Lower Rio Grande Valley Groundwater Transport Model: Status Report

Region M Meeting

Sorab Panday, Bill Hutchison,
Jim Rumbaugh, Staffan Schorr

February 8, 2017

Topics

- Brief Overview of Project
- Project Status
- Overview of Conceptual Model
- Overview of Numerical Model Development
- Next Steps

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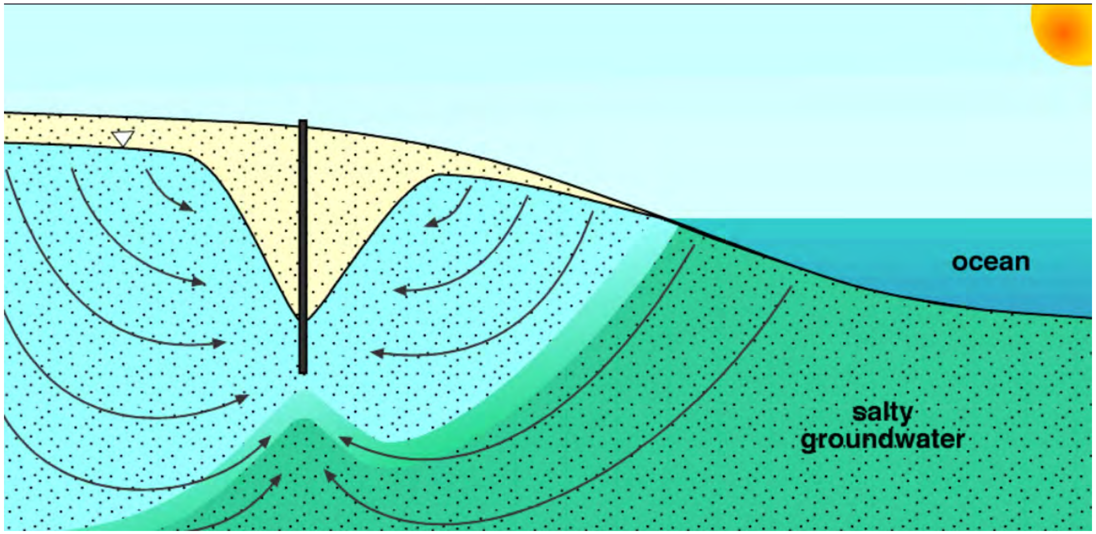
Background

- LRGV has seven brackish groundwater desalination plants
- Region M plan recommends an additional 23 brackish groundwater desalination plants
  - Supply an additional 92,000 AF/yr by 2060
- Model is needed to:
  - Evaluate groundwater level changes
  - Evaluate groundwater quality changes
  - Evaluate impacts to surface water
  - Evaluate potential for subsidence

Objective (from TWDB)

- The primary objective of this project is to develop a numerical groundwater model to simulate impacts of brackish water withdrawal by the current and recommended desalination plants in the Lower Rio Grande Valley



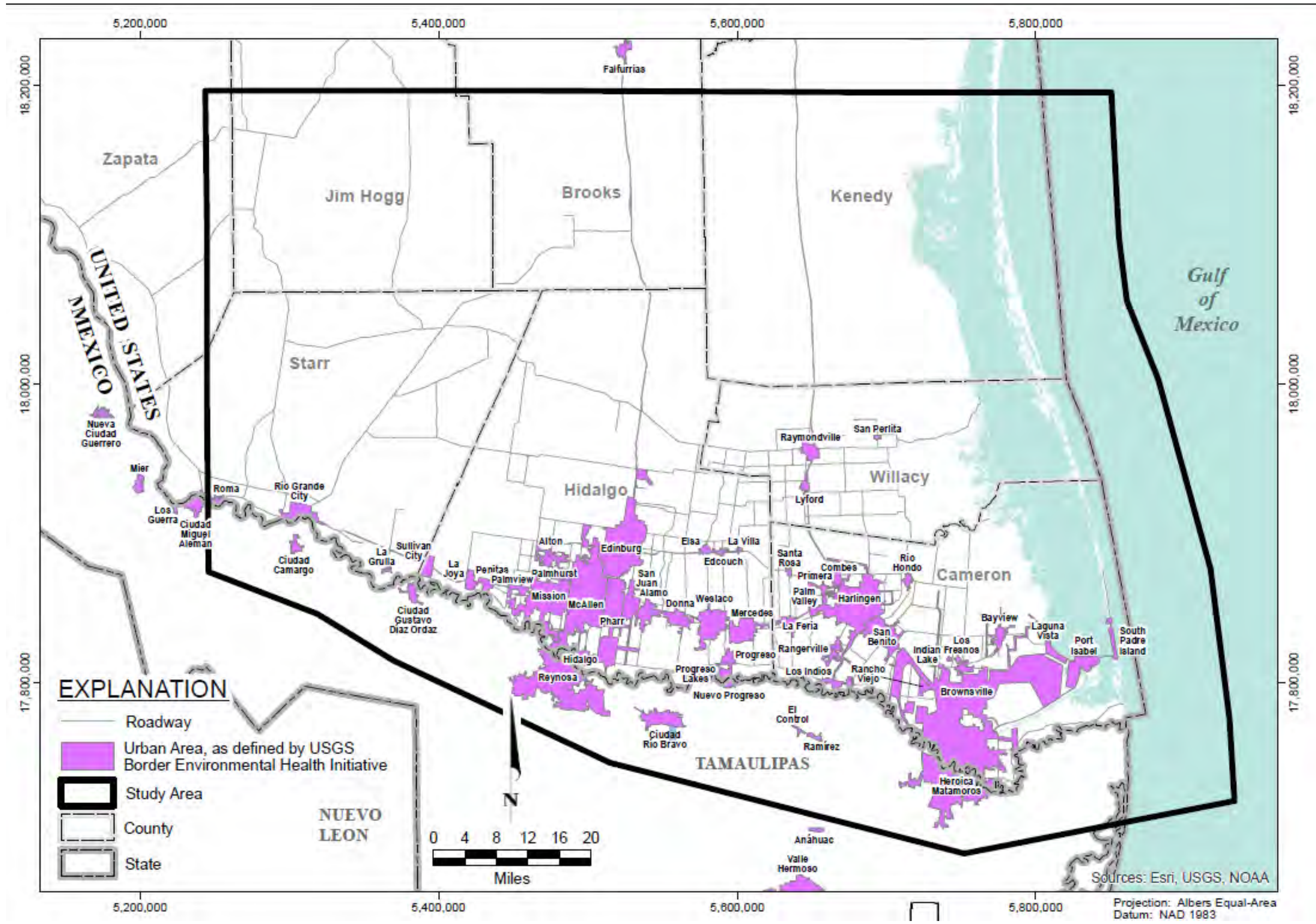
Current GAM of LRGV

- Does not provide the ability to simulate water quality changes that are likely with increased pumping
- Does not account for the density effects of brackish groundwater
- Uses a coarse grid (1 sq. mi.)
  - Insufficient resolution in critical locations
  - Limited ability to simulate groundwater-surface water interactions

Model Selection – MODFLOW-USG

- Built on Standard MODFLOW and uses MODFLOW conventions and formats
- Unstructured Grids
  - Better representation of boundary features
  - Can refine for salinity gradients
    - Horizontal and vertical
  - Better representation for outcrops and pinch-outs
  - Can have multiple wells in a single cell
    - Well drawdown independent of cell size
  - Robust solution schemes
    - No “dry” cells

Model Domain



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Project Status

- Final Conceptual Model Report delivered to TWDB on January 31, 2017
  - http://www.twdb.texas.gov/groundwater/models/research/lrgv_t/lrgv_t.asp
- Flow model calibration essentially completed
- Awaiting final review of initial salinity distributions for transport model (TWDB)
- Draft calibration report completed by the end of February 2017
- Stakeholder Advisory Forum (SAF) meeting to be held after draft model calibration report completed (March or May?)
  - More detailed presentation at the SAF meeting

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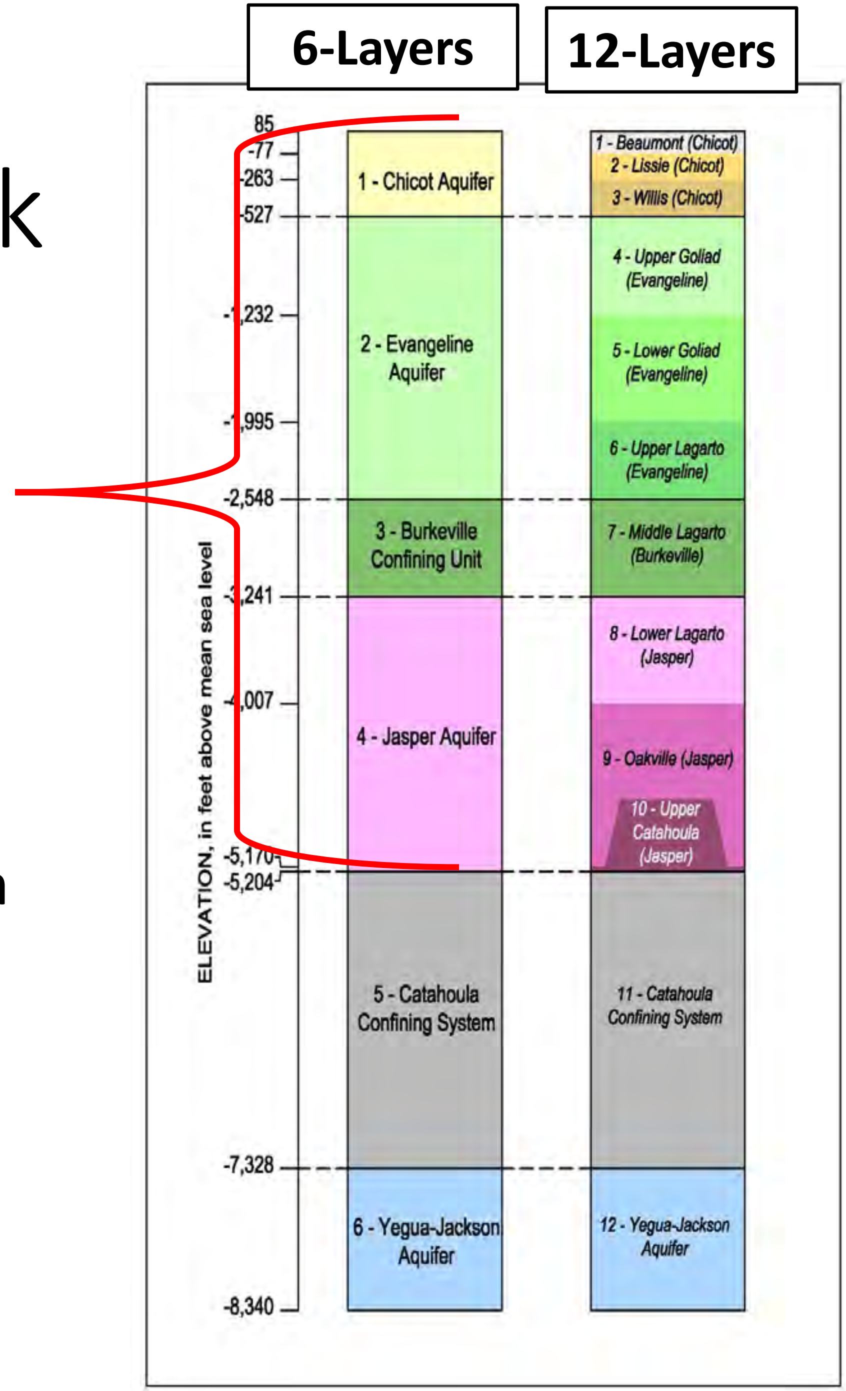
Conceptual Model

