.72
Hopkins	1.00	1.00	1.00	1.00	1.00	68.29	0.96	3.53	1.20
Houston	1.00	1.87	1.00	10.60	1.00	9.50	1379.00	1.00	1.00
Marion	1.00	1.00	1.00	89.86	1.00	2.03	2.14	2.16	1.33
Morris	1.00	1.00	1.00	65.88	1.00	2.22	1.89	1.81	1.25
Nacogdoches	1.00	1.53	1.00	15.13	1.00	1.10	2.33	2.37	1.00
Panola	1.00	1.00	1.00	1.00	1.00	1.53	2.58	2.80	1.20
Rains	1.00	1.00	1.00	1.00	1.00	1.00	1.23	6.29	0.89
Rusk	1.00	1.00	1.00	2.31	1.00	3.15	2.66	2.41	1.00
Sabine	1.00	5.36	1.00	1.00	1.00	8.07	7.79	7.69	7.69
SanAugustine	1.00	8.87	1.00	1.00	1.00	2.42	1.68	3.00	0.00
Shelby	1.00	1.00	1.00	1.00	1.00	1.16	3.50	2.63	3.15
Smith	1.00	1.00	1.00	48.01	1.00	2.19	2.21	2.28	1.00
Titus	1.00	1.00	1.00	1.00	1.00	2.98	4.57	4.84	2.54
Trinity	1.00	32.26	1.00	0.00	1.00	65.18	1.00	1.00	1.00
Upshur	1.00	1.00	1.00	18.73	1.00	1.26	1.22	1.36	1.00
VanZandt	1.00	1.00	1.00	18.40	1.00	1.75	1.51	1.77	2.14
Wood	1.00	1.00	1.00	5.64	1.00	3.52	3.58	3.73	0.75

