2023 JOINT REGULATORY PLAN REVIEW

STAKEHOLDER MEETING EXECUTIVE SUMMARY

NAME OF MEETING:	Stakeholder Meeting 1 / Stakeholder Advisory Forum 1
DATE:	May 20, 2020
LOCATION:	Virtual

On Wednesday, May 20, 2020 at 10:00 am, the Harris Galveston and Fort Bend Subsidence Districts (the Districts) held their first Joint Regulatory Plan Review Stakeholder Meeting. This meeting was originally scheduled for March 31, 2020 and was rescheduled as a virtual meeting to comply with best practices and directions provided by the State of Texas for the COVID-19 situation. Numerous board members, elected officials, regional water authorities, and representatives from local, State and Federal agencies joined the meeting, with more than 80 panelists and attendees. A full list of meeting participants is included in **Attachment A**.

The purpose of this meeting was to introduce the Joint Regulatory Plan Review project and also hold a Stakeholder Advisory Forum for the Gulf Coast Land Subsidence and Groundwater Flow (GULF)-2023 model. The GULF-2023 model will be an update to the groundwater availability model (GAM) for the northern portion of the Gulf Coat Aquifer System GAM.

The meeting was initiated by Michael J. Turco, who welcomed the stakeholders to the Districts' first virtual stakeholder meeting. Jason Afinowicz of Freese and Nichols then introduced the Joint Regulatory Plan Review project team, including Dr. Sunil Kommineni with KIT Professionals and Wade Oliver of INTERA. They provided a review of the Joint Regulatory Plan Review project elements. Cindy Ridgeway of the TWDB then gave a brief introduction to the GAM Program and discussed how GAMs are used in Texas water resources planning. She then discussed how GAMs relate to modeled available groundwater as well as the importance of the stakeholder process. Ms. Ridgeway then introduced John Ellis and Linzy Foster with the USGS, who provided a presentation on the following topics:

- Project overview
- Introduction to groundwater flow and numerical groundwater flow modeling
- Study area
- Planned approach, including model properties and model features
- Observations and a request for relevant data to support the model
- Proposed schedule

The formal presentation concluded with a review of the overall project schedule. A copy of the meeting presentation is provided in **Attachment B.**

A question and answer session was held after the meeting. A summary of the questions and responses is provided as **Attachment C.**

ATTACHMENT A – MEETING ATTENDANCE

FIRST	LAST	AFFILIATION
Jason	Afinowicz	Freese and Nichols
Jildardo	Arias	City of Friendswood
Susan	Baird	HGSD board member
Justin	Bartlett	.
James	Beach	WSP USA
Steve	Berckenhoff	
Andrew	Bohac	City of Needville
Stephen	Bond	TWDB
John	Branch	Clear Lake City Water Authority
Christopher	Braun	U.S. Geological Survey
John	Burke	Region K
Chris	Canonico	HGSD Board Member
Sarah	Carlock	Undine Texas LLC
Ki	Cha	TWDB
Jun	Chang	NHCRWA
Yun	Cho	Texas Water Development Board
Sharon	Citino	City of Houston
Katie	Clayton	City of Sugar Land
Heather	Cook	San Jacinto River Authority
Bruce	Cunningham	Mo Co MUD 6
Grayson	Dowlearn	TWDB
Gregory	Ellis	GM Ellis Law Firm PC
John	Ellis	USGS
Mark	Evans	North Harris County Regional Water Authority
Linzy	Foster	USGS
Larry	French	TWDB
Matt	Froehlich	BGE, Inc./North Fort Bend Water Authority
Yassin	Gallardo	Lower Neches Valley Authority
Jeff	Garner	LMSLP
Neil	Gaynor	Montgomery County Municipal Utility District No. 6
Ashley	Greuter	HGSD
Daryn	Hardwick	TWDB
Linda	Harnist	FBSD Board Member
Zach	Holland	Bluebonnet GCD
Jace	Houston	San Jacinto River Authority
Roel	Huerta	
Bill	Hutchison	
Mike	Keester	LRE Water

FIRST	LAST	AFFILIATION
Ron	Kelling	San Jacinto River Authority
Marcel	Khouw	IDS Engineering Group
Sunil	Kommineni	KIT Professionals
MICHAEL	LEE	USGS
Jason	Long	HGSD Board
John	Maresh	City of Rosenberg
Andrea	Martin	Professional Utility Services
John	Martin	Southeast Texas Groundwater Conservation District
Mac	Martin	Texas A&M Forest Service
Leah	Martinsson	TAGD
Dan	McGraw	City of Fulshear - Water Utilities
Tom	Michel	SJRA
Tiffany	Moore	NFBWA
Tiffany	Moore	NFBWA
Jennifer	Morrow	Clear Lake City Water Authority
Laura	Norton	MUD 47
Wade	Oliver	INTERA, Inc
Veronica	Osegueda	Houston Public Works
Paula	Paciorek	City of Houston
Kevin	Padgett	City of Seabrook
Tina	Petersen	HGSD
Kristi	Pierce	HGSD
Jason	Ramage	USGS
Mitchell	Ramon	City of Houston
Samantha	Reiter	Lone Star GCD
Cindy	Ridgeway	TWDB
Thompson	Robert	HGSD
Kathy	Rogers	HGSD Board Member
William	Seifert	
Melinda	Silva	Dannenbaum
Colleen	Spencer	City of Sugar Land
Brent	Spier	City of Clear Lake Shores TX
Greg	Stanton	USGS
Shaun	Theriot-Smith	HGSD Board
Ronda	Trow	HGSD
Michael	Turco	HGSD
Robert	Valenzuela	City of Sugar Land
Christopher	Varela	City of Houston
Alia	Vinson	WHCRWA/ABHR
Shirley	Wade	TWDB
Jeremy	White	USGS

FIRST	LAST	AFFILIATION
B T	Williams	Fort Bend Subsidence District
Eric	Wilson	Gulf Coast Water Authority
John	Yoars	YOARS CONSULTING LLC
Mayor Joe	Zimmerman	City of Sugar Land

ATTACHMENT B
MEETING PRESENTATION

2023 Joint Regulatory Plan Review

Stakeholder Meeting 1

20 May 2020

Project Sponsors and Collaborators

HARRIS-GALVESTON SUBSIDENCE DISTRICT

FORT BEND SUBSIDENCE DISTRICT

Texas Water Development Board

USGS science for a changing world

Stakeholder Participants

- Regulated community
- Decision-makers
- Elected officials
- GMA 14 and GCDs
- River authorities
- Region H Water Planning Group
- Texas Water Development Board

Purpose and Objectives

- Refresh population and per-capita water demand projections within and surrounding the Regulatory Areas
- Improve the understanding of future alternative source waters
- Update and improve predictive tools
- Evaluate regulatory and climatic scenarios versus the occurrence of subsidence through 2100

Keys Stakeholder Engagement Opportunities

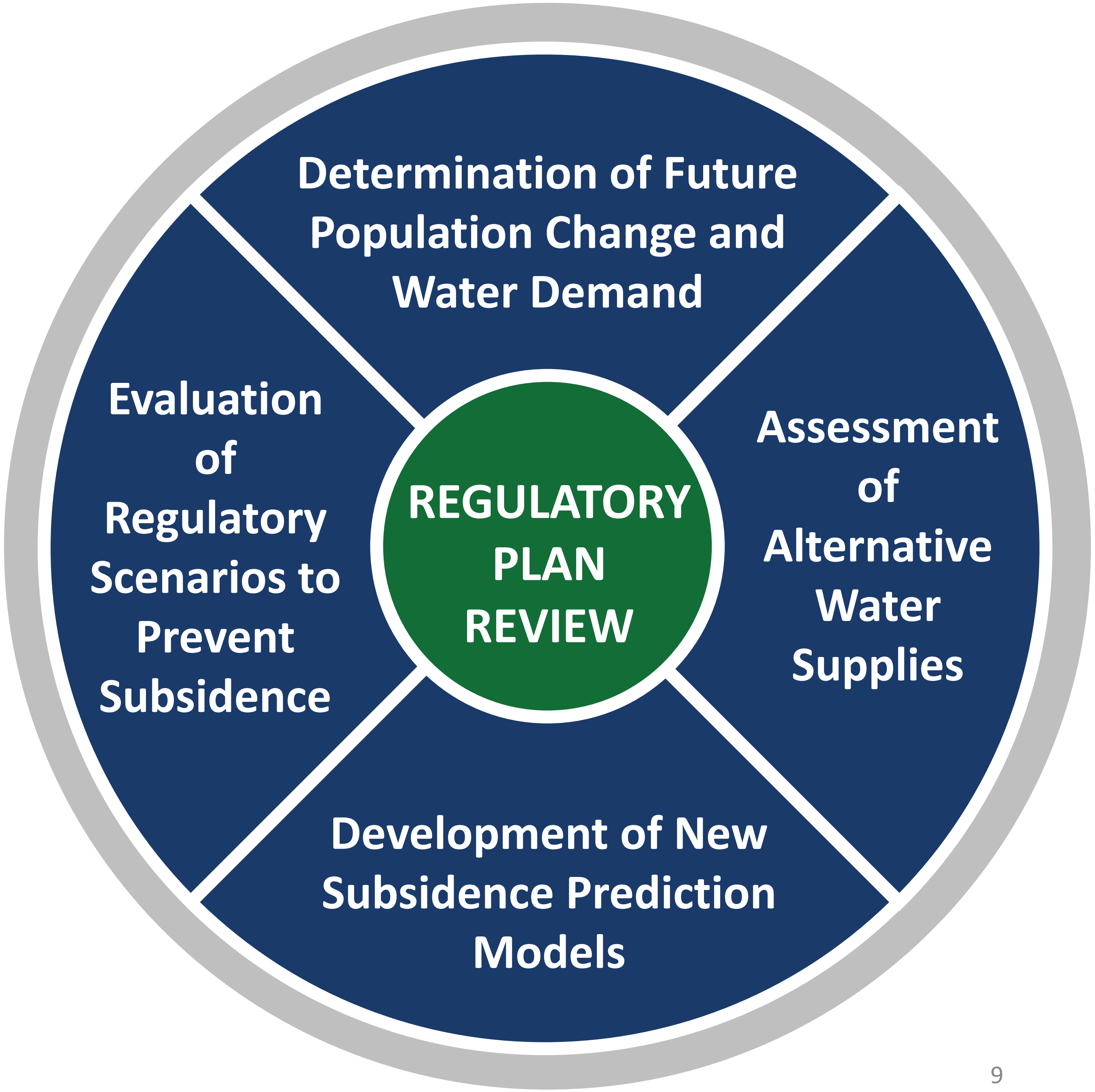
Meeting attendance and project awareness

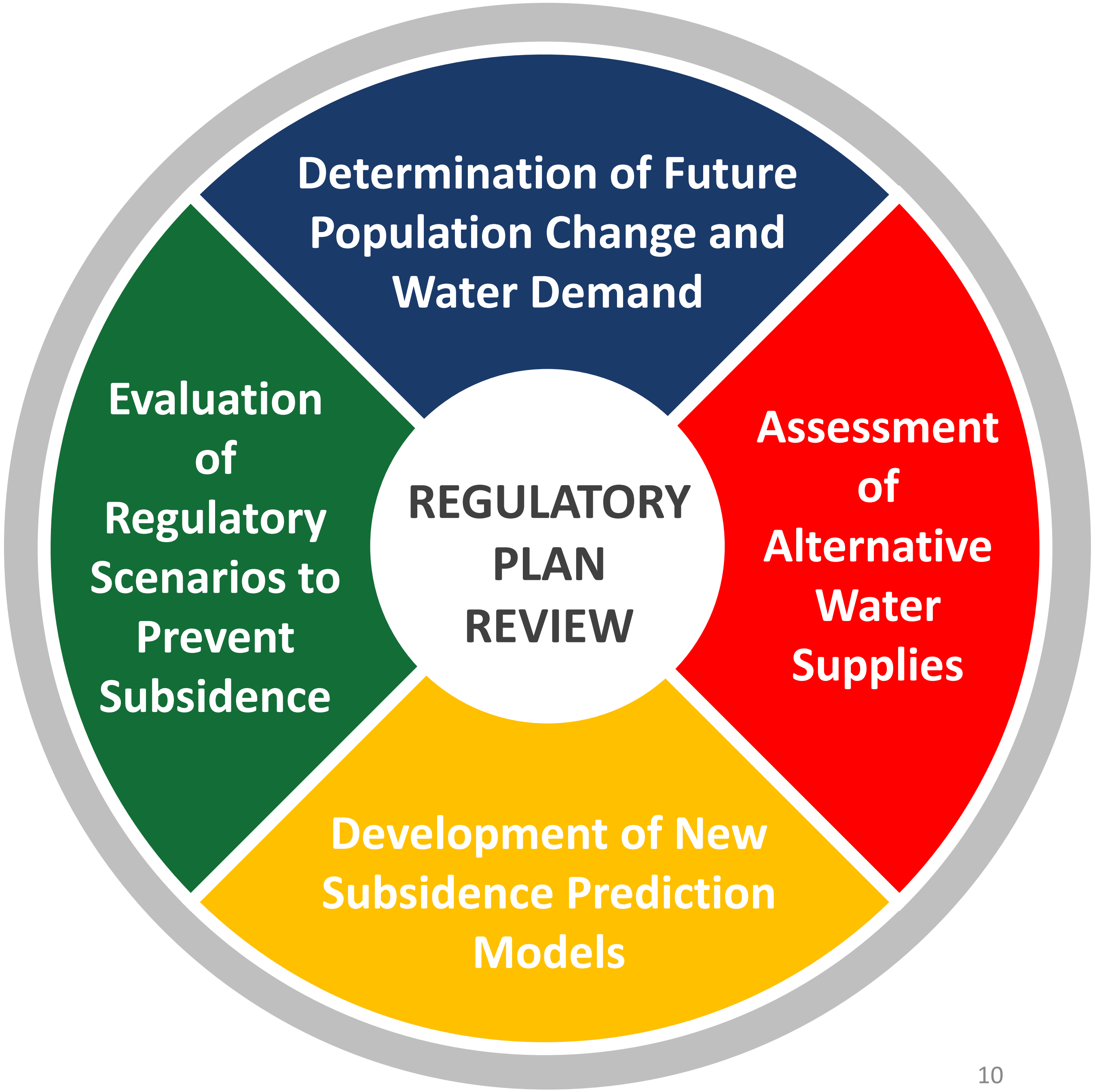
Providing data for technical analyses

Providing feedback on draft material

Participate in targeted outreach efforts

PROJECT ELEMENTS




Determination of Future Population Change and Water Demand
Assessment of Alternative Water Supplies
Development of New Subsidence Prediction Models
Evaluation of Regulatory Scenarios to Prevent Subsidence
REGULATORY PLAN REVIEW

Jason Afinowicz
- Freese and Nichols

Wade Oliver
- INTERA

Sunil Kommineni
- KIT

Cindy Ridgeway
- TWDB

John Ellis
- USGS

Linzy Foster
- USGS

Project Elements and Updates

PROJECT ELEMENTS

2013 Regulatory Plan Post Audit

Alternative Water Supply Availability

Projected Water Needs

Modeling

- Groundwater Availability Modeling
- Development of GULF 2023 Model
- PRESS Assessment

Water Use Scenario Development

2013 Regulatory Plan Post Audit

<u>Background:</u> Models are tools that help us understand cause and effect – primarily the relationship between groundwater pumping and subsidence

Evaluate process and data used to develop 2013 Regulatory Plan

Compare to observed water use and aquifer data

Identify lessons learned to apply and inform current round of planning

Evaluate Collected Data

- Pumping
- Water Levels
- Compaction
- Subsidence

2013 Regulatory Plan Post Audit

Where do model observations match and diverge from collected data?

Does modeling actual pumping reproduce observations?

How does actual pumping compare to forecast pumping?

What can we do differently to improve modeling and forecast use?