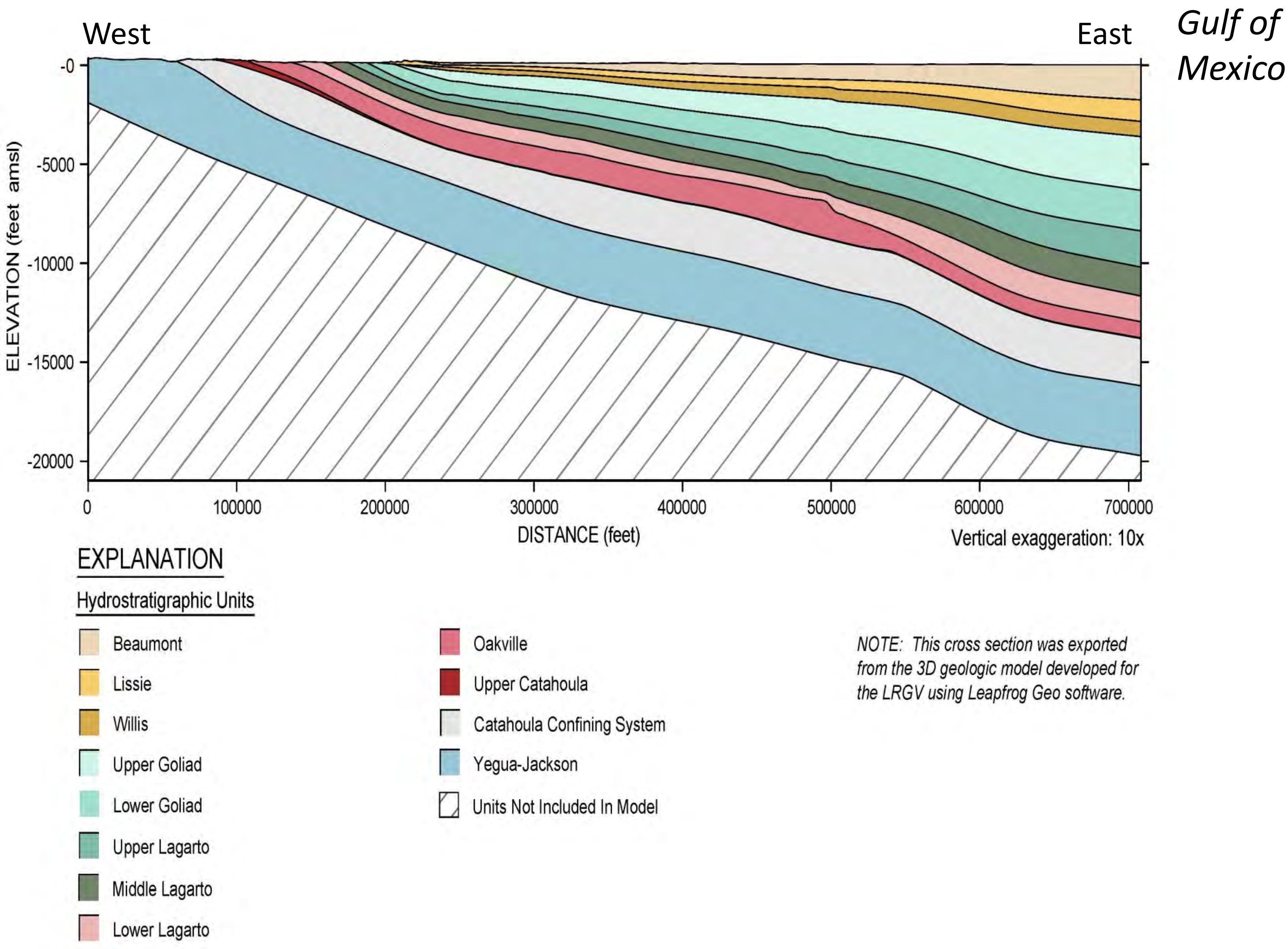
- Covered in conceptual model report
- Aquifer framework
- Inflows and Outflows
- Salinity distribution

Aquifer Framework

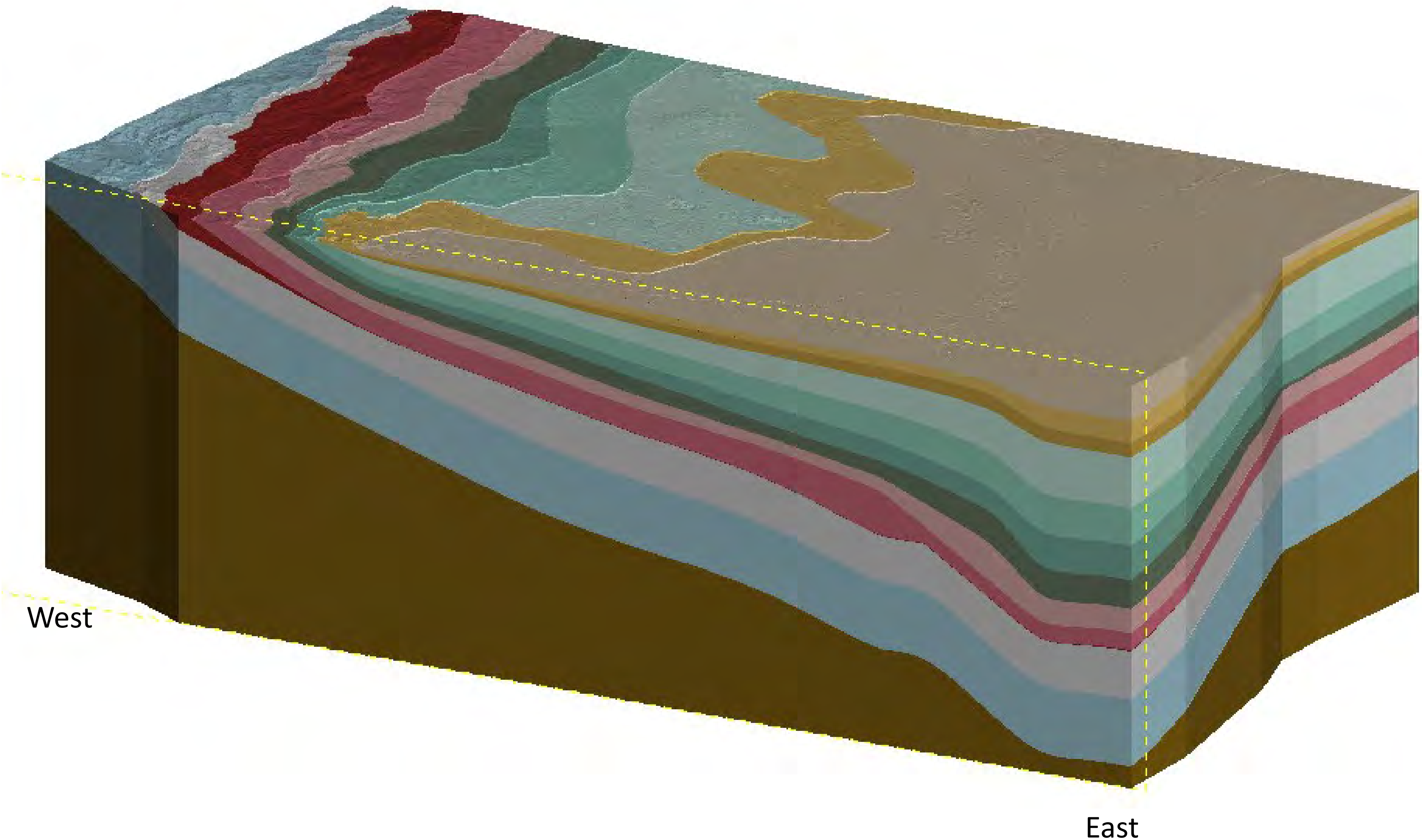
- 12-layer aquifer system
  - Gulf Coast Aquifer System
    - Chicot Aquifer
    - Evangeline Aquifer
    - Burkeville Confining System
    - Jasper Aquifer
  - Catahoula Confining System
  - Yegua-Jackson Aquifer



Aquifer Framework



Aquifer Framework: 3D view



Groundwater Inflows and Outflows

- Inflows:
  - Recharge from precipitation
  - Recharge from river/canal seepage
  - Recharge from deep percolation of excess applied irrigation water on agricultural fields
  - Subsurface inflows from west and northwest

Groundwater Inflows and Outflows

- Outflows:
  - Groundwater withdrawals by pumping
  - Discharge to Rio Grande and Arroyo Colorado
  - Evapotranspiration by riparian vegetation
  - Subsurface discharge to Gulf of Mexico

- Cross-formational flows between aquifer layers

Groundwater Salinity

- Salinity Categories used by TWDB (USGS System)
  - Freshwater (0 – 999 mg/L TDS)
  - Slightly Saline (1,000 – 2,999 mg/L TDS)
  - Moderately Saline (3,000 – 9,999 mg/L TDS)
  - Very Saline (10,000 – 35,000 mg/L TDS)
  - Brine (>35,000 mg/L TDS)