Carrizo

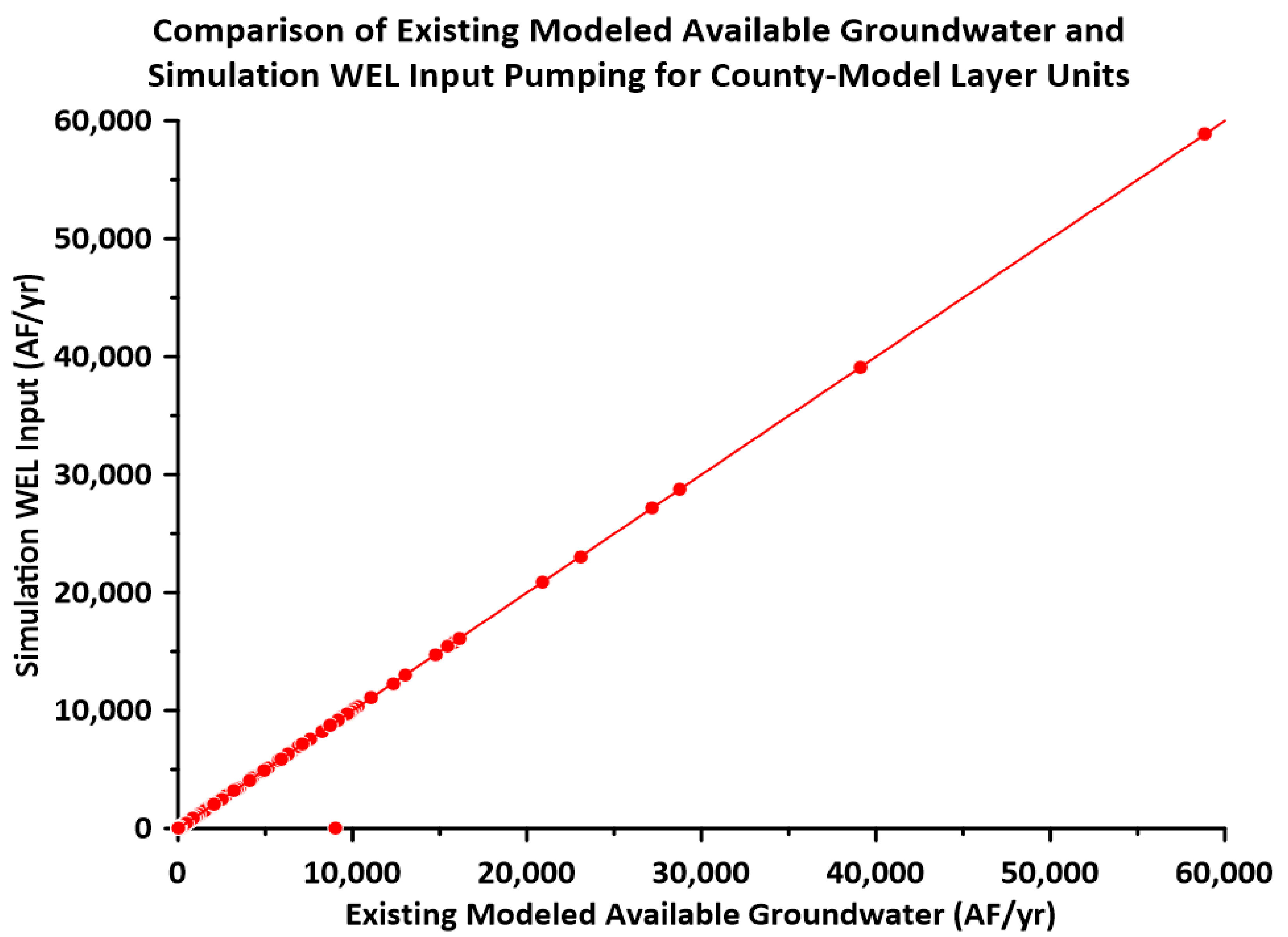
County	Layer 1	Layer 2	Layer 3	Layer 4	Layer 5	Layer 6	Layer 7	Layer 8	Layer 9
Anderson	1.00	11.20	1.00	28.45	1.00	2.60	7.41	39.26	1.54
Angelina	1.00	2.02	1.00	11.36	1.00	1.24	1.75	1.00	1.00
Bowie	1.00	1.00	1.00	1.00	1.00	1.00	0.62	11.03	2.52
Camp	1.00	1.00	1.00	23.61	1.00	2.59	2.88	3.55	1.00
Cass	1.00	1.00	1.00	66.63	1.00	6.12	5.31	14.69	5.45
Cherokee	1.00	1.61	1.00	20.94	1.00	1.41	1.94	304.43	1.00
Franklin	1.00	1.00	1.00	1.00	1.00	12.22	6.41	30.13	2.01
Gregg	1.00	1.00	1.00	28.89	1.00	2.46	2.35	2.69	1.00
Harrison	1.00	1.00	1.00	25.87	1.00	2.55	2.57	4.08	1.46
Henderson	1.00	1.00	1.00	20.78	1.00	1.40	1.53	1.56	1.72
Hopkins	1.00	1.00	1.00	1.00	1.00	68.29	0.96	3.53	1.20
Houston	1.00	1.87	1.00	10.60	1.00	9.50	1379.00	1.00	1.00
Marion	1.00	1.00	1.00	89.86	1.00	2.03	2.14	2.16	1.33
Morris	1.00	1.00	1.00	65.88	1.00	2.22	1.89	1.81	1.25
Nacogdoches	1.00	1.53	1.00	15.13	1.00	1.10	2.33	2.37	1.00
Panola	1.00	1.00	1.00	1.00	1.00	1.53	2.58	2.80	1.20
Rains	1.00	1.00	1.00	1.00	1.00	1.00	1.23	6.29	0.89
Rusk	1.00	1.00	1.00	2.31	1.00	3.15	2.66	2.41	1.00
Sabine	1.00	5.36	1.00	1.00	1.00	8.07	7.79	7.69	7.69
SanAugustine	1.00	8.87	1.00	1.00	1.00	2.42	1.68	3.00	0.00
Shelby	1.00	1.00	1.00	1.00	1.00	1.16	3.50	2.63	3.15
Smith	1.00	1.00	1.00	48.01	1.00	2.19	2.21	2.28	1.00
Titus	1.00	1.00	1.00	1.00	1.00	2.98	4.57	4.84	2.54
Trinity	1.00	32.26	1.00	0.00	1.00	65.18	1.00	1.00	1.00
Upshur	1.00	1.00	1.00	18.73	1.00	1.26	1.22	1.36	1.00
VanZandt	1.00	1.00	1.00	18.40	1.00	1.75	1.51	1.77	2.14
Wood	1.00	1.00	1.00	5.64	1.00	3.52	3.58	3.73	0.75