Lessons Learned

PROJECT ELEMENTS

2013 Regulatory Plan Post Audit

Alternative Water Supply Availability

Projected Water Needs

Modeling

- Groundwater Availability Modeling
- Development of GULF 2023 Model
- PRESS Assessment

Water Use Scenario Development

Alternative Water Supply Availability

- Focus of evaluation is to compile and characterize alternative water supplies and their availability for use by systems in the regulatory areas
- Assessment will include supplies originating both within (i.e., reclaimed water) and outside the regulatory areas (i.e., seawater, new reservoirs)

Alternative Water Supply Availability

Identified 18 Options

Surface Water Development
- New Reservoirs
- Off Channel Reservoirs
- Inter-Basin Transfers
- Appropriated but Undeveloped Water

Water Demand Management
- Basic Conservation
- Advanced Conservation
- Water Loss Control w/ Advanced Metering Infrastructure
- Industry-Driven Innovative Strategies

Brackish Groundwater Desalination
- Brackish Groundwater Wells and Desalination

Seawater Desalination
- Onshore Facility Desalination
- Offshore Facility Desalination

Reclaimed Water
- Indirect Potable Reuse
- Direct Potable Reuse
- Purple Pipe Network
- Scalping Plants / Onsite Reuse

Aquifer Storage and Recovery
- ASR w/ Surface Water
- ASR w/ Stormwater
- Inter-Basin Transfers

Alternative Water Supply Availability

Shortlisted Seven Options through Consistent Methodology

Review Regional Water Plans, Prior Studies, Available Literature and Data

Assess Scalability, Efficacy and Implementability

Discussions with HGSD and FBSD

ALTERNATIVE WATER SUPPLY AVAILABILITY

Shortlisted Options

Alternative Water Supply Availability

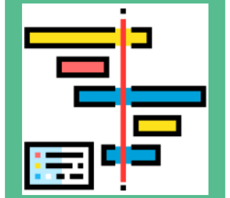
Characterization of Shortlisted Options

Develop Narrative Descriptions

Estimate Water Yields

Prepare Planning Level Cost Estimates

Identify Implementation Timelines



Assess Vulnerability to Climate Change

Project Elements

2013 Regulatory Plan Post Audit

Alternative Water Supply Availability

Projected Water Needs

Modeling

- Groundwater Availability Modeling
- Development of GULF 2023 Model
- PRESS Assessment

Water Use Scenario Development

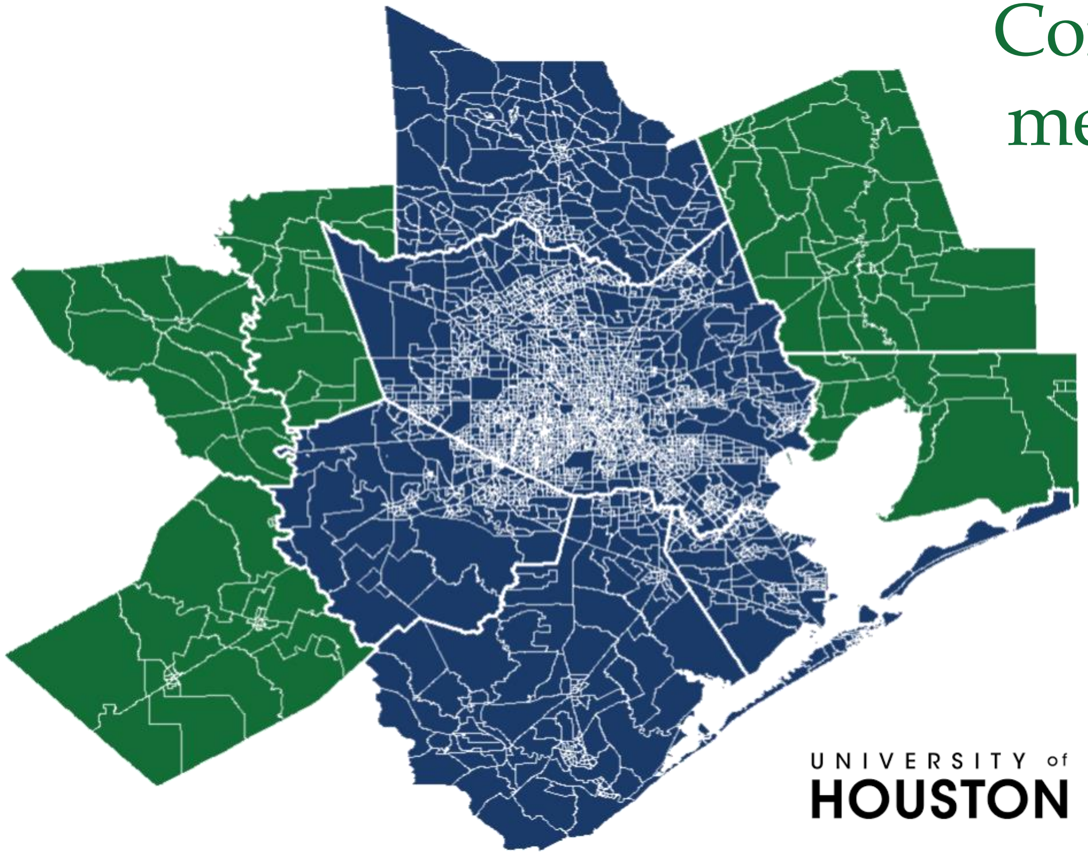
Projected Water Needs

Enhancements to 2013 Regulatory Plan Update methodology

- Ten counties
- Evaluate single- and multi-family growth
- Refine industrial projections
- Water use data from stakeholders
- Various demand futures
- Projections to 2100

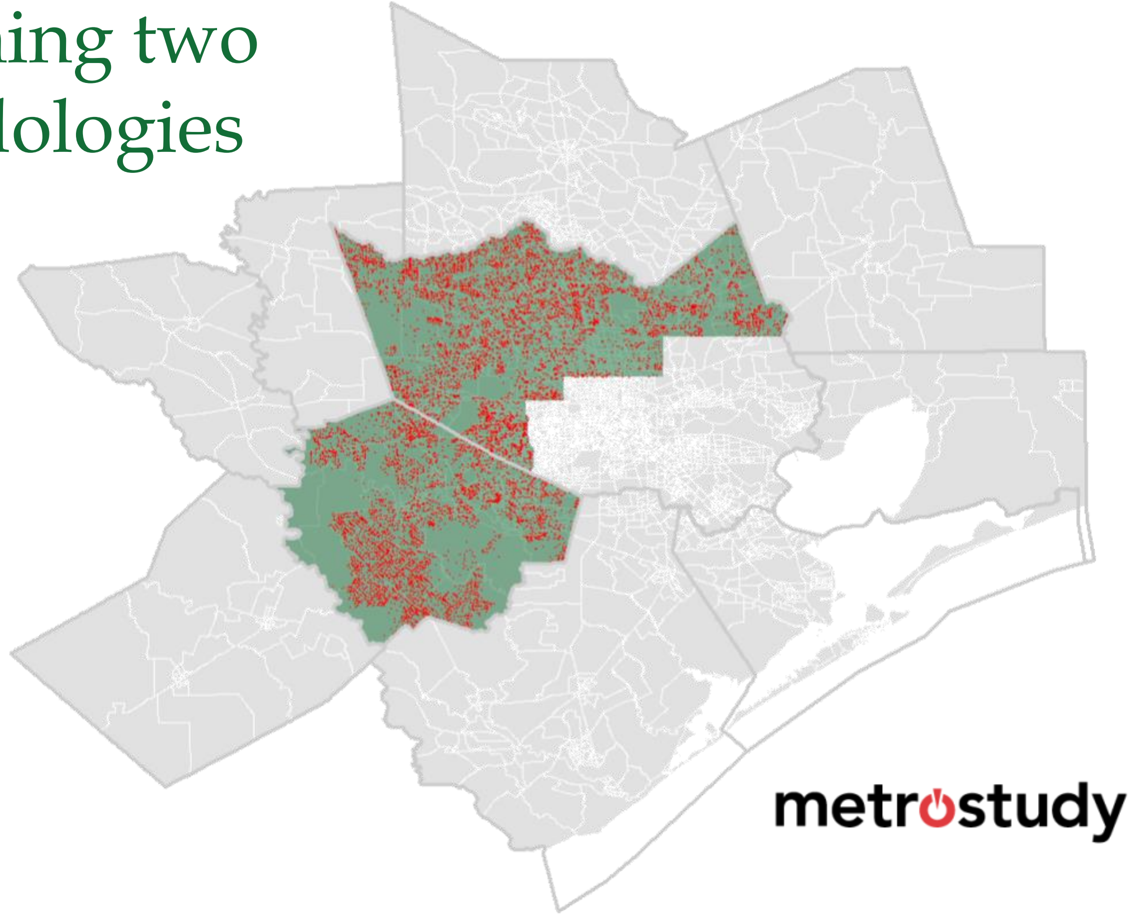
PROJECTED WATER NEEDS

Combining two methodologies



Small Area Model Houston (SAM-Houston)

Long-range, wide-area projections



Projected Development Methodology

Short-range, detailed projections

Project Elements

2013 Regulatory Plan Post Audit

Alternative Water Supply Availability

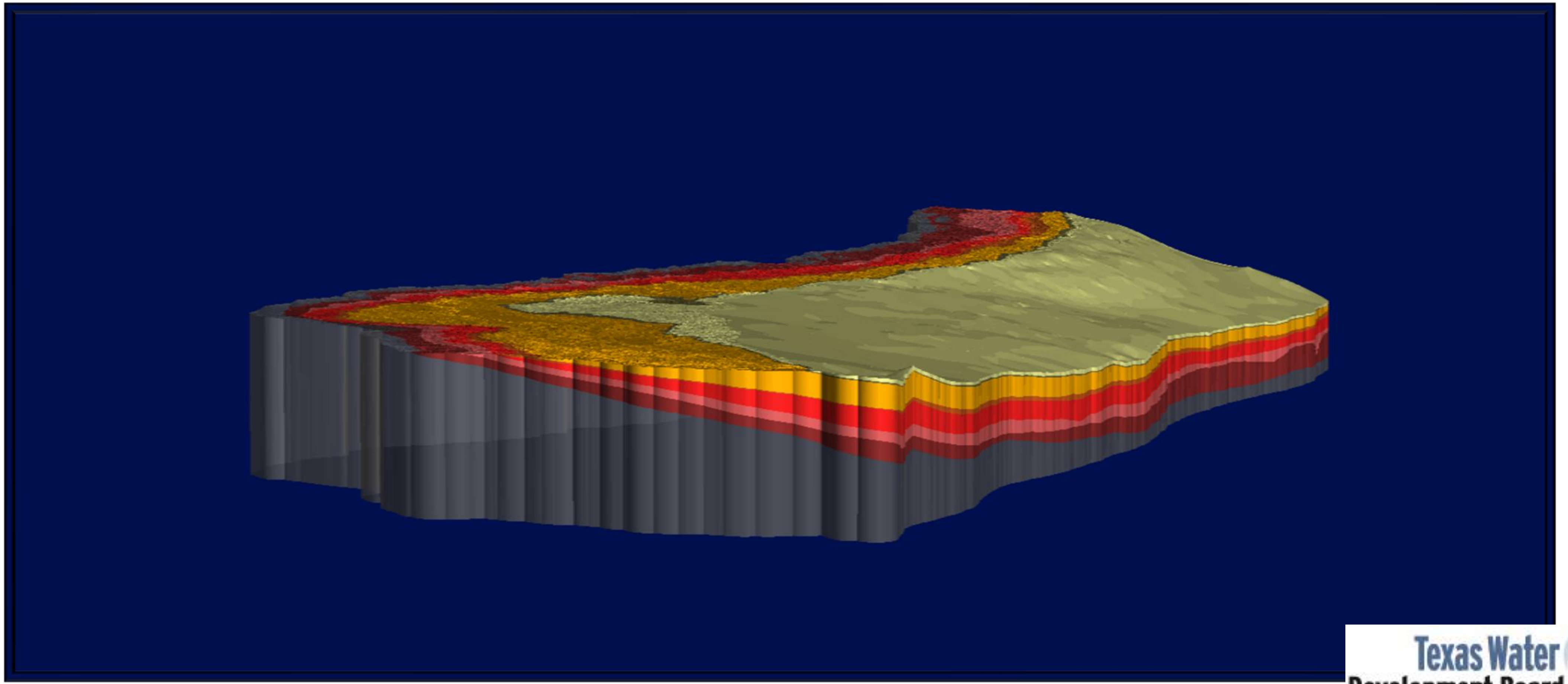
Projected Water Needs

Modeling

- Groundwater Availability Modeling
- Development of GULF 2023 Model
- PRESS Assessment

Water Use Scenario Development

GROUNDWATER AVAILABILITY MODELING



Texas Water Development Board

GROUNDWATER AVAILABILITY MODELING

In Statute: Develop groundwater flow models for the major and minor aquifers of Texas.

Purpose: Tools that can be used to aid in groundwater resources management by stakeholders.

Public process: Stakeholder involvement during model development process.

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

Living tools: Periodically updated.

Purpose of Stakeholder Meetings

Opportunity for input and data to help with model development

Updates on model progress

Providing feedback on draft material

Learn how to best use model & model limitations

Groundwater Availability Modeling

Cindy Ridgeway, P.G.

Manager of Groundwater Availability Modeling Section

512-936-2386

Cindy.ridgeway@twdb.texas.gov

Texas Water Development Board

P.O. Box 13231

Austin, Texas 78711-3231

Web information:

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

USGS
science for a changing world

HARRIS-GALVESTON SUBSIDENCE DISTRICT

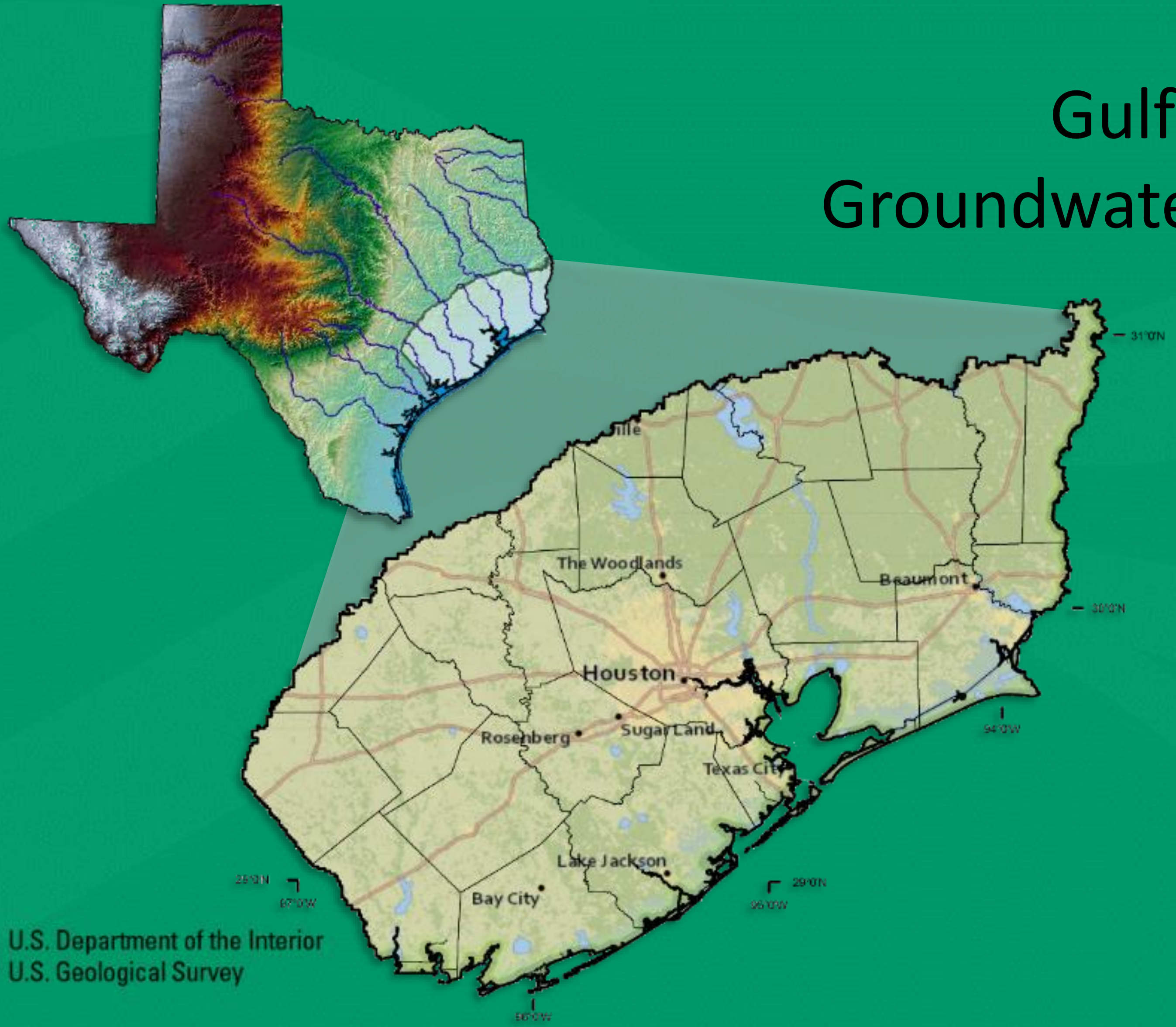
FORT BEND SUBSIDENCE DISTRICT TEXAS

Gulf Coast Land Subsidence and Groundwater-Flow Model (GULF 2023):

Stakeholder meeting

John H. Ellis | jellis@usgs.gov
USGS Oklahoma–Texas Water Science Center
Gulf Coast Branch

Linzy Foster | lfoster@usgs.gov
USGS Oklahoma–Texas Water Science Center
Central Texas Branch



In cooperation with the Harris-Galveston and Fort Bend Subsidence Districts

U.S. Department of the Interior
U.S. Geological Survey

1 Overview

- This project is in cooperation with the Harris-Galveston and Fort Bend Subsidence Districts (collectively "subsidence districts")
- This project was developed to update the Houston-Area Groundwater Model (HAGM) due to: 1) the length of time since publication of the HAGM (15 years), 2) advances in modeling technology, and 3) availability of new hydrogeologic data.
- This model (GULF 2023) is a refinement of the larger Costal Lowlands (CLAS) model that includes the U.S. Gulf Coast from Texas to the Florida panhandle.
- The GULF model will be used by a subsidence district consultant (Intera Geosciences) to develop and simulate predictive water-use and water planning scenarios.