Groundwater Salinity

- Complex distribution of groundwater salinity zones and relationships in the aquifer system
  - Especially at shallow and intermediate depths
- Salinity generally increases with depth and to the east; and lower salinity in outcrop areas
- Salinity concentrations and distributions have remained relatively stable through time
- However, future groundwater withdrawals could induce movement of brackish groundwater

Groundwater Salinity

- Salinity distributions were prepared for this study using data provided by the TWDB BRACS group
  - 2014 Brackish Groundwater Study
  - New well control points for each aquifer layer
- Measured TDS concentrations at wells are not consistent with BRACS data in areas of the valley
- Work has progressed to resolve issues with salinity distribution
  - Awaiting TWDB review

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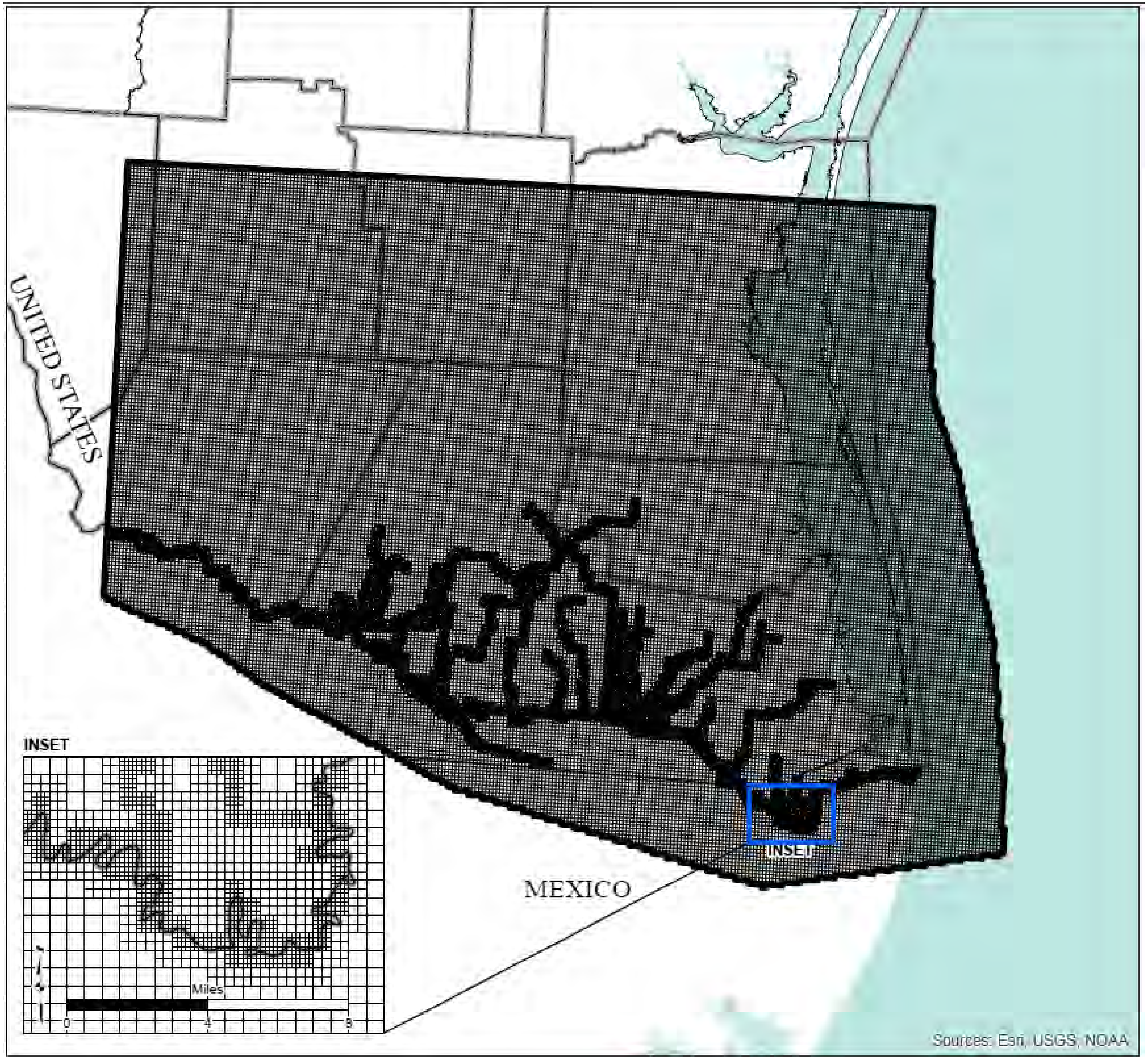
Model Grid

- Base grid (744,324 Active Cells)
  - 12 Layers
  - 220 Rows
  - 292 Columns
  - Half mile grid size = 2640 feet
- Quadtree refinement along streams:
  - Grid size = 330 feet
- Pinch-out layers less than 1 ft thick (0.3 ft limit set on conceptual model)

Model Grid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MEXICO
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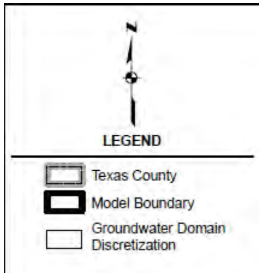
Sources: Esri, USGS, NOAA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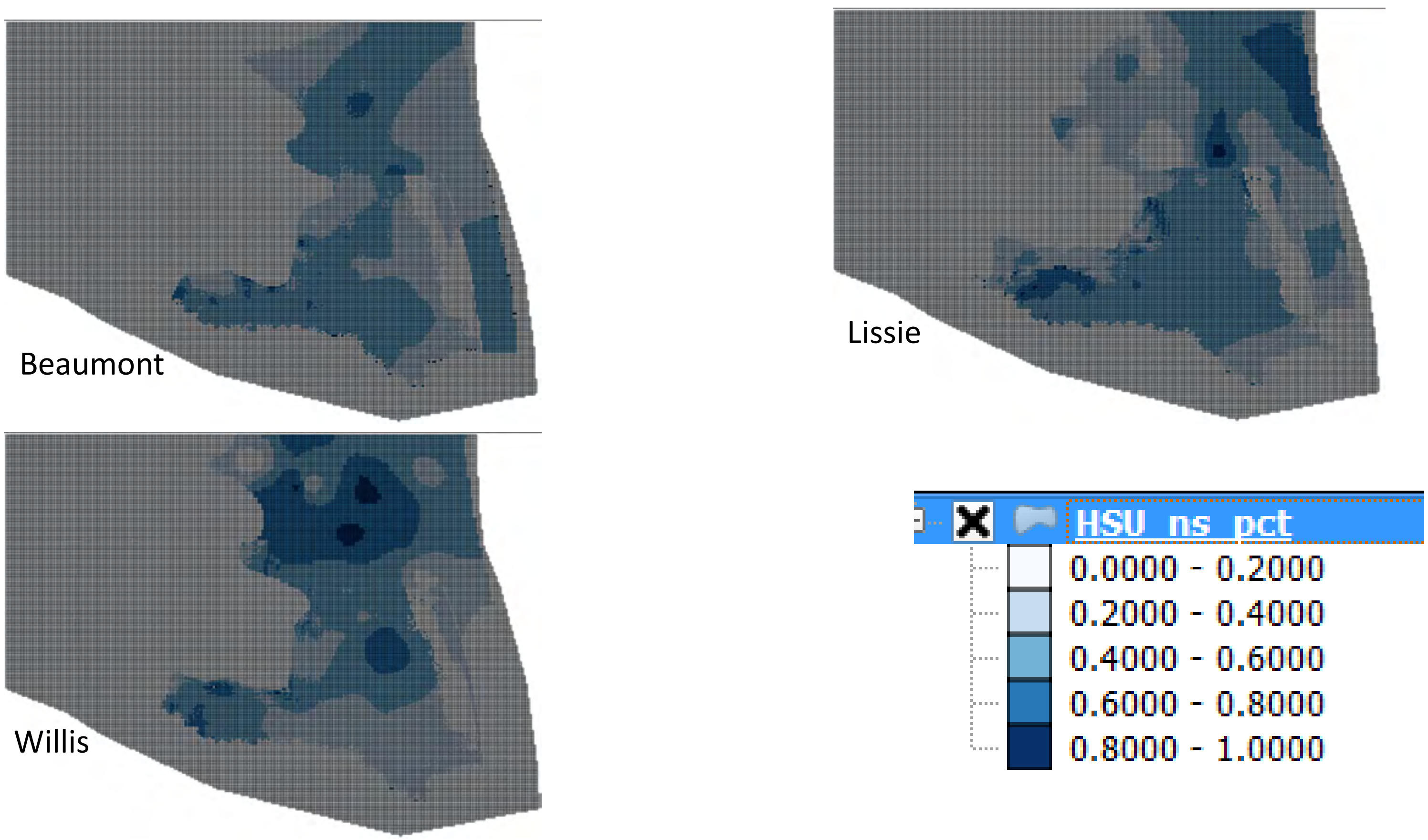
LEGEND
Texas County
Model Boundary
Groundwater Domain Discretization

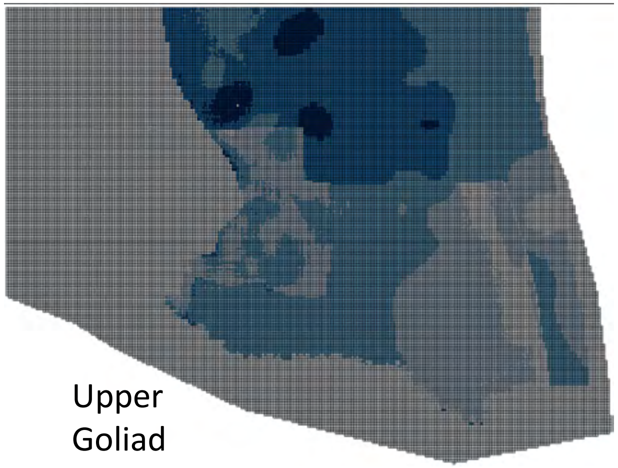
Aquifer Parameters

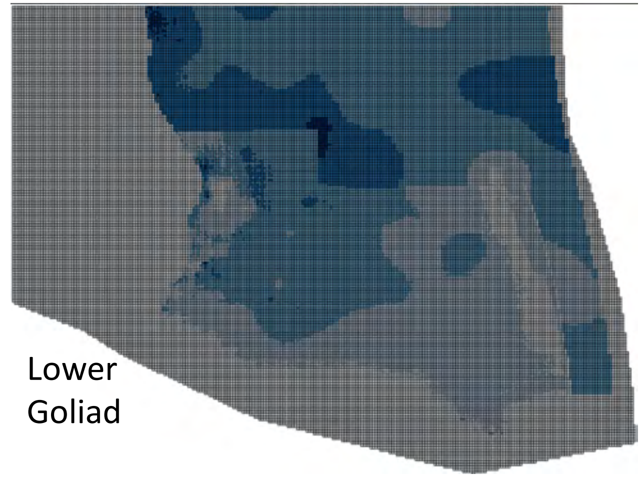
- Hydraulic Conductivity
  - K-value is calculated based on sand fraction for each cell
  - K-values for sand and clay are calibrated for each geologic formation
- Specific Storage: 1E-6 for all geologic layers
- Specific Yield: 1e-4 for layer 7; 1e-3 for remaining geologic layers