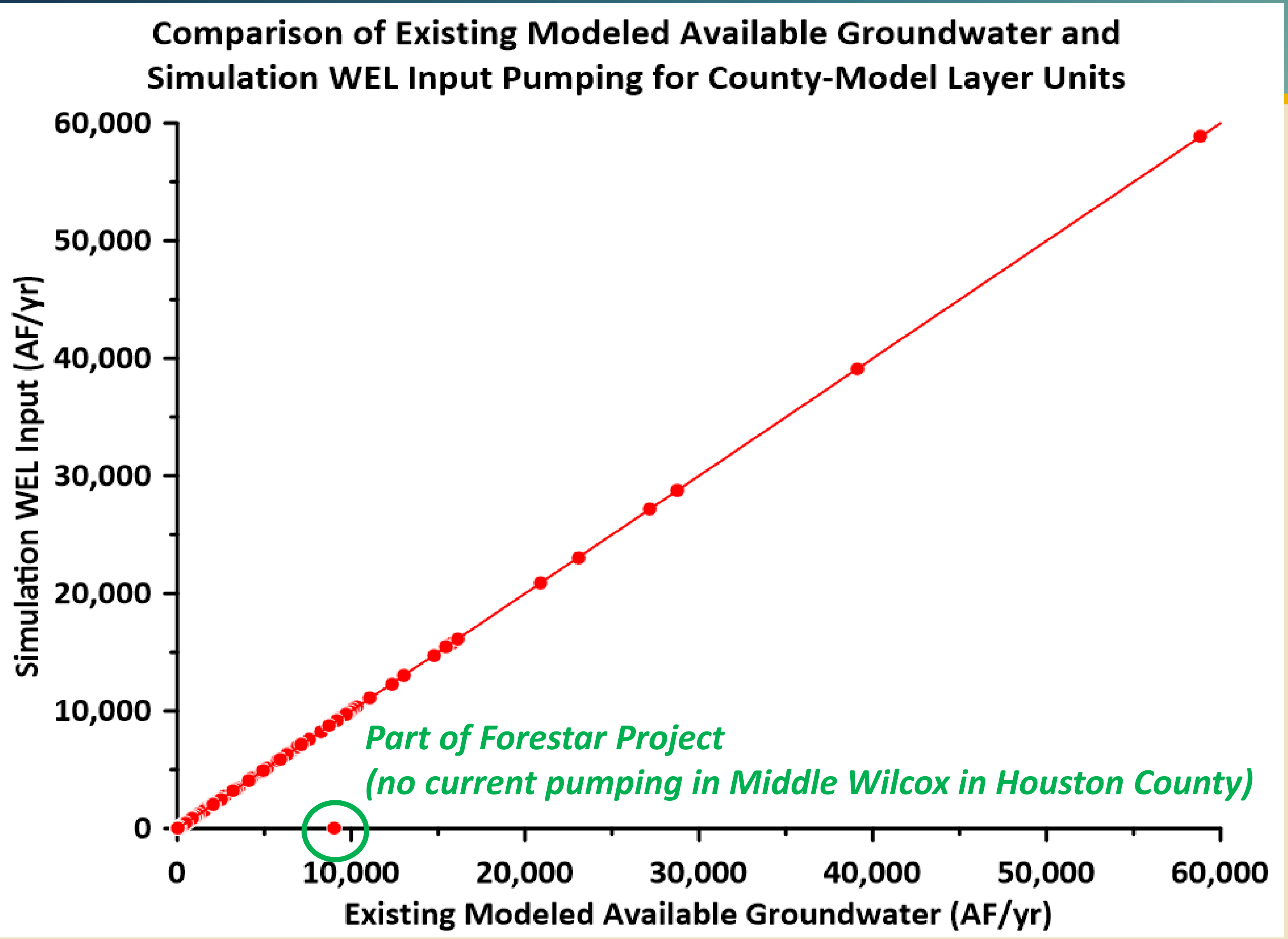
Wilcox

County	Layer 1	Layer 2	Layer 3	Layer 4	Layer 5	Layer 6	Layer 7	Layer 8	Layer 9
Anderson	1.00	11.20	1.00	28.45	1.00	2.60	7.41	39.26	1.54
Angelina	1.00	2.02	1.00	11.36	1.00	1.24	1.75	1.00	1.00
Bowie	1.00	1.00	1.00	1.00	1.00	1.00	0.62	11.03	2.52
Camp	1.00	1.00	1.00	23.61	1.00	2.59	2.88	3.55	1.00
Cass	1.00	1.00	1.00	66.63	1.00	6.12	5.31	14.69	5.45
Cherokee	1.00	1.61	1.00	20.94	1.00	1.41	1.94	304.43	1.00
Franklin	1.00	1.00	1.00	1.00	1.00	12.22	6.41	30.13	2.01
Gregg	1.00	1.00	1.00	28.89	1.00	2.46	2.35	2.69	1.00
Harrison	1.00	1.00	1.00	25.87	1.00	2.55	2.57	4.08	1.46
Henderson	1.00	1.00	1.00	20.78	1.00	1.40	1.53	1.56	1.72
Hopkins	1.00	1.00	1.00	1.00	1.00	68.29	0.96	3.53	1.20
Houston	1.00	1.87	1.00	10.60	1.00	9.50	1379.00	1.00	1.00
Marion	1.00	1.00	1.00	89.86	1.00	2.03	2.14	2.16	1.33
Morris	1.00	1.00	1.00	65.88	1.00	2.22	1.89	1.81	1.25
Nacogdoches	1.00	1.53	1.00	15.13	1.00	1.10	2.33	2.37	1.00
Panola	1.00	1.00	1.00	1.00	1.00	1.53	2.58	2.80	1.20
Rains	1.00	1.00	1.00	1.00	1.00	1.00	1.23	6.29	0.89
Rusk	1.00	1.00	1.00	2.31	1.00	3.15	2.66	2.41	1.00
Sabine	1.00	5.36	1.00	1.00	1.00	8.07	7.79	7.69	7.69
SanAugustine	1.00	8.87	1.00	1.00	1.00	2.42	1.68	3.00	0.00
Shelby	1.00	1.00	1.00	1.00	1.00	1.16	3.50	2.63	3.15
Smith	1.00	1.00	1.00	48.01	1.00	2.19	2.21	2.28	1.00
Titus	1.00	1.00	1.00	1.00	1.00	2.98	4.57	4.84	2.54
Trinity	1.00	32.26	1.00	0.00	1.00	65.18	1.00	1.00	1.00
Upshur	1.00	1.00	1.00	18.73	1.00	1.26	1.22	1.36	1.00
VanZandt	1.00	1.00	1.00	18.40	1.00	1.75	1.51	1.77	2.14
Wood	1.00	1.00	1.00	5.64	1.00	3.52	3.58	3.73	0.75