1 Overview

Project Objectives:

- Construction and calibration of a refined groundwater model for the northern Texas Gulf Coast that can be used as a decision-support tool to assess groundwater availability and subsidence
- The model will be provided to support groundwater management decisions at a regional to sub-regional scale
- Development and simulation of predictive climate scenarios
- Provide technical and quality-assurance assistance to the subsidence districts regarding modification of the model

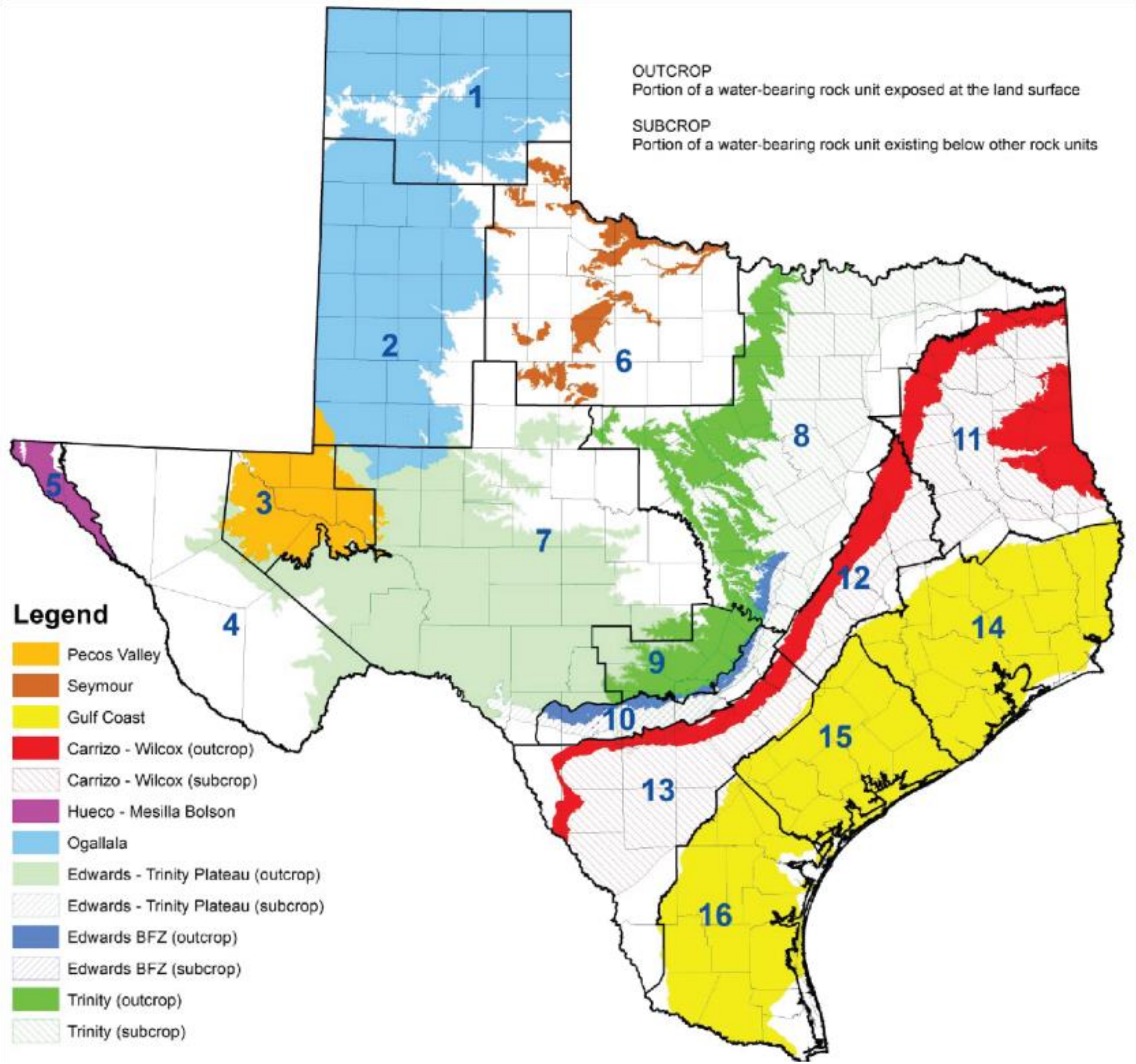
Approach:

- **Phase I:** Construction and calibration of the model, generate and run climate scenarios, model publication and archiving
- **Phase II:** Predictive water-use and water-planning scenarios to be run by Intera Geosciences

Groundwater-flow definitions

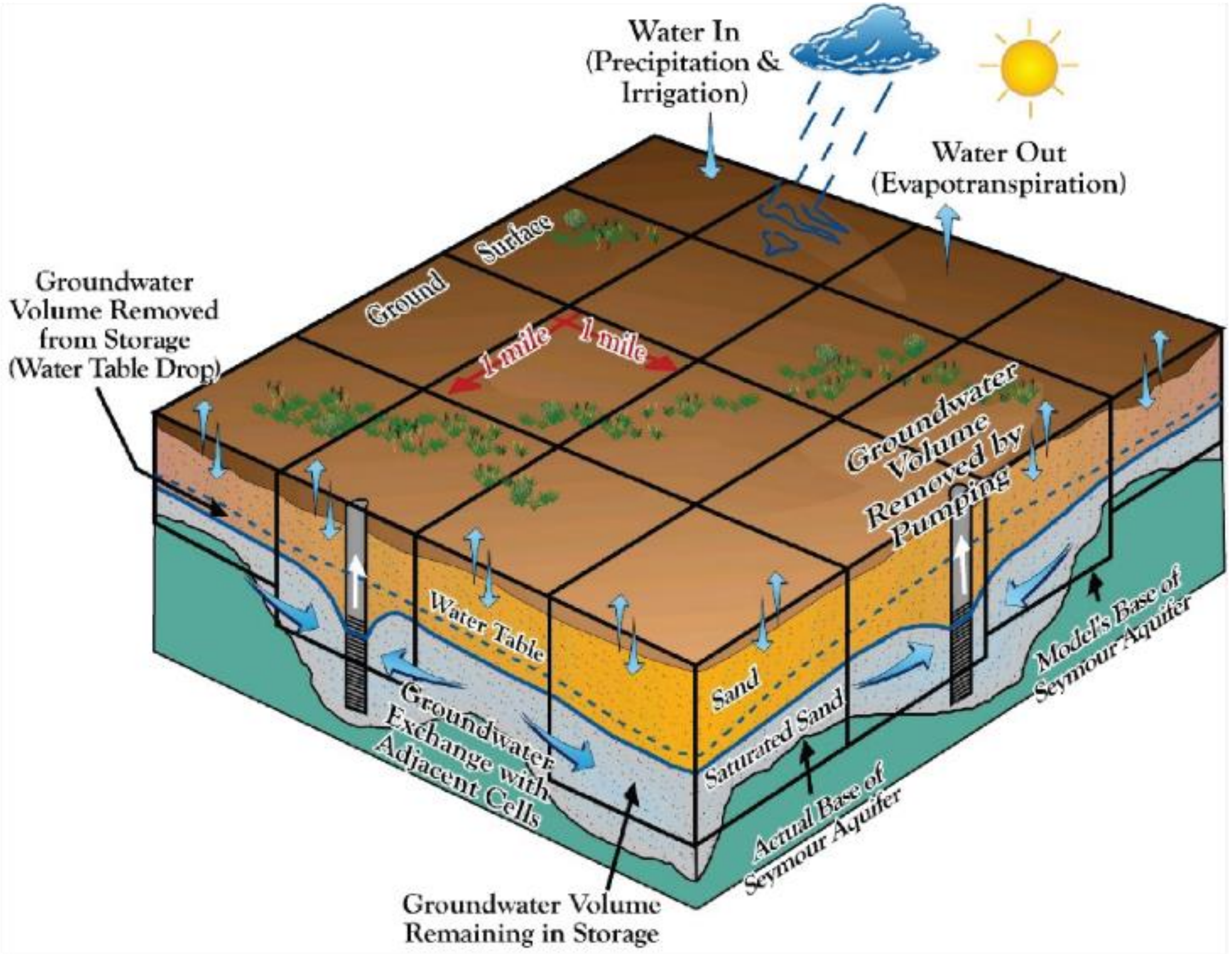
- Aquifer: Water saturated permeable geologic unit that can transmit significant quantities of water
- Water table: The level at which water stands in a shallow screened well in an unconfined aquifer
- Recharge: The entry of water to the saturated zone at the water table
- The primary observable quantity describing groundwater flow is the water level as measured in a well

1 Major aquifers



Texas Water Development Board

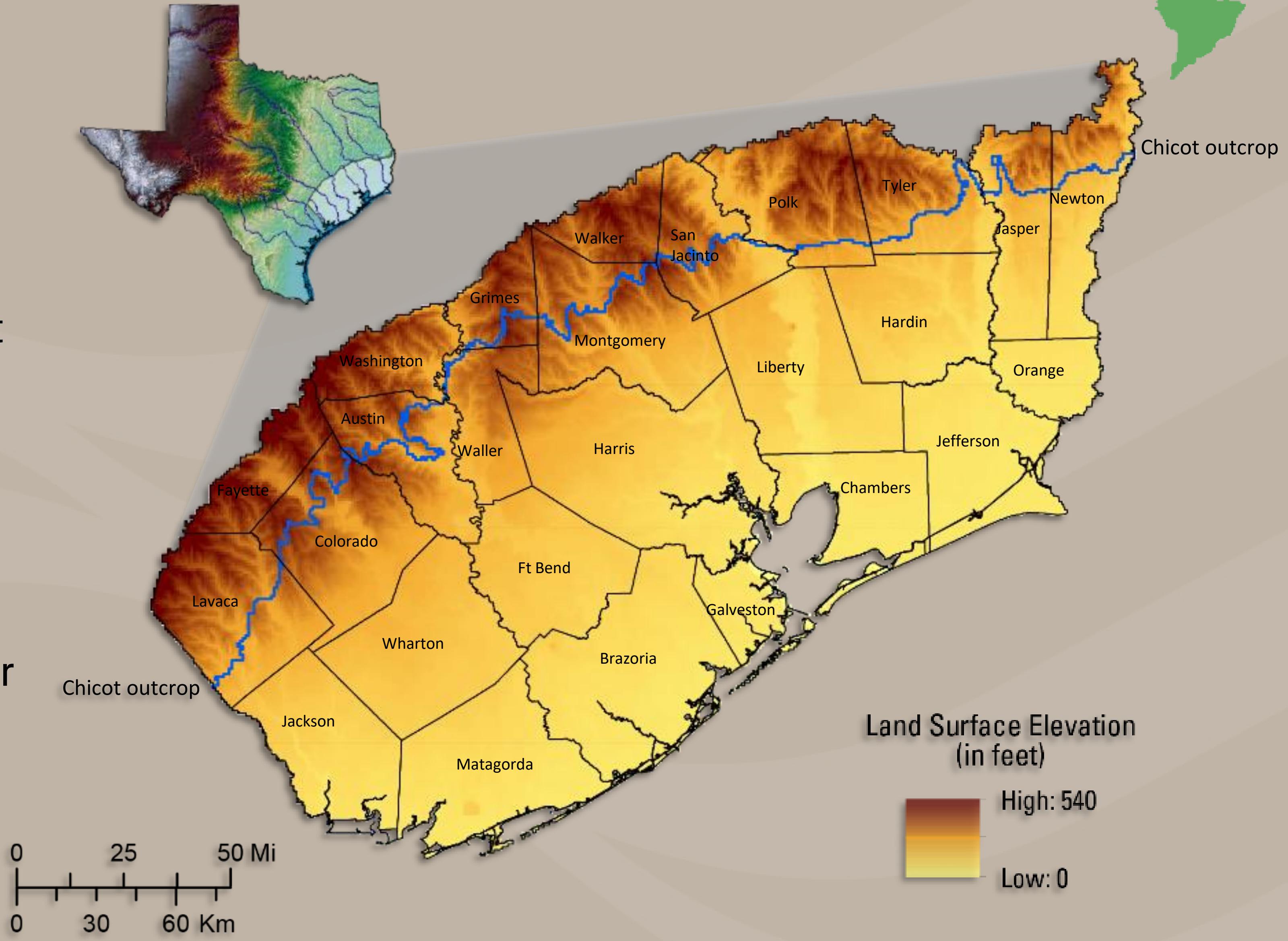
Numerical Groundwater Model: Model Cells and their interactions



2 Study area

Physical setting

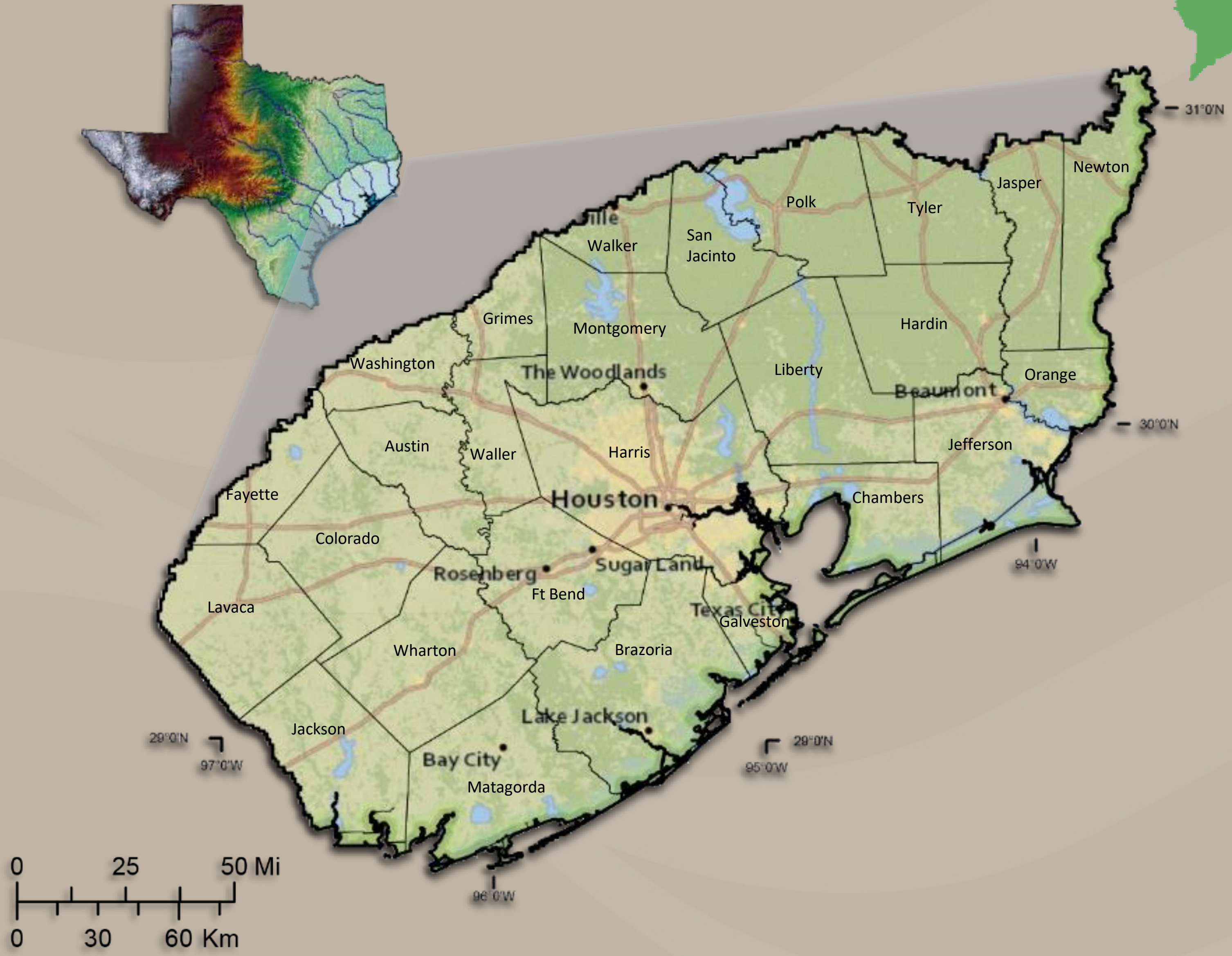
- Approximately 20,900 mi^2 of sand, silt, and clay across 26 counties
- Fluvial deltaic environment with river alluvium dissecting the Chicot aquifer
- About 540 feet of surface relief based on a 10m digital elevation map
- Land surface has substantial variation updip of the Chicot aquifer outcrop



3 Model Properties

Spatial extent

- Northern boundary corresponds with the upgradient extent of the Jasper outcrop
- Eastern extent is the TX—LA border (Sabine River)
- Western extent is Lavaca and Jackson Counties
- Southern boundary is nearshore area
- Barrier islands removed in model (shown here)



