# Numerical Model for the Brazos River Alluvium Aquifer GAM

## Stakeholder Advisory Forum #3
## Milano, TX

Presented By:

INTERA
GEOSCIENCE & ENGINEERING SOLUTIONS

Texas Water Development Board

May 26, 2016

# Presentation Outline

- Introduction to the Groundwater Availability Program by Cindy Ridgeway (TWDB)
- Conceptual model review
- Model construction
  - Structure
  - Head boundaries
  - Properties
  - Flux boundaries
- Steady-state and transient calibration
- Model results
- Sensitivity analysis
- Schedule

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

Cindy Ridgeway, P.G.
Contract Manager and Manager
Groundwater Availability Modeling
Texas Water Development Board

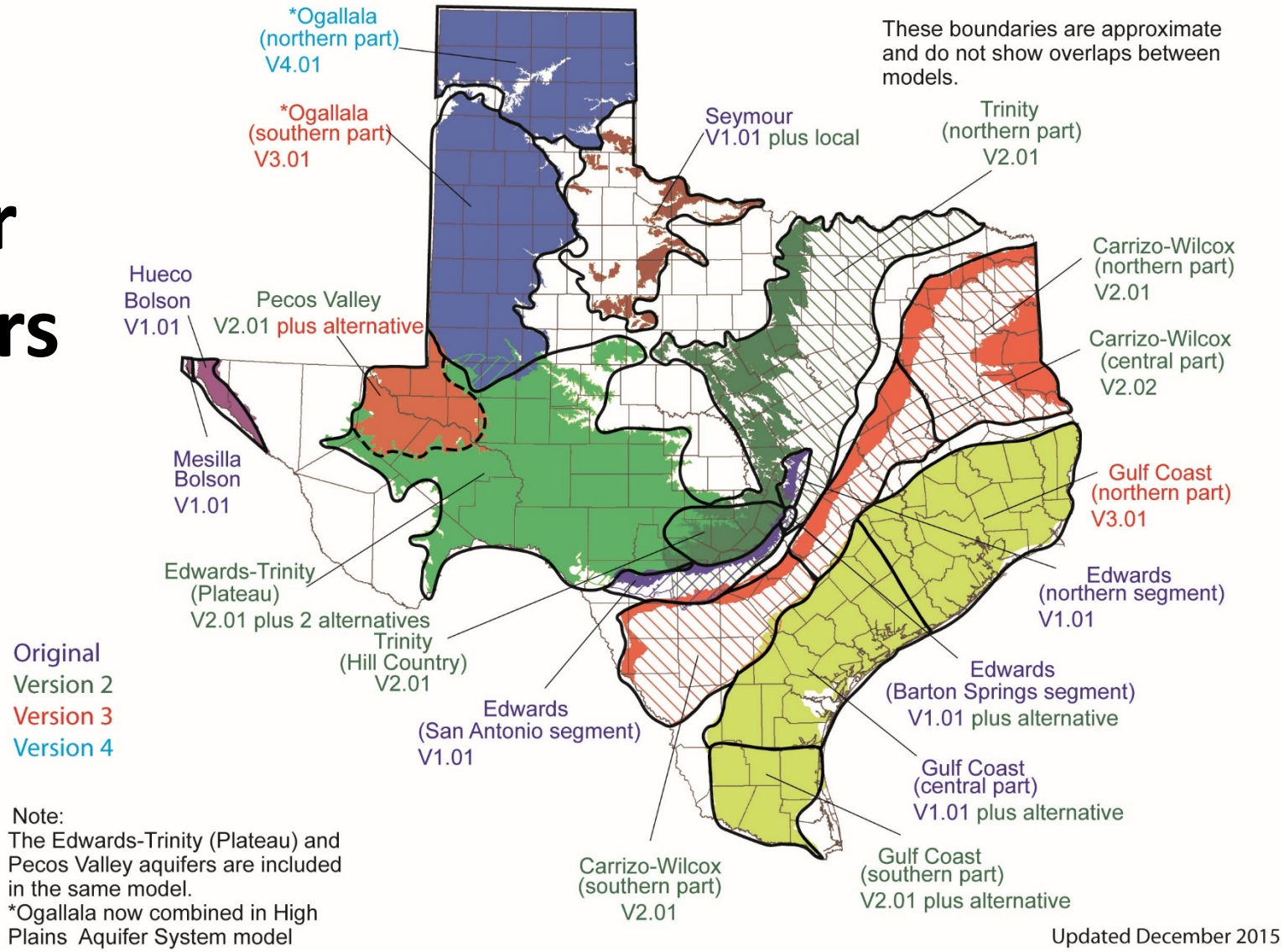
# Disclaimer

The following presentation is based upon professional research and analysis within the scope of the Texas Water Development Board's statutory responsibilities and priorities but, unless specifically noted, does not necessarily reflect official Board positions or decisions.

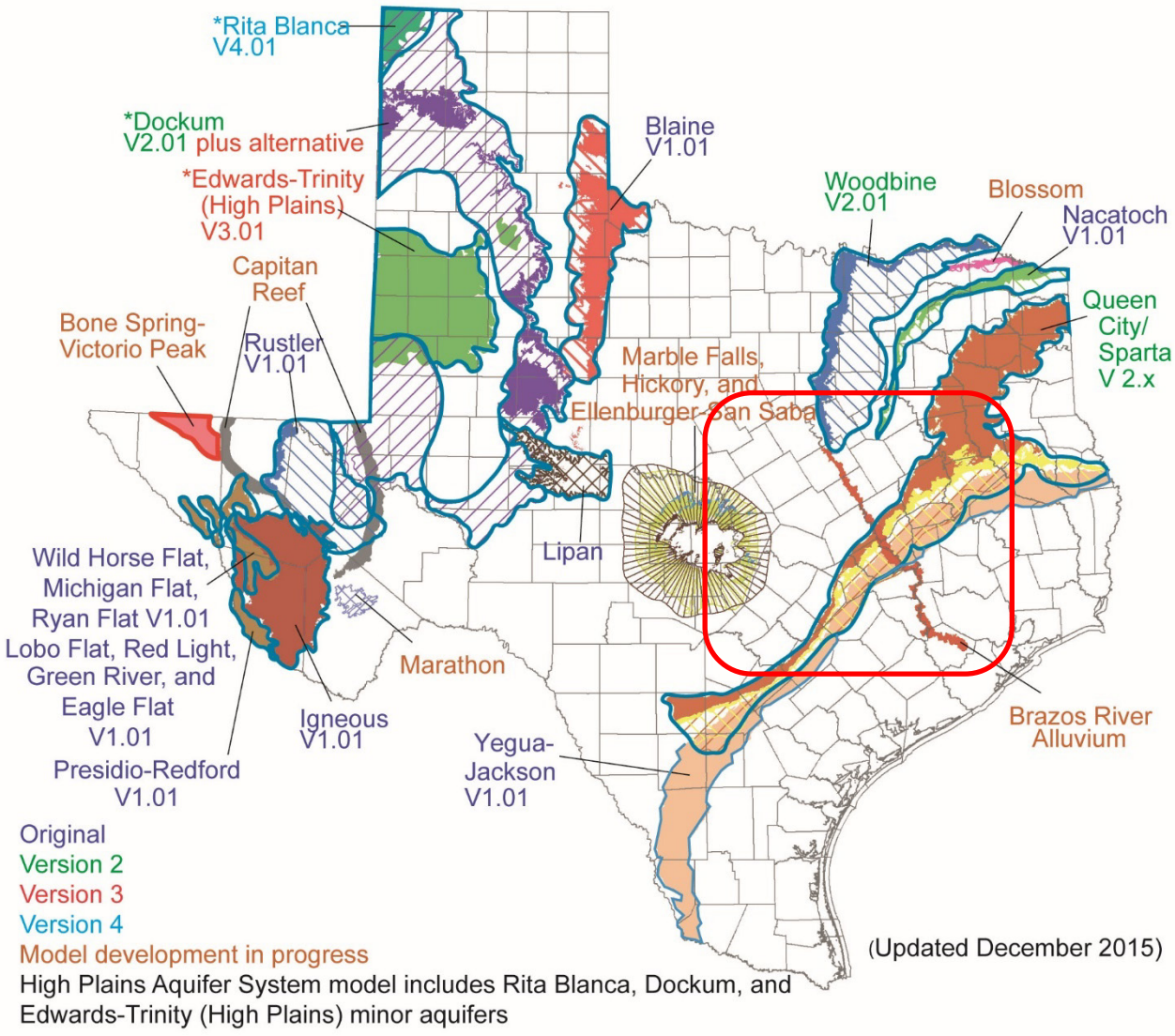
# Groundwater Availability Modeling Program

- **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.

# Major Aquifers



# Minor Aquifers



# 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 stakeholders updated about progress of the model-related project
- Provide stakeholders with the opportunity to provide input and data to assist with model-related project development
- Discuss limitations and applications of the project

# Contact Information

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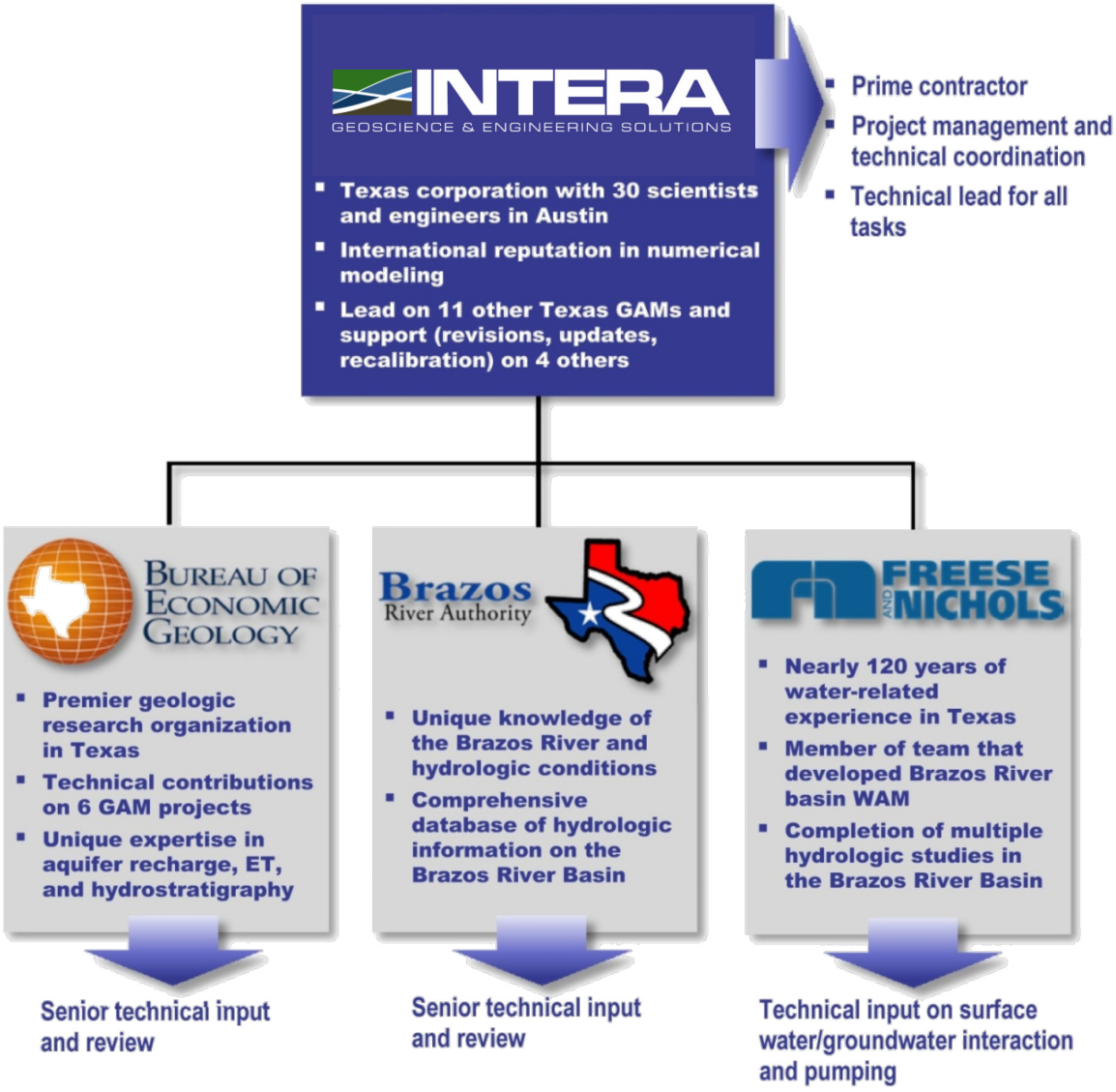
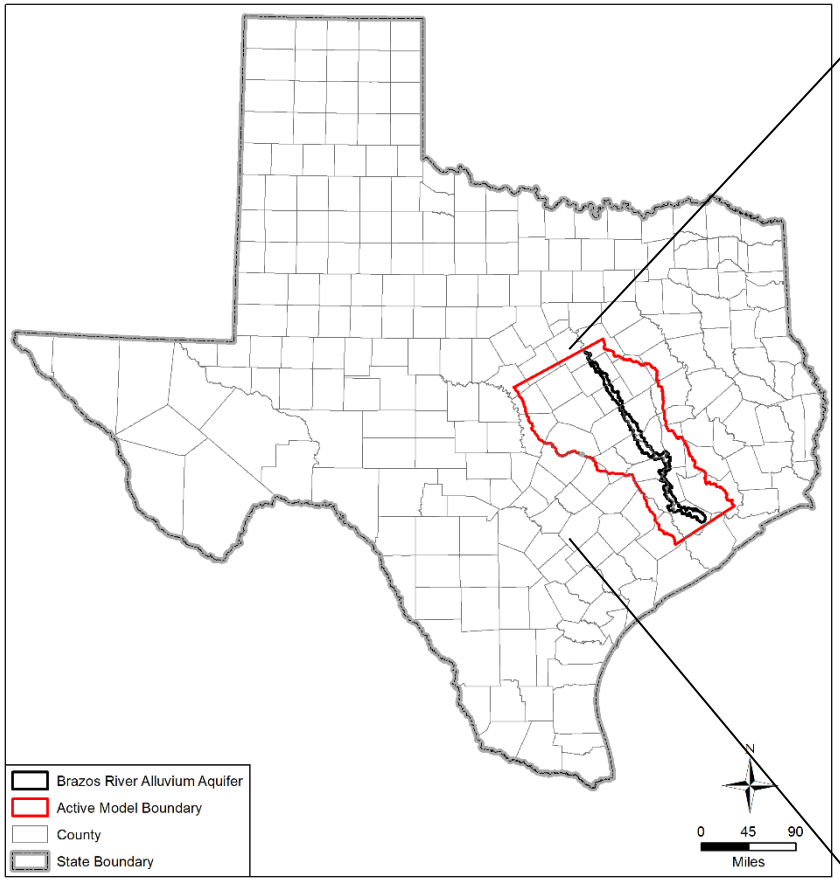
**Texas Water Development Board**
**P.O. Box 13231**
**Austin, Texas 78711-3231**

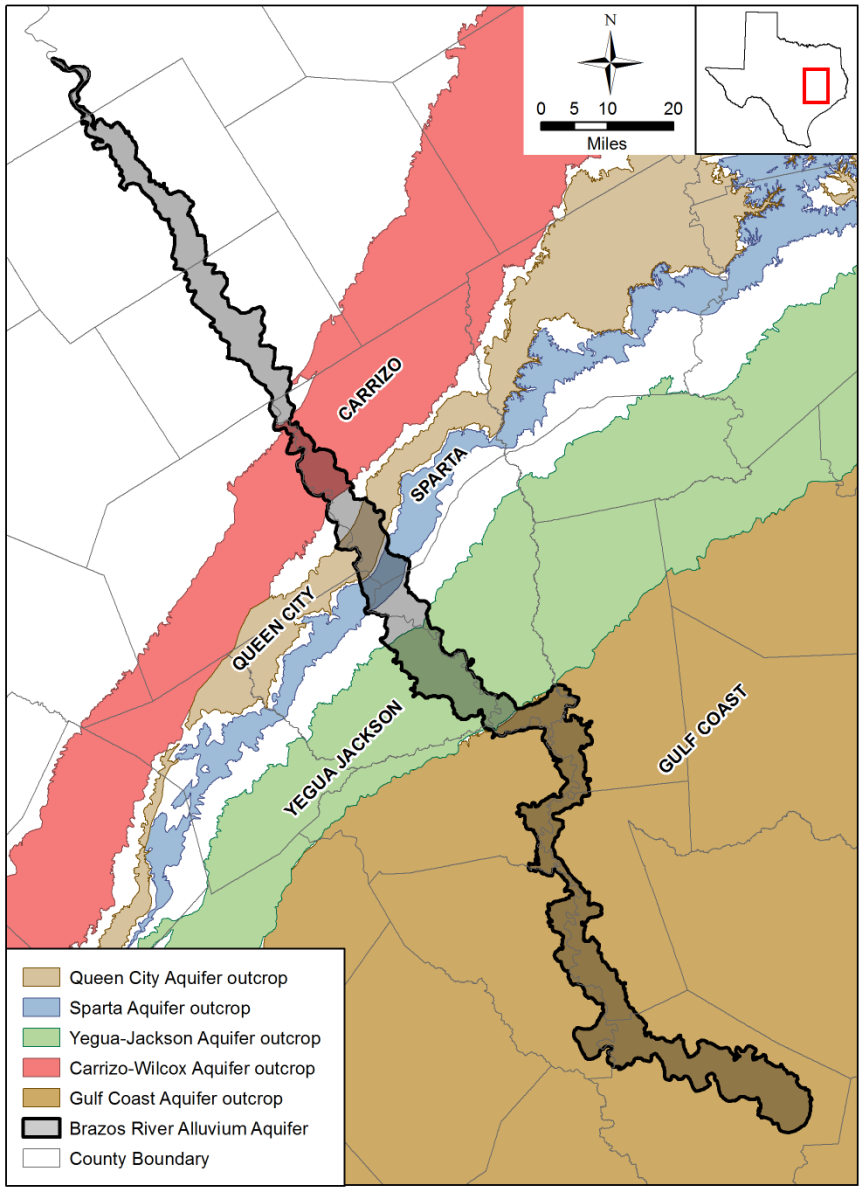
**Web information (includes meeting information):**
**http://www.twdb.texas.gov/groundwater/models/gam/bzrv/bzrv.asp**