PUMPING FACTORS

- All represent increases from 2011 pumping
- Some factors represent a "significant" increase in pumping
  - Queen City increases are notable (rooted in 2010 DFC development)
- Completed check on applying factors and predictive simulation pumping

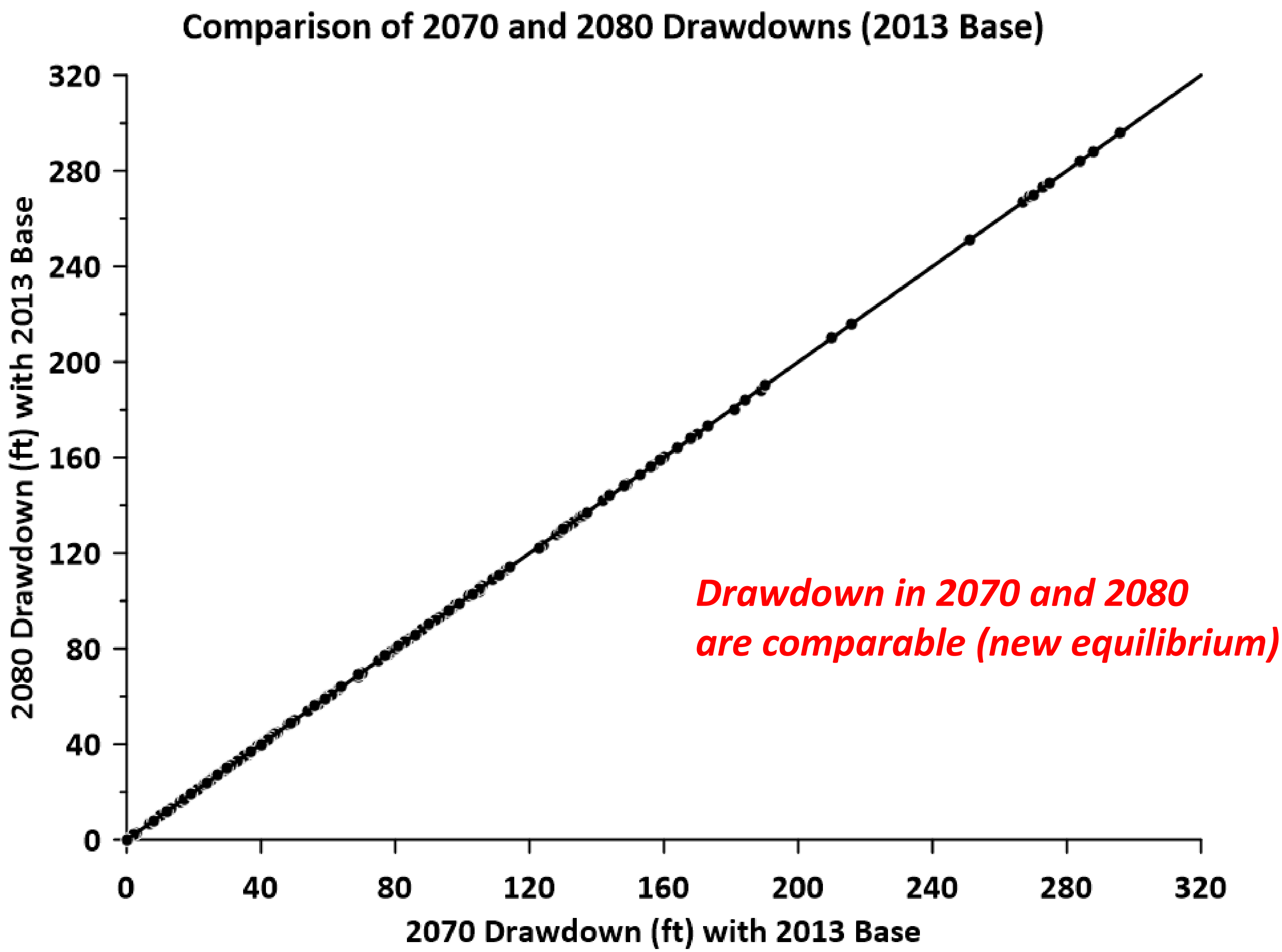

Comparison of Existing Modeled Available Groundwater and
Simulation WEL Input Pumping for County-Model Layer Units
Simulation WEL Input (AF/yr)
60,000
50,000
40,000
30,000
20,000
10,000
0