3 Model Properties

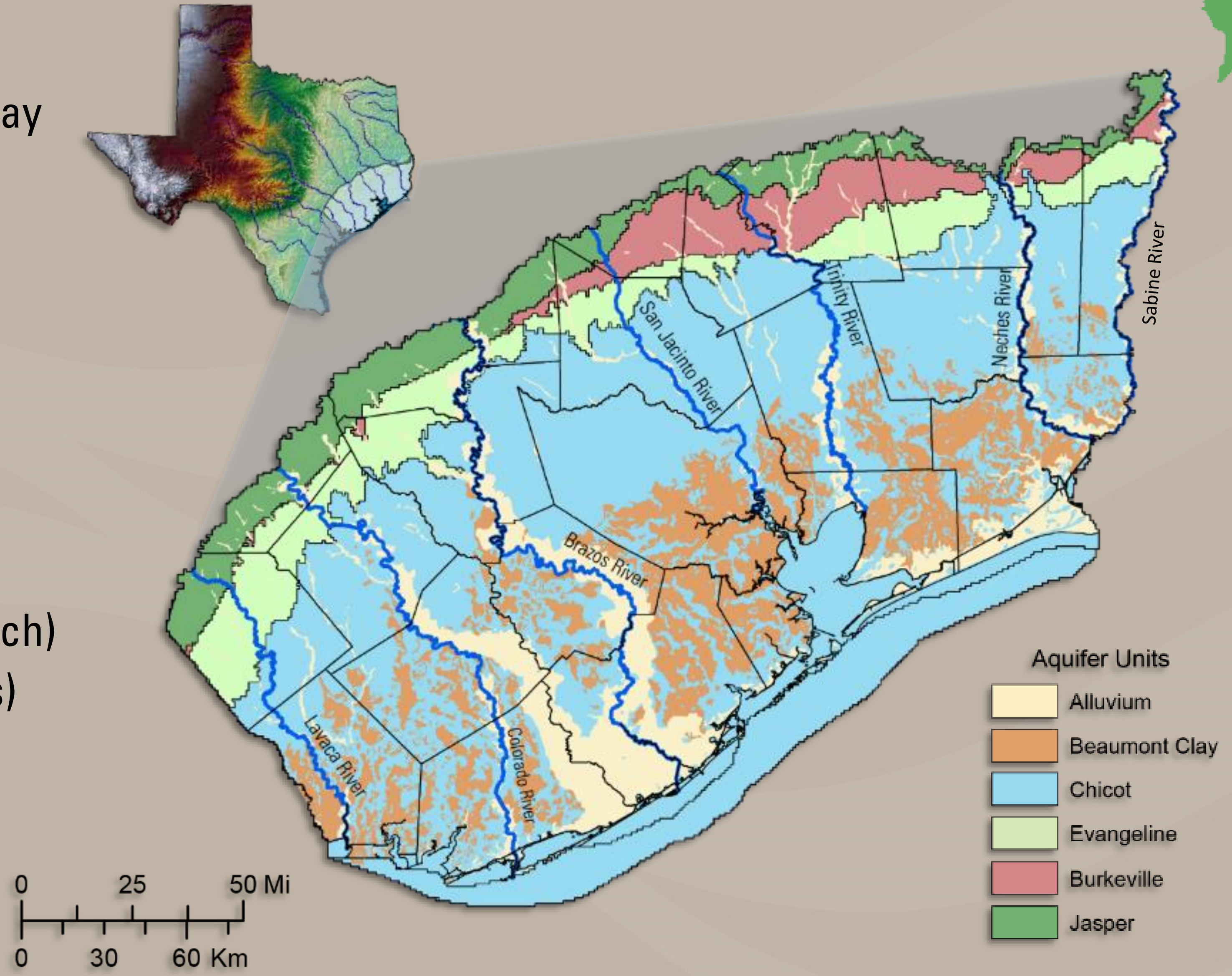
Model Layering

- Layer 1: Alluvium and Beaumont Clay
- Layer 2: Chicot Aquifer
- Layer 3: Evangeline Aquifer
- Layer 4: Burkeville Confining Unit
- Layer 5: Jasper Aquifer

Time Discretization

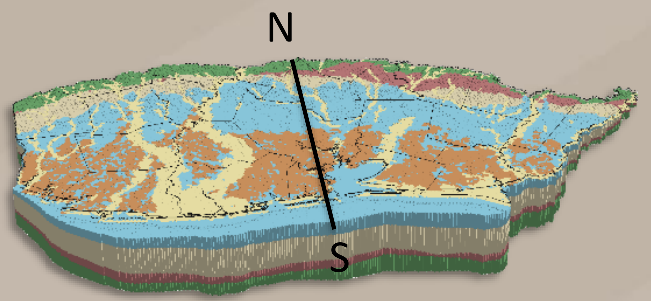
- 1896: 1 (Predevelopment)
- 1897–1939: 3 (about 14 years each)
- 1940–1969: 6 (5 year increments)
- 1970–1999: 30 (annual)
- 2000–2018: 228 (monthly)

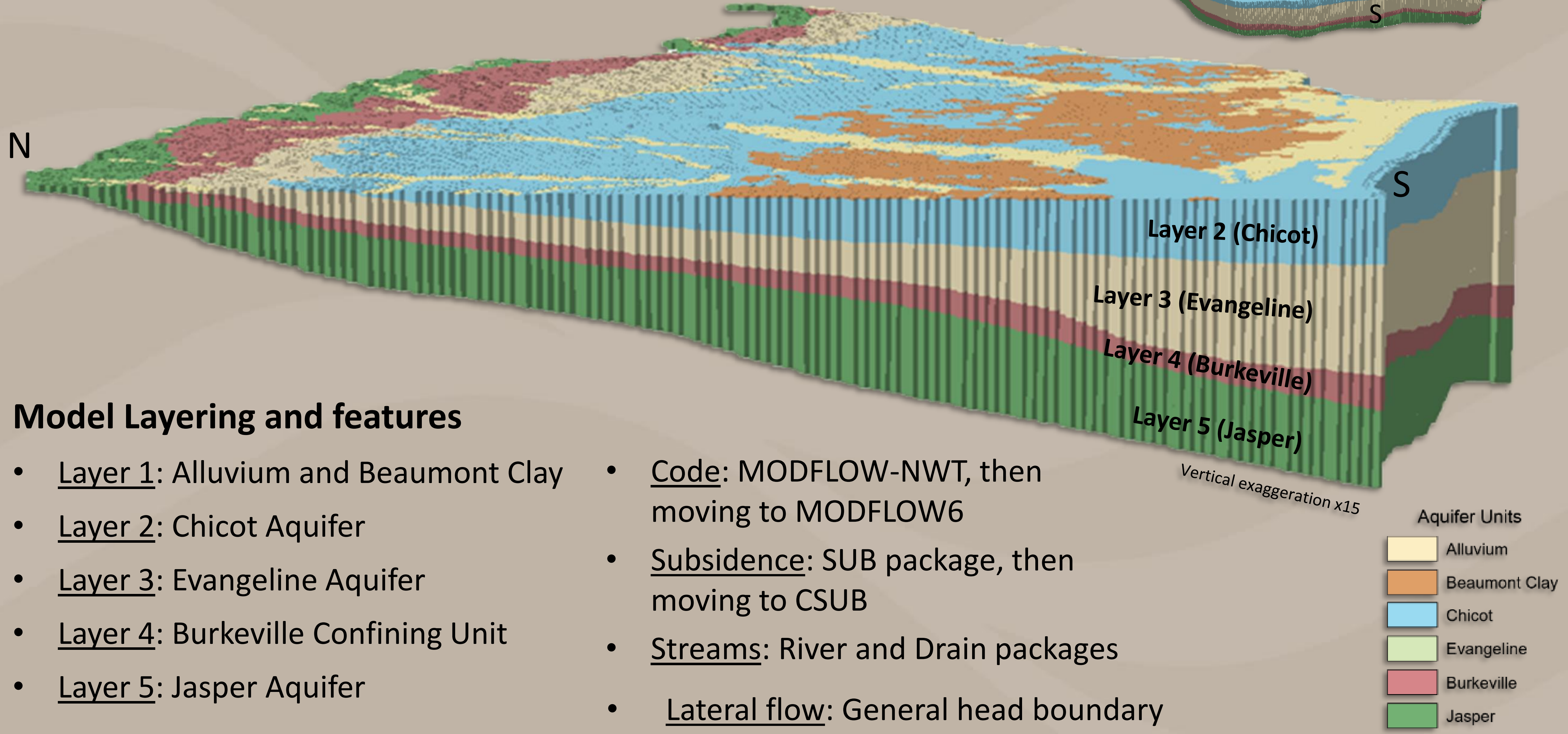
268 Total



3 Model Properties

North-South cross-section in Houston area





Model Layering and features

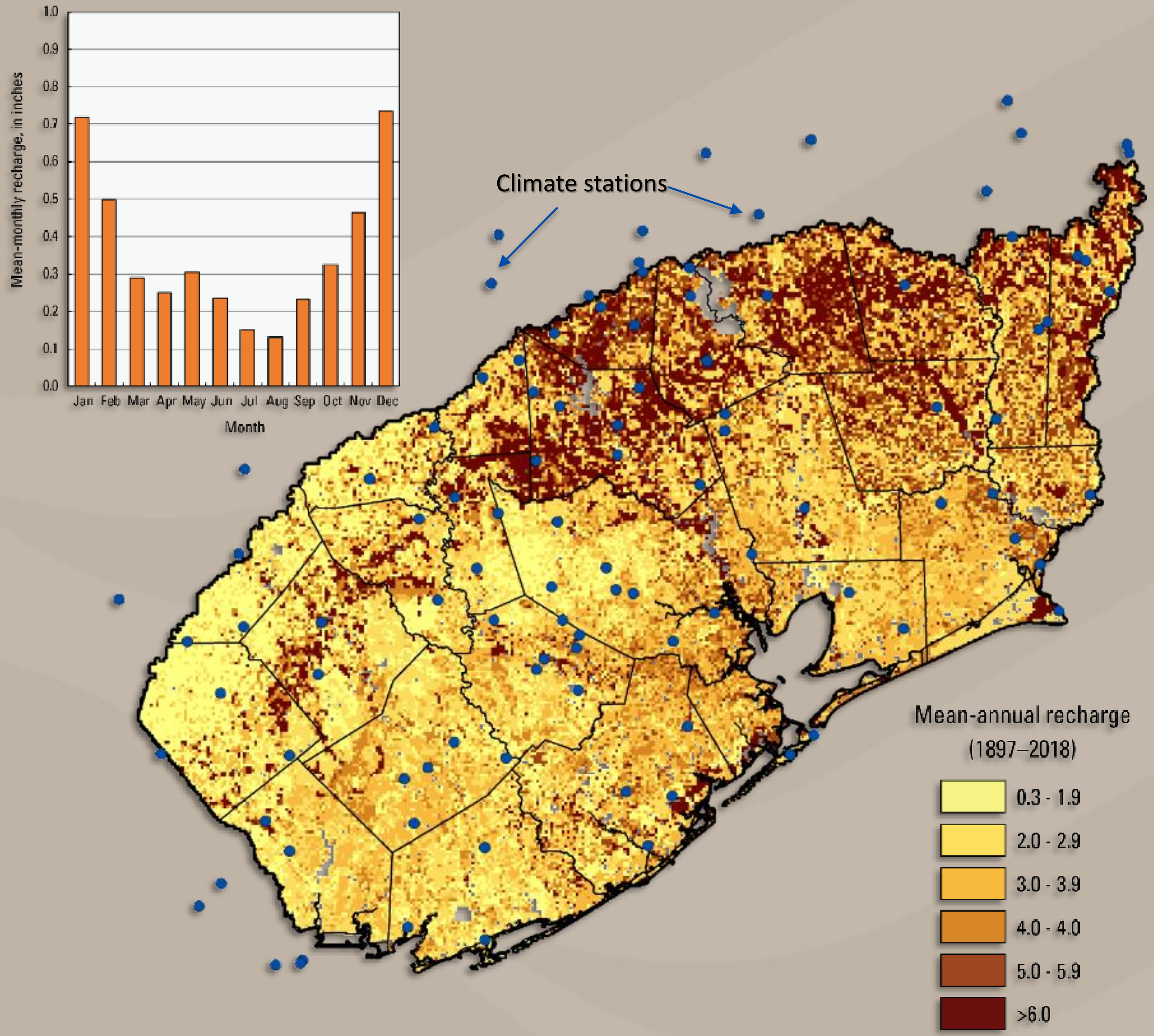
- Layer 1: Alluvium and Beaumont Clay
- Layer 2: Chicot Aquifer
- Layer 3: Evangeline Aquifer
- Layer 4: Burkeville Confining Unit
- Layer 5: Jasper Aquifer

- Code: MODFLOW-NWT, then moving to MODFLOW6
- Subsidence: SUB package, then moving to CSUB
- Streams: River and Drain packages
- Lateral flow: General head boundary

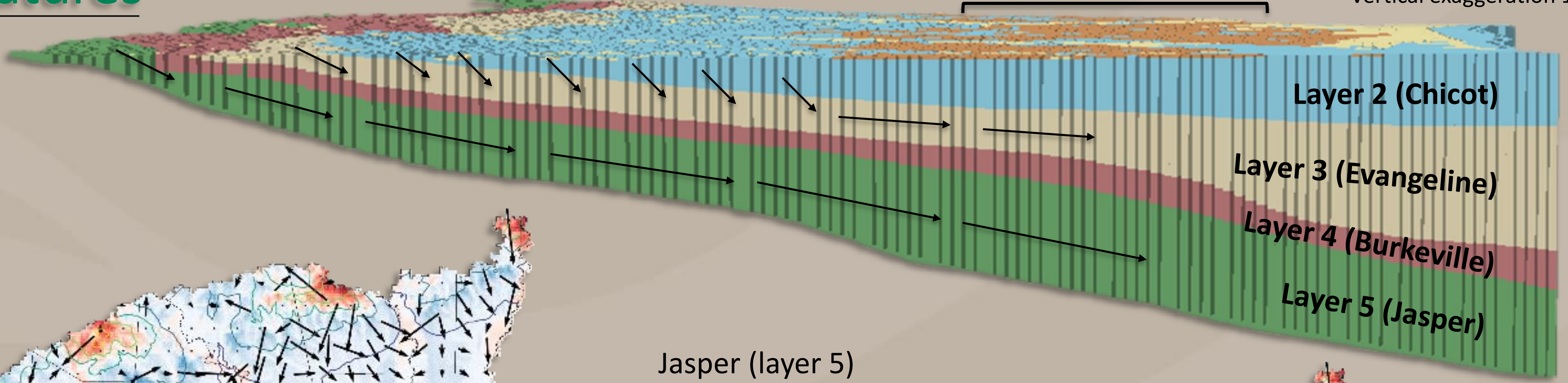
4 Model Features

Recharge

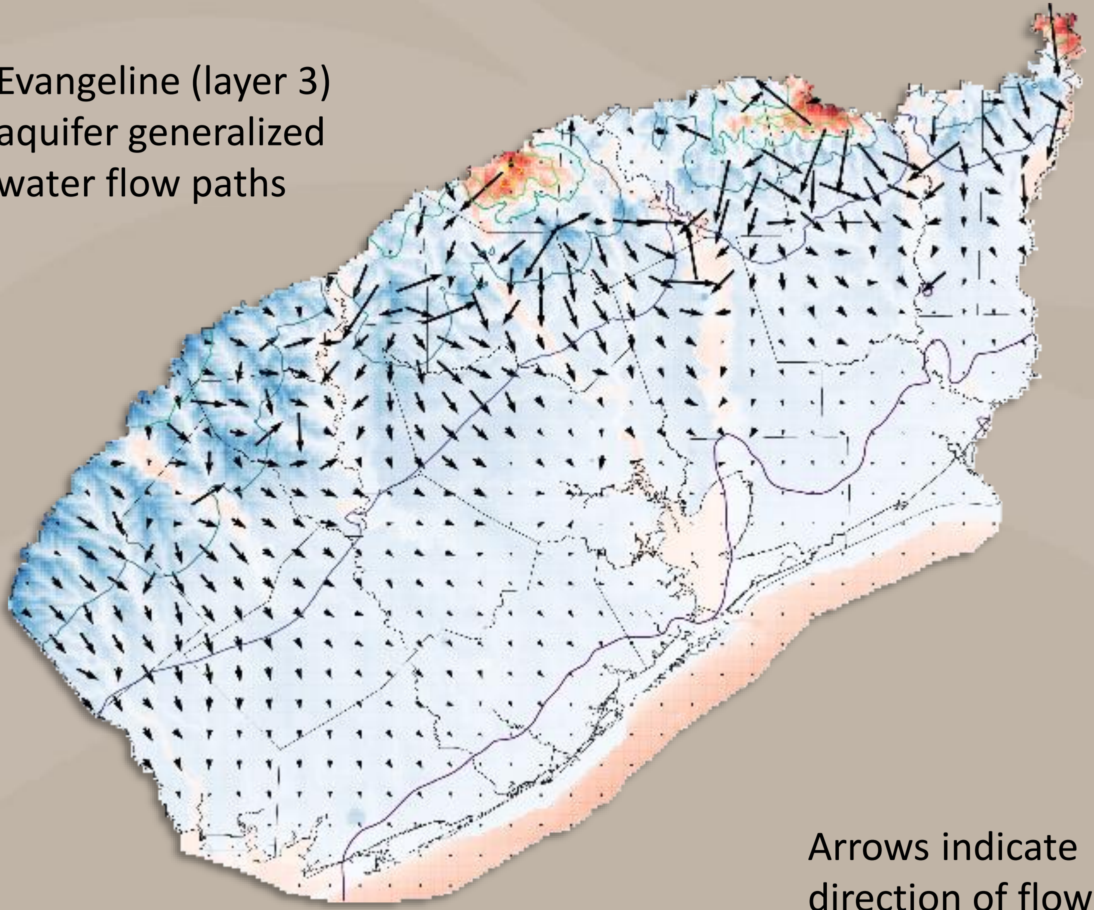
- Groundwater recharge here is defined as water that infiltrates from land surface to the top of the water table
- Can use many different methods to estimate. This project used the Soil-Water-Balance code.
- SWB-derived recharge occurs primarily in outcrop area (dark brown colors on map)
- Majority of the estimated recharge is discharged to streams
- Vertical movement of water in the model is adjusted to limit downward recharge movement