# Project Team and Responsibilities



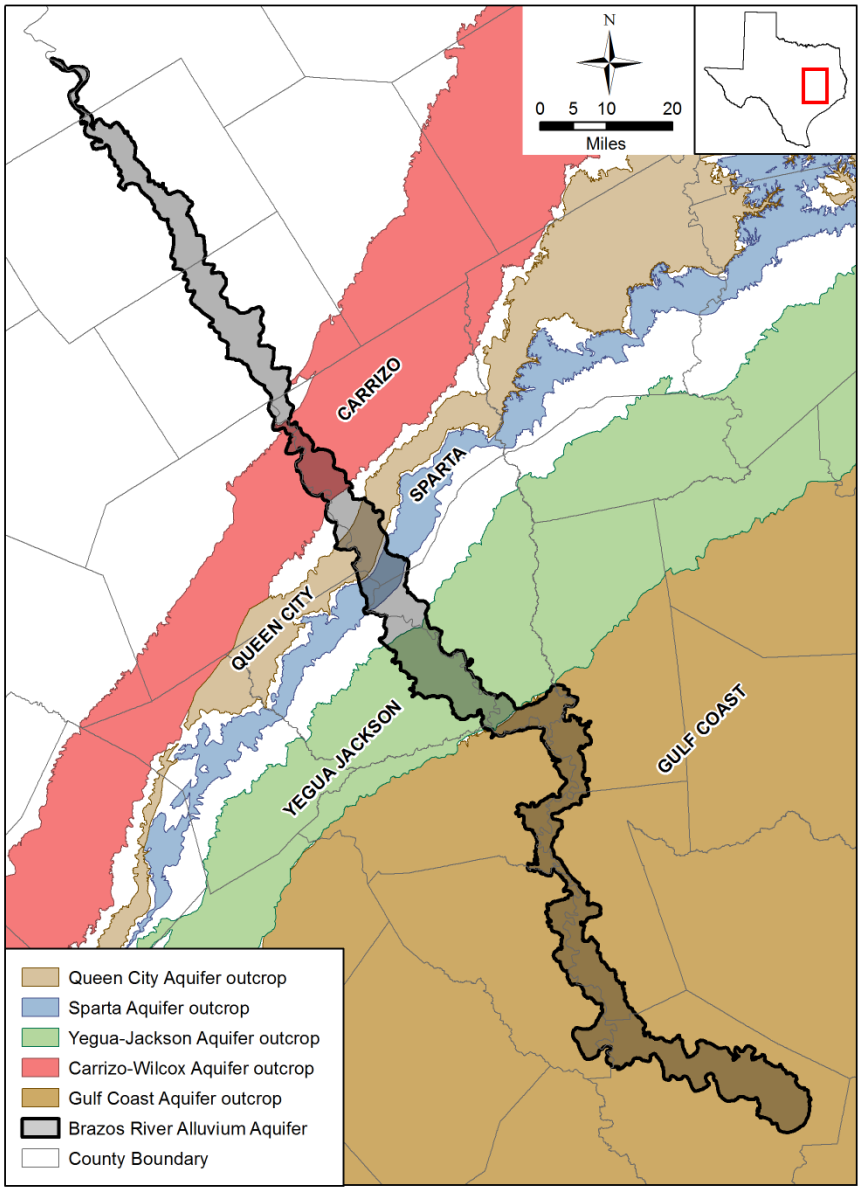
# Study Area


Brazos River Alluvium Aquifer
Active Model Boundary
County
State Boundary
N
0 45 90
Miles


N
0 5 10 20
Miles
CARRIZO
SPARTA
QUEEN CITY
YEGUA JACKSON
GULF COAST
Queen City Aquifer outcrop
Sparta Aquifer outcrop
Yegua-Jackson Aquifer outcrop
Carrizo-Wilcox Aquifer outcrop
Gulf Coast Aquifer outcrop
Brazos River Alluvium Aquifer
County Boundary

# Extent and Hydrostratigraphy

| System | Series | Geologic Unit | Aquifer | Model Layer |
|---|---|---|---|---|
| Quaternary | Holocene | Alluvium | Brazos River Alluvium | 1 & 2 |
| | Pleistocene | Fluvial terrace deposits | Gulf Coast | 3 |
| | | Beaumont Formation | | |
| | | Lissie Formation | | |
| Tertiary | Pliocene | Willis Sand | | |
| | Miocene | Goliad Sand | | |
| | | Fleming Formation | | |
| | | Oakville Sandstone | | |
| | Oligocene | Catahoula Sandstone | | |
| | Eocene | Jackson Group | Yegua-Jackson | |
| | | Yegua Formation | | |
| | | Cook Mountain Formation | | |
| | | Sparta Sand | Sparta | |
| | | Weches Formation | | |
| | | Queen City Sand | Queen City | |
| | | Reklaw Formation | | |
| | | Carrizo Sand | Carrizo-Wilcox | |
| | | Wilcox Group | | |
| | Paleocene | Midway Group | | |
| Cretaceous | Gulfian | Navarro Group | | |
| | | Taylor Marl | | |
| | | Austin Chalk | | |
| | | Eagle Ford Group | | |
| | | Grayson Marl | | |
| | Comanchean | Washita Group | | |
| | | Fredericksburg Group | | |



# Extent and Hydrostratigraphy

| System | Series | Geologic Unit | Aquifer | Model Layer |
|---|---|---|---|---|
| Quater | Holocene | Alluvium | Brazos River Alluvium | 1 & 2 |
| Tertia | | Reklaw Formation | | |
| | | Carrizo Sand | Carrizo-Wilcox | |
| | | Wilcox Group | | |
| | Paleocene | Midway Group | | |
| Cretaceous | Gulfian | Navarro Group | | |
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| | Comanchean | Washita Group | | |
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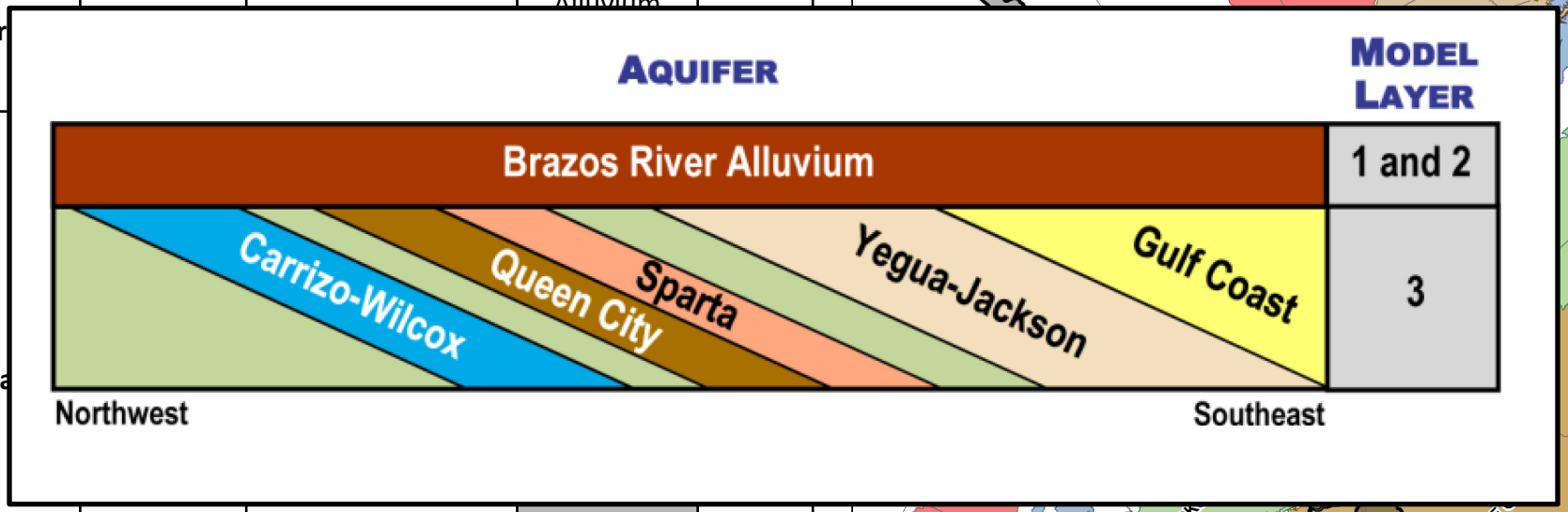
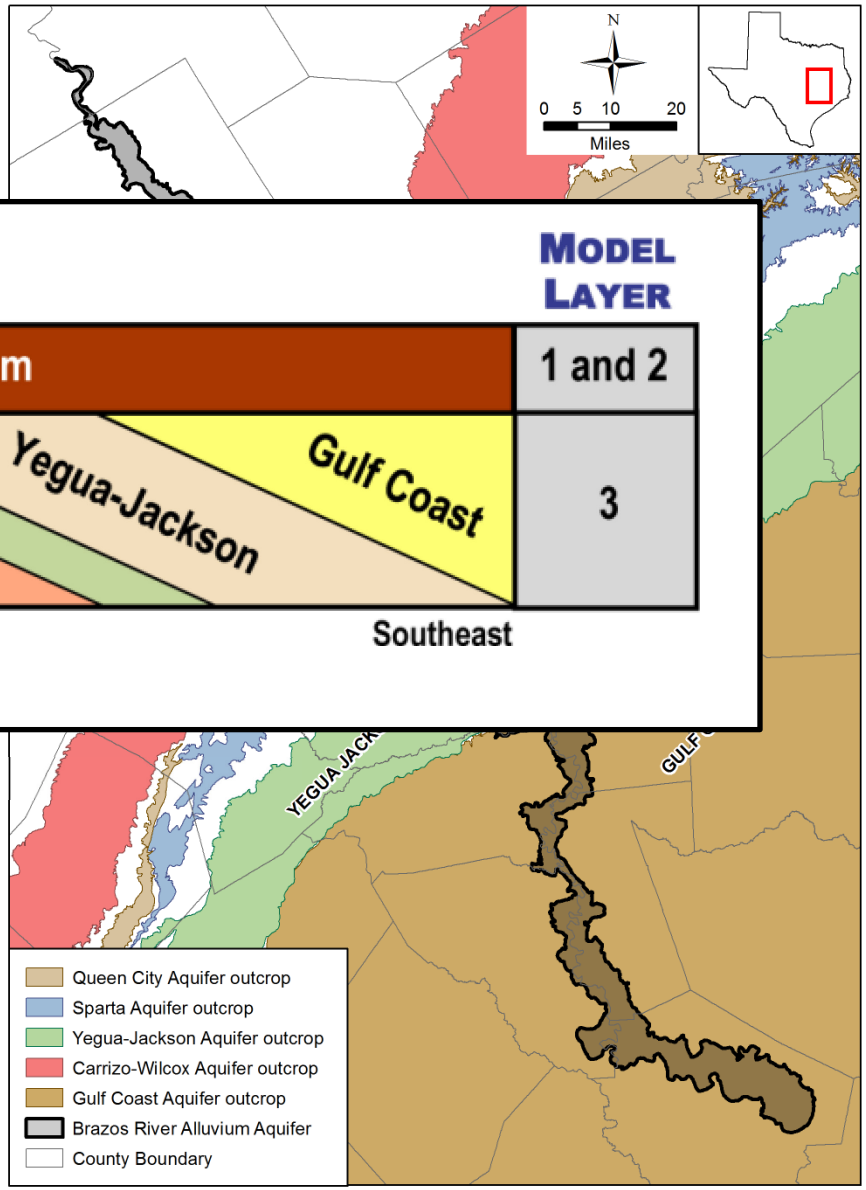
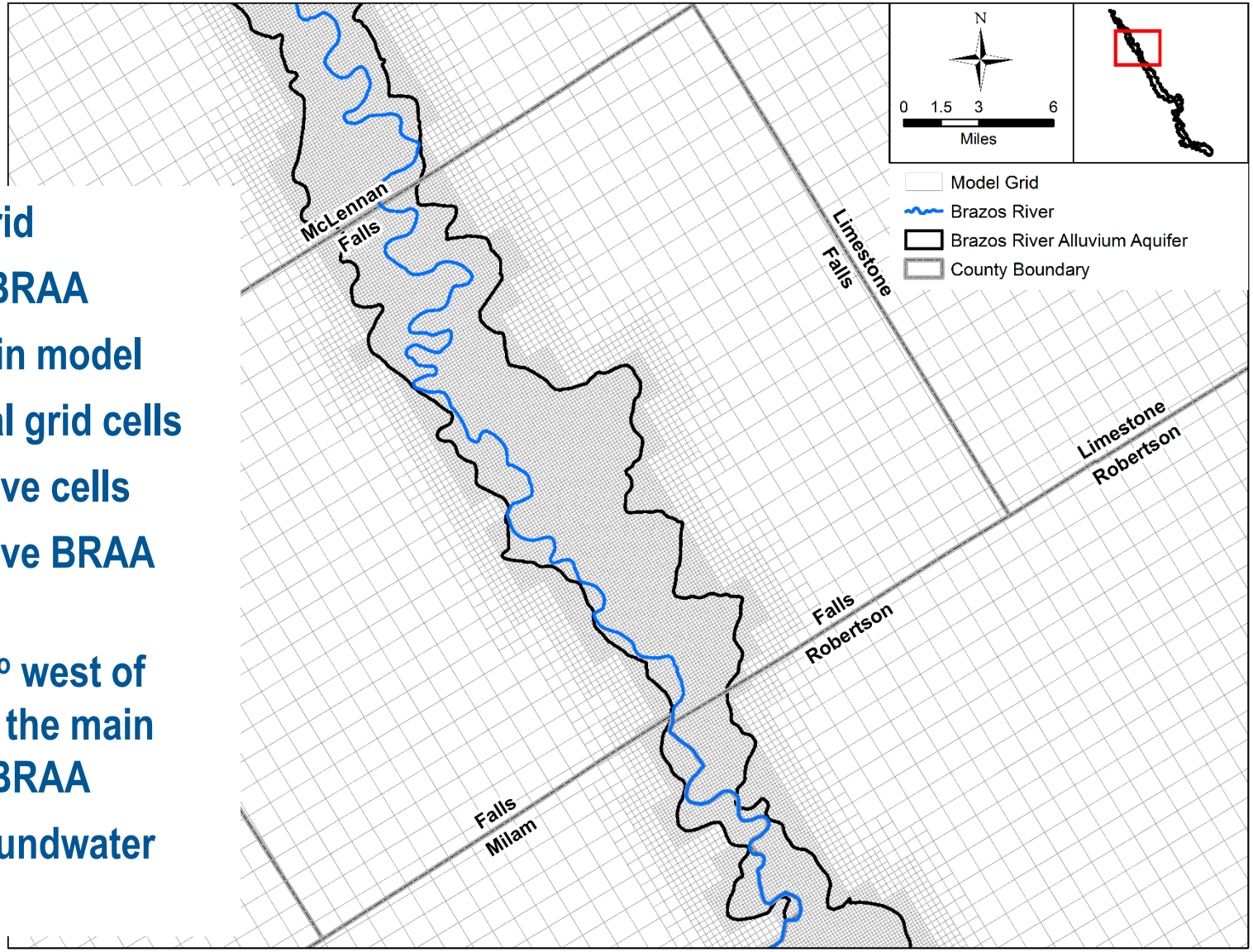


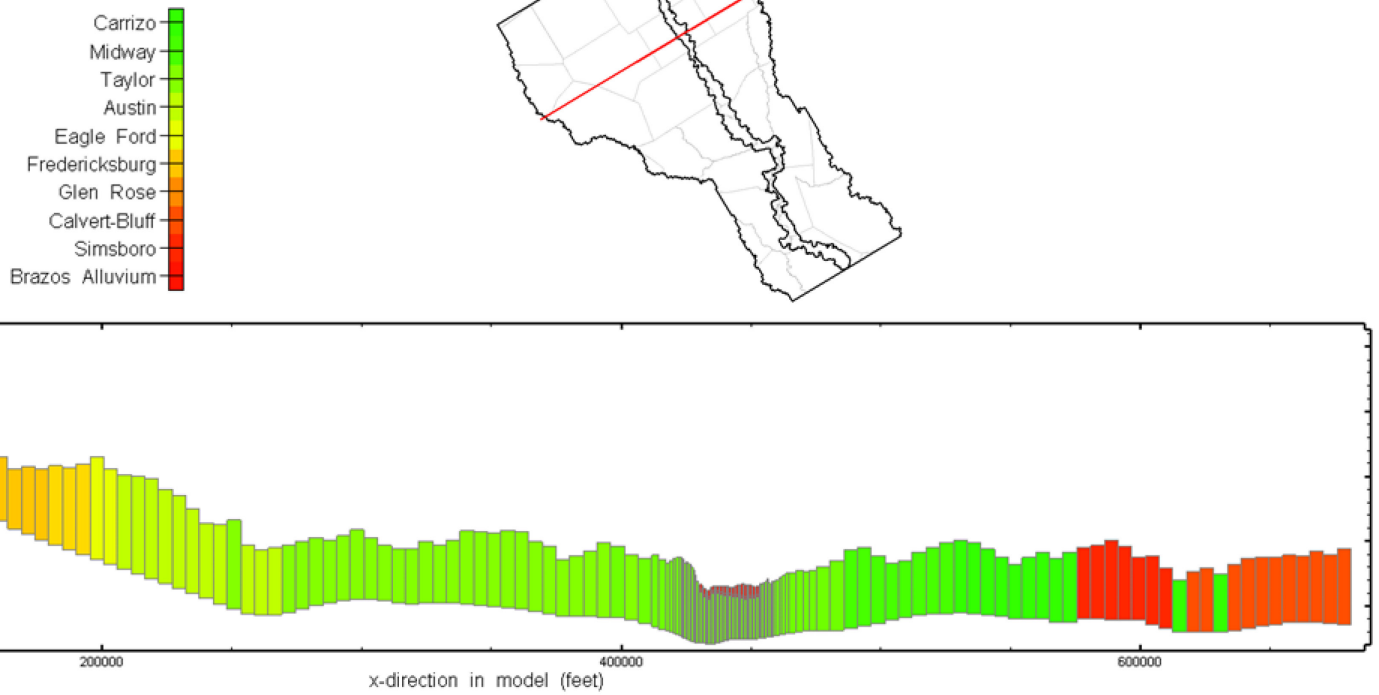



# Model Grid

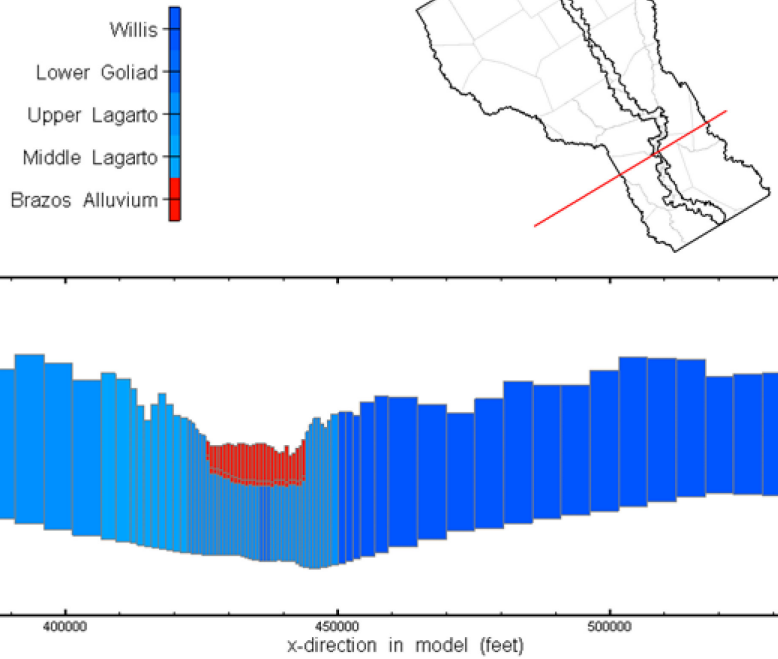
- Quadtree grid
- 1/8-mile in BRAA
- 1-mile max in model
- 374,487 total grid cells
- 251,378 active cells
- 135,352 active BRAA cells
- Oriented 31° west of north along the main axis of the BRAA
- Built in Groundwater Vistas