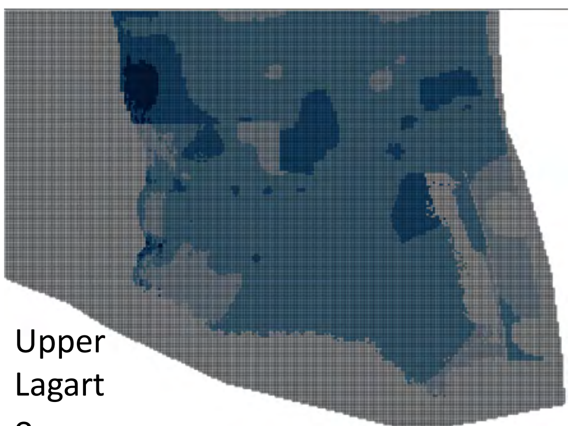
Sand fraction of LRGV model layers: Chicot

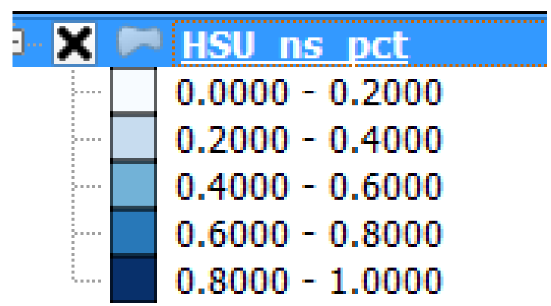


Sand fraction of LRGV model layers: Evangeline

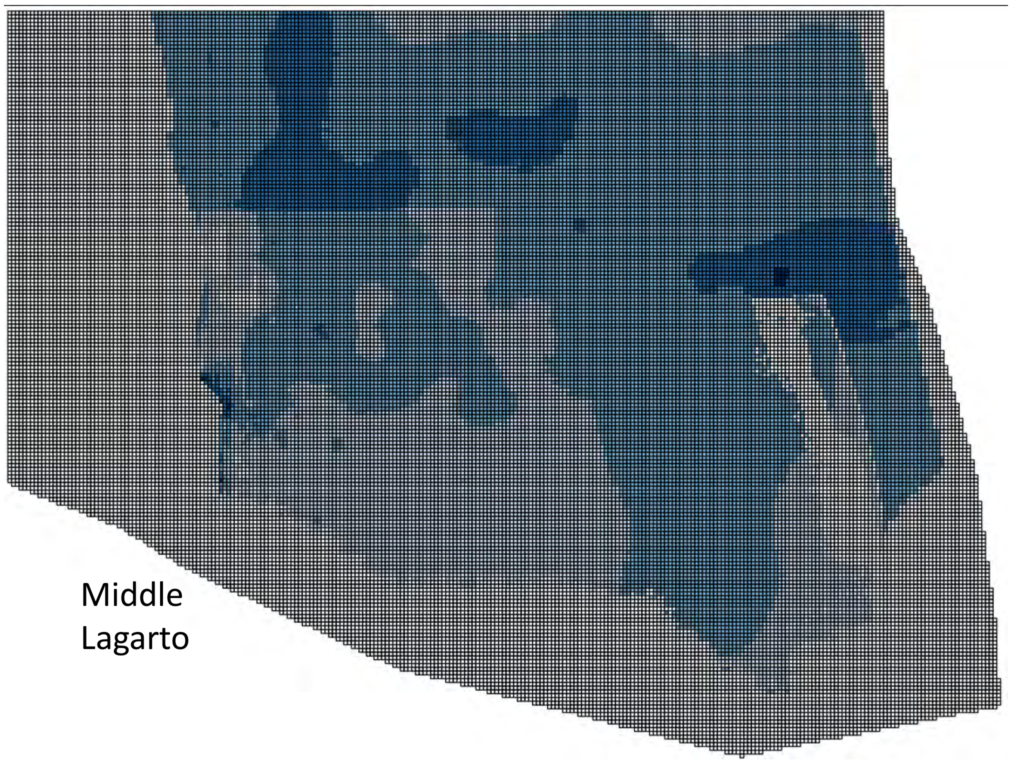


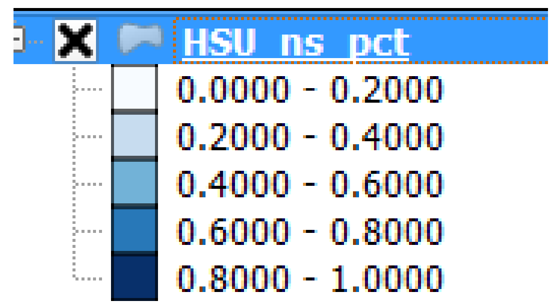




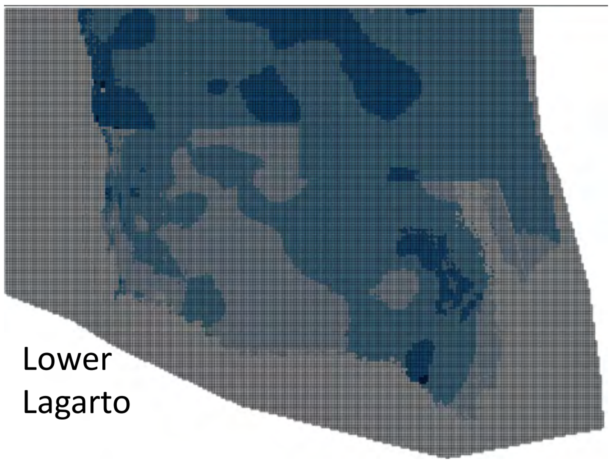


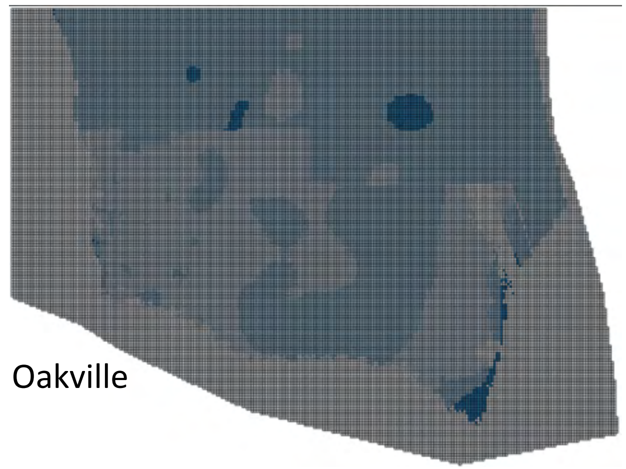
Sand fraction of LRGV model layers: Burkeville

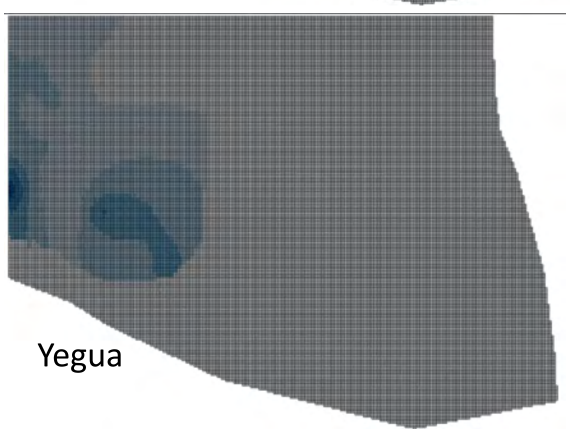




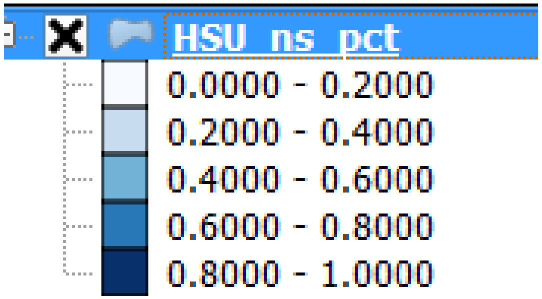
Sand fraction of LRGV model layers: Jasper / Y-J



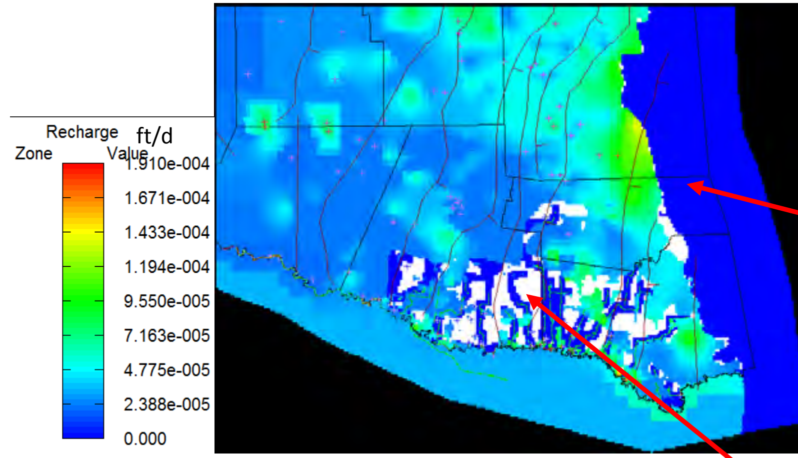




Sand Fractions not available for Upper Catahoula (in Jasper) and Catahoula Confining System