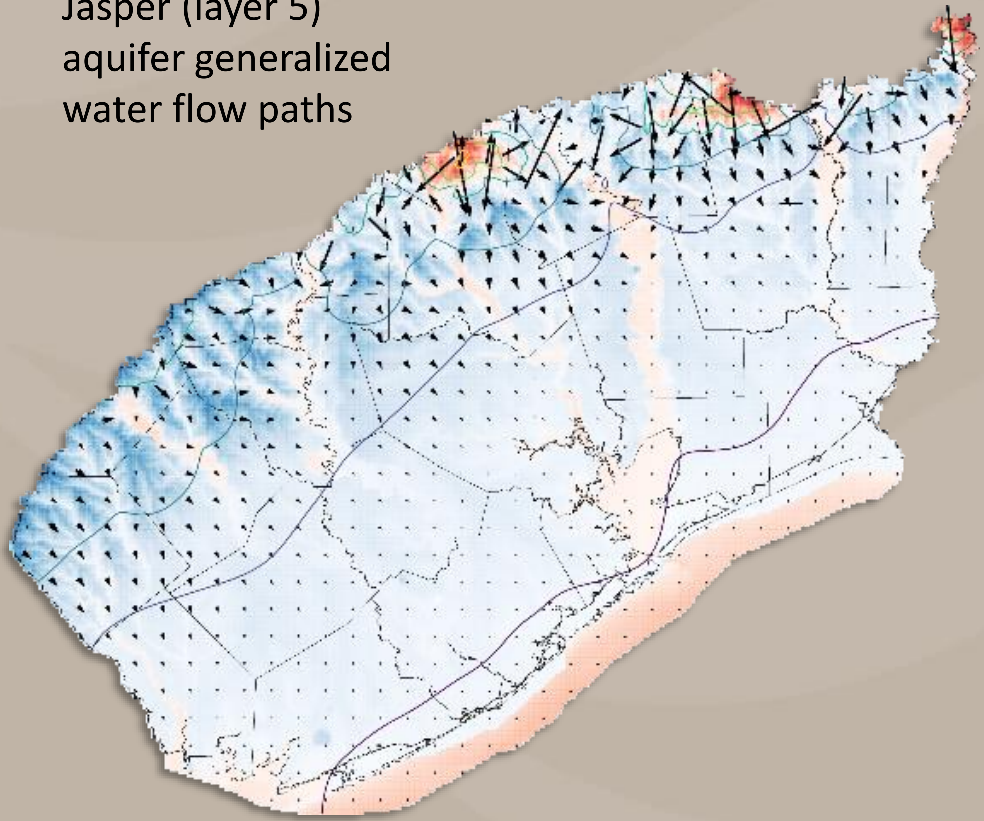
4 Model Features



Evangeline (layer 3) aquifer generalized water flow paths



Jasper (layer 5) aquifer generalized water flow paths

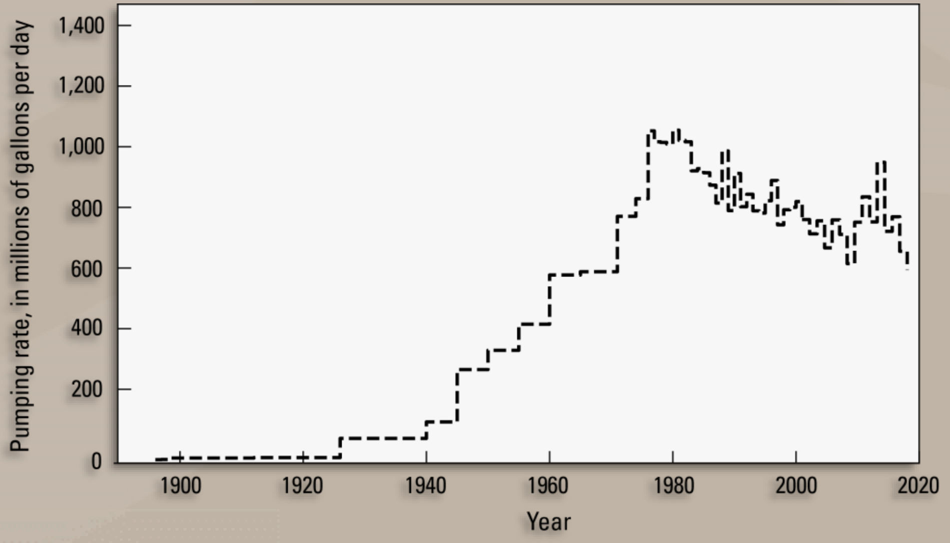


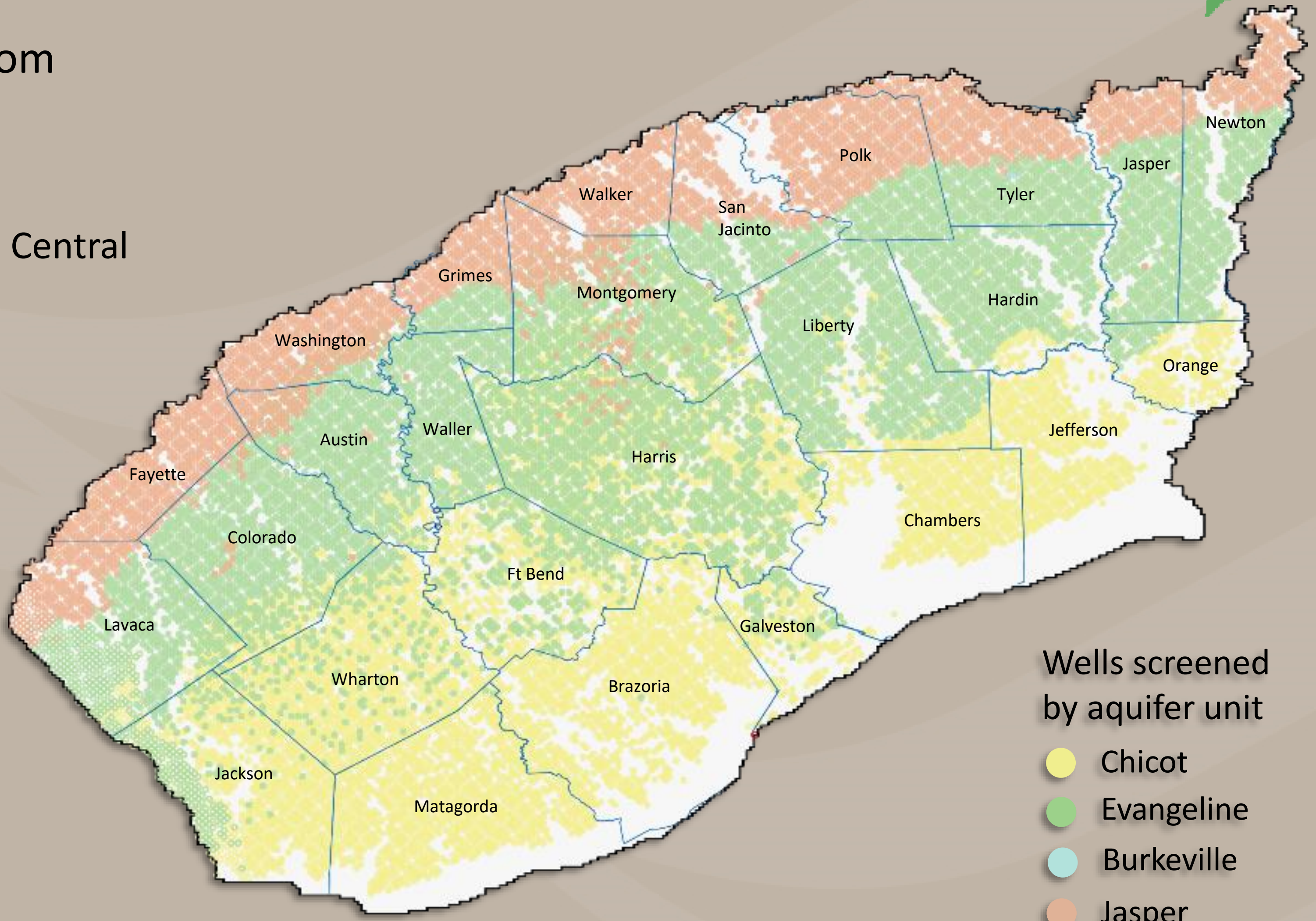
Arrows indicate direction of flow

4 Model features

Groundwater use

- The GULF model uses water-use data from multiple sources:
  - 1897–1999: HAGM[1], Central GAM[2]
  - 2000–2018: TWDB water-use database, Central GAM[2]





[1]Kasmarek (2012)
[2]Chowdhury and others (2004)

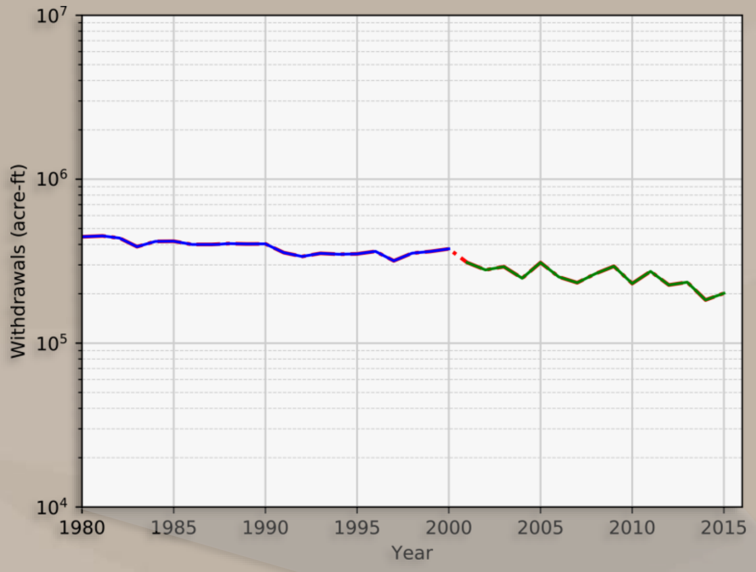
4 Model Features

Groundwater use

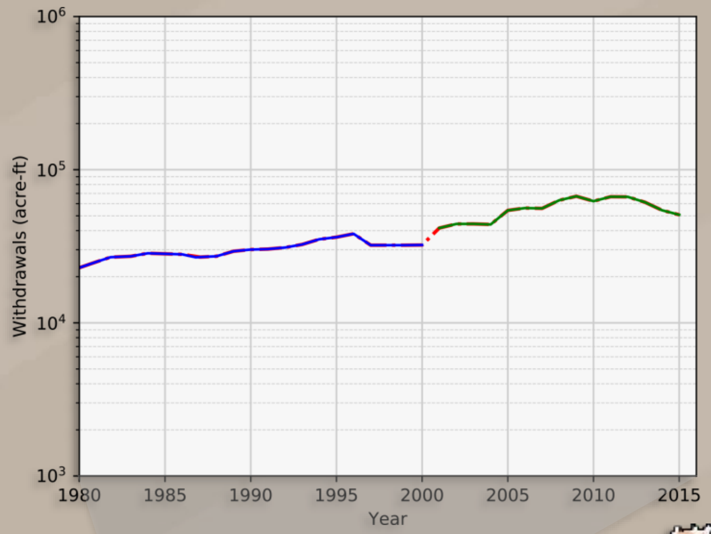
Groundwater data:

- 1897–1999: HAGM[1], Central GAM[2]
- 2000–2018: TWDB water-use database, Central GAM[2]
- TWDB water-use sources include:
  - Submitted Drillers Reports
  - Groundwater Database
  - Historical Groundwater Pumpage Estimates