# Structure on Grid – Northern Cross-Section

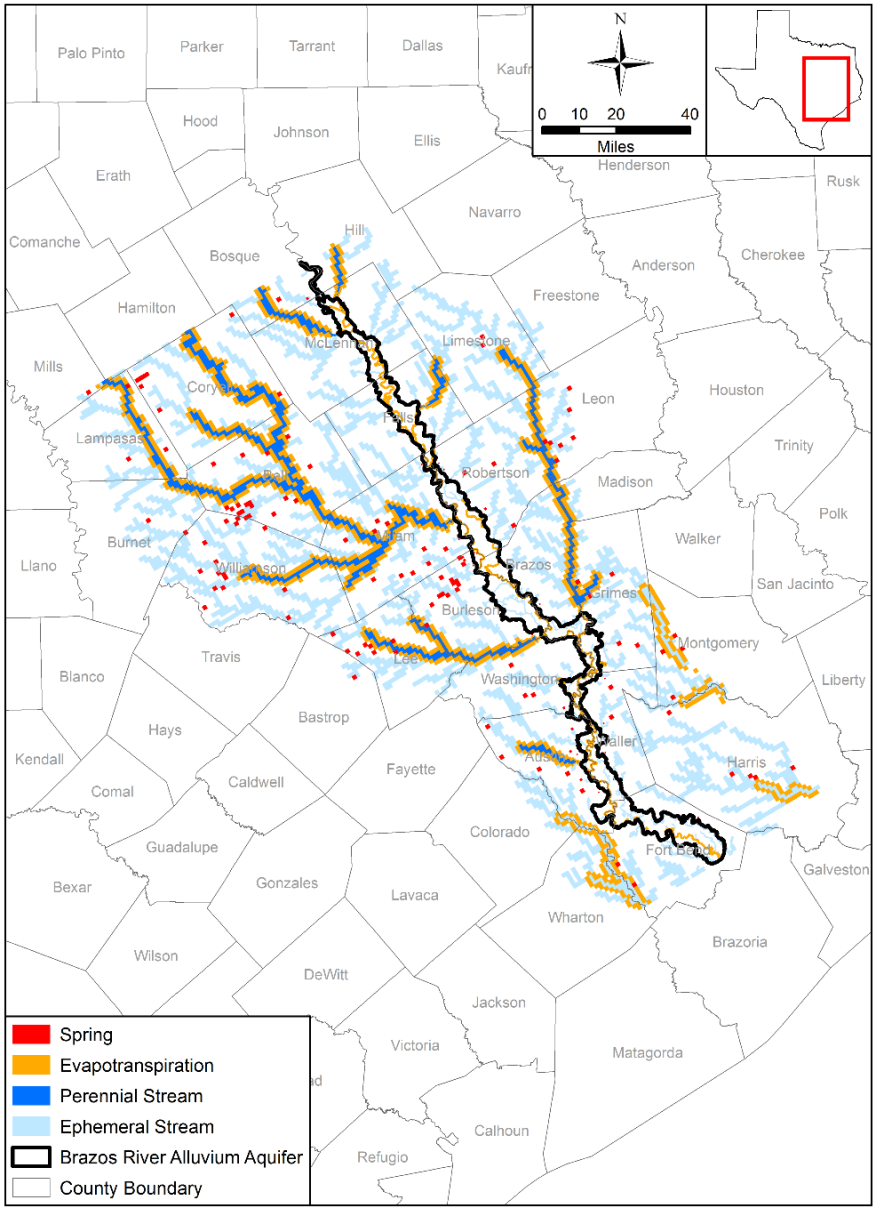


# Structure on Grid – Southern Cross-Section



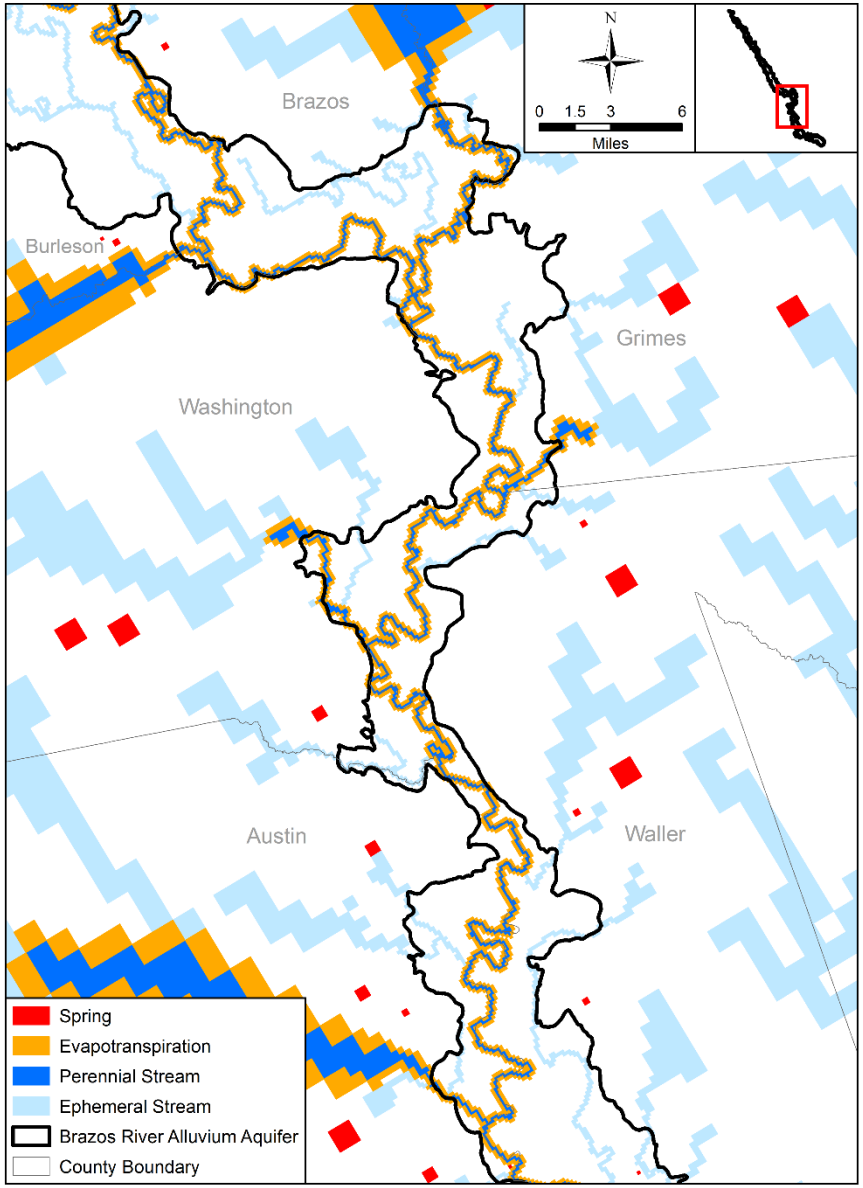
# Head boundaries:

- SFR cells represent perennial streams
- RIV cells represent ephemeral streams
- EVT cells represent riparian evapotranspiration
- DRN cells represent springs



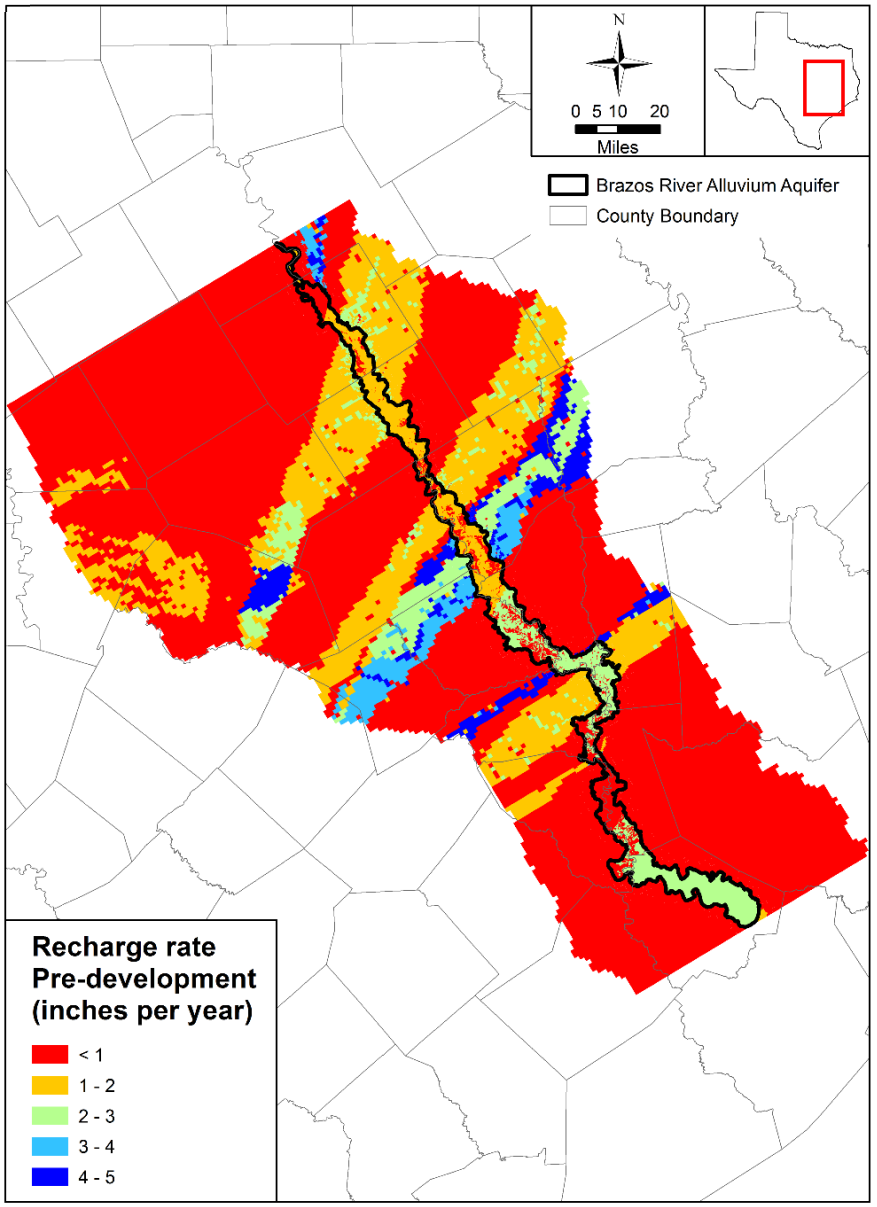
# Head boundaries: zoomed

- SFR cells represent perennial streams
- RIV cells represent ephemeral streams
- EVT cells represent riparian evapotranspiration
- DRN cells represent springs



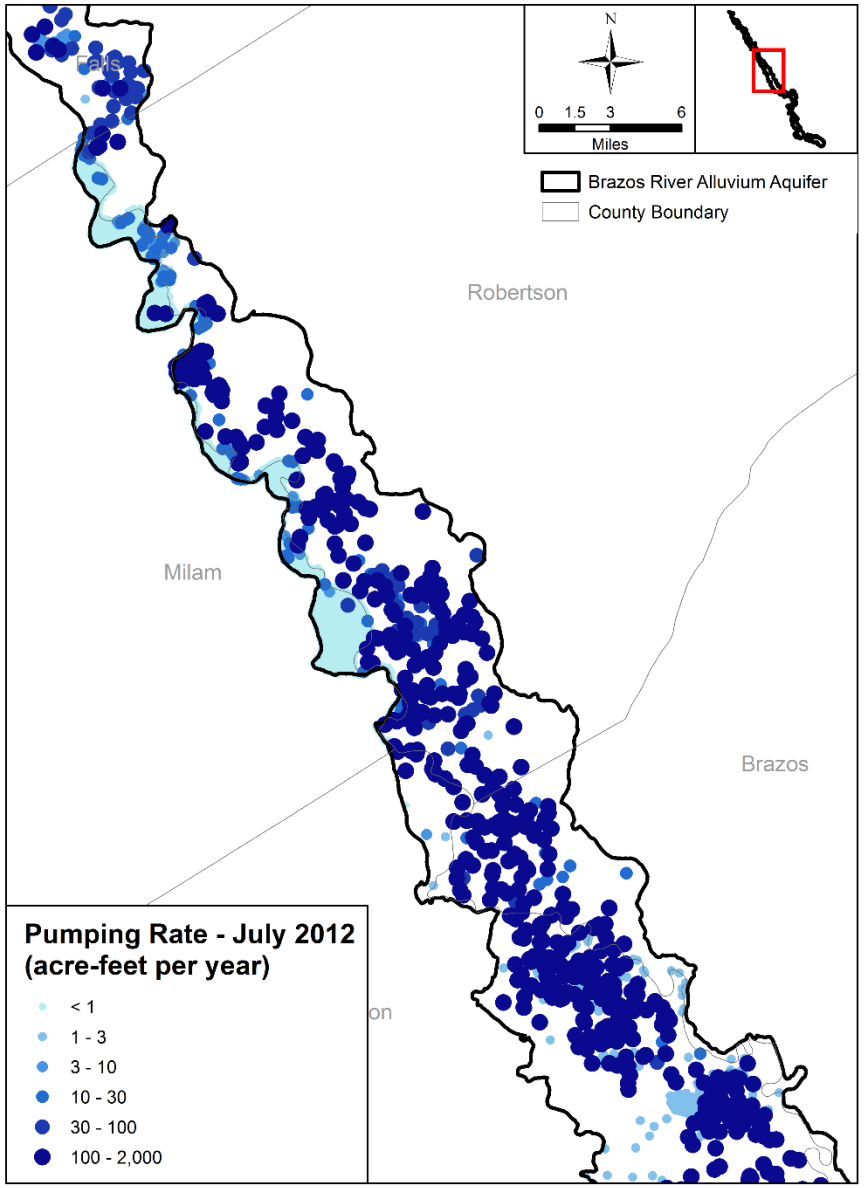
# Flux Boundary: Recharge

- Steady-state recharge to BRAA was based on:
  - Baseflow separation analyses
  - Surficial soil type
- Steady-state recharge to underlying formations was varied by formation
- Transient recharge was based on steady-state with variations in precipitation



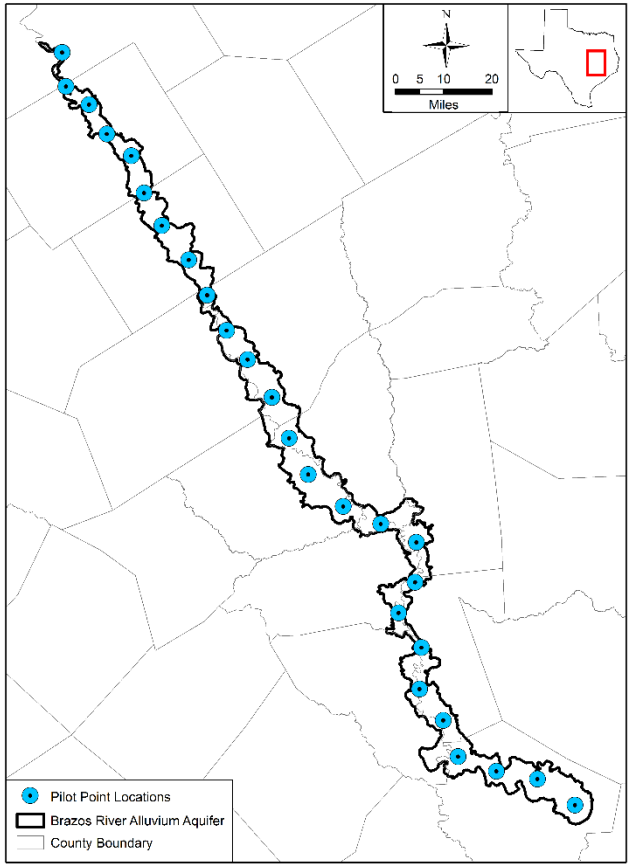
# Flux Boundary: Pumping

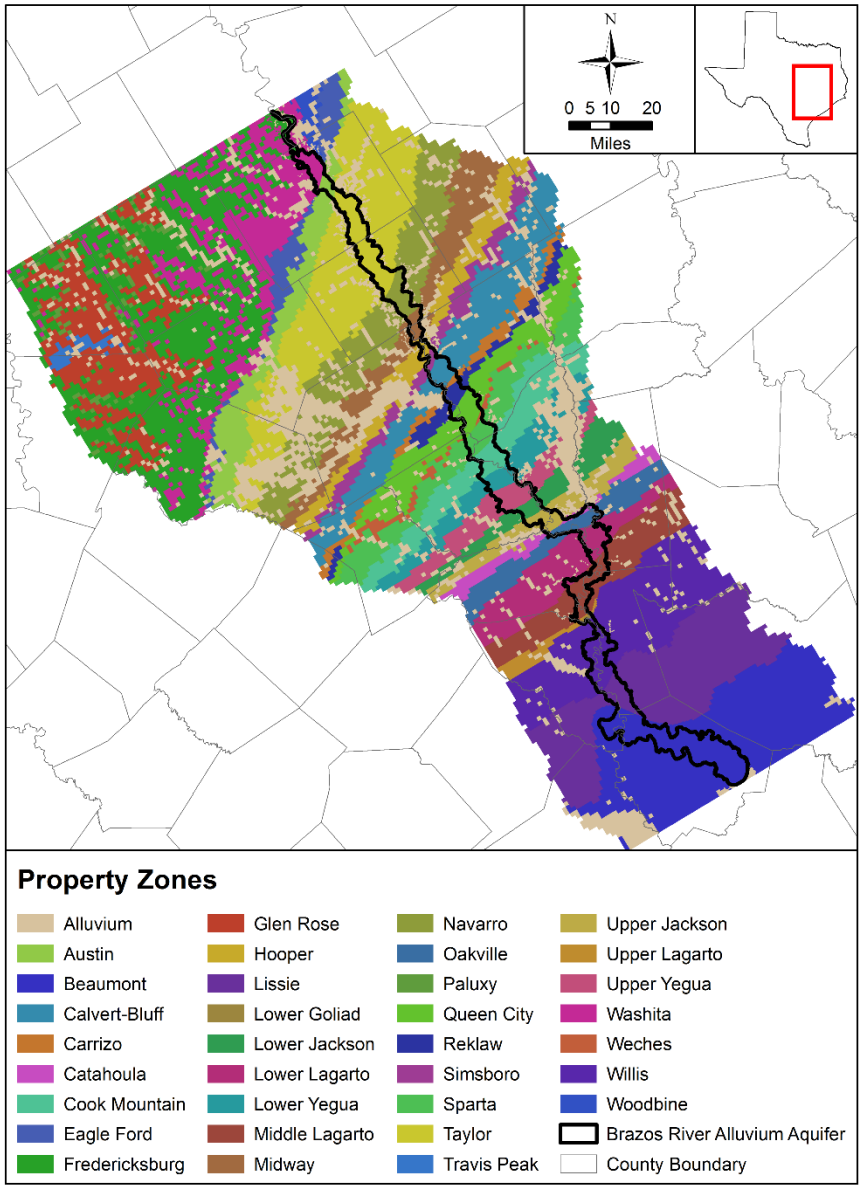
- Created combined database of all known wells from all sources
  - TWDB GWDB
  - Driller databases
  - TCEQ PWS
  - GCDs
- Used actual wells for pumping assignment when possible
- Added some wells based on either irrigation areas or population centers
- Associated irrigation wells with crop types based on cropland coverage
- Varied pumping seasonally based on crop type