0
10,000
20,000
30,000
40,000
50,000
60,000
Existing Modeled Available Groundwater (AF/yr)

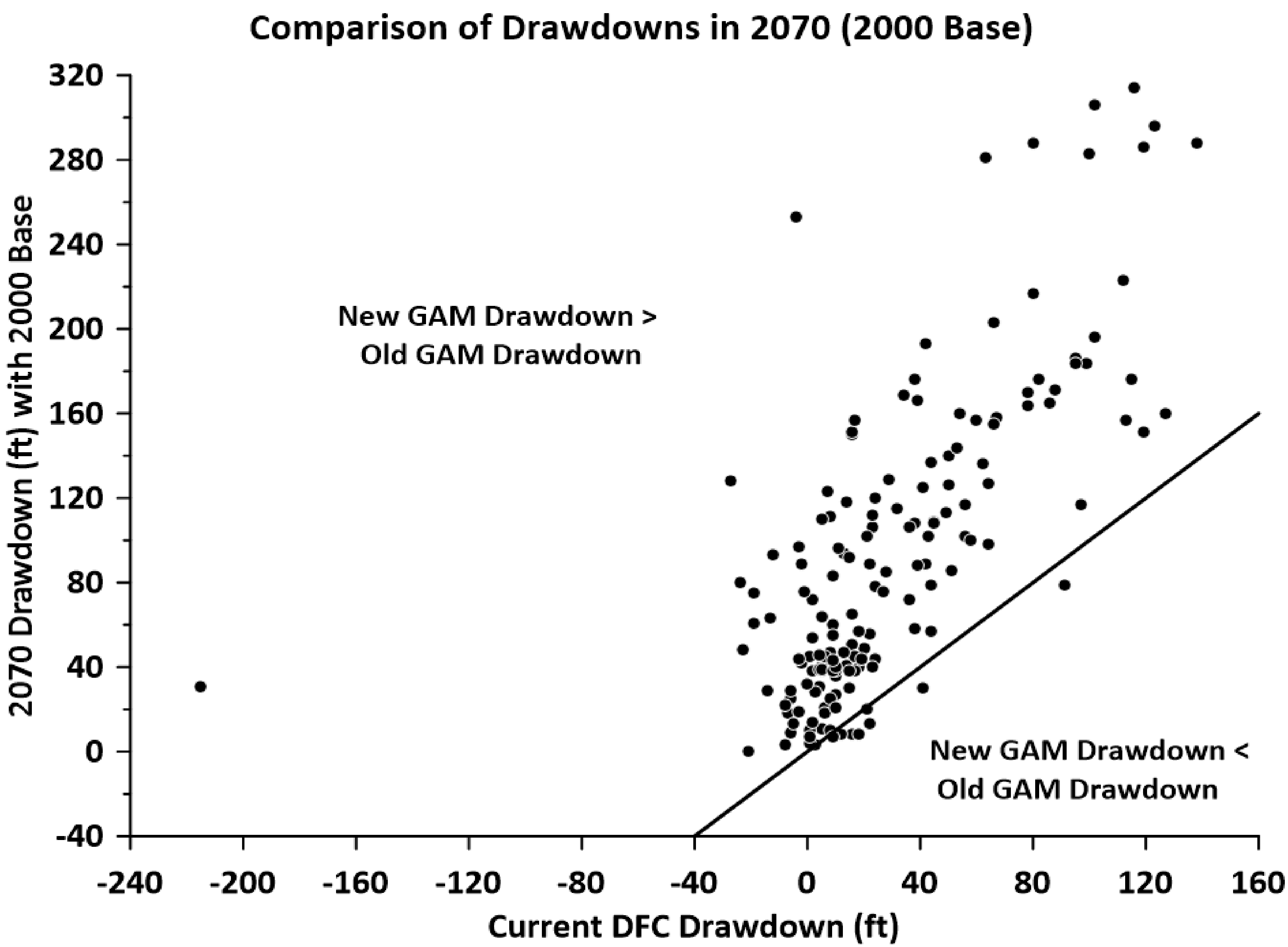


Comparison of Existing Modeled Available Groundwater and
Simulation WEL Input Pumping for County-Model Layer Units
Simulation WEL Input (AF/yr)
60,000
50,000
40,000
30,000
20,000
10,000
0
10,000
20,000
30,000
40,000
50,000
60,000
Existing Modeled Available Groundwater (AF/yr)
Part of Forestar Project
(no current pumping in Middle Wilcox in Houston County)