Boundary Conditions

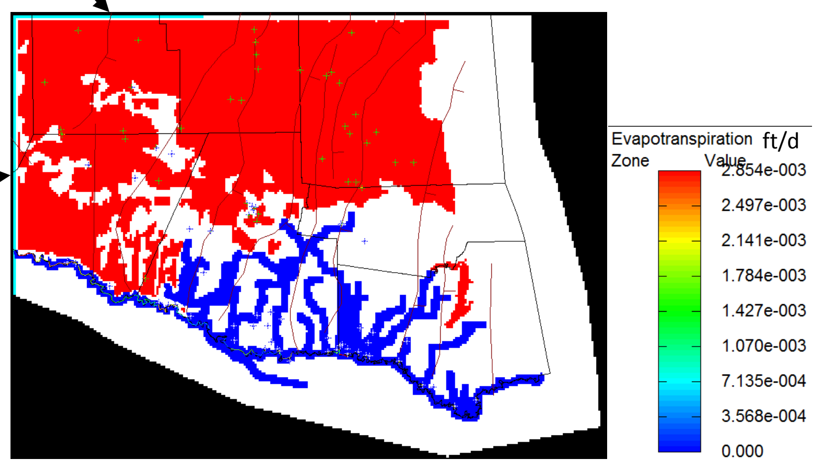


Prescribed Head in Layer 1

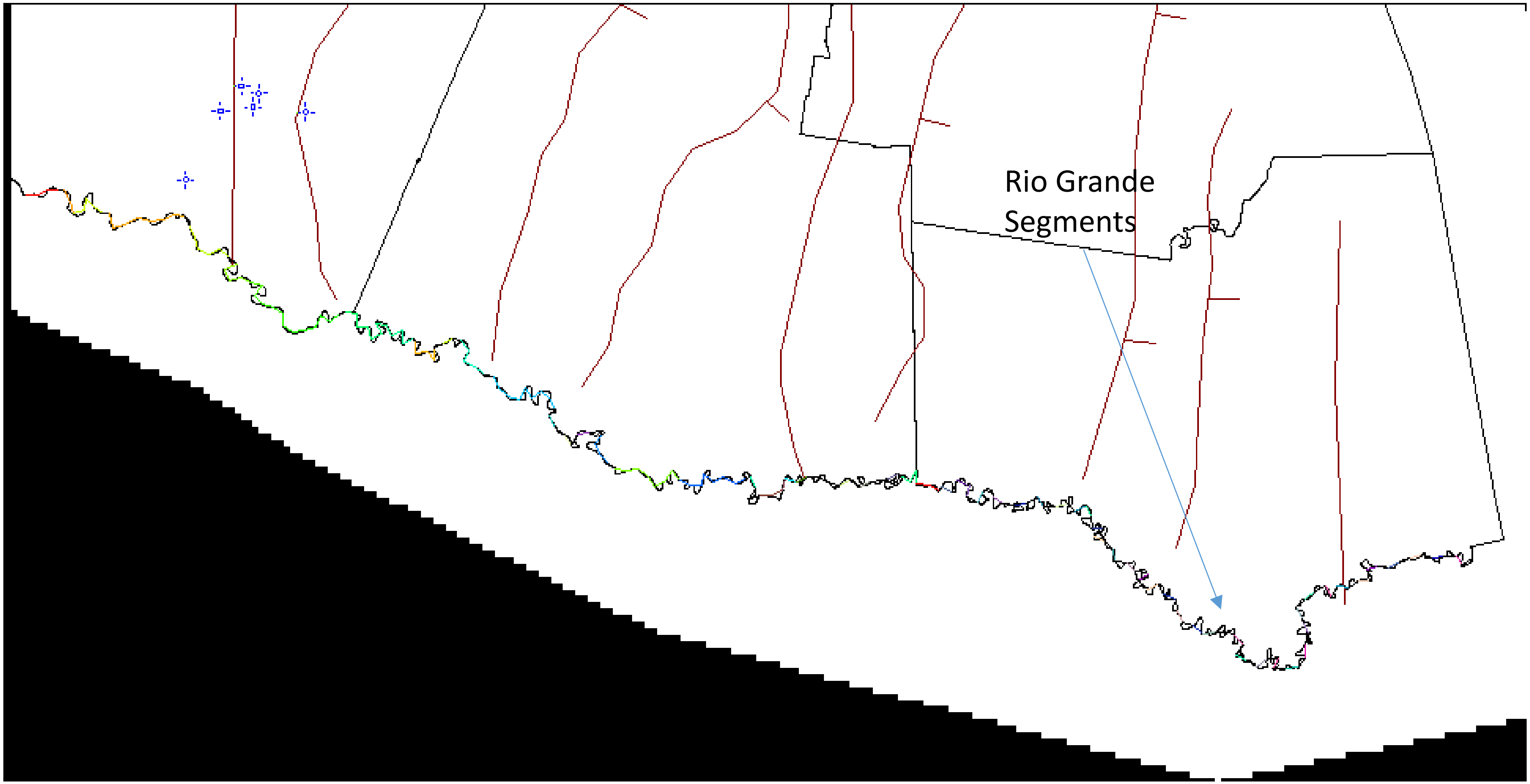
Removed double-counting of recharge in irrigated areas