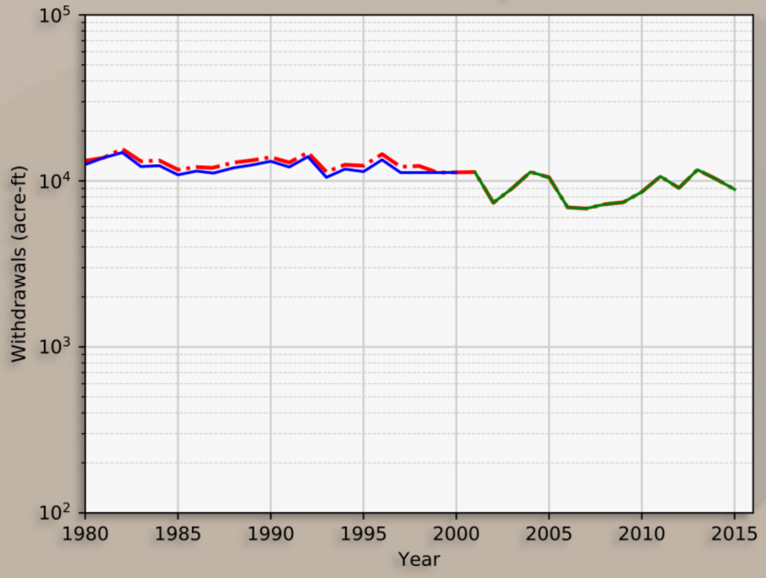
Harris County

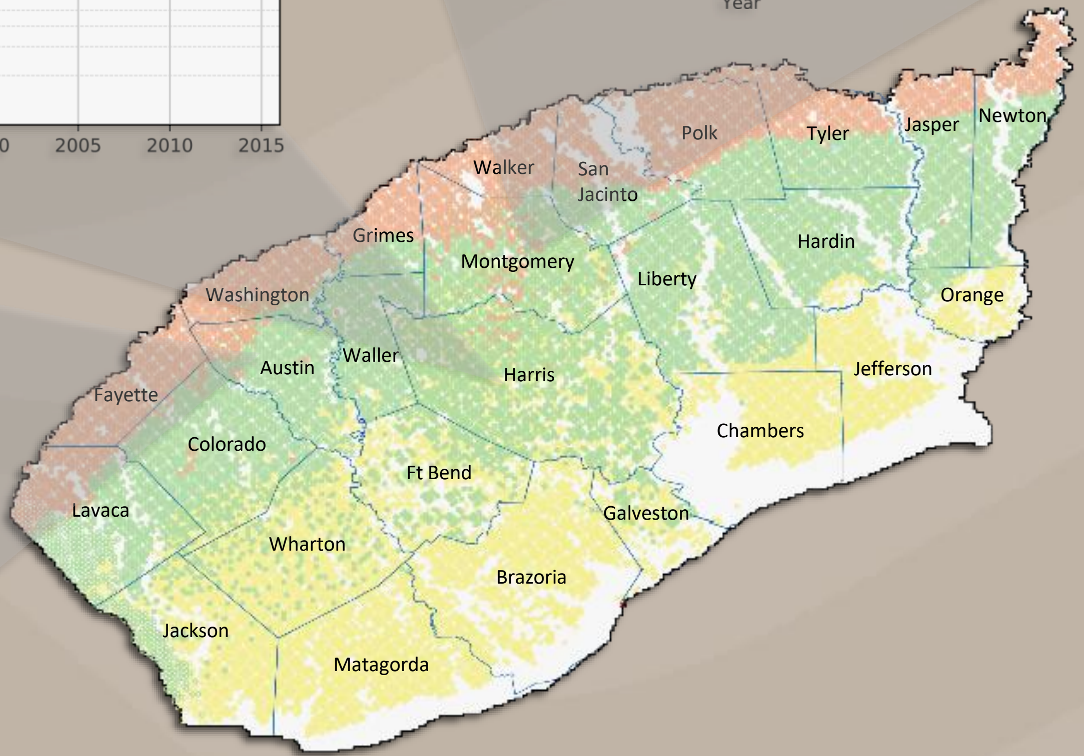


Montgomery County



Austin County





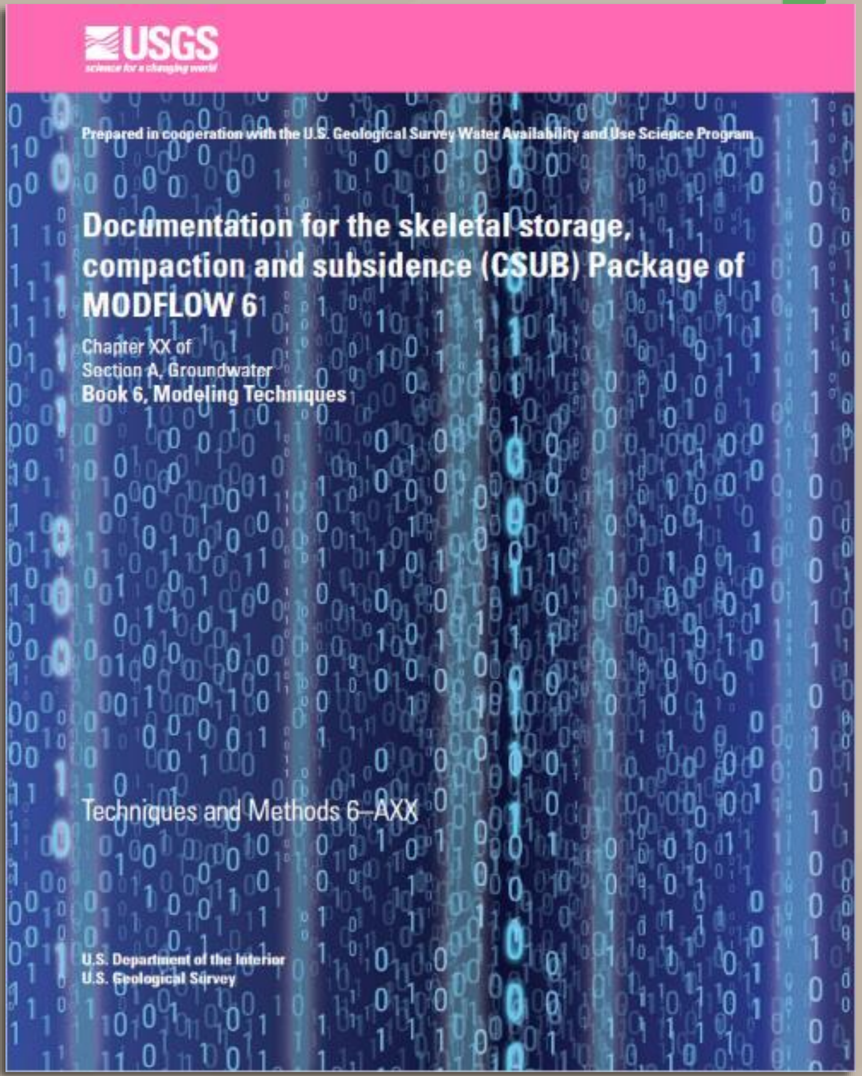
Data source

- Model sum
- HAGM
- TWDB

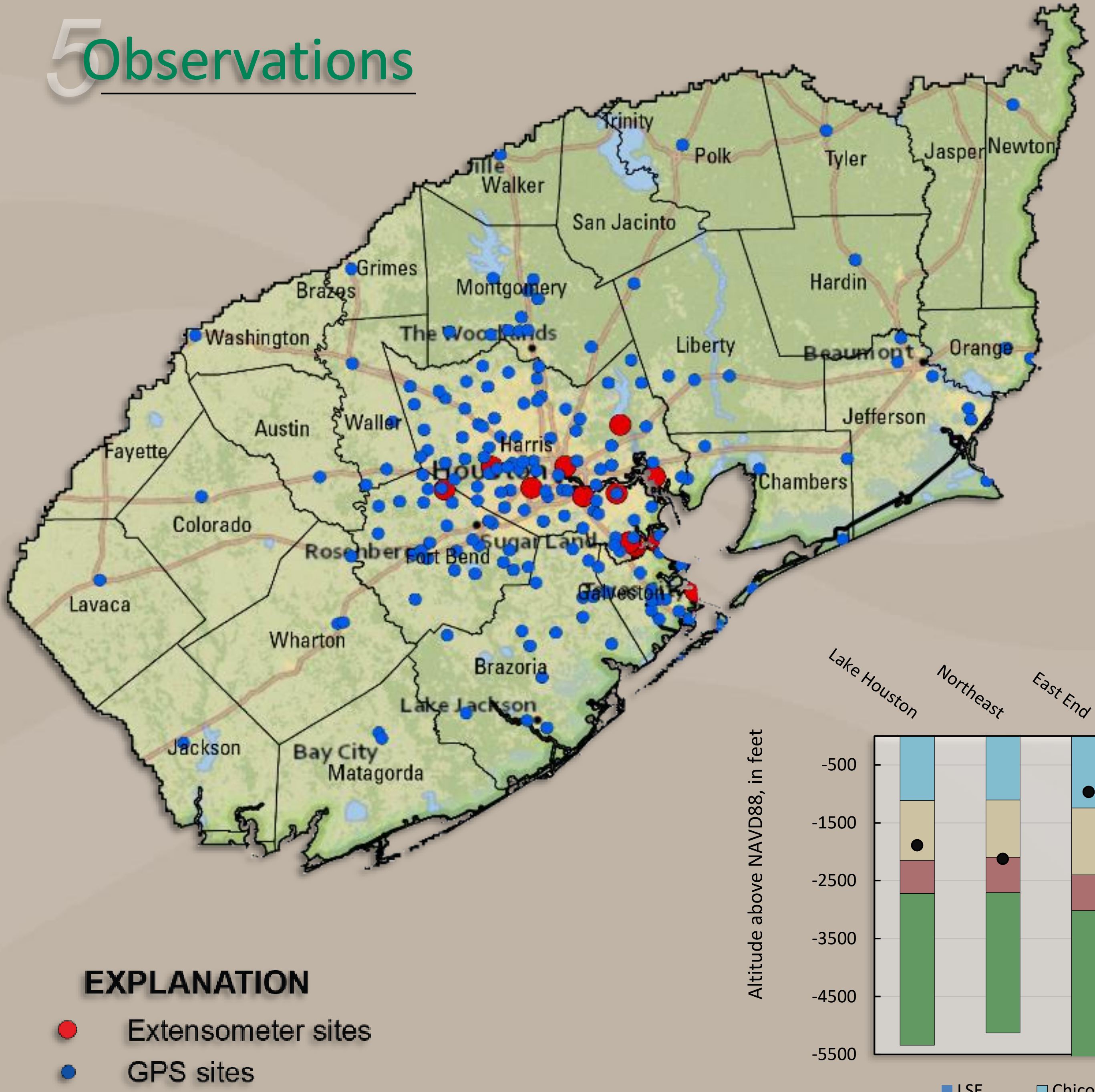
Model features

Subsidence Package

- Newly formulated for the MODFLOW6 model code
- Can simulate groundwater-storage changes and compaction
  - Can simulate elastic compaction in coarse-grained sediment
  - Can simulate elastic and inelastic compaction in discontinuous, fine-grained interbeds or confining units
- Outputs simulated compaction separately for each model layer
- Using delay bed functionality for all subsidence in the GULF model
  - Allows the amount of delay to be driven by the clay thicknesses versus a pre-determined value

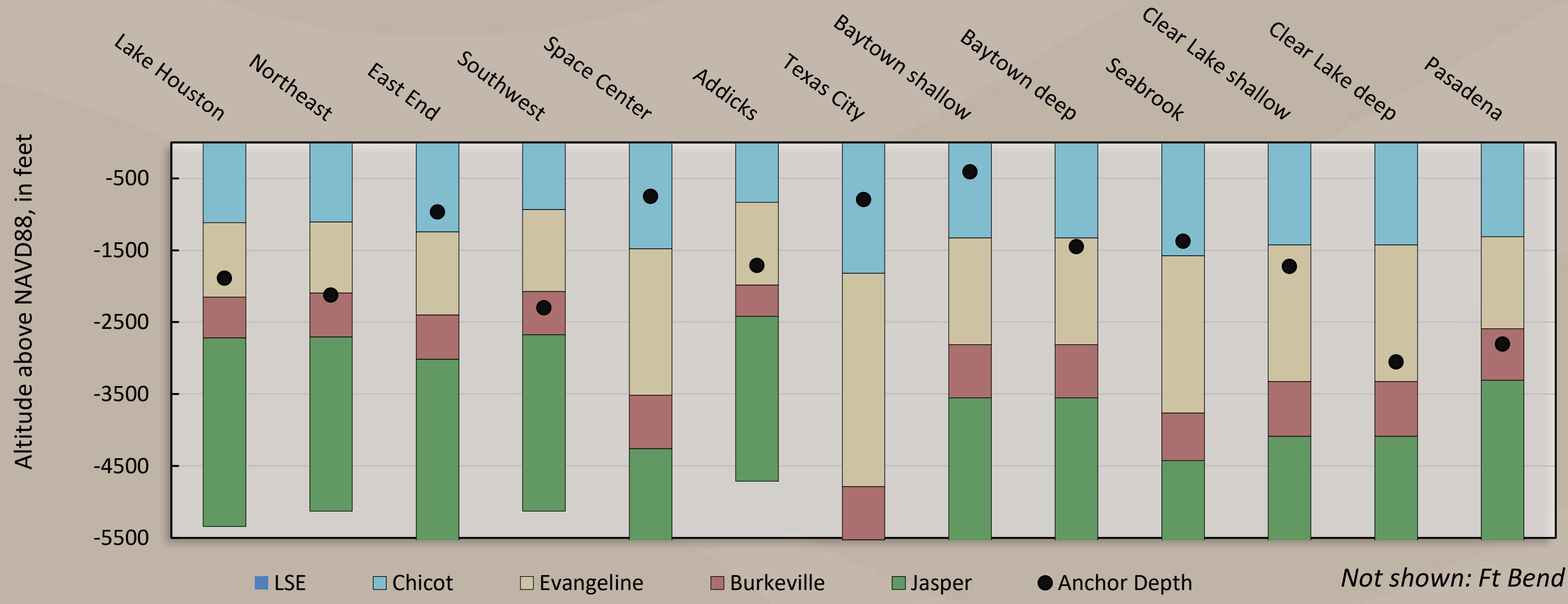


Observations



Subsidence estimation methods

- Extensometers–measure compaction in the aquifer system
  - Fourteen extensometers at 12 sites
- GPS sites, leveling–measure total vertical displacement
  - GPS: 173 sites
  - Leveling data: 60-70 measurements, about half prior to 1960



Not shown: Ft Bend extensometer

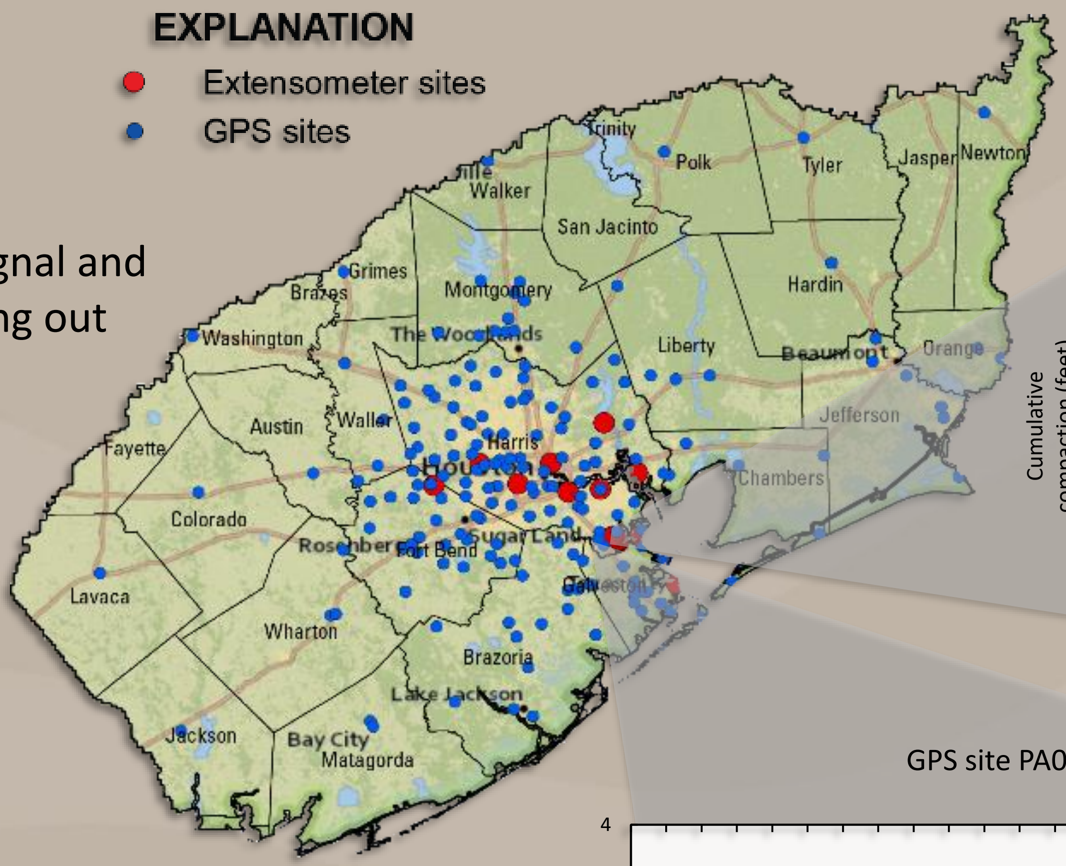
5 Observations

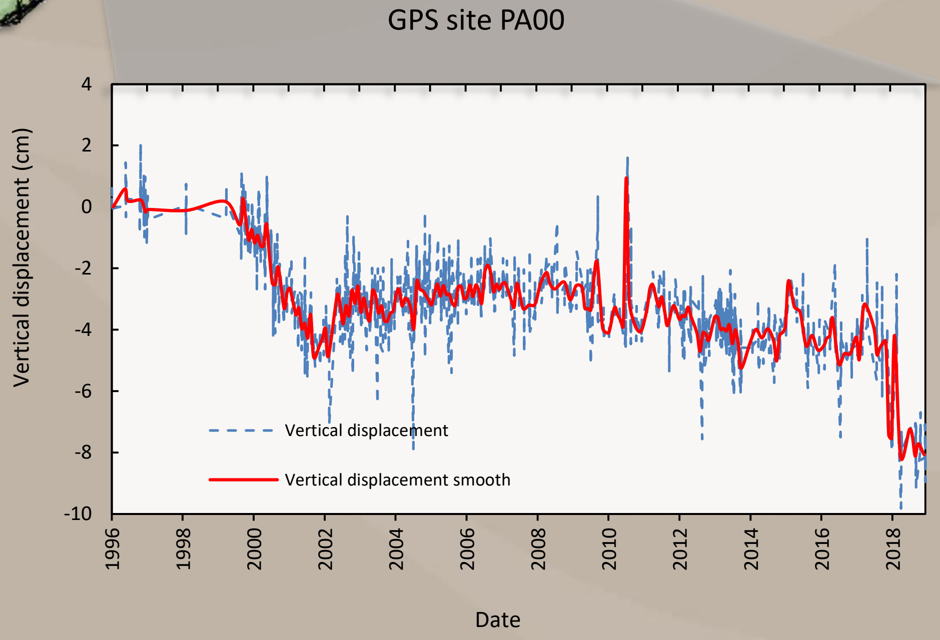
GPS sites

- Smooth applied: preserves signal and long-term trends while filtering out high-frequency noise
- Duplicate sites in same model cell removed
- Shorter period of record (1995 – present)

Extensometers

- Use end-of-month recorded compaction at 12 sites across the period of record
- Measure compaction in Chicot and/or Evangeline units
- Longer period of record (early 1970's – present)



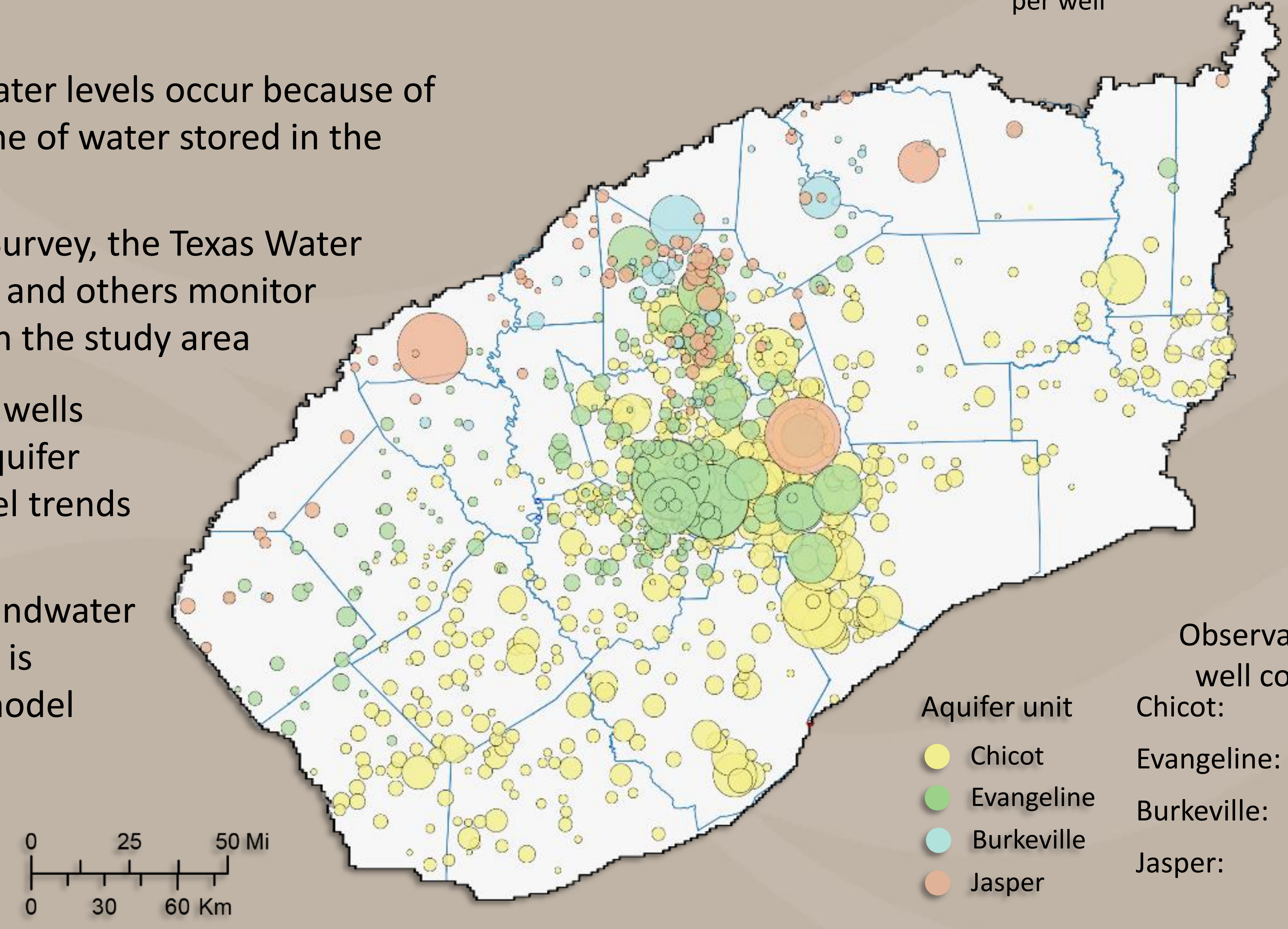


5 Observations

Groundwater levels

Radius of circle represents relative number of observations per well

- Changes in groundwater levels occur because of changes in the volume of water stored in the aquifer
- The U.S. Geological Survey, the Texas Water Development Board, and others monitor groundwater levels in the study area
- The model includes wells representative of aquifer units and water-level trends through time
- A match to the groundwater levels in these wells is attempted during model calibration