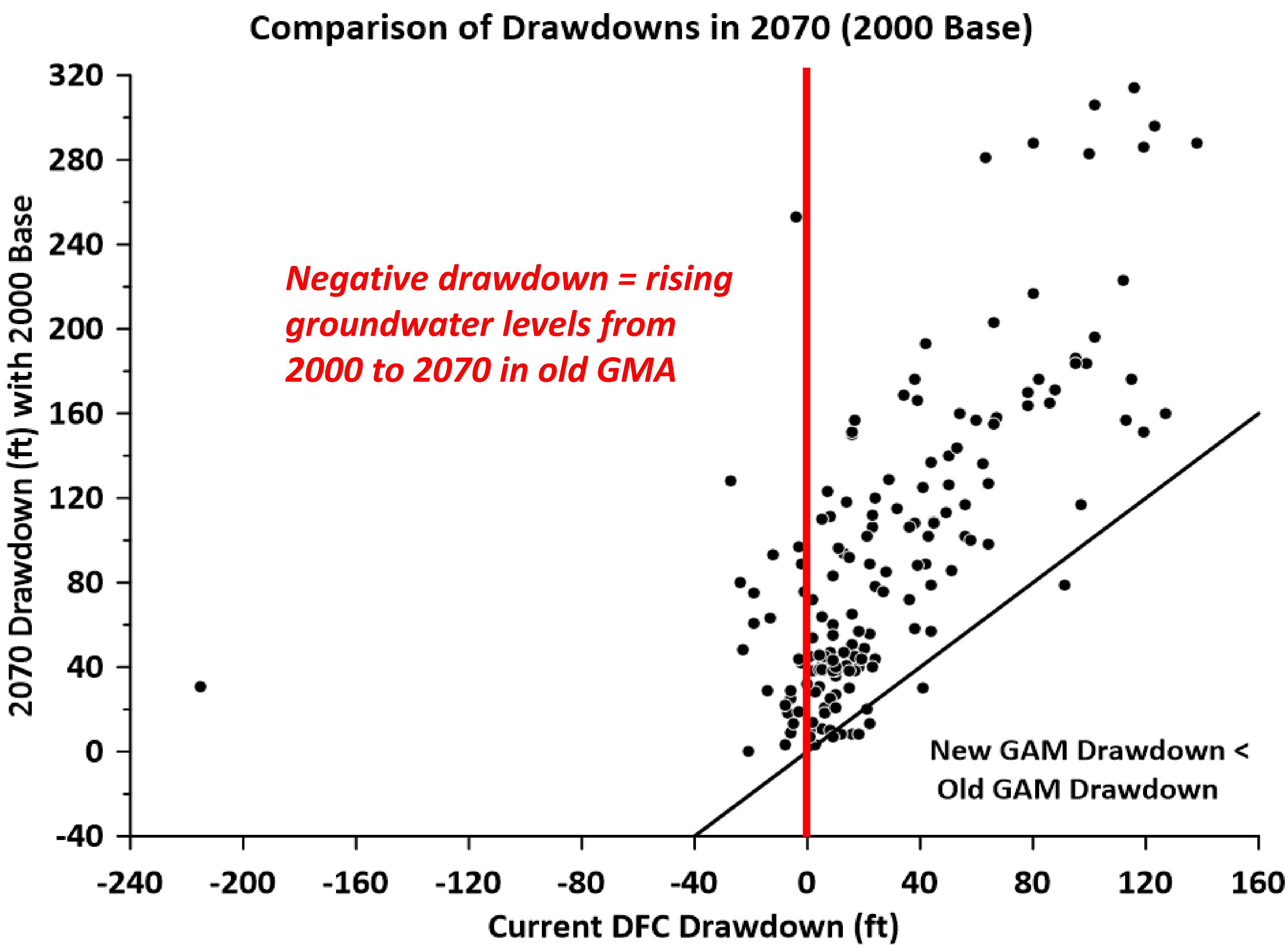
PREDICTIVE SIMULATION

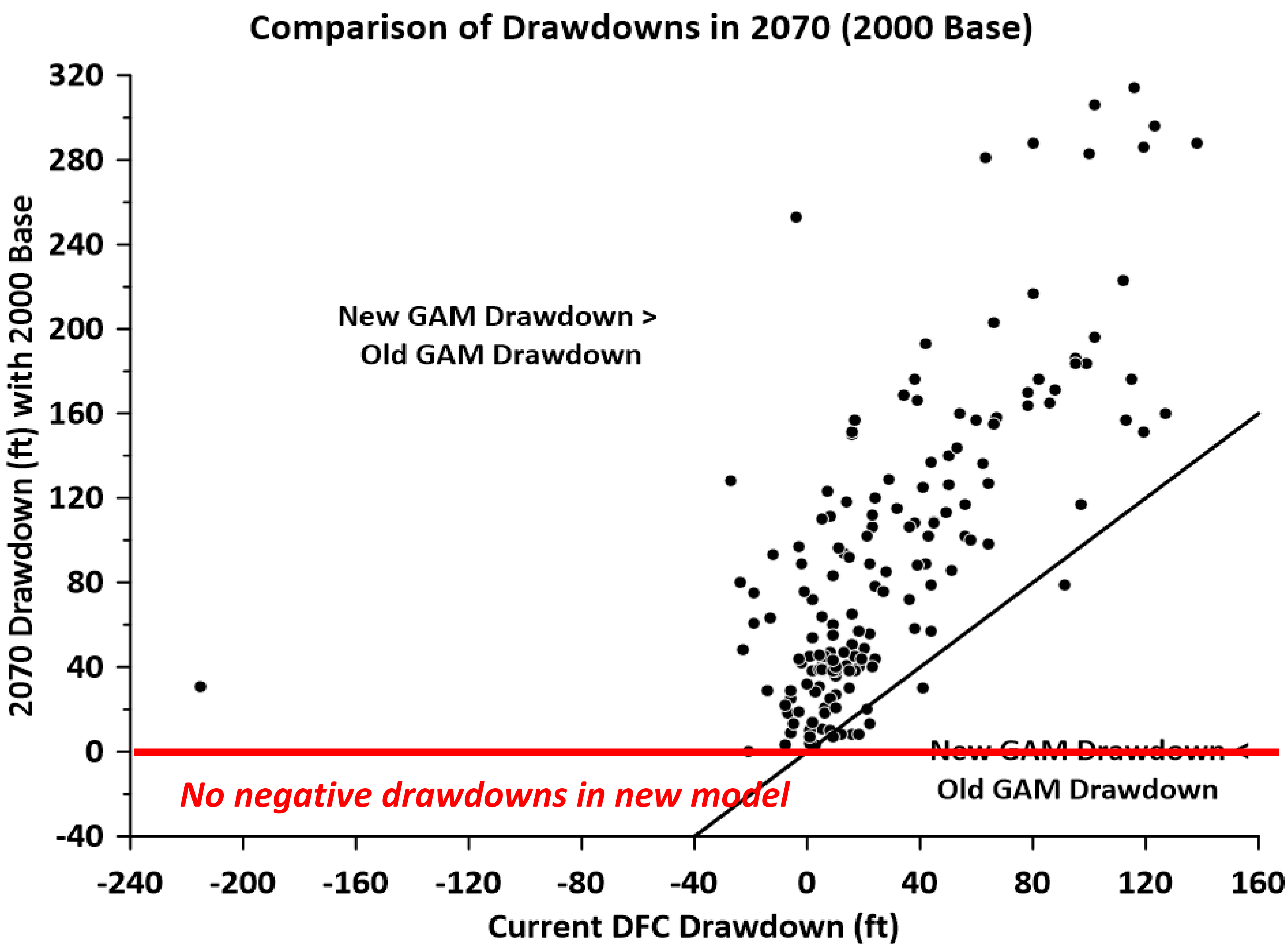
- 2014 to 2080
- Calculated drawdowns:
  - 2000 to 2070 (comparable to current MAG)
  - 2013 to 2070 (current calibration period to old MAG period)
  - 2013 to 2080 (full use of new model)


Comparison of 2070 and 2080 Drawdowns (2013 Base)
2080 Drawdown (ft) with 2013 Base
2070 Drawdown (ft) with 2013 Base
0
40
80
120
160
200
240
280
320
Drawdown in 2070 and 2080
are comparable (new equilibrium)



Comparison of Drawdowns in 2070 (2000 Base)
2070 Drawdown (ft) with 2000 Base
Current DFC Drawdown (ft)
New GAM Drawdown > Old GAM Drawdown
New GAM Drawdown < Old GAM Drawdown
320
280
240
200
160
120
80
40
0
-40
-240
-200
-160
-120
-80
-40
0
40
80
120
160