GHB in layers 8-12

GHB in layer 12

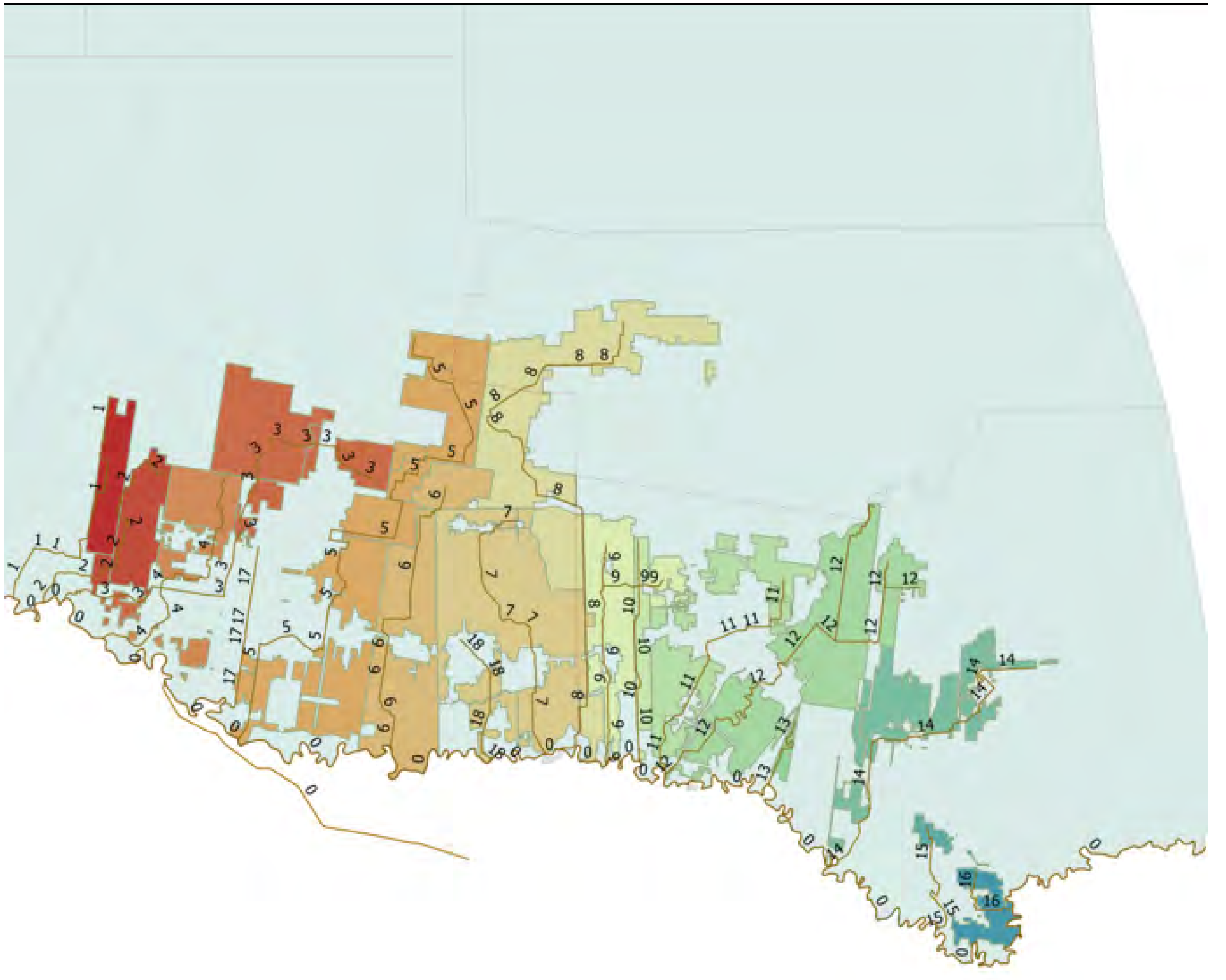


Rio Grande Discretization



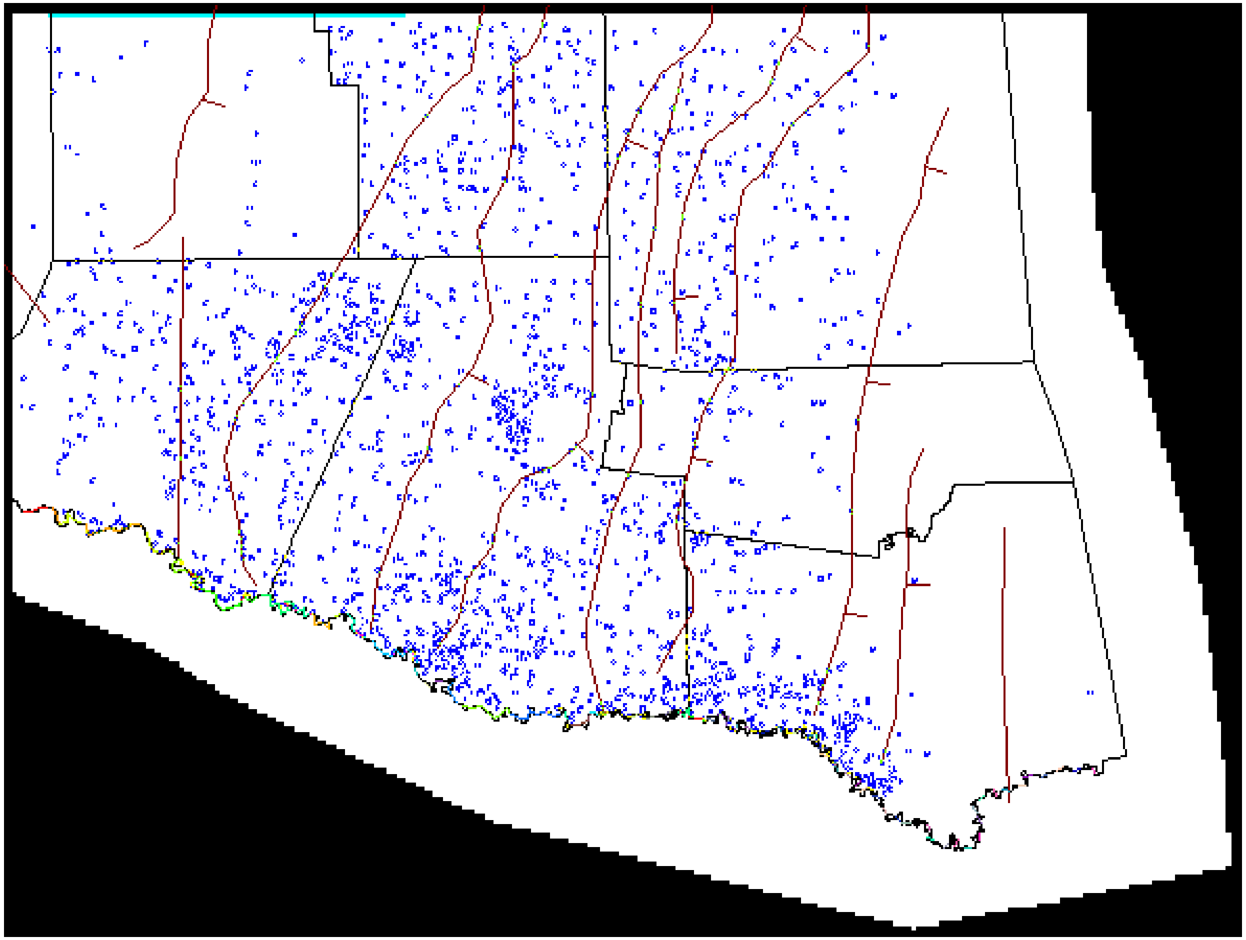
Canals and Return Flow Areas

- Canal-groundwater interaction (canal losses) simulated using RIV package
- Return flow = 10% of (diversion amount minus canal losses) applied using QRT Package



Pumping

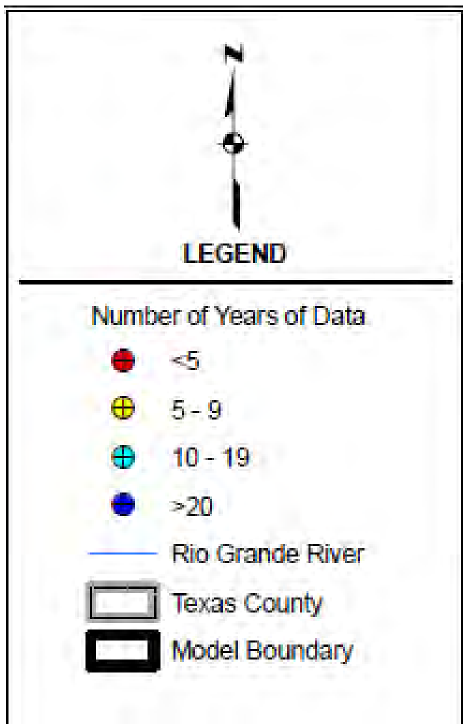
- Locations and annual pumping rates estimated during conceptual model development

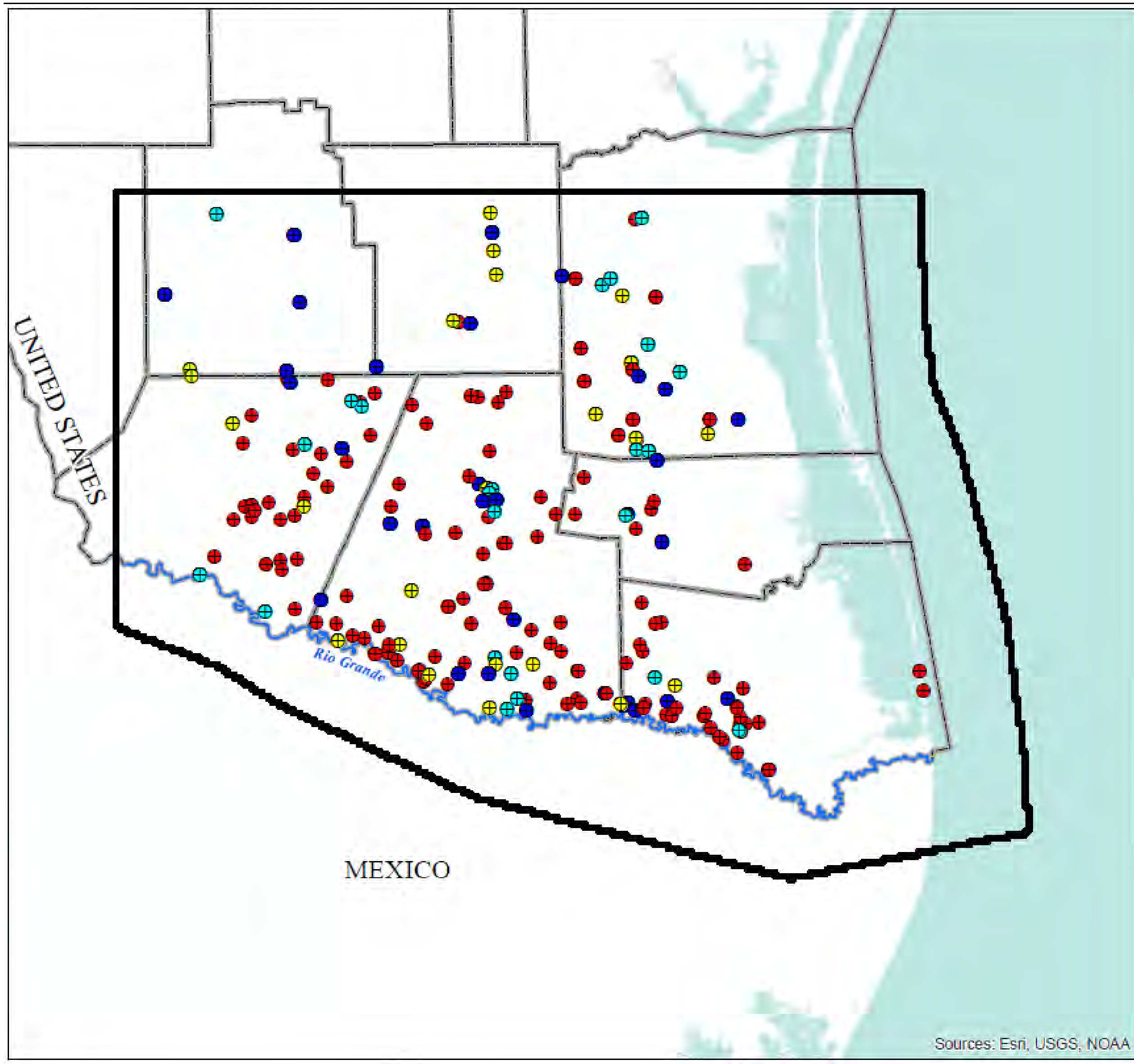


Calibration Metrics

- Water Levels:
  - 218 monitoring well locations
  - 115 wells have only one annual measurement
  - 32 wells have annual records for over 20 years
  - 26 wells have annual records for between 10 and 20 years
- Groundwater/surface-water interaction flux
  - Estimated canal losses
  - Estimated interaction between LRG River and groundwater
    - Between western model domain and Anzalduas Dam
    - Between Anzalduas Dam and gage near Brownsville