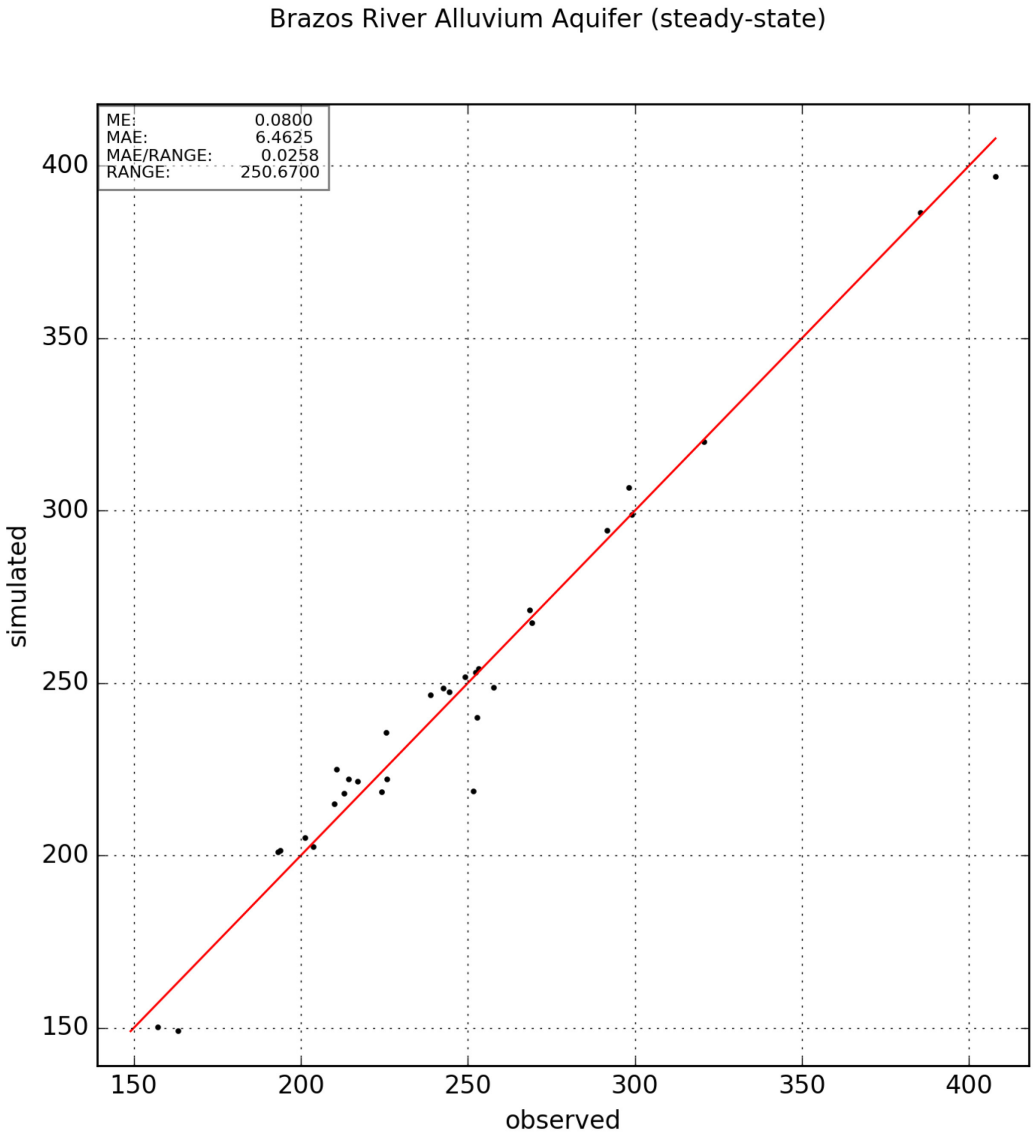
# Steady-state Calibration

- Pilot points used to warp Kh in BRAA
- Kh and recharge of underlying formations varied by formation



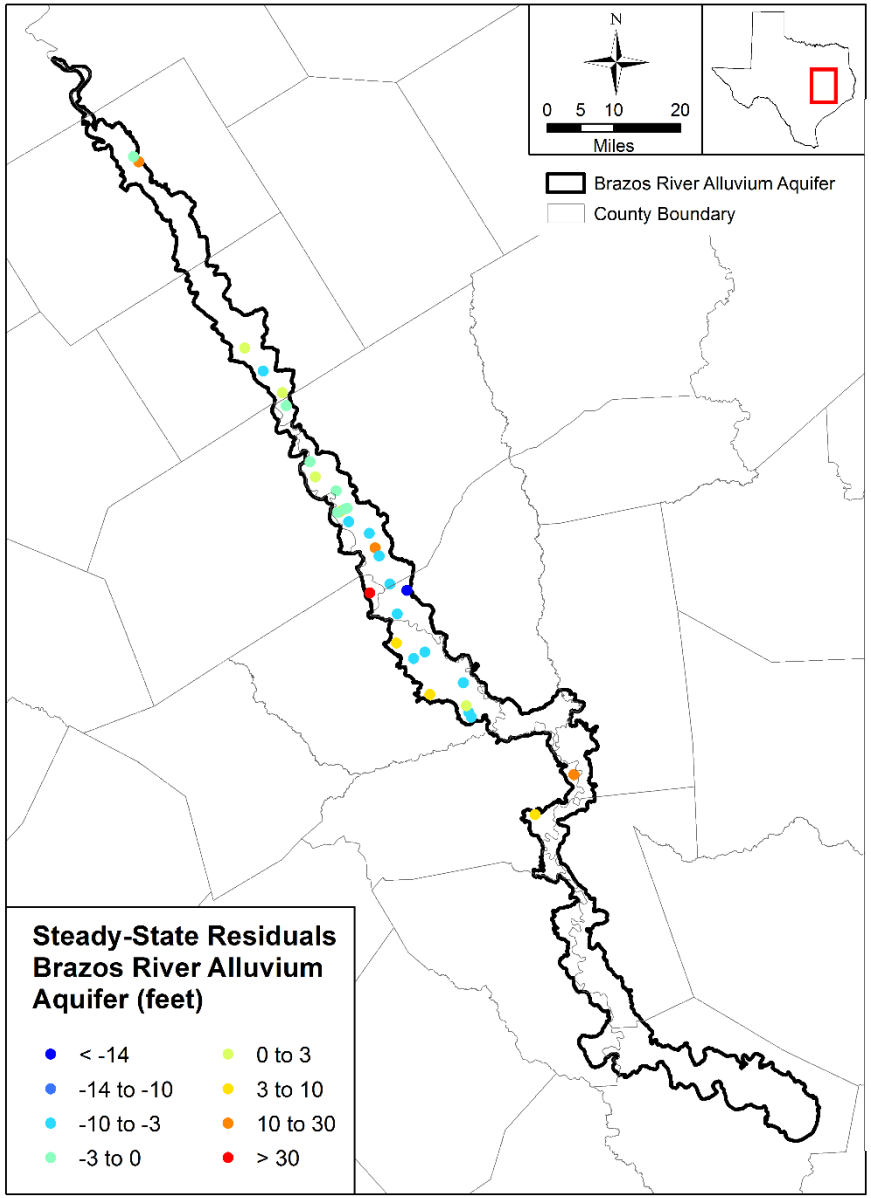



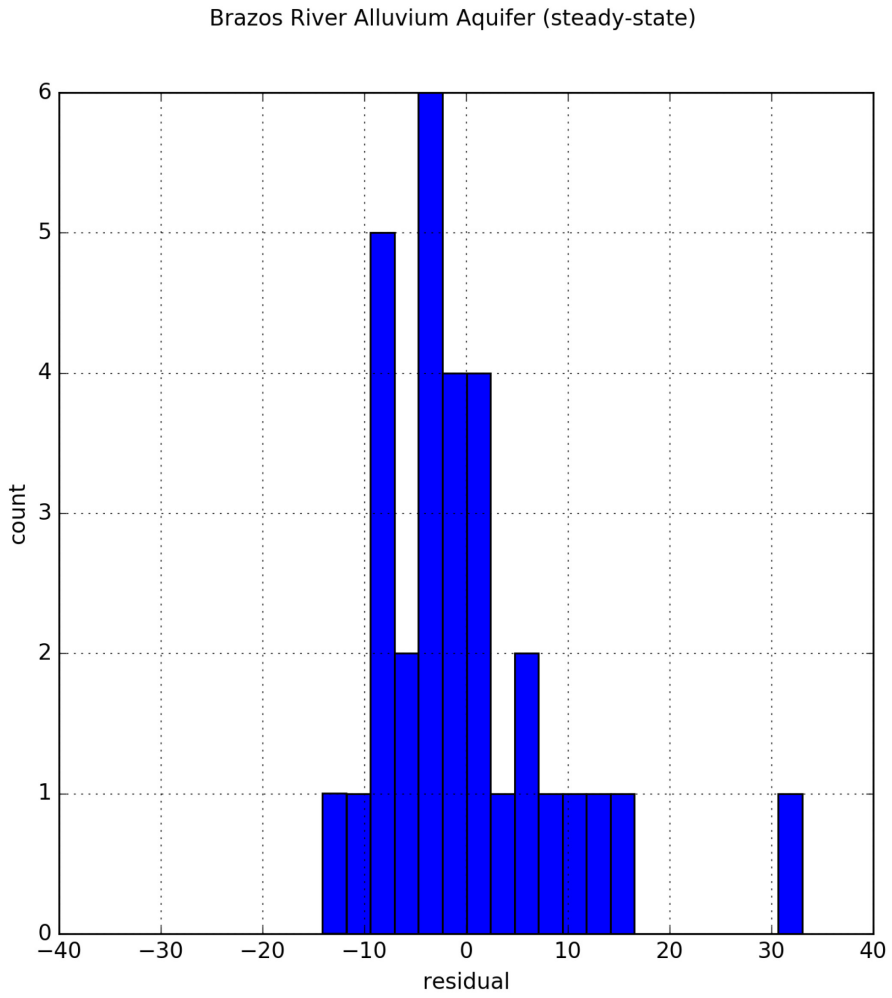
# Steady-State Calibration




- Few predevelopment targets available for the BRAA
- Good fit to available targets

# Steady-State Calibration



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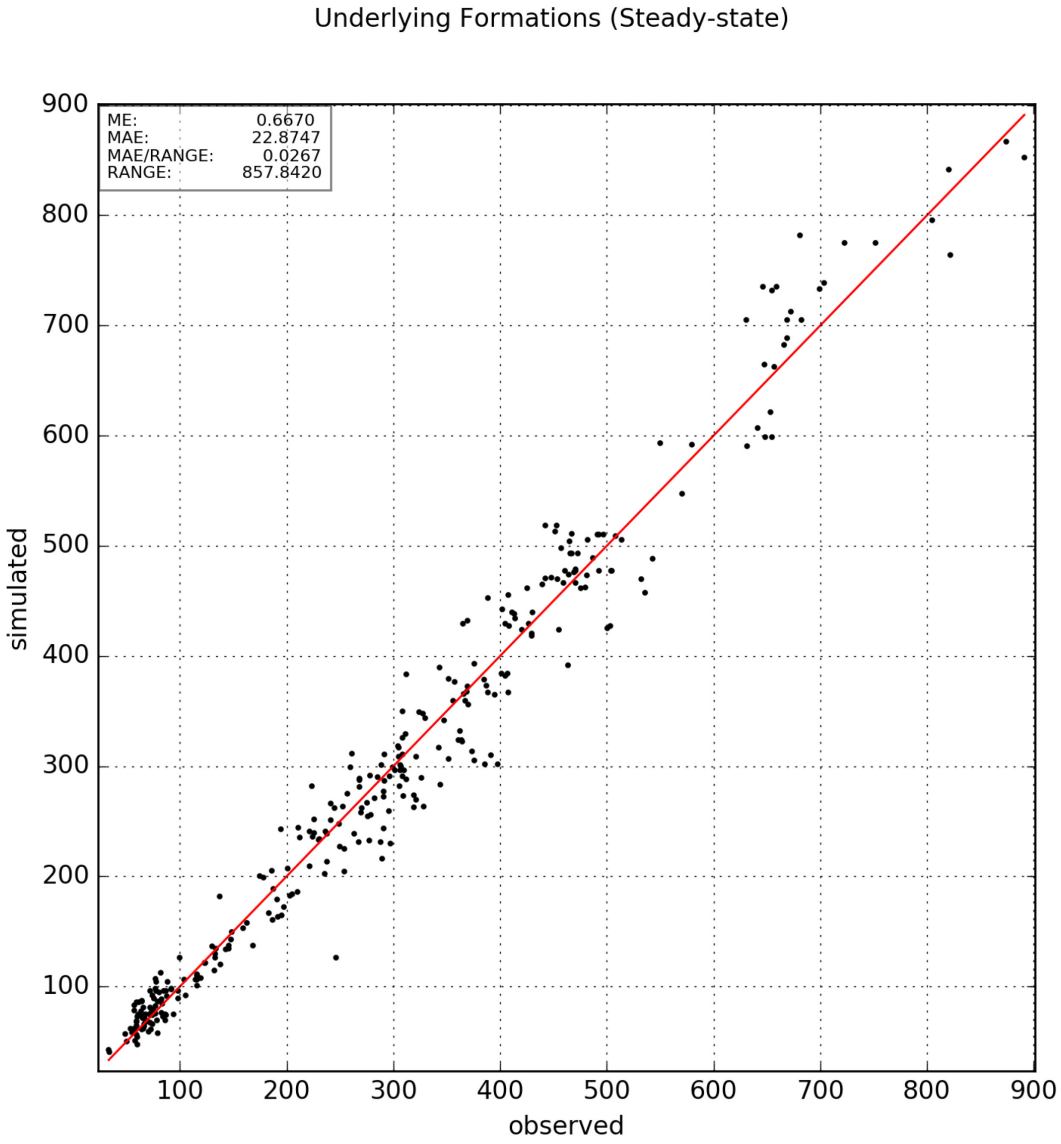
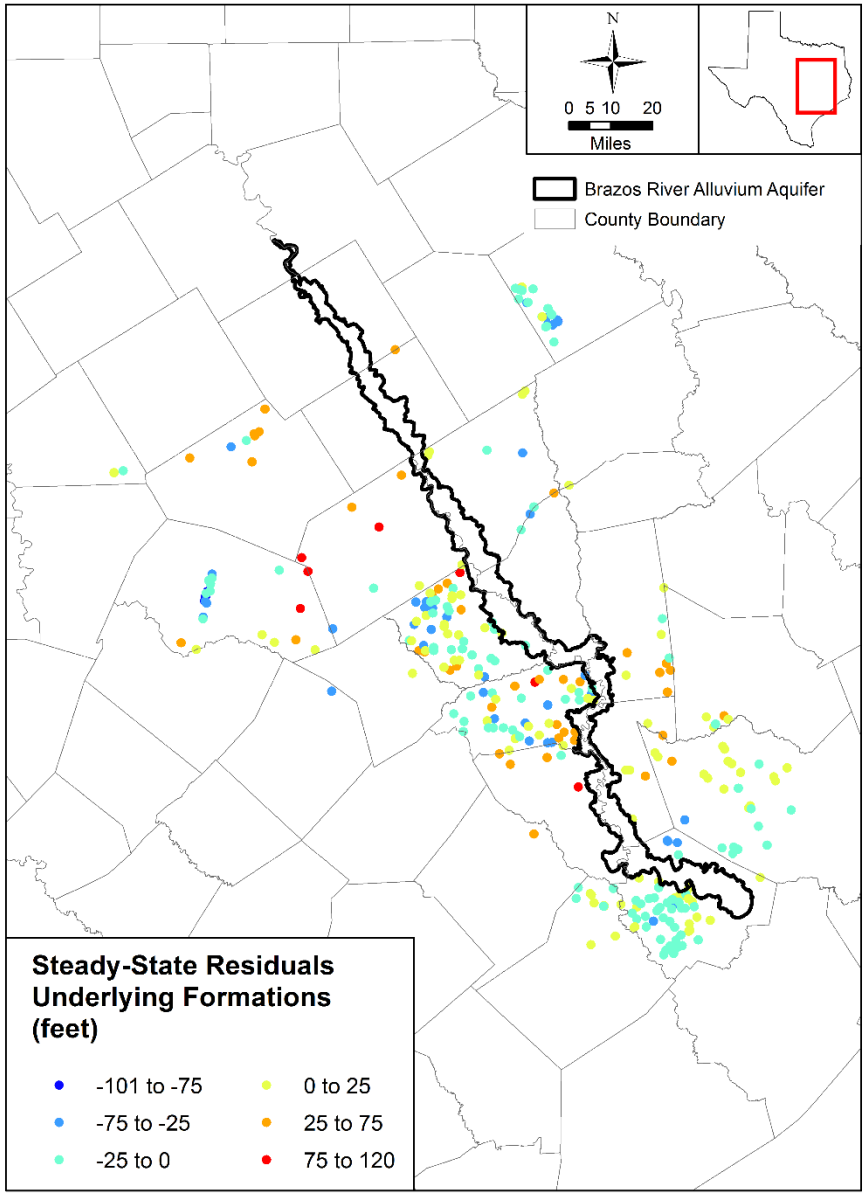
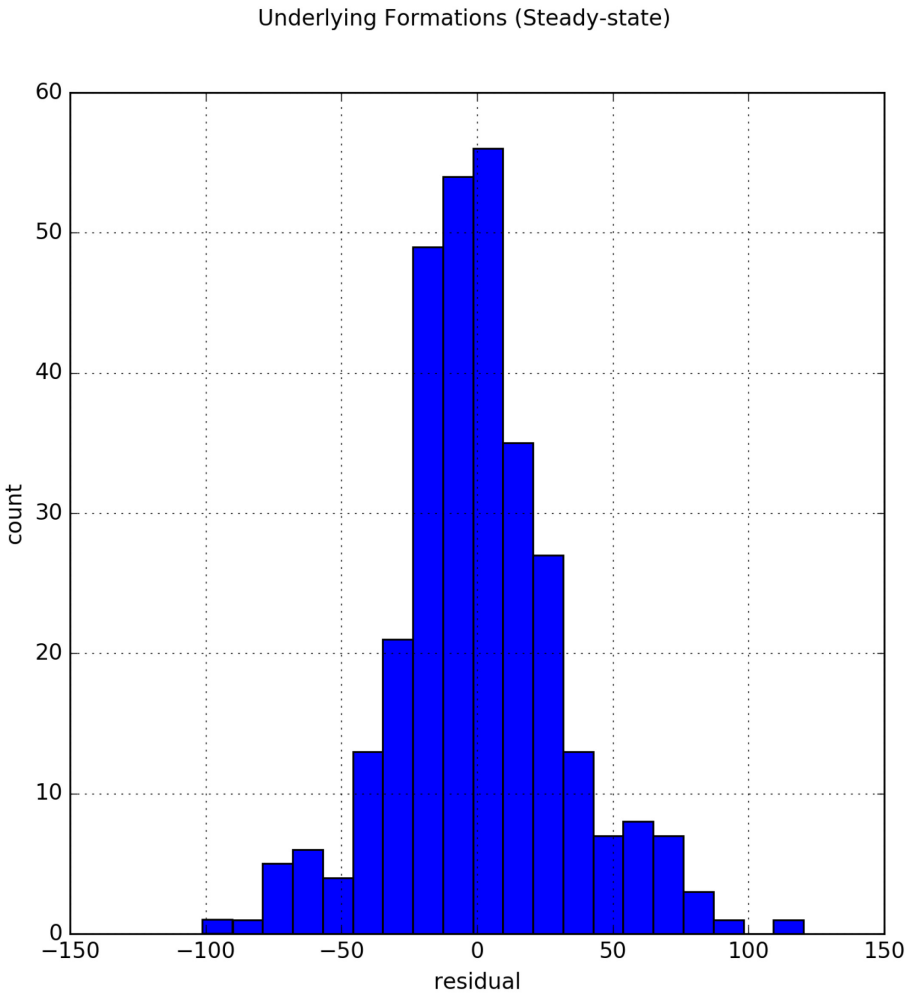



- Many predevelopment targets for the shallow portions of the underlying units
- Good fit between simulated and observed heads