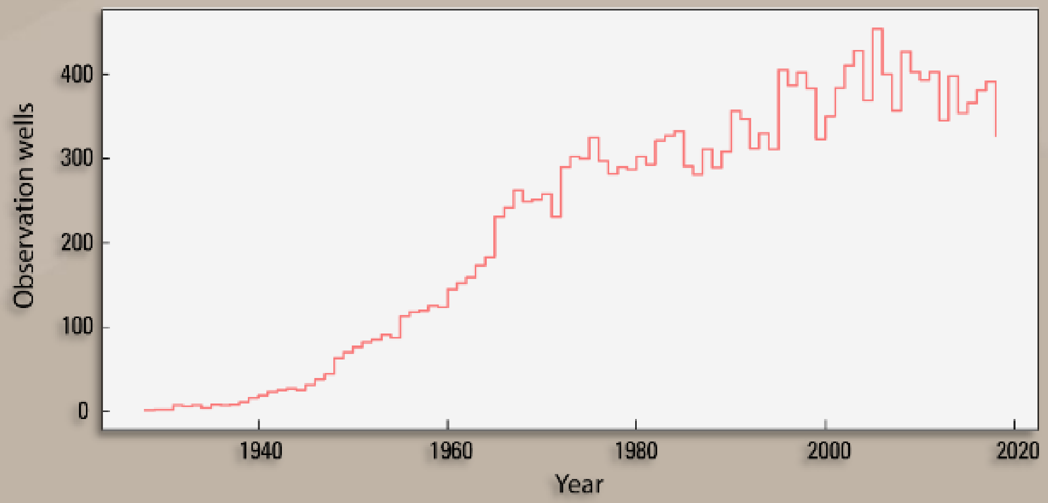


Observation well count

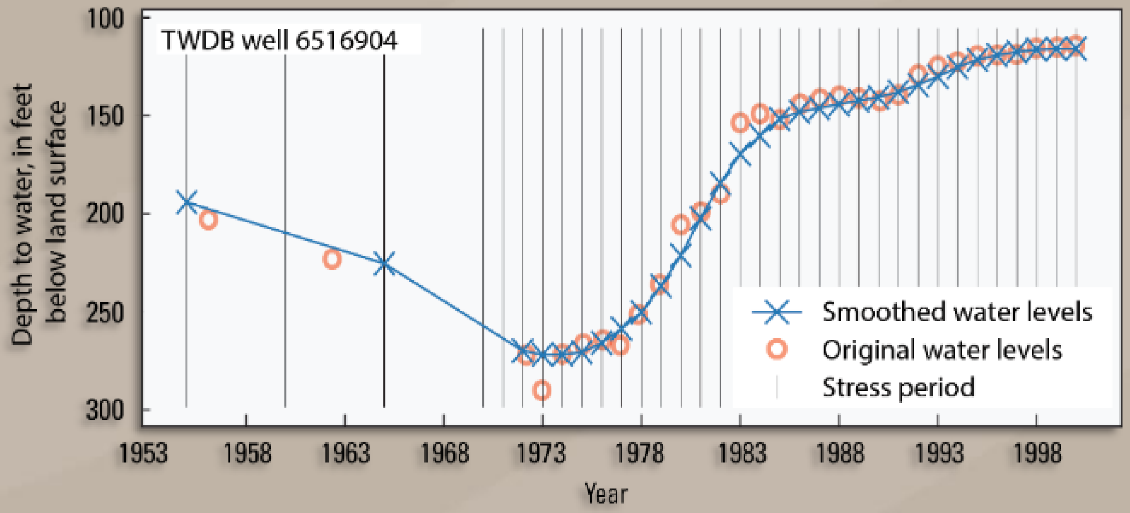
Chicot:	557
Evangeline:	225
Burkeville:	40
Jasper:	86
	908

5 Observations

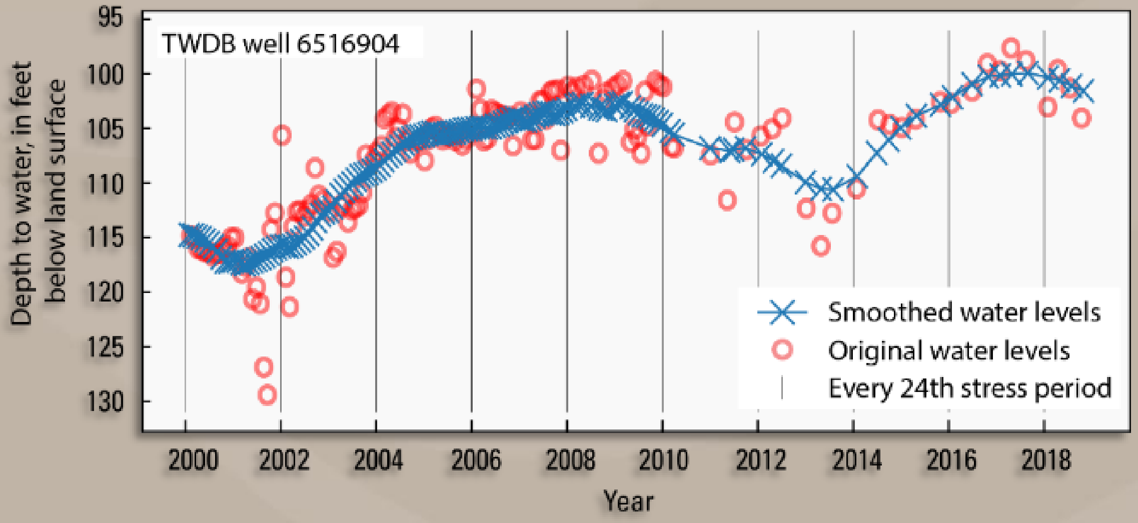
- Model groundwater levels: Include dataset of wells representative of aquifer units and water-level trends through time
- Goal is to ensure 1) disparate water levels don't occur in a spatially dense area, and 2) all model areas are represented during calibration
- Final dataset: 908 wells with a total of 67,451 observations during the model period to use for model calibration



Pre-2000 observations (5-year rolling average)

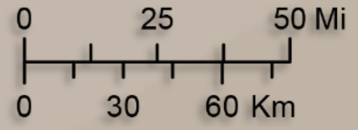


Post-2000 observations (2-year rolling average)

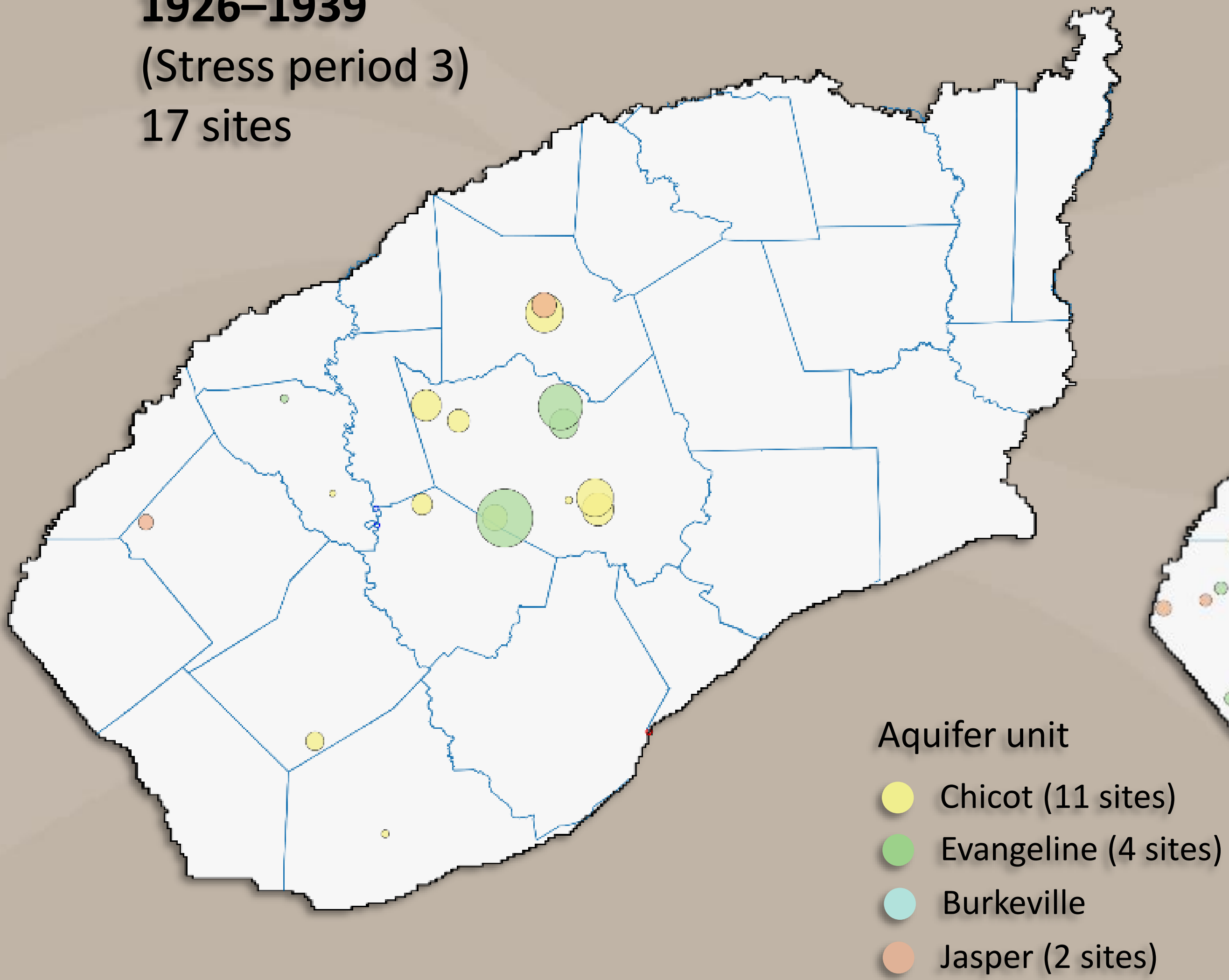


5 Observations

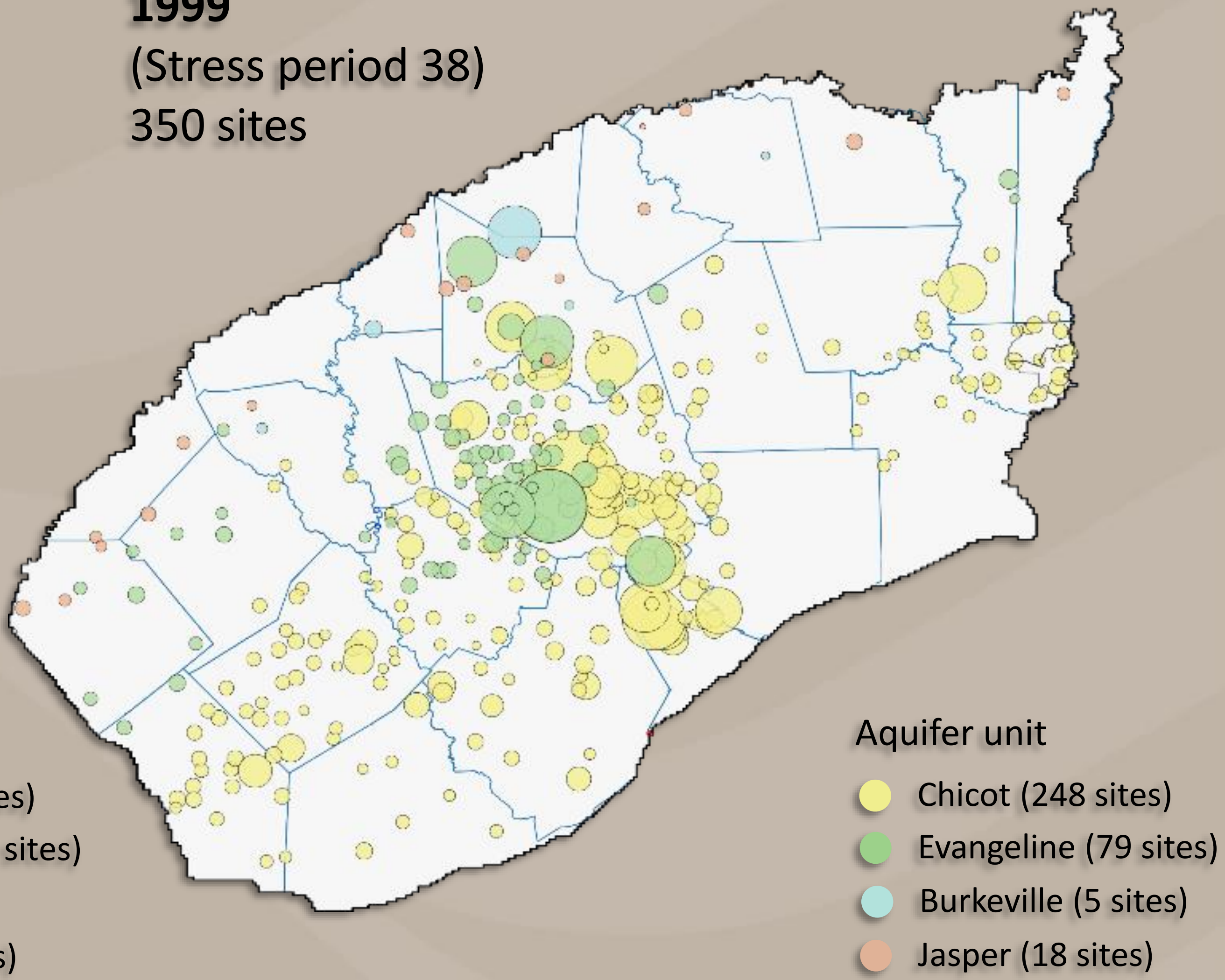
- Includes observation wells submitted by districts to USGS
- Radius of circle represents relative number of observations per well



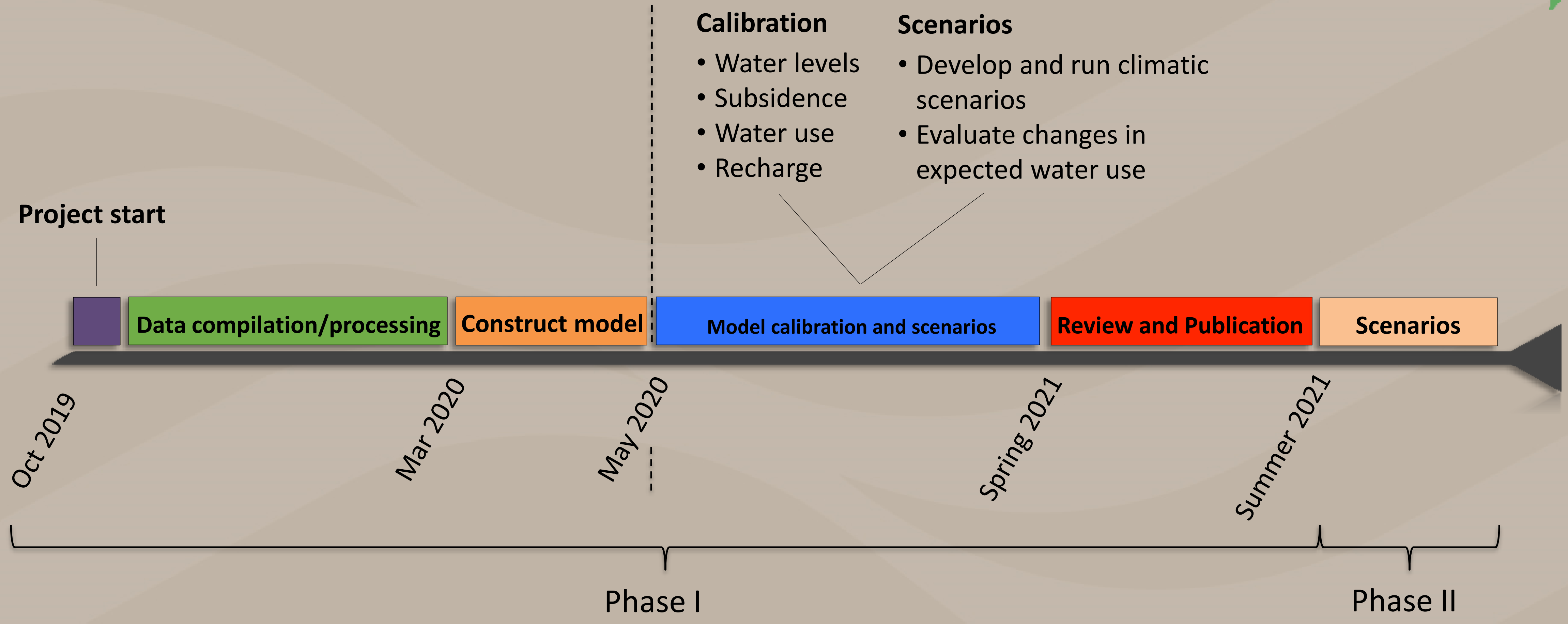
1926–1939
(Stress period 3)
17 sites



1999
(Stress period 38)
350 sites



6 Timeline/next steps



PROJECT ELEMENTS

2013 Regulatory Plan Post Audit

Alternative Water Supply Availability

Projected Water Needs

Modeling

- Groundwater Availability Modeling
- Development of GULF 2023 Model
- PRESS Assessment