Comparison of Drawdowns in 2070 (2000 Base)
2070 Drawdown (ft) with 2000 Base
320
280
240
200
160
120
80
40
0
-40
-240
-200
-160
-120
-80
-40
0
40
80
120
160
Current DFC Drawdown (ft)
Negative drawdown = rising groundwater levels from 2000 to 2070 in old GMA
New GAM Drawdown < Old GAM Drawdown



Comparison of Drawdowns in 2070 (2000 Base)
2070 Drawdown (ft) with 2000 Base
320
280
240
200
160
120
80
40
0
-40
New GAM Drawdown > Old GAM Drawdown
New GAM Drawdown < Old GAM Drawdown
No negative drawdowns in new model
-240
-200
-160
-120
-80
-40
0
40
80
120
160
Current DFC Drawdown (ft)

TAKEAWAYS FOR JOINT PLANNING (DFCS AND MAGS)

- The new GAM shows greater drawdowns than the old GMA.
  - Old GAM had rising groundwater levels (probably underestimated drawdown)
- Sparta and Queen City pumping needs careful review
  - 2010 DFCs may have been a result of "exploiting" model limitations
- Key limitations of Old GAM addressed and corrected in new model
  - Rising groundwater levels with time due to recharge and the ability of water to move from the outcrop areas to the downdip areas

GSI ENVIRONMENTAL

MEMORANDUM

TO: Natalie Ballew, TWDB

CC: Cindy Ridgeway, TWDB

FROM: Julie Spencer, GSI Environmental Inc.

RE: Notes from the Stakeholder Advisory Forum for the Update to the Existing Groundwater Availability Model for the Northern Portion of the Queen City, Sparta, and Carrizo-Wilcox Aquifers project

A Stakeholder Advisory Forum (SAF) for the Update to the Existing Groundwater Availability Model (GAM) for the Northern Portion of the Queen City, Sparta, and Carrizo-Wilcox Aquifers project was held virtually via a Zoom Webinar on August 27, 2020. The purpose of the SAF was to present findings of the Draft Numerical Model Report, which is currently under Texas Water Development Board (TWDB) and Stakeholder review. A summary of the meeting, questions asked and answers provided, and a list of attendees is provided below.

The meeting began at 10:00 AM with an introduction to the project and TWDB's GAM process by Ms. Natalie Ballew. After TWDB's introduction, Dr. Sorab Panday with GSI Environmental Inc. and Dr. Bill Hutchison, an independent groundwater consultant, gave a presentation summarizing the findings of the Numerical Model Report. During the presentation, two questions were received from the audience. These questions and answers are summarized below:

Q1: What process did you use to decide how to change pumping "outliers" and changes to TWDB data?

A1: We filled in gaps and adjusted outliers by linearly interpolating between available years of reasonable data. Where there was a sudden change in pumping in the dataset of a county, the values were scaled such that the averages are the same before and after where the change occurred.

Q2: Aren't there some areas where groundwater levels are rising due to decreased pumping in the last couple decades?

A2: Slides 45 and 46 show where there has been a rebound in water levels from 1980 conditions due to decreased pumping in that area.

Q3: Were those areas inconsistent with the areas where water levels were rising in the old model?

A3: That was a separate issue from where water levels increased during predictive simulations with constant pumping and constant recharge. This was due to issues with recharge and the inability of the old GAM to move water from the outcrop area to the downdip area. As demonstrated in simulations documented in Technical Memoranda 1 and 2, the new model has addressed this problem.

The audience was reminded that the presentation given today would be available for download from the TWDB website in about 1 week. The meeting was adjourned at approximately 11:00 AM. A list of attendees is provided below:

Name	Affiliation
Sorab Panday	GSI Environmental Inc.
Julie Spencer	GSI Environmental Inc.
Bill Hutchison	Independent Groundwater Consultant
Staffan Schorr	Montgomery & Associates
Jim Rumbaugh	Environmental Simulations, Inc.
Natalie Ballew	Texas Water Development Board
Cindy Ridgeway	Texas Water Development Board
Shirley Wade	Texas Water Development Board
Ki Cha	Texas Water Development Board
Robert Bradley	Texas Water Development Board
Daryn Hardwick	Texas Water Development Board
David Bailey	Mid-East Texas Groundwater Conservation District
John McFarland	Pineywoods Groundwater Conservation District
Robert Thornton	Rusk County Groundwater Conservation District
Neil Blandford	Daniel B. Stephens & Associates
George Rice	GRGwH
James Beach	WSP
Zak Brown	WSP
Rohit Goswami	WSP

To provide information for use in updating the Existing Groundwater Availability Model for the Northern Portion of the Queen City, Sparta, and Carrizo-Wilcox Aquifers project, please contact any of the following:

Natalie Ballew
Texas Water Development Board
Contract Manager
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GAM Update Project, Administrative Lead
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Sorab Panday
GSI Environmental Inc.
GAM Update Project, Technical Lead
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spanday@gsienv.com