# Steady-State Calibration



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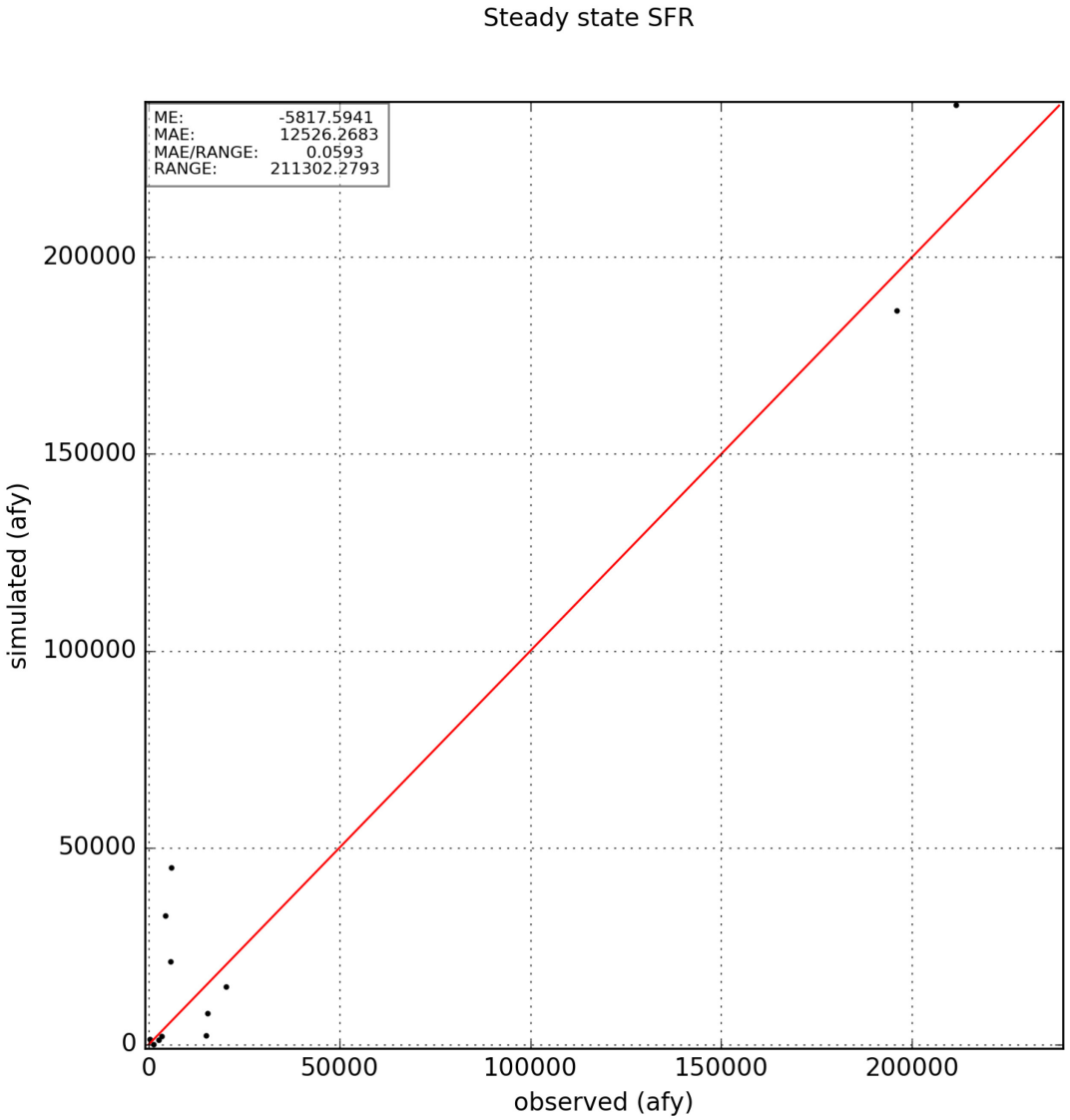
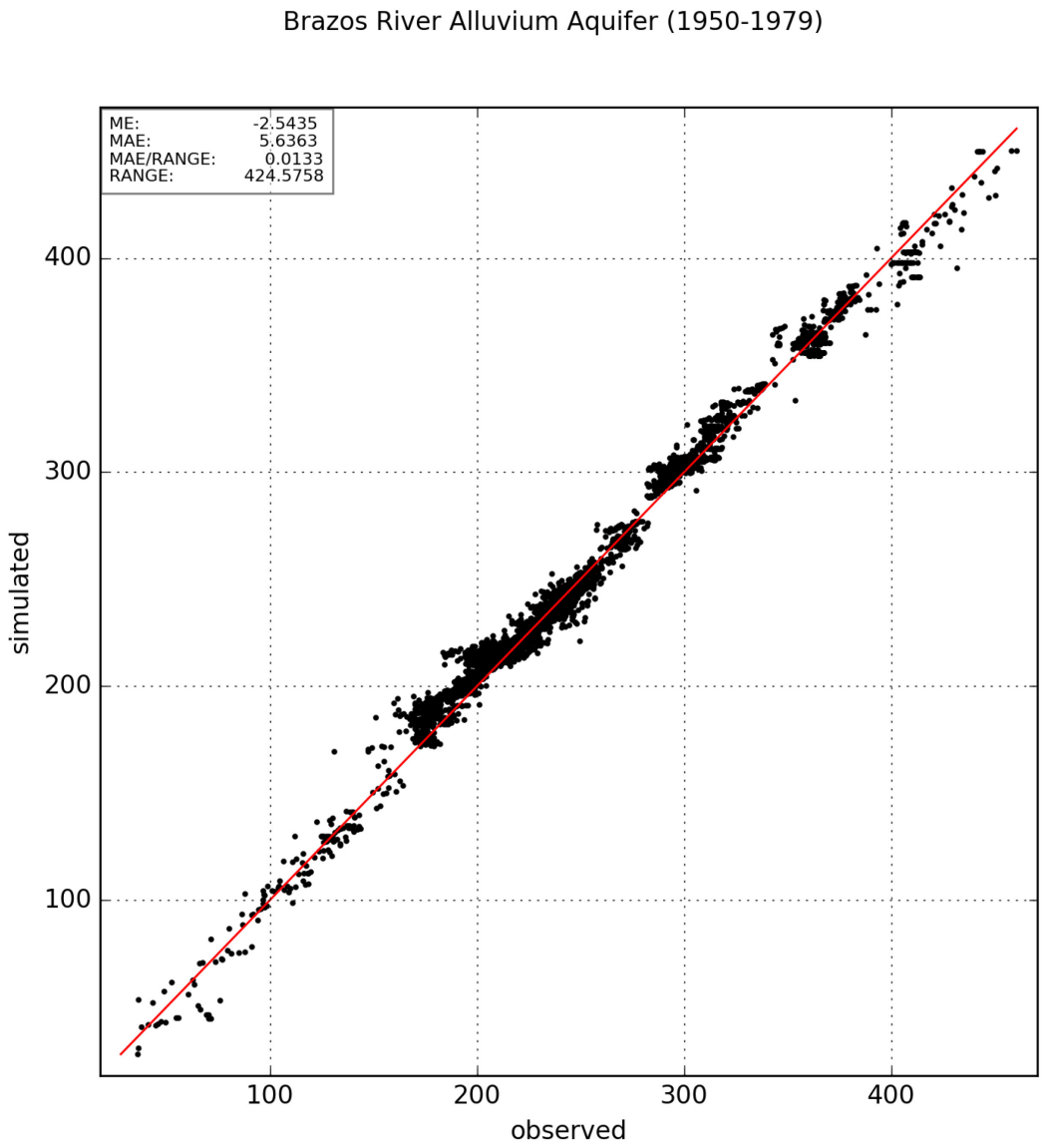


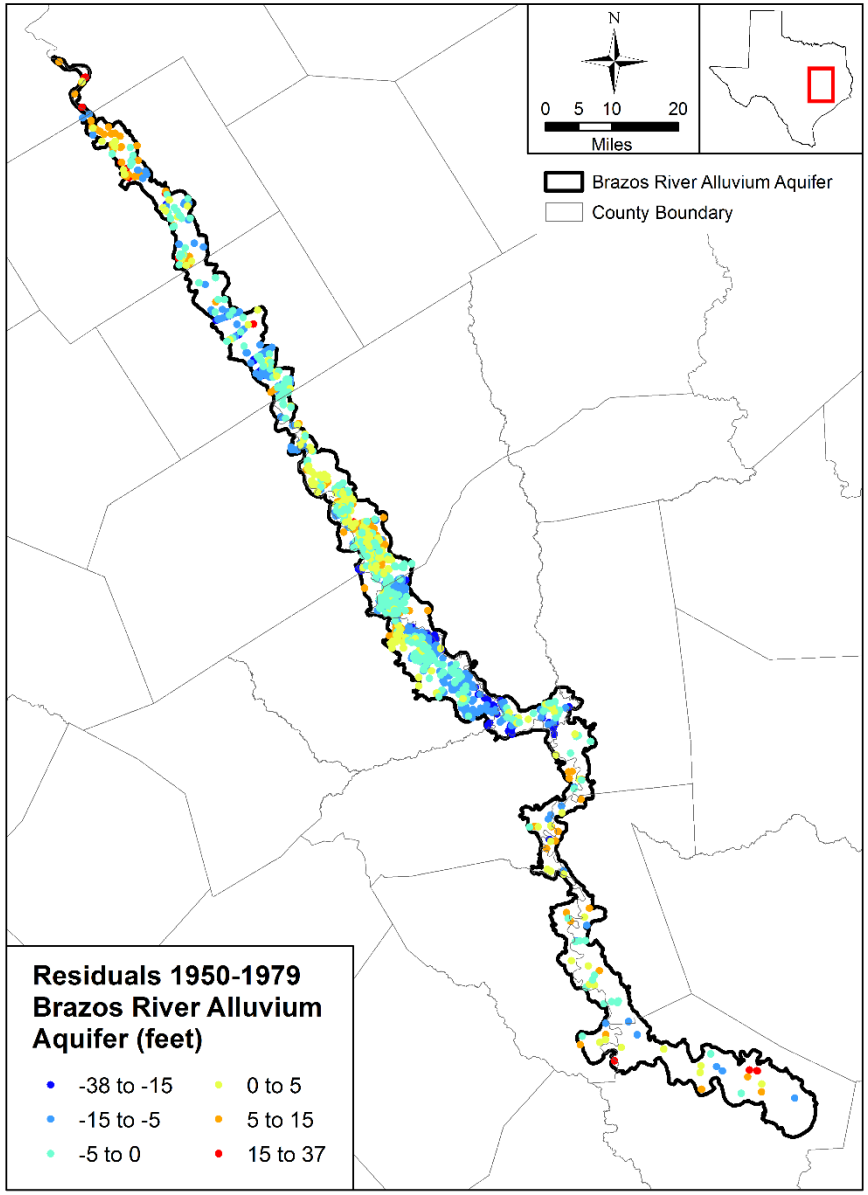

- Few long-term baseflow estimates available
- High observed flows are simulated high
- Low observed flows are simulated low

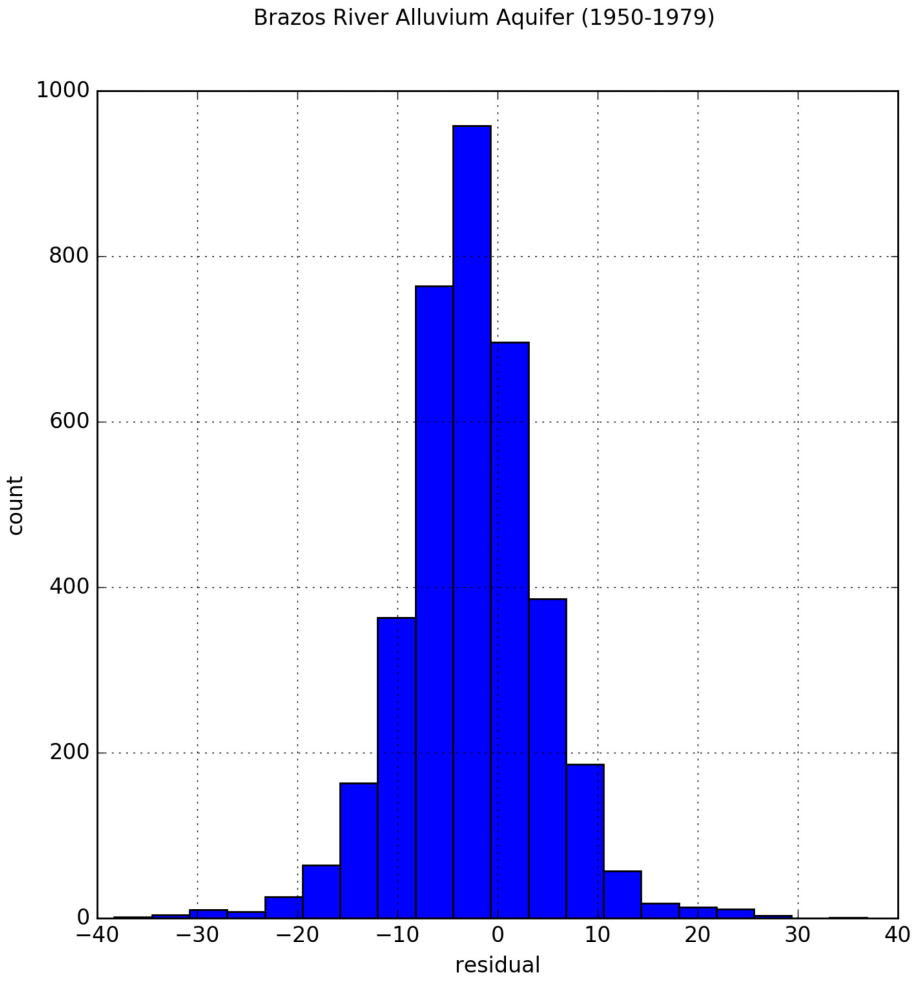
# Transient Calibration – Early Period



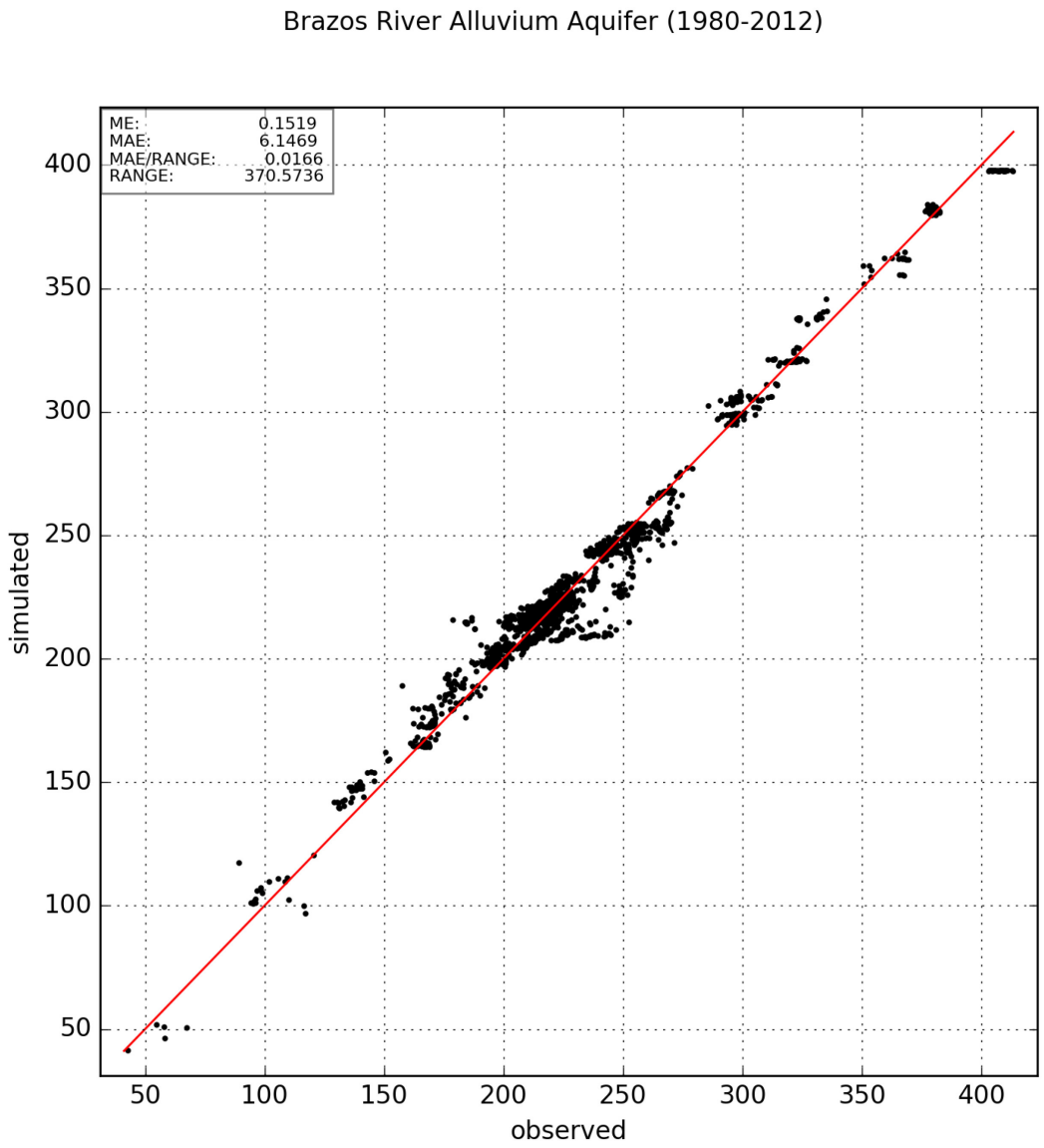

- Many transient head targets between 1950 and 1979
- Good fit between simulated and observed heads
- Early time data helps constrain steady-state model