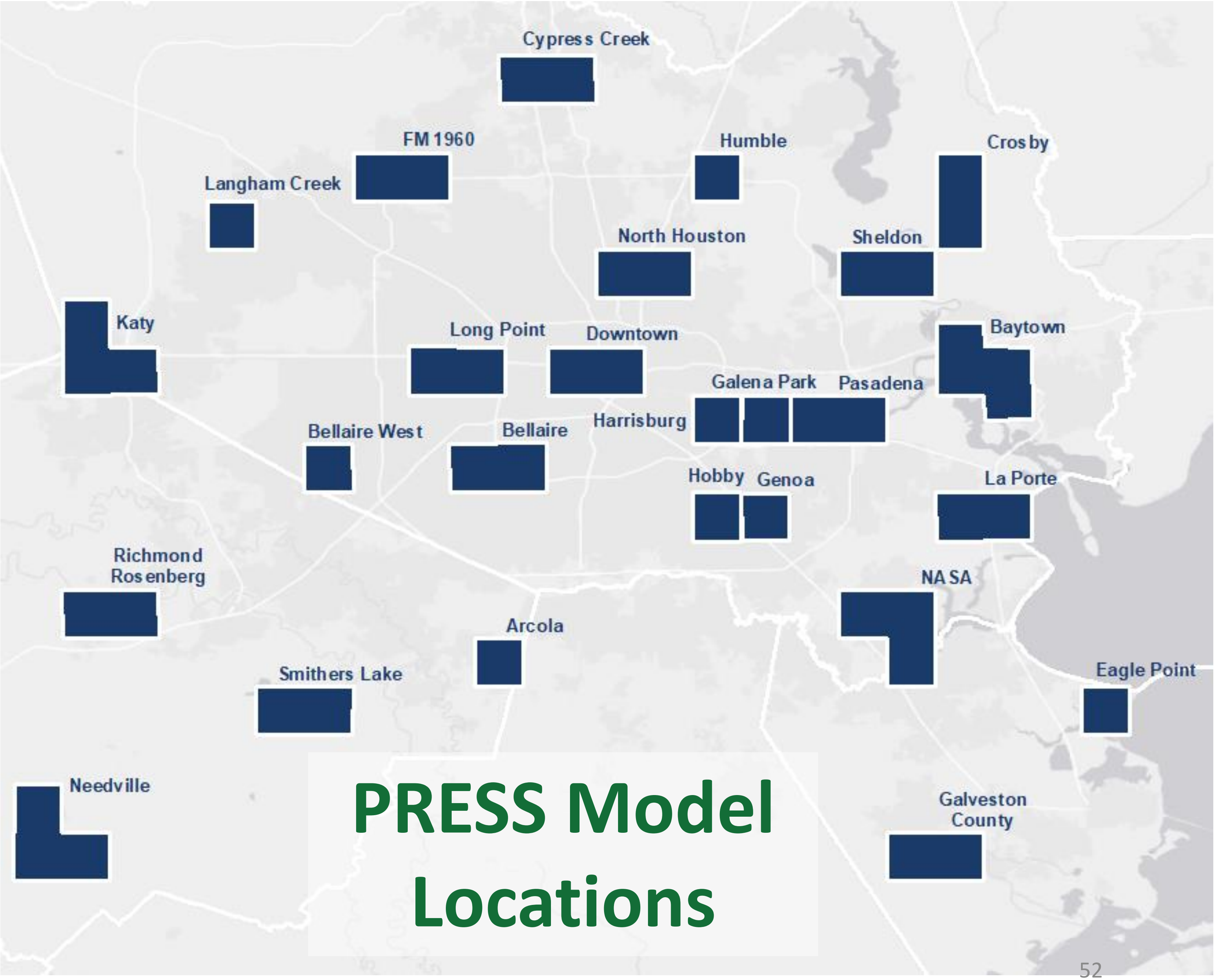
Water Use Scenario Development

PRESS Assessment

What is PRESS?

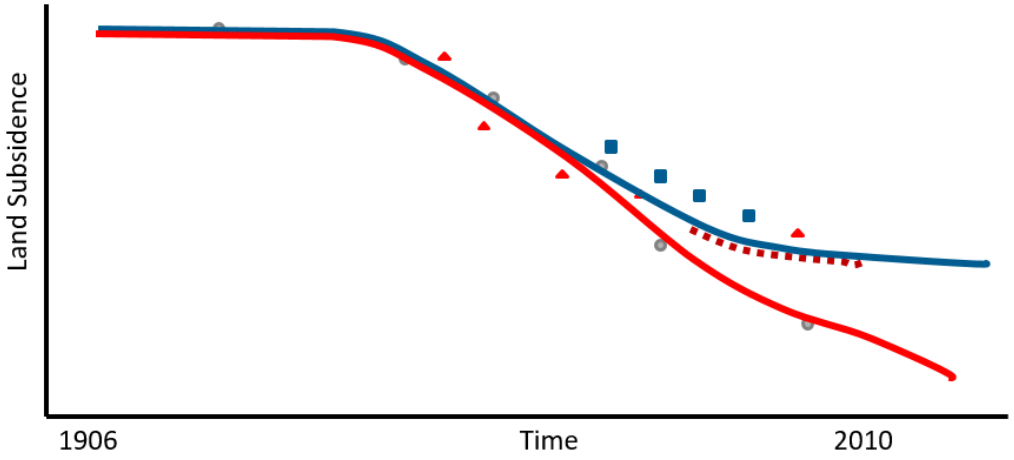
Predictions
Relating
Effective
Stress to
Subsidence

Site-specific models used to assess subsidence.



PRESS ASSESSMENT

Verification of existing PRESS models



Comparing results to MODFLOW

Validated PRESS Model Results

↔

Site-Specific MODFLOW 6 CSUB Package Results

Project Elements

2013 Regulatory Plan Post Audit

Alternative Water Supply Availability

Projected Water Needs

Modeling

- Groundwater Availability Modeling
- Development of GULF 2023 Model
- PRESS Assessment

Water Use Scenario Development

WATER USE SCENARIO DEVELOPMENT

Human Variables

Total Water Use

Water Use Distribution

Pumping in Neighboring Area

Natural Variables

Hydrogeologic and Compaction Properties

Drought (short-term)

Climate (long-term)

Regulatory Variables

Regulatory Area Boundaries

Conversion Timeline

Use of Credits

Conversion Percentages

Alternative Water Supply Availability

Water Use Scenario Development

Define and Evaluate Regulatory Scenarios

↓

Develop Management Recommendations

Considerations:

- Expected subsidence impacts
- Identified risks and uncertainty
- Availability of alternative water supplies
- Feasibility of implementing proposed changes (if any)
- Stakeholder input

Schedule and Next Steps

	GULF 2023 Model	Projected Water Needs	Alternative Water Supplies	PRESS Assessment	Water Use Scenarios
2020	Model Conceptual Report	Methodology, Model Updates	Overview of Alternatives	PRESS Model Validation	
2021	Complete Model Update	Population and Demand Projections	Technical Characterization, Final Report		
2022		Direct Stakeholder Process, Final Projections			Scenario Development
2023				Scenario Testing	Scenario Testing, Recommendations

Upcoming Milestones

Q3 2020

- Post Audit Results
- Overview of Water Supply Alternatives
- PRESS Evaluation Results
- Projected Water Needs Methodology

Q4 2020

- GULF 2023 Conceptual Model Briefing

Questions and Answers

Thank you for attending the Joint Regulatory Plan Review Stakeholder Meeting

We appreciate your interest and engagement in this meeting.

If you have time, please take a moment to complete the survey at the end of this webinar. We will also include a link to the survey in a follow-up email if you cannot complete the survey now.

ATTACHMENT C

The following summary documents questions that were received during the stakeholder meeting as well as formal responses provided for the record.

QUESTIONS WITH RESPONSES

1. ***Has the council looked at investing in forest stewardship to protect source water supplies to ease surface water treatment?***

   The goal of Alternative Water Supplies Availability task is to identify and characterize the water supply options and their availability for use by the participants in the regulatory areas. Focus of this task is on water quantities (or yields) and not necessarily water quality. However, the District certainly recognizes the value of source water protection and will consider noting that source water protection – and forest stewardship specifically – can be a mechanism to reduce life-cycle treatment costs.

2. ***Will a recording of this meeting be available? How about a copy of the presentations? Thank you***

   The recording of the webinar, a PDF of the presentation, and the Q/A will be posted on the District website within a week of the meeting.

3. ***For the Water Alternatives, were any specific proposed aquifer locations identified? If so, where would they be located?***

   There are two alternative water supplies being evaluated that include use of the aquifer – brackish groundwater development and aquifer storage and recovery. We will not be proposing specific aquifer locations in our evaluation of either of these potential sources. Instead, our efforts will focus on quantifying the additional water supply that could be developed using these strategies regionally without contributing to subsidence.

4. ***Will there be connectivity within the model to the Brazos River Alluvium?***

   Yes, alluvium for major rivers is simulated in layer 1 in the model.

5. ***Why is 2018 the last year and not include 2019 data?***

   The project with the USGS began in 2019 and the pumpage data and water-level data are not yet available from 2019 to be incorporated into the model calibration. If they become available and can be incorporated into the model they will be; otherwise they will be used in future evaluations of model predictions.

6. ***Will the future groundwater model use demands include emergency scenarios, such as droughts we have experienced in the area?***

   Yes. Predictive modeling using the updated groundwater model will include analysis of many different scenarios. Though we have not yet defined the specifics of each of the scenarios, we anticipate multiple scenarios that evaluate the impacts of drought and short-term heightened water demand. The technical methodology and core data, such as water demands, being used in the study will be flexible to allow for testing a number of potential future scenarios.

Questions with Responses

7. I think I misheard the cell size. And is it going to be expressed in meters or feet?

The cell size is 1,000 by 1,000 meters. The cell size is in units of metric in the model and will appear in units of metric and feet in the final report.

8. How is the general head boundary issue from the existing model addressed?

The general head boundary (GHB) in the Houston Area Groundwater Model (HAGM) associated with flow through the top of the model (simulating recharge) will be replaced with the recharge package in the GULF model. This package will specify spatially and time-varying recharge based on results from the USGS Soil-Water-Balance (SWB) code. The recharge estimated by the SWB code includes recharge to the surficial system that is expected to be primarily discharged to rivers (simulated in the model using a combination of the River and Drain packages). During model history matching, the SWB-derived recharge estimates to the deeper system will be adjusted commensurate with published recharge values.

9. What is the GPCD used for the worst-case scenario (highest demand + drought)

Unit demand data for municipal demand projections will be gathered from stakeholders as well as central repositories such as the TWDB Water Use Survey and will most closely reflect data for each individual utility, as available. Although specific data have not yet been selected, the Districts anticipate the ability to use these resources to develop both long-term average gallons per capita day (GPCD) values as well as peak, dry year values. While groundwater modeling is typically conducted using long-term average demands, this breadth of data will allow the Districts to consider a wide range of futures considering development patterns, climate, and drought impacts.

10. Can you describe the process of "declustering" water level measurements during the calibration process?

The process of declustering the groundwater-level observations (hereafter “water levels”) used in the GULF model was performed to: 1) remove multiple (and potentially non-commensurate) water levels in the same or adjacent model cells leading to residual conflicts during the history matching process that cannot easily be resolved, and 2) reduce the implicit importance that a geographic area with many water levels would receive during history matching.

Declustering, as defined here, is separate from other data filtering processes used for the water levels that could be included in a broader ‘declustering’ definition. These processes were completed after the declustering process and included the following: 1) application of a smooth to water levels to remove high-frequency noise associated with continuously-recording sites to preserve long-term trends, 2) removal of wells with less than three water levels due to the greater uncertainty associated with these measurements, and 3) removal of wells that had a screened interval split between two aquifer units (more than 30 percent).

Questions with Responses

11. ***When do you expect the reg plan update to be fully completed? Is that likely to be in 2021 or 2022?***

    The regulatory plan review is scheduled for completion in 2023. Deliverables will be developed as the project progresses, and these will be compiled into a final report at the end of the project. This schedule is driven largely by the time required for groundwater model development and the development of population and demand projections upon release of data from the 2020 Census.

12. ***Can you describe the factors affecting GPS noise and how it is incorporated in the compaction assessment and attributed to a vertical hydrogeologic unit?***

    Global positioning system (GPS) signals are affected by variable atmospheric conditions, random walk (Brownian) noise, and other effects not directly related to land-surface-elevation change. GPS vertical motion observations establish the movement of the monument attached to the GPS antenna based on a benchmark near the land surface. GPS derived vertical movement is determined with respect to the horizontal reference frame developed and published by University of Houston researchers. GPS vertical motion data can be combined with historical water-use and water-level data to estimate the likely intervals within the hydrogeologic column that are experiencing compaction. However, extensometers are the only measurement tool that can measure compaction over a given hydrogeologic interval. There are continuously operating reference stations (CORS) at the extensometers to monitor the movement of the benchmark at depth.

13. ***How is the GPS compaction data applied to a particular unit (i.e., Chicot, Evangeline and Jasper)?***

    GPS vertical motion data represent the total of all compaction and heave at that location. As such, additional information including water use, aquifer response, geologic, hydrogeologic, and depth of stress can be used to estimate the likely location(s) of compaction in the geologic column. Recent research has confirmed that deep seated, below the area of fluid extraction, movement does not contribute vertical motions that are observed at the surface.

14. ***The grid size will match the CLAS grid of 1km by 1km. Thus, it appears that they will be able to migrate Confined Lowland Aquifer System (CLAS) input into the new GULF-2023 model. If the CLAS model is developed using the meters as the length parameter, will the GULF-2023 model also be developed using meters? If it is, this may create some issues with processing model results. Clearly, conversions could be made, but they could also be made during development in order to make the model more consistent with TWDB standards.***

    Yes, it is in units of metric in the model and will appear in units of metric and feet in the final report.

15. ***USGS representatives today stated that the model will be developed initially with MODFLOW-NWT and then later migrated to MODFLOW 6. Since layer 1 will represent the alluvium, will they be using dummy layers to transmit water between layer 1 and lower layers where the Evangeline and Jasper crop out?***

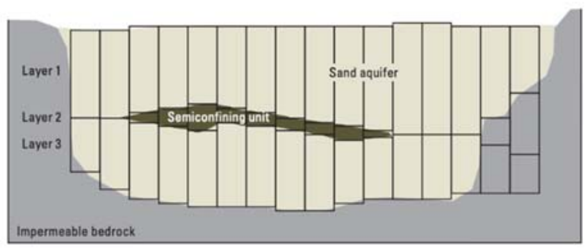
    Yes, this is current how the model in MODFLOW-NWT is configured.

16. ***As you know, we were able to define an alluvial layer in the Northern Carrizo-Wilcox model and eliminate all dummy layers where the deeper formations cropped out by using MODFLOW 6. Eliminating the dummy layers was critical to developing water budgets and***

improving the interpretive value of the model. I am concerned that the Subsidence District will not view that as necessary and allow the dummy layers to remain in the MODFLOW 6 version.

Will those dummy cells remain in the MODFLOW 6 version or will they modify the grid to take advantage of the MODFLOW 6 code?
With MODFLOW6 this setup will no longer be necessary. The ‘dummy layers’ can be excluded using the IDOMAIN (see Figure 3-3 from Langevin and others, 2017). This is the approach that will be used for the model once it is converted to MODFLOW6.

3–6 Documentation for the MODFLOW 6 Groundwater Flow Model



Layer 1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Layer 2	–1	–1	1	1	1	1	1	1	1	1	1	–1	–1	–1	0	0
Layer 3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0

EXPLANATION
IDOMAIN codes
>0 Included cell
=0 Excluded cell
<0 Excluded pass-through cell

Figure 3–3. Diagram showing *IDOMAIN* variable in cross section for a single row or column. The sand aquifer overlies impermeable bedrock and contains a discontinuous semiconfining unit. *IDOMAIN* codes of -1 are assigned to the second layer in areas where the semiconfining unit is absent. The -1 *IDOMAIN* code indicates that the cell will be an excluded pass-through cell, in which case a vertical connection will be made between the overlying and underlying cells.

17. ***As you recall, the last version of the model was going to replace the GHBs with the recharge package and the RIV package. However, (with no consultation) the USGS abandoned this approach and reverted to the GHBs when they could not get the RCH and RIV to work. Given where they are in the work schedule with this update, have they actually passed the point where they are confident that the RCH and RIV will work? Put another way, is there still the possibility that they will abandon the RCH and RIV approach and go back to GHBs in order to meet their schedule?***
USGS is confident that the current approach—using SWB-derived recharge applied using the recharge package—will work in combination with a surficial layer (layer 1) using the river and drain package to simulate model-area rivers.