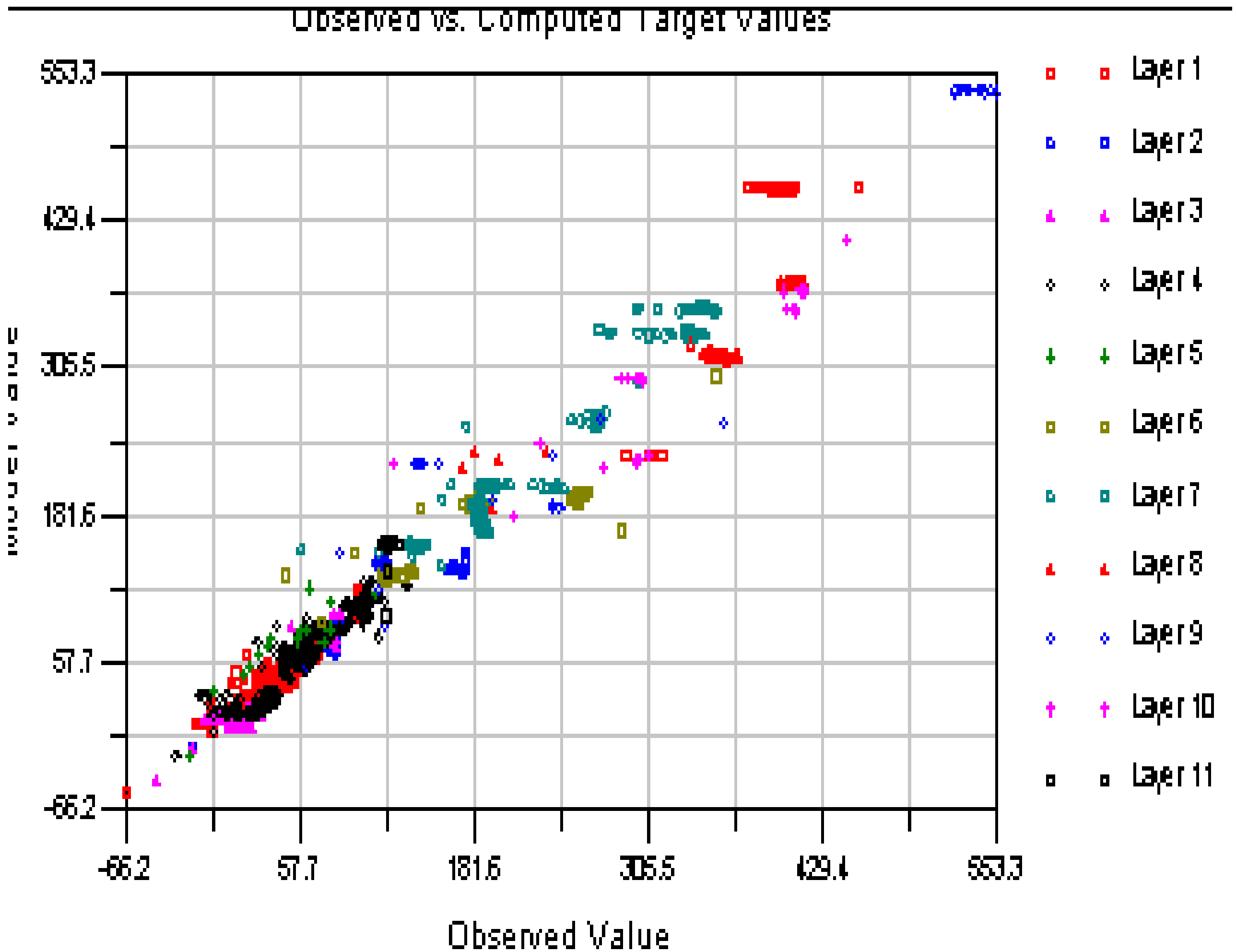
Water levels

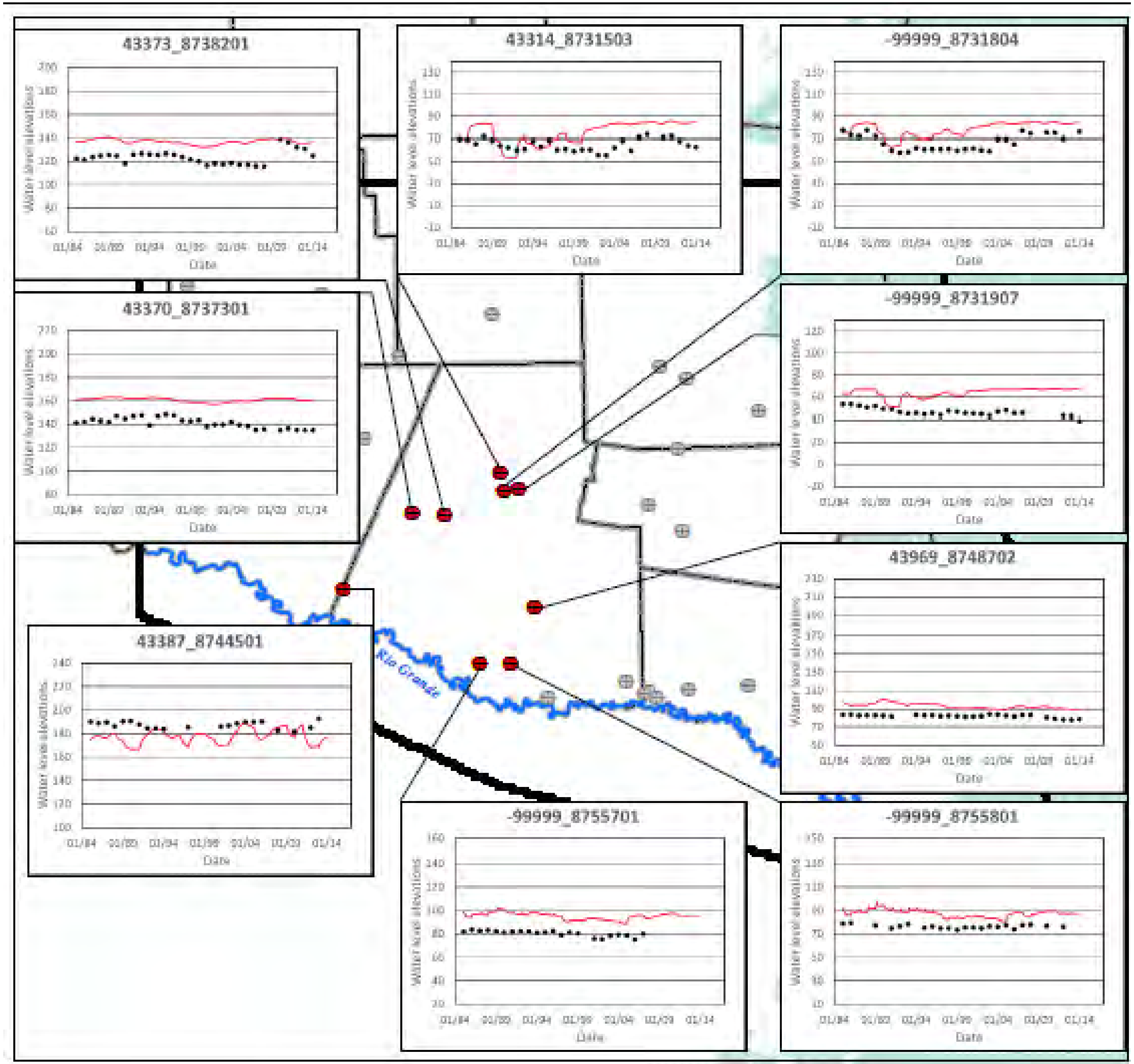




Regression Statistics for 1984-2013 simulation

Residual Mean	= -1.38
Residual Standard Dev.	= 20.36
Absolute Residual Mean	= 13.38
Residual Sum of Squares	=6.18e+005
RMS Error	=20.41
Minimum Residual	= -98.52
Maximum Residual	= 118.42
Range of Observations	= 619.50
Scaled Res. Std. Dev.	= 0.033
Scaled Abs. Mean	= 0.022
Scaled RMS	= 0.033
Number of Observations	= 1483

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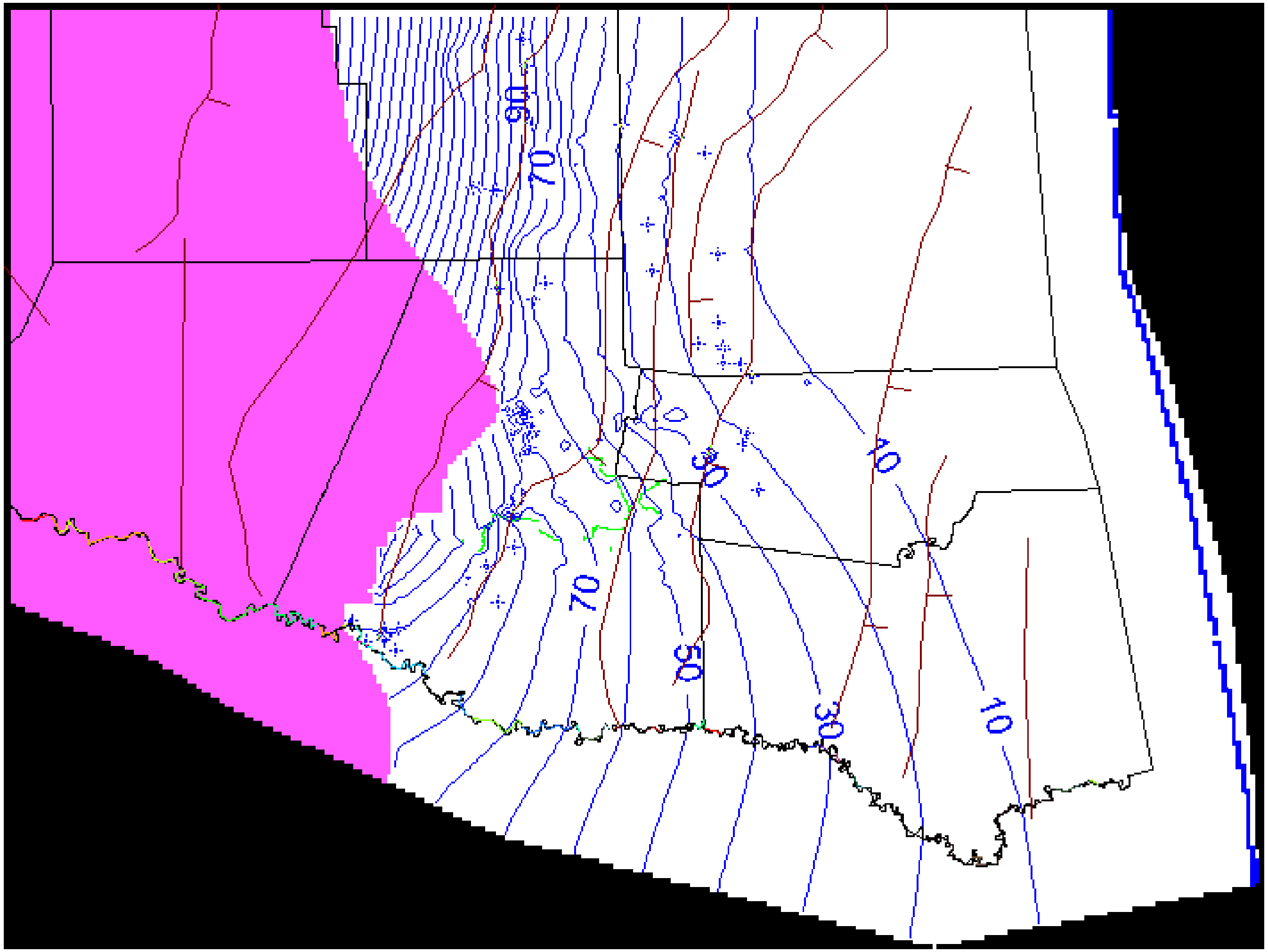
43370_8737301
-99999_8731907
43969_8748702
43387_8744501
-99999_8755701
-99999_8755801
Water level elevations
Date
Rio Grande