# Transient Calibration – Early Period



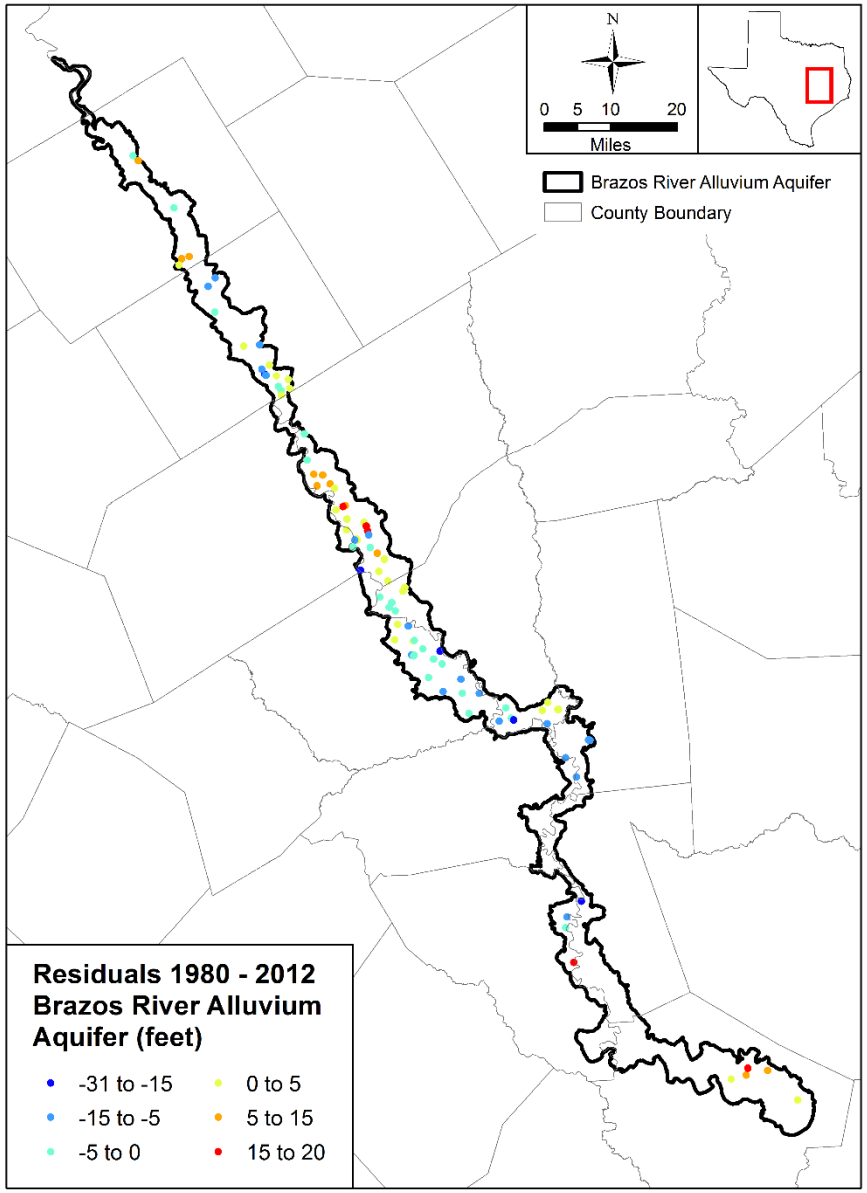



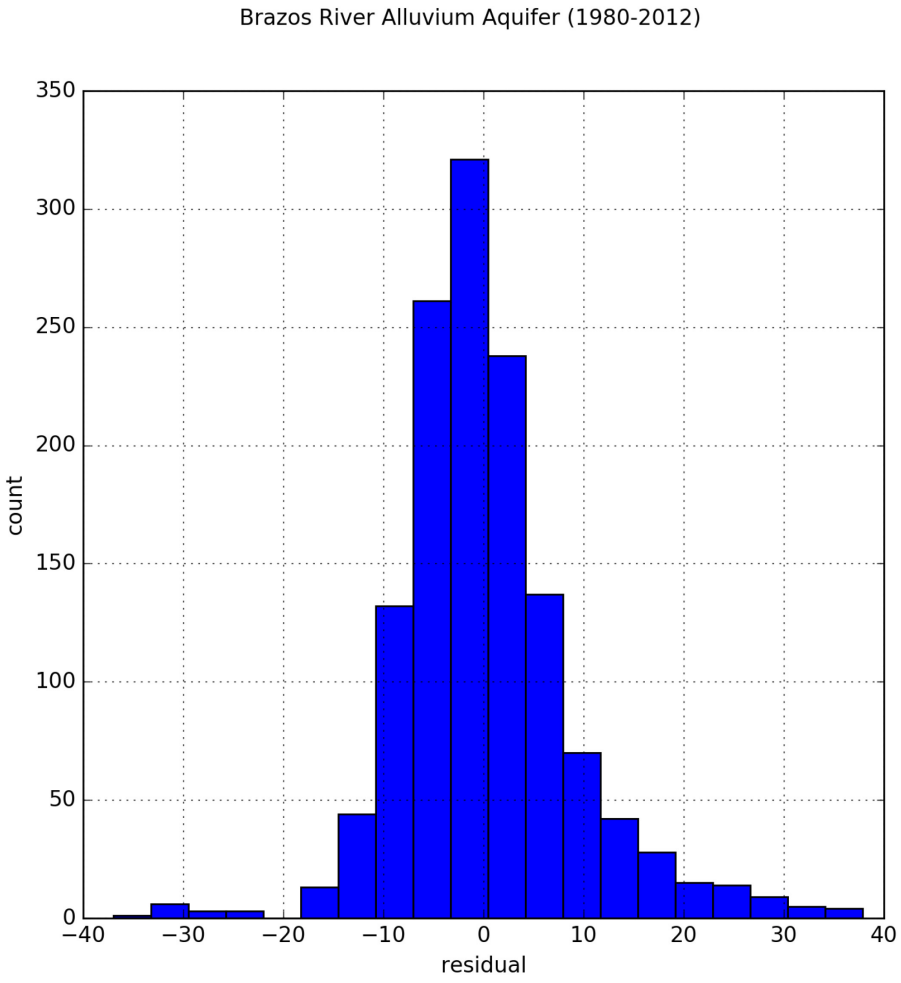
# Transient Calibration – Late Period



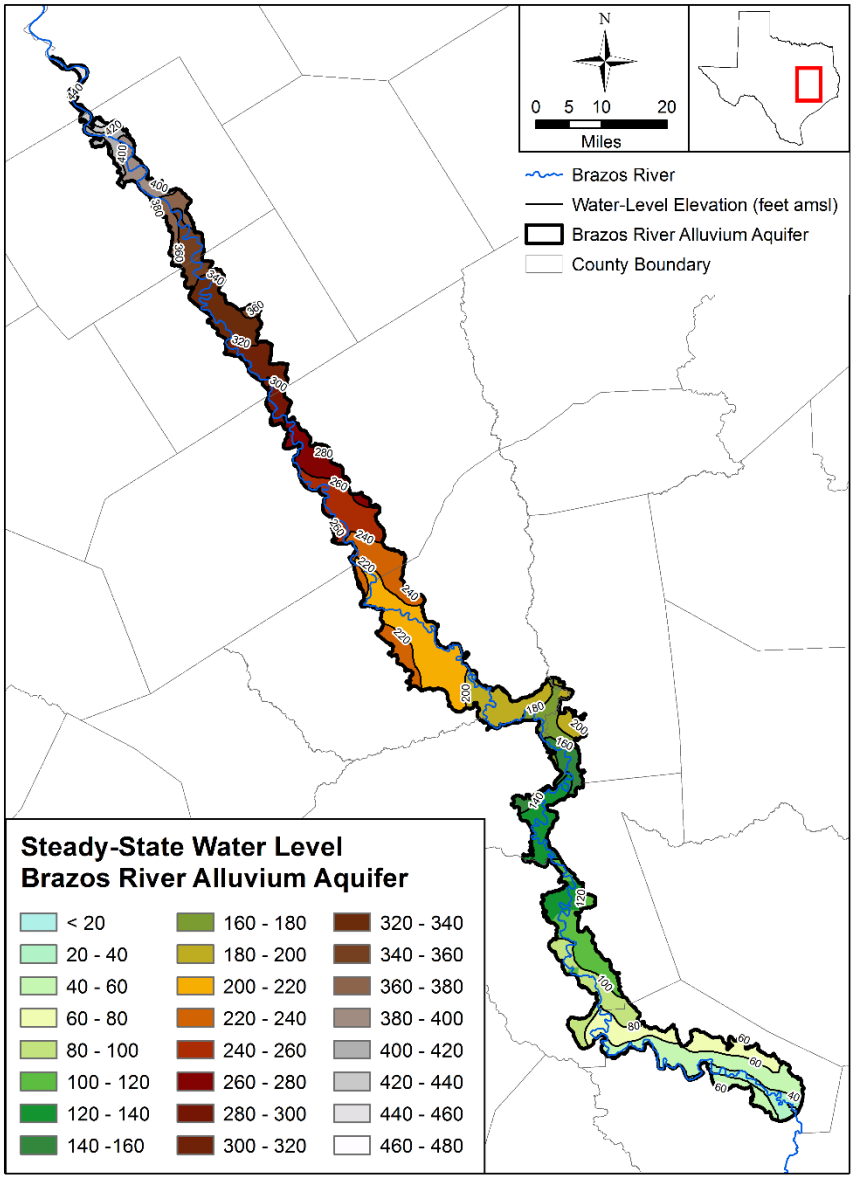

- Many transient head targets between 1980 and 2012
- Good fit between simulated and observed heads

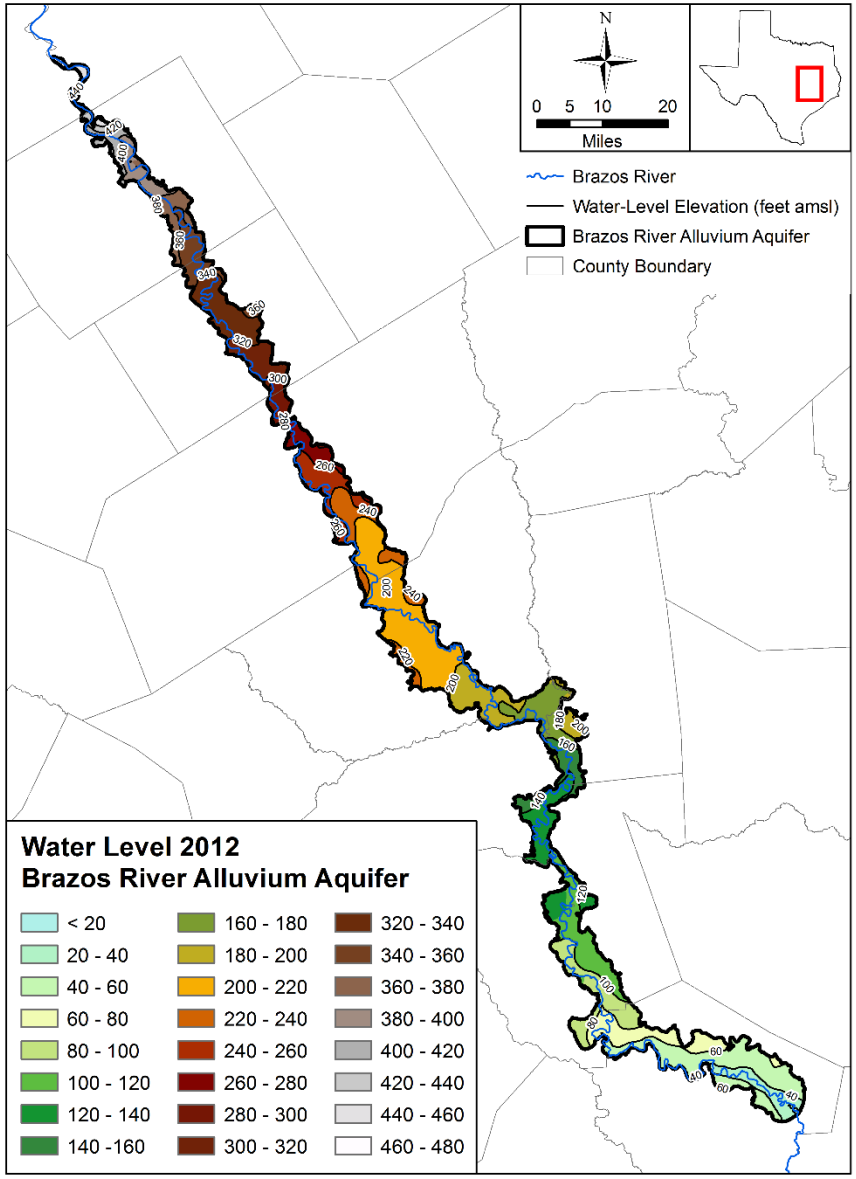
# Transient Calibration – Late Period



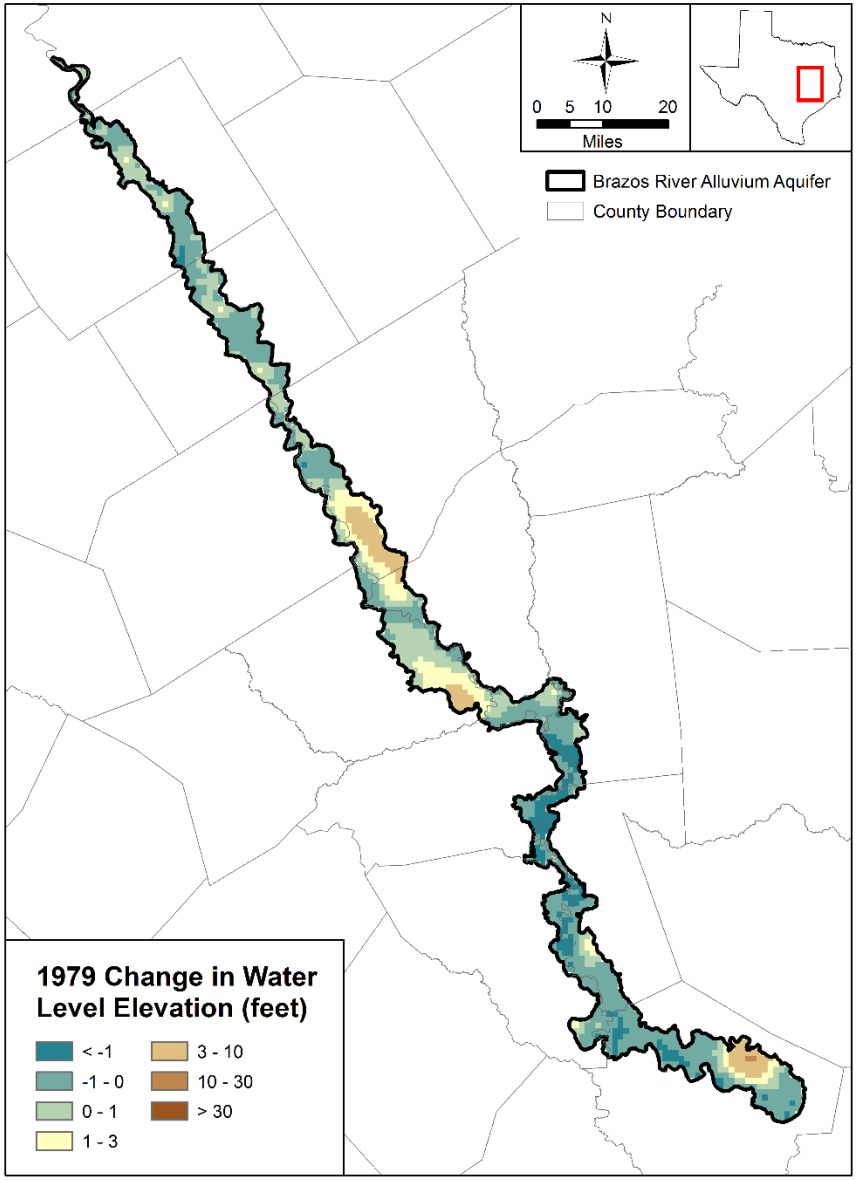



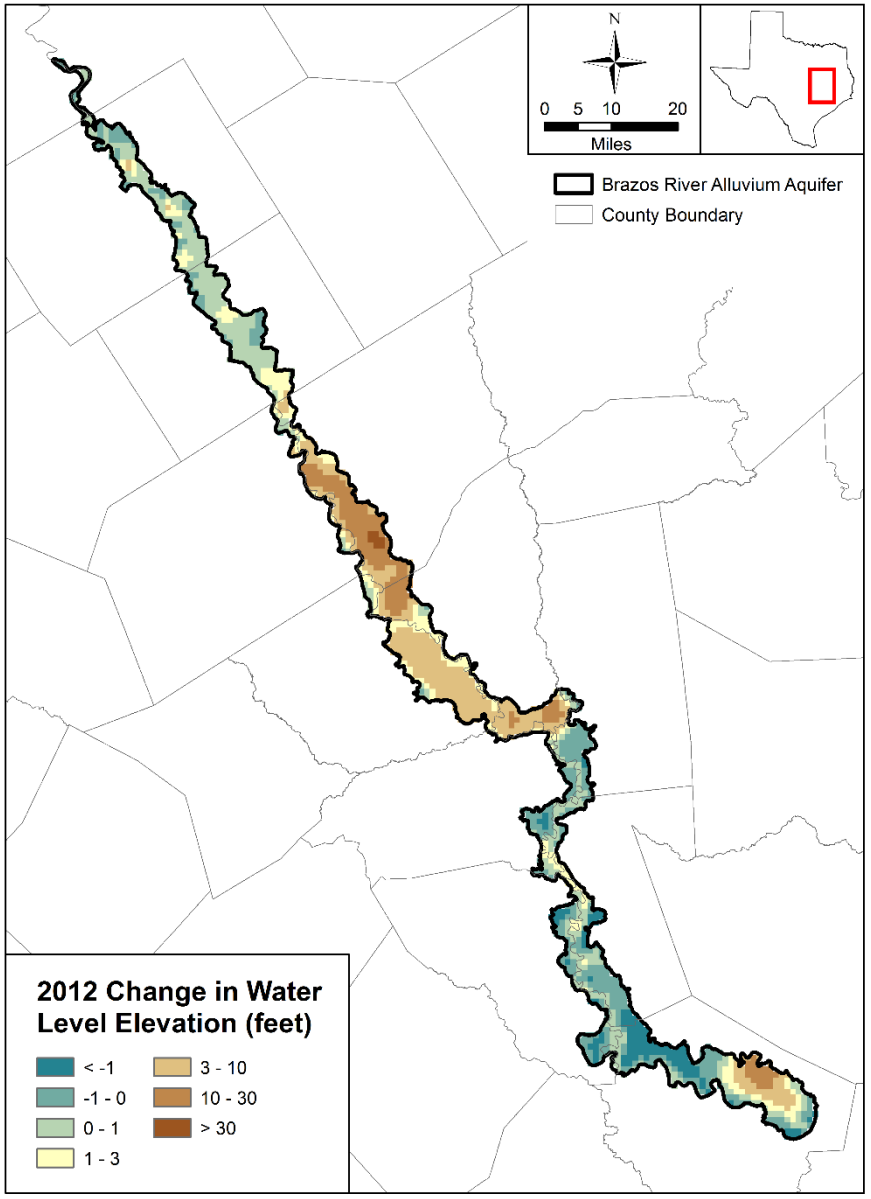
# Simulated Water Levels



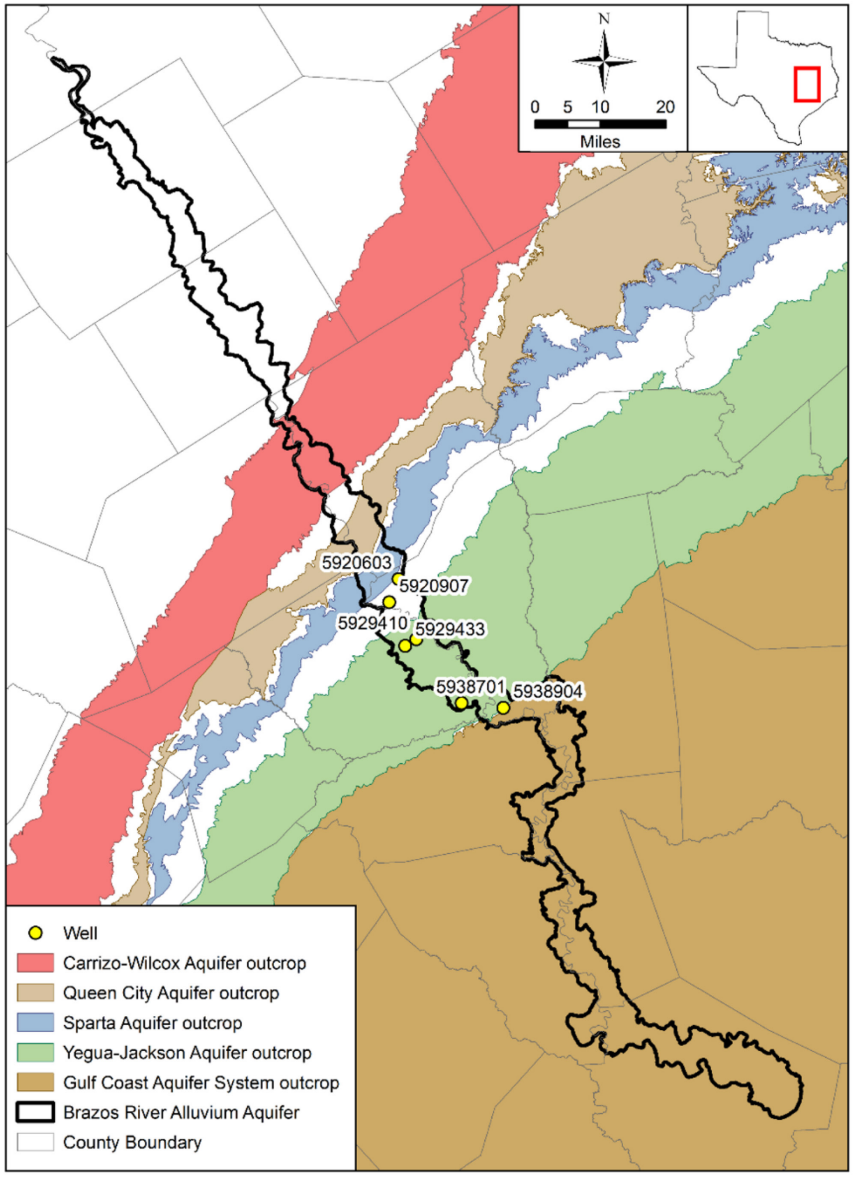



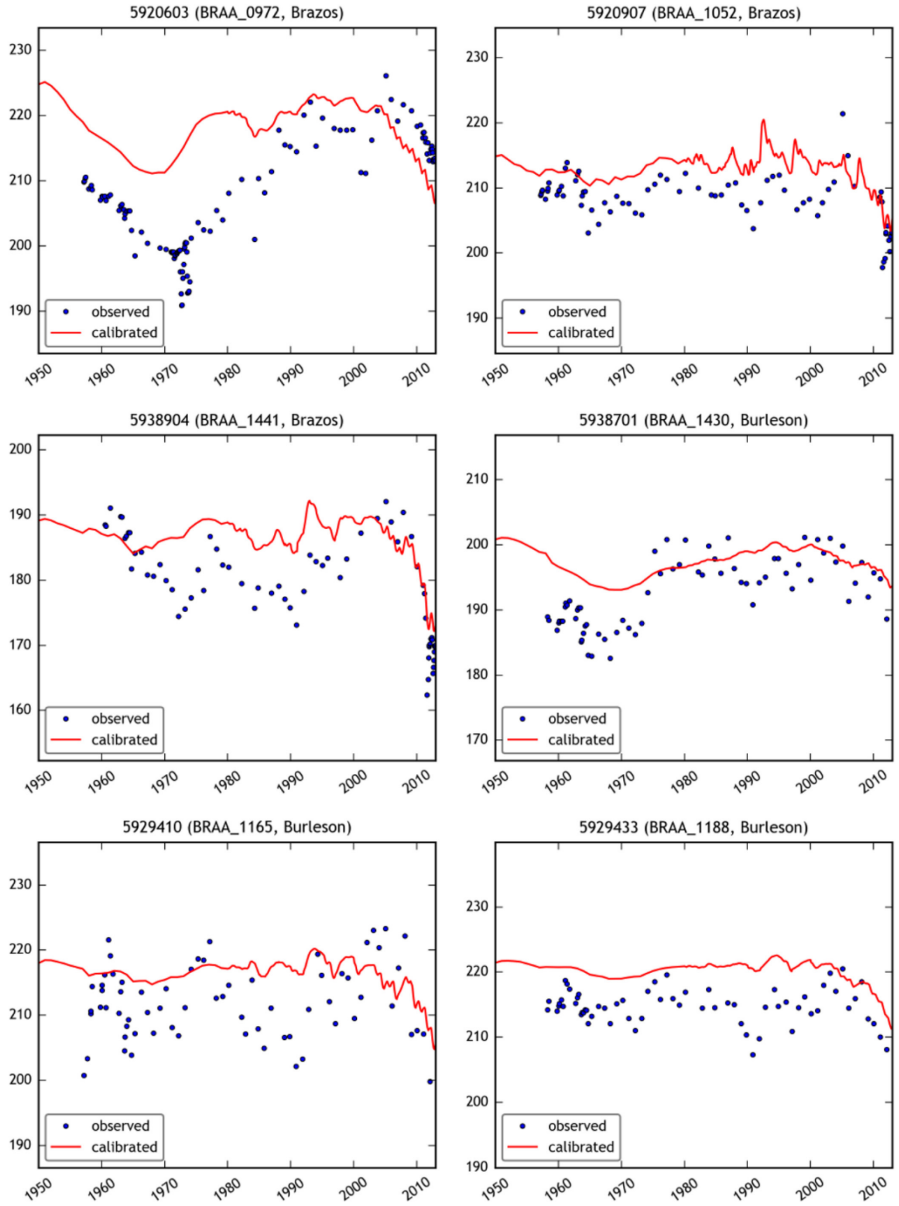
# Simulated Drawdown



# Simulated and Observed Hydrographs



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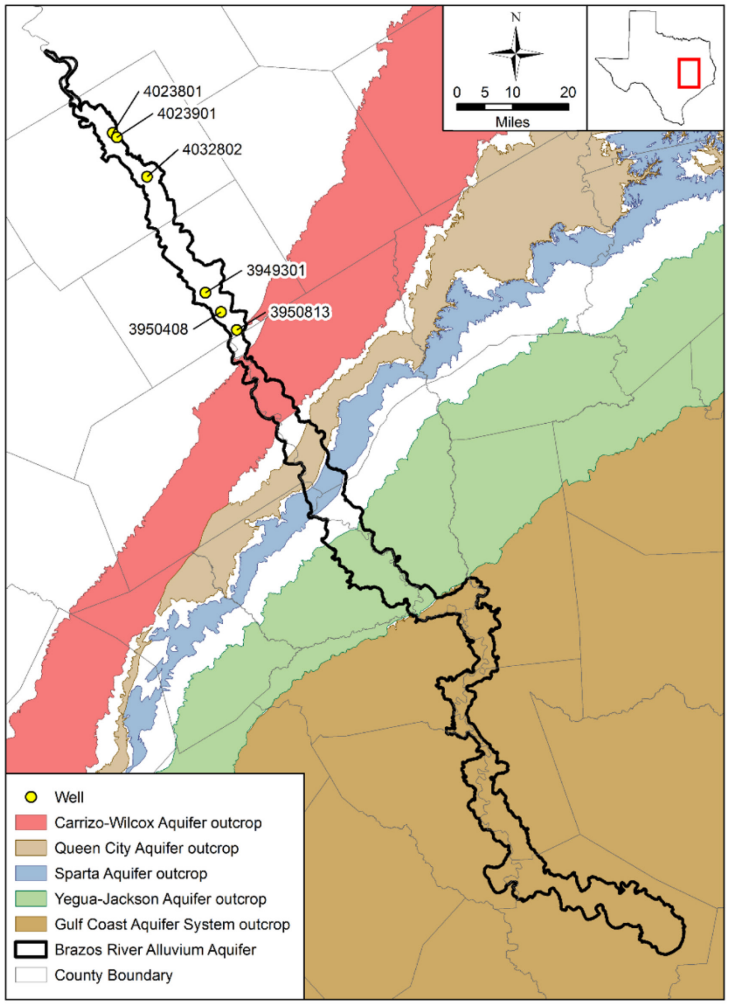
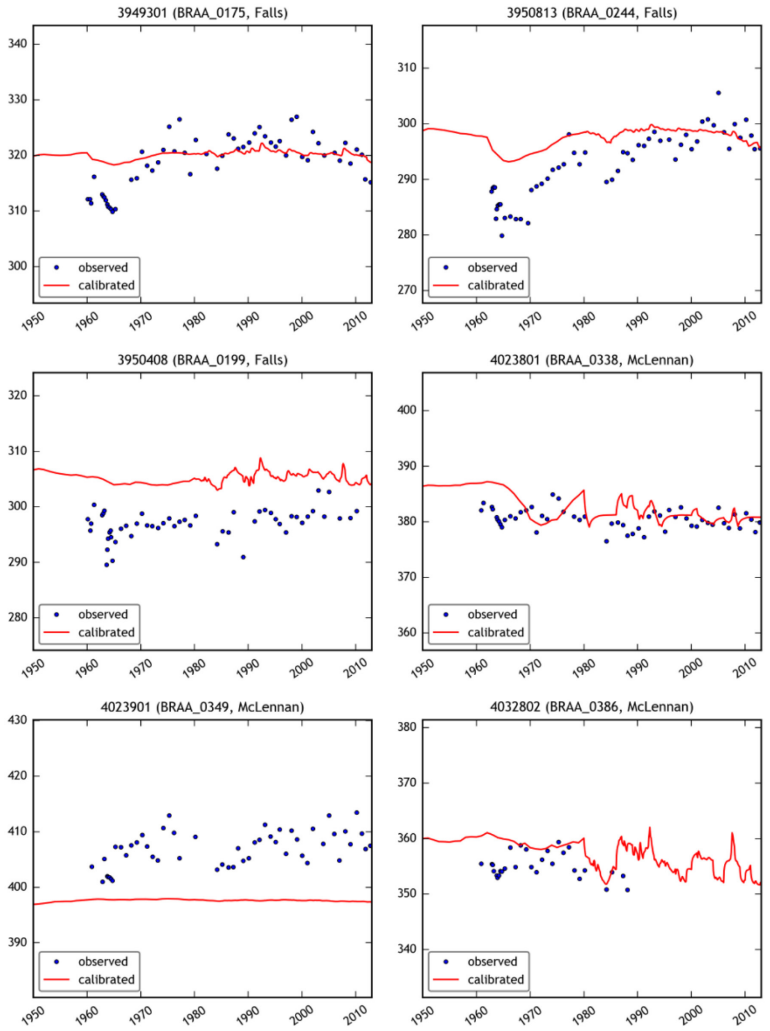
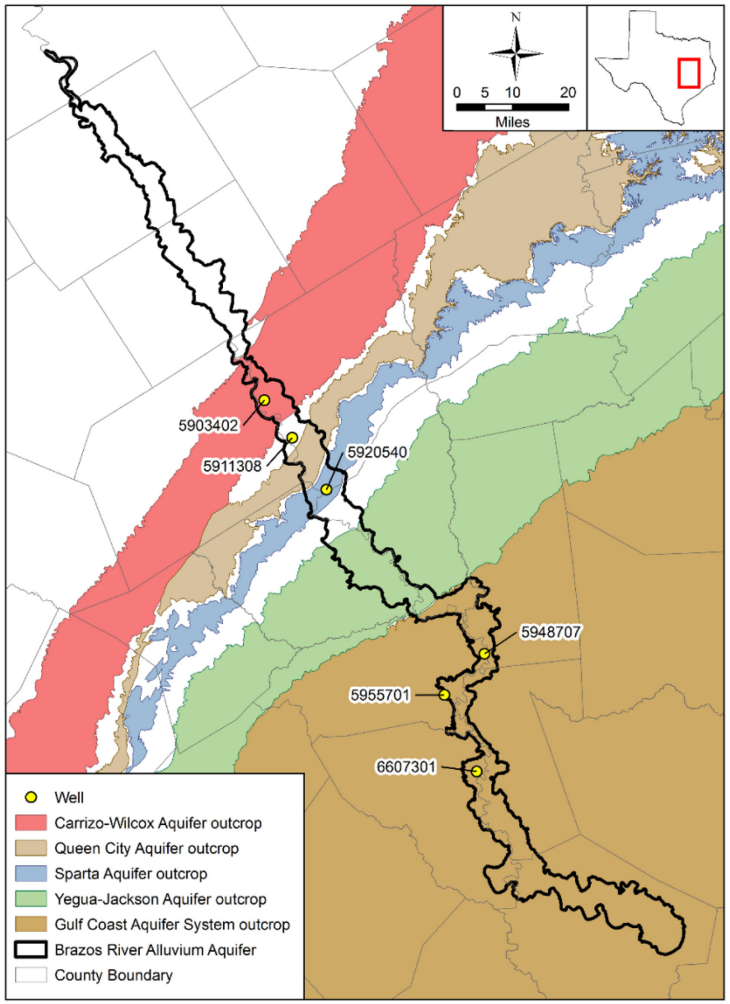
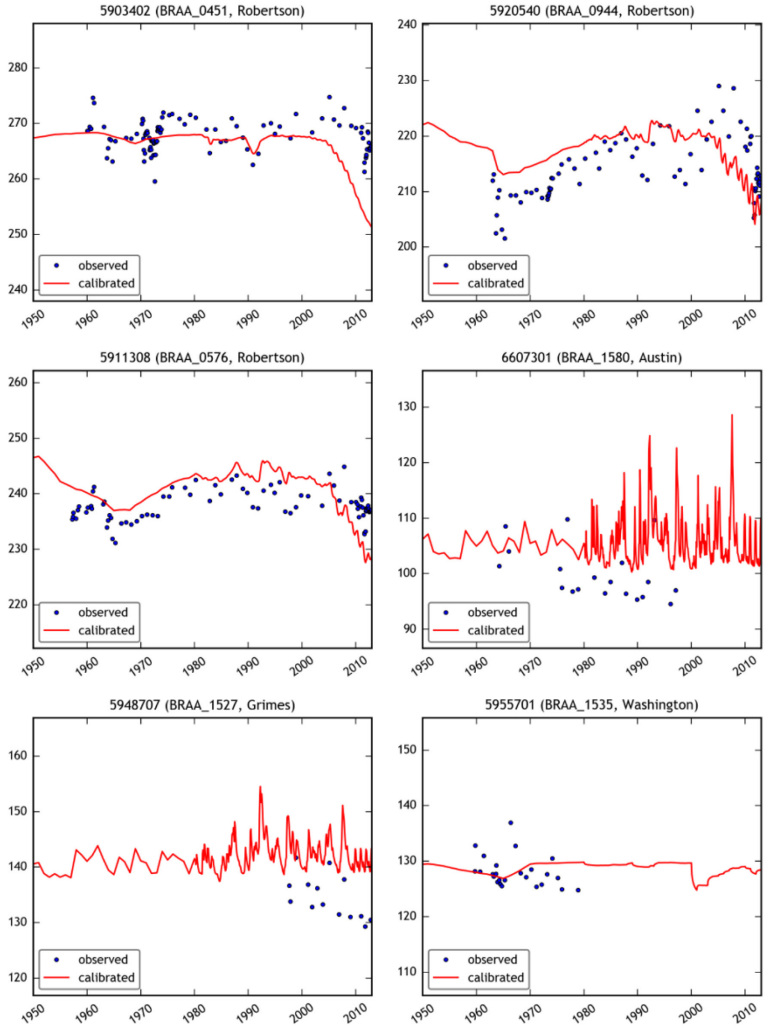


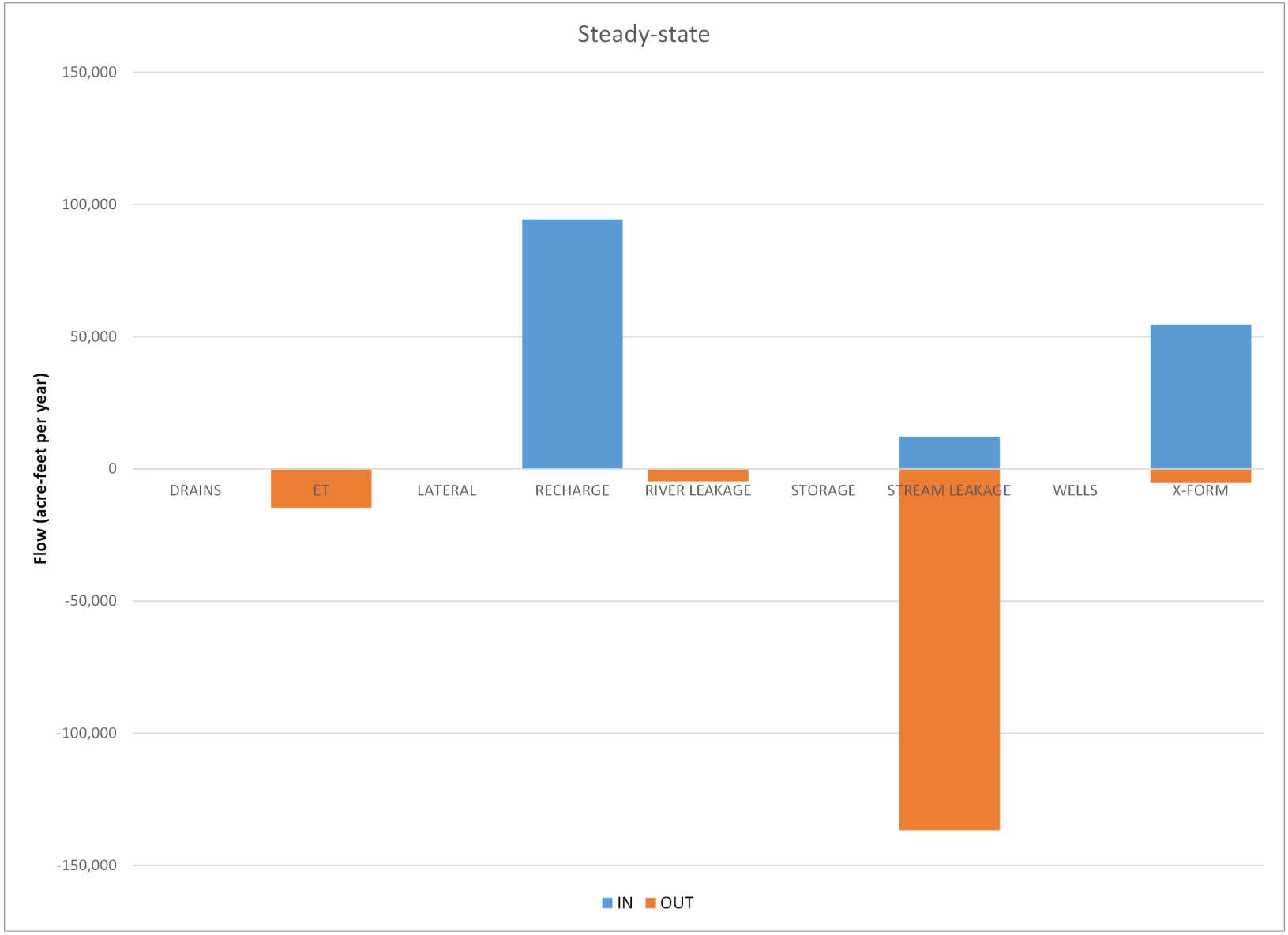



# Simulated and Observed Hydrographs

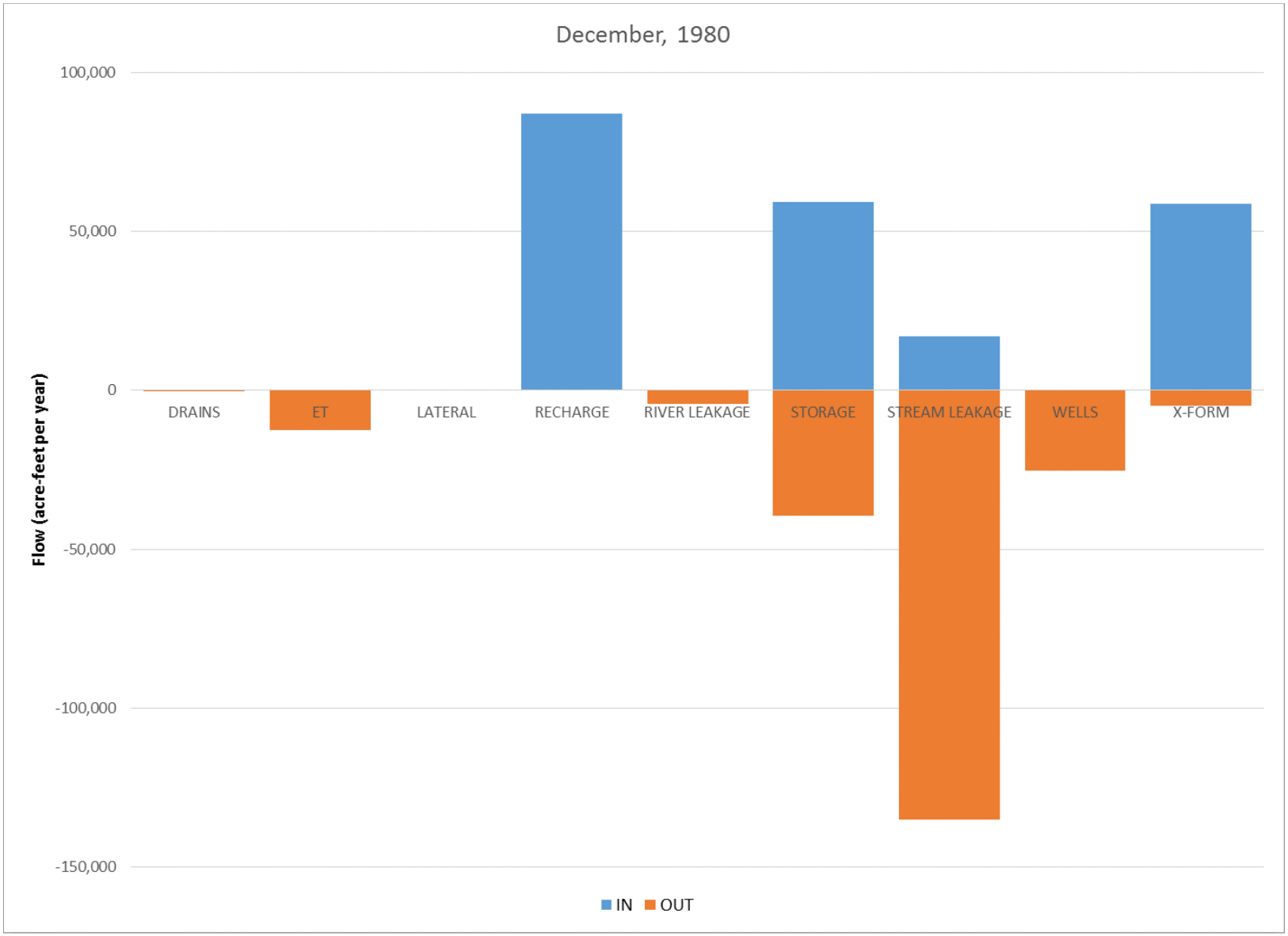


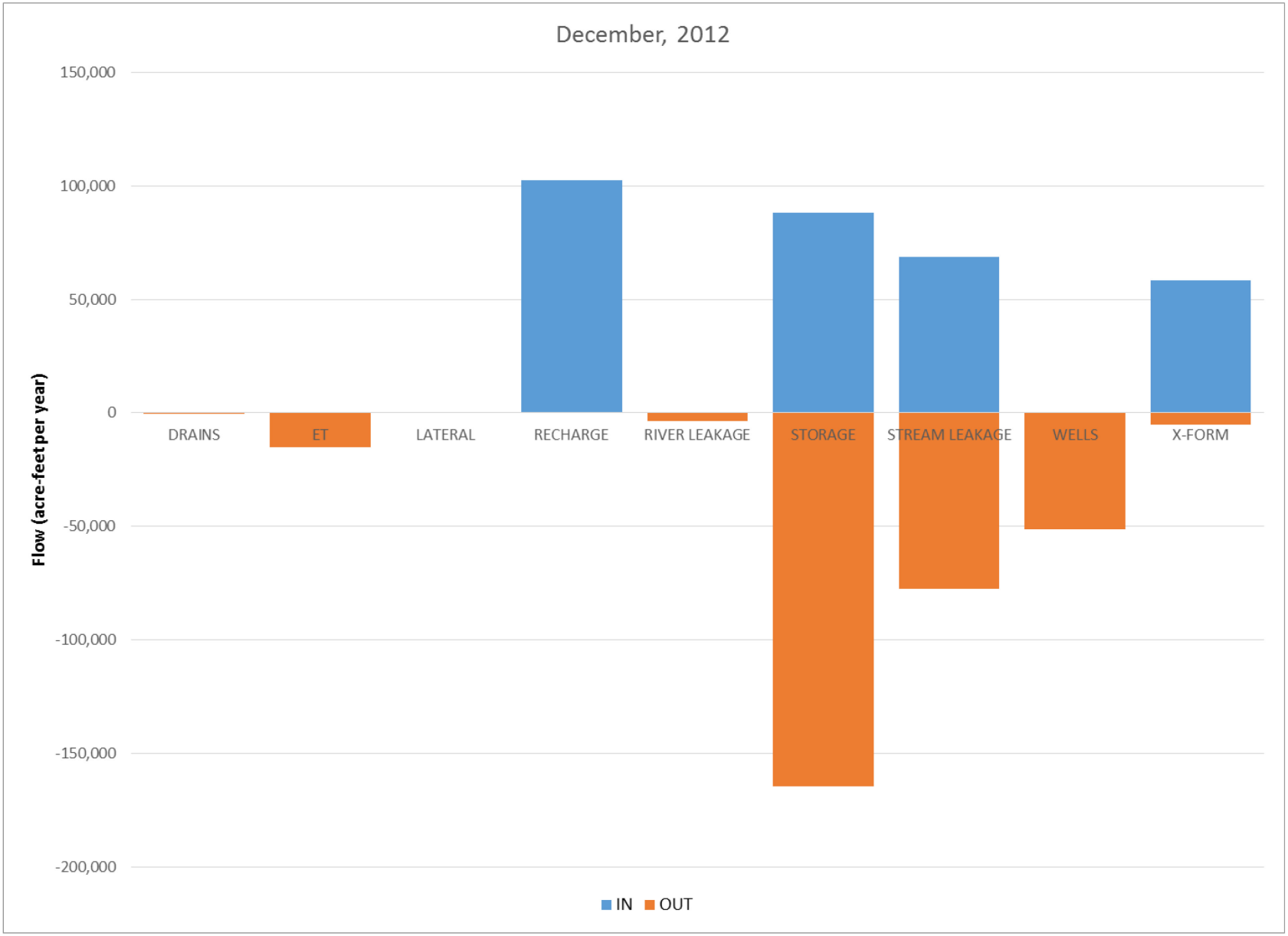
# Steady-State Water Balance



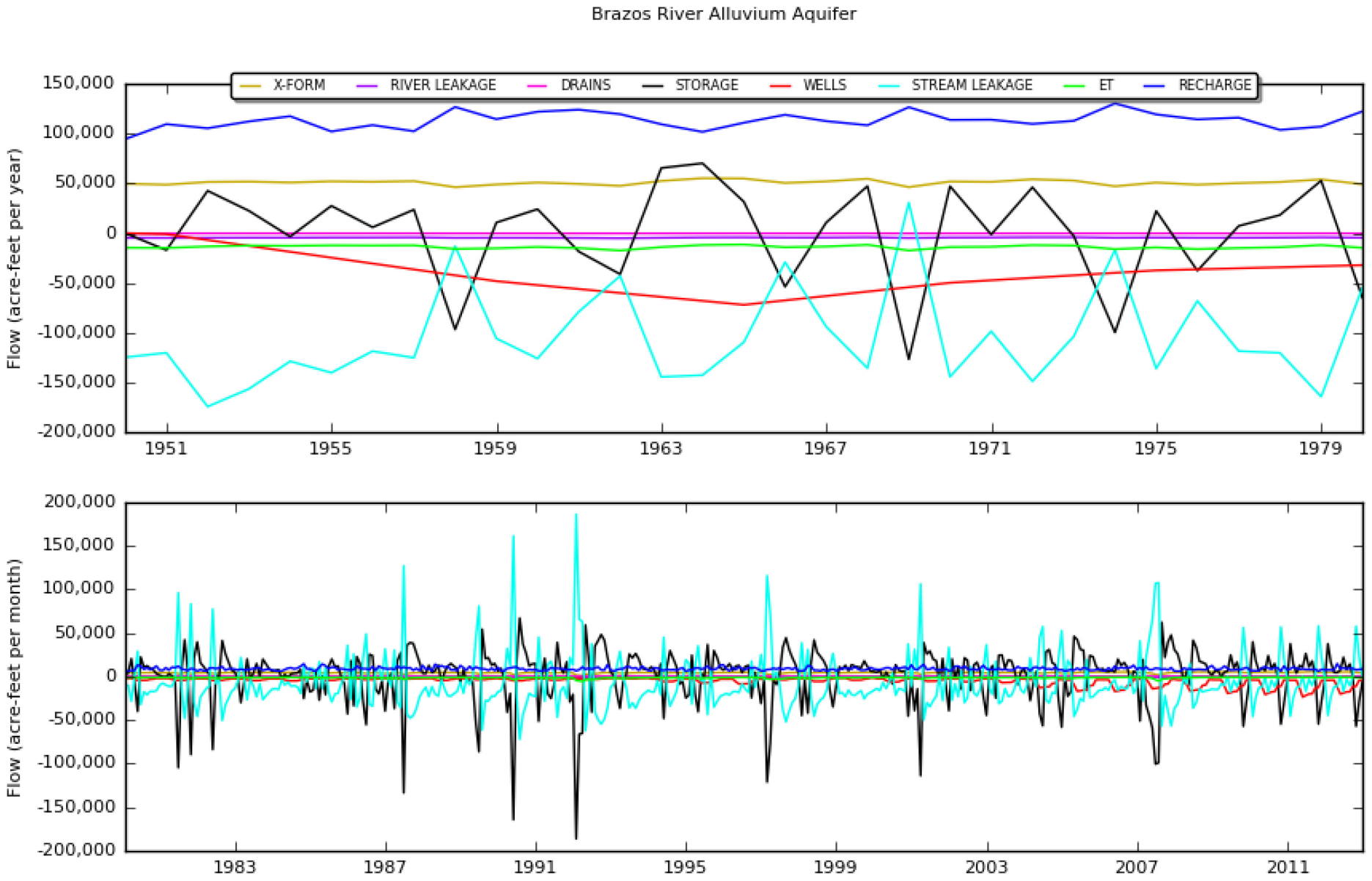
# Transient Water Balance – December, 1980



# Transient Water Balance – December, 2012



# Transient Water Balance



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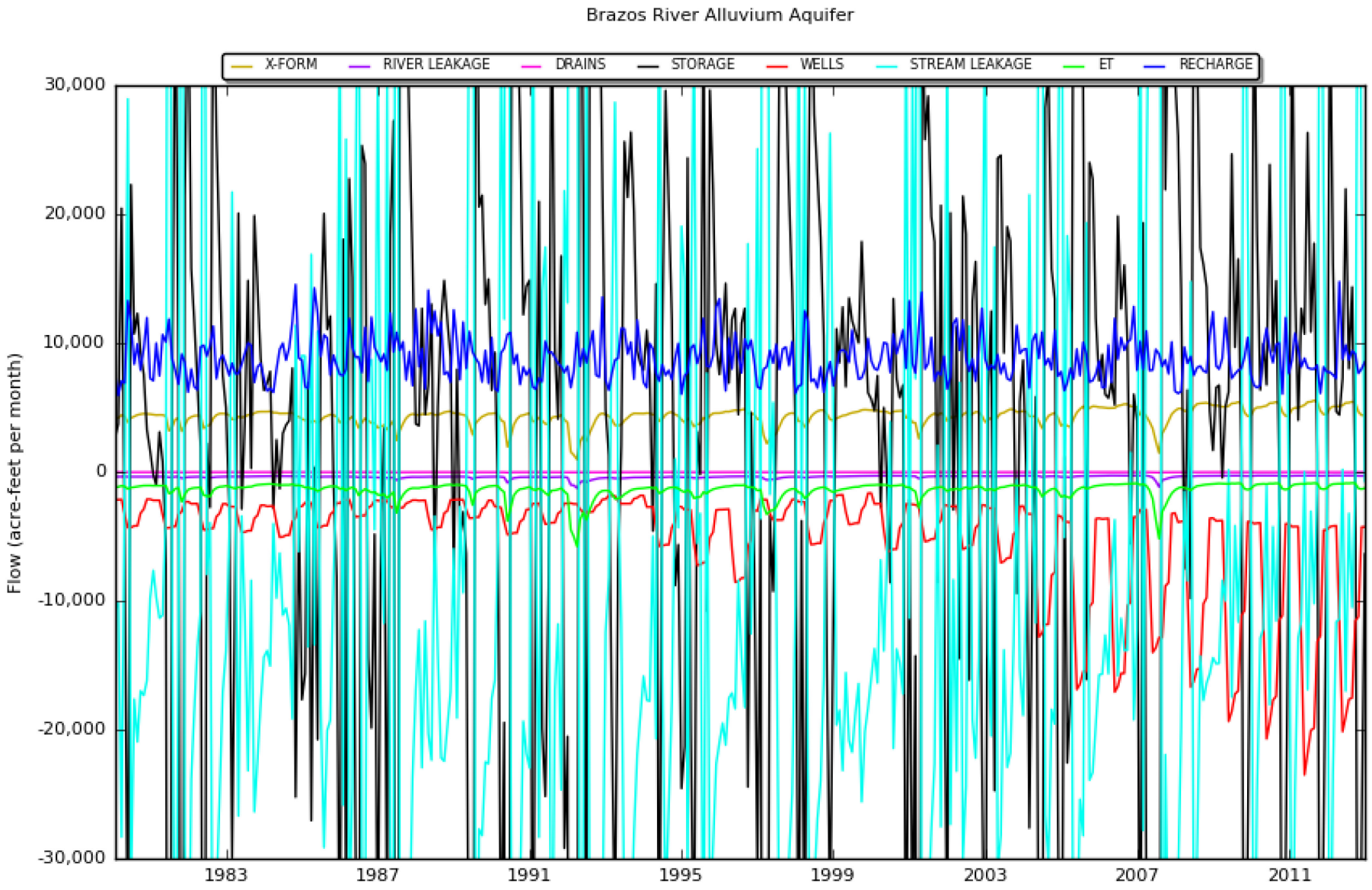
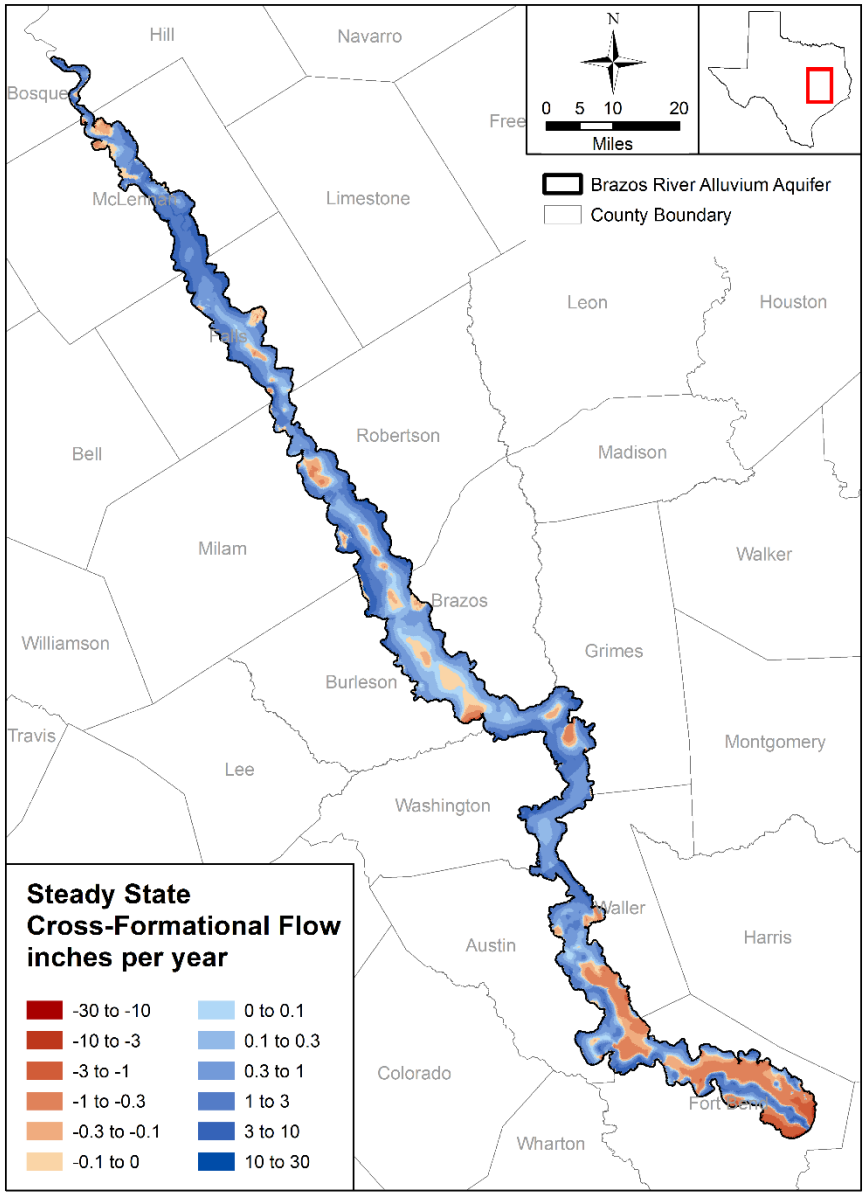
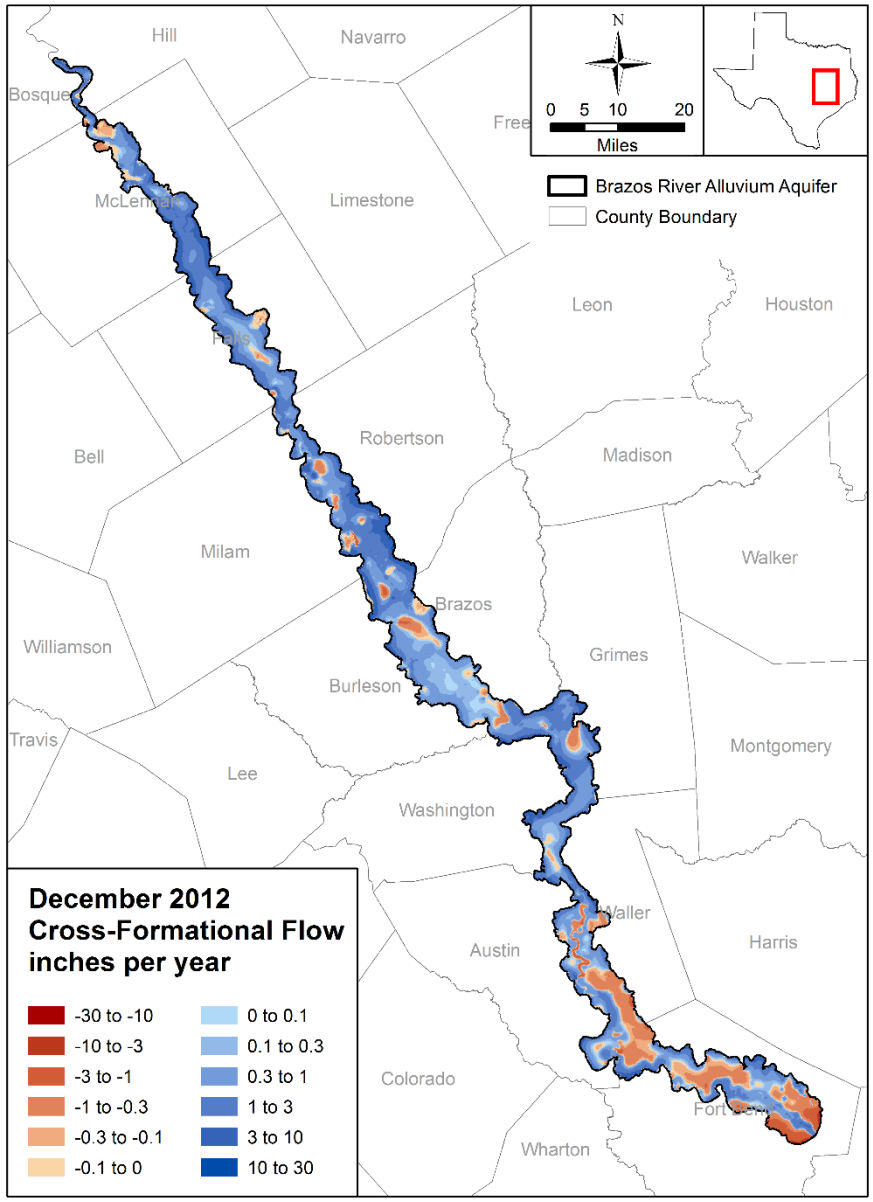