Water Levels – Layer 4



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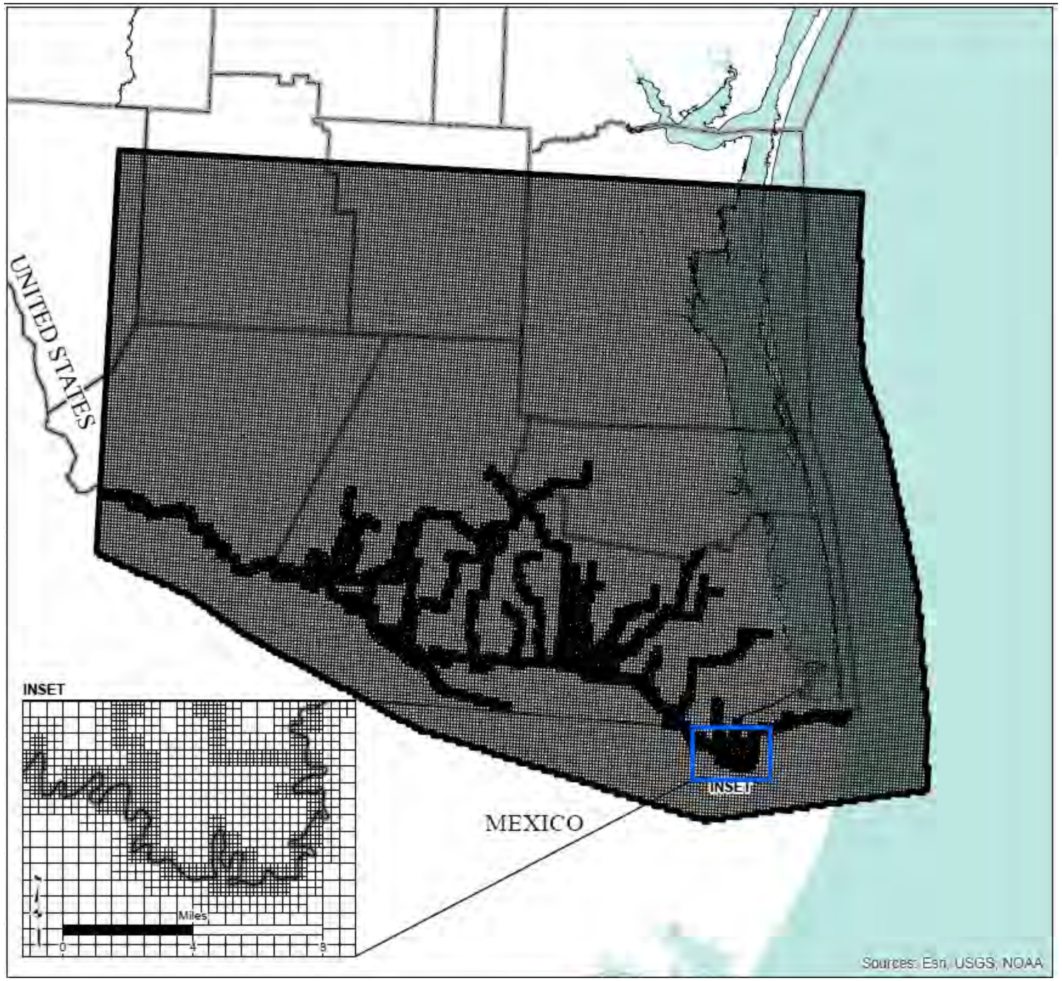
Next Steps

- Complete transport model
- Model sensitivity and uncertainty evaluation
- Model Prediction (desalination plant simulations)



Questions and Discussion

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sschorr@elmontgomery.com

MEMORANDUM

TO: Rohit Goswami, TWDB

CC: Cindy Ridgeway, TWDB

Larry French, TWDB

FROM: Julie Spencer, GSI Environmental Inc.

RE: Notes from a progress report of the Lower Rio Grande Valley Groundwater Transport Model project at the Region M meeting of February 8, 2017

A progress report on the Lower Rio Grande Valley (LRGV) Groundwater Transport Model was made at the Rio Grande Regional Water Planning Group (RGRWPG) – Region "M" meeting on February 8, 2017. The meeting was held in the Lower Rio Grande Valley Development Council Main Campus Ken Jones Executive Board Room located at 301 West Railroad Street, in Weslaco, Texas. The portion of the RGRWPG related to the LRGV Transport Model was item 9 on the agenda, and began at approximately 10:00 AM and was concluded at approximately 10:30 AM. The presentation was given by Bill Hutchison, Ph.D., P.E., P.G., a member of the LRGV Groundwater Transport Model team.

The objective of the presentation was to give an overview of progress made to date on the project. Detailed information on the numerical model and simulation will be made at the next SAF. A summary of the questions asked and answers provided during the presentation, and a list of attendees is provided below.

Q1: As related to a slide showing the aquifer framework, it was noted that there are no outcrops on the Gulf side of the model area.

A1: Because of the dipping nature of the aquifer, there are outcrops located in the western portion of the model area.

Q2: As related to a slide showing groundwater levels, it was asked if the water levels shown were relative to sea level.

A2: It was confirmed that water levels are groundwater elevations relative to sea level.

Q3: As related to model prediction, it was asked if the completed model would have the ability to change prediction scenarios to account for information obtained at a later date. Currently, the model is using information from the 2016 plan. Can it be changed to reflect potential changes in the 2021 plan?

A3: Yes. A report will outline what the initial effects of the currently foreseen desalination plants will be. However, the completed model can be used as a tool to run alternate simulations if that scenario changes. The model will actually help you evaluate some strategies.

Q4: Has any consideration been given to getting data from the Mexico side of the river?

A4: Yes. There have been some attempts to obtain information from Mexico, but it has been difficult. Our primary focus was on this side of the border. However, the river it is acting somewhat as a boundary condition. So, not having a lot of information from that side of the river is not critical to the model.

Q5: So, you have not had access to information to permitted wells and annual allowed pumpage on the Mexican side of the river?

A5: That is correct. However, the model extends into Mexico some and we are including the information that we do have. The model will have some limitation due to not having that data; however, a larger issue is the impact that brackish groundwater pumpage will have on surface water flow given the institutional nature of surface water rights.

Q6: But you do know the geologic make up in Mexico, correct?

A6: Yes, and that information just across the river in Mexico has been added to the model.

Q7: Can you assess the effects of pumpage in Mexico and any impacts that may have on water planning?

A7: The model will have some limited capability related to that.

Q8: With pumping of brackish water, will subsidence be an issue as it is in East Texas?

A8: Geologically, this area would be considered susceptible to subsidence. So, that is something that we are considering as part of model development. The completed model will have projected drawdown and will make some correlation based on subsidence information from the Houston area. We will make some general statements about potential effects of subsidence. It will be a qualitative assessment, however, as there is no actual subsidence data from the LRGV to calibrate the model.

Q9: How will this model predict subsidence?

A9: It model itself will not "predict" subsidence as there is no way to calibrate it with actual subsidence data. Results of our work will be made available to help bolster other studies that are more focused on the effects of subsidence. The bottom line is that without a lot of pumping in this area, we do not know what the cause and effect relationship is. We could say is that it is similar to the Houston area and apply some of those factors, but that is still a qualitative assessment.

Q10: We are very concerned about subsidence. We can't wait for this to happen before we act. It looks like we are going into this blind. You mentioned saltwater incursion. This is happening. We've got wells out there that have saltwater coming up from under. Locally, there are wells that have good water and a mile away they have terrible water. With this massive pumping we are going to lose our water. That may satisfy the cities, but as far as the ranch and land owners we may be left dry.

A10: The model looks at the effects of brackish water extraction on a regional scale. Unfortunately, there will be effects on a local scale that cannot be modeled.

Q11: Related to saltwater incursion into freshwater areas, is that sea water or brackish water?

A11: Due to the complex distribution, it is usually more brackish water from other areas being drawn in and displacing the fresh water at shallow depths.

GSI ENVIRONMENTAL

Q12: You are going to wipe-out the area that I am in. There are no massive subsidies to drill deeper. What is the connectability? There are some lenses in there that are not connected.

A12: That is the reason we are including sand fraction in our model to honor the data and try to recognize where the good water is located and how it flows.

Q13: Have you done any study into porosity?

A13: Yes. That is the sand distribution which will be part of the model.

Q14: Does it have to do with sand distribution or porosity or both?

A14: Sand and clay both have porosity. Clay has a higher porosity, but sand has a higher effective porosity which is more important in the movement of groundwater

Q15: With this pumping, in general, as we go deeper the groundwater becomes more saline.

A15: Lateral movement of groundwater in the model area is dominant and will cause the most change or impact. However, the model handles both horizontal and vertical flow.

Q16: If we get subsidence, what will we do?

A16: The simulation results will include estimates of drawdown. General estimates of potential subsidence will be provided based on analogs so that the potential for subsidence will be known to some qualitative degree. The model is not going to "make decisions" but provide information to decision-makers.

Q17: Is there a .PDF of the report containing the information presented today?

A17: Yes. The Conceptual Model Report has been finalized and posted to the TWDB website. Information on the numerical model and simulations will be presented at the next SAF.

Q18: Is the U.S. Geological Survey (USGS) or anybody else using this model?

A18: Yes. The model uses a USGS code.

It was asked if the SAF members would like to hold the next SAF as a stand-alone meeting, or in conjunction with the next Region M meeting. The next Region M meeting is currently scheduled for June 14, 2017. The LRGV Modeling Project team will check their availability to present detailed information on the numerical model and simulations on June 14, 2017.

A list of attendees is provided below:

Name	Affiliation
Donald K. McGhee	RGRWPC Executive Committee Member
Frank Schuster	RGRWPC Executive Committee Member
Nick Benavides	RGRWPC Executive Committee Member
Glenn Jarvis	RGRWPC Voting Member
John Bruciak	RGRWPC Voting Member/Brownsville PUB
Carlos Garza	RGRWPC Voting Member

Dennis Goldsberry	RGRWPC Voting Member
Jorge Barrera	RGRWPC Voting Member
Judge Joe Rathmell	RGRWPC Voting Member
Jaime Flores	RGRWPC Voting Member
Armando Vela	RGRWPC Voting Member
Judge Humberto Gonzalez	RGRWPC Voting Member
Raizul Mia	RGRWPC Voting Member
Rohit R. Goswami	TWDB
Nathan van Oort	TWDB
Adam R. Gonzalez	City of San Benito
Moises Martinez	City of San Benito
Debby Truman	City of San Benito
Eileen Mattei	Freelance Writer
Jorge Arroyo	Water Management Consultant
Alfredo Resendez	Brownsville PUB
Juan Bujanos	Brownsville PUB
Bill Hutchison	Independent Consultant/LRGV Modeling Team
Julie Spencer	GSI Environmental Inc./LRGV Modeling Team
Kevin Spencer	R.W. Harden & Associates
Steven Sanchez	North Alamo WSC
Andy Garza	Kenedy County GCD
Felix Saenz	Brush Country GCD
Kip Averitt	Averitt and Associates
Nora N. Garza	North Alamo Water
Steven Young	Intera
Kristina Leal	Halff Associates
Aaron Wendt	Texas State Soil and Water Conservation Board
Juan Santana	TWDB
Carlos Gonzales	McAllen Public Utility
Nelda L. Barrera	Texas Department of Agriculture
Sergio Espinoza	McAllen Public Utility

Alfonso A. Gonzalez	SWG Engineering, LLC
Connie Townsend	TWDB
Debby Morales	Lower Rio Grande Valley Development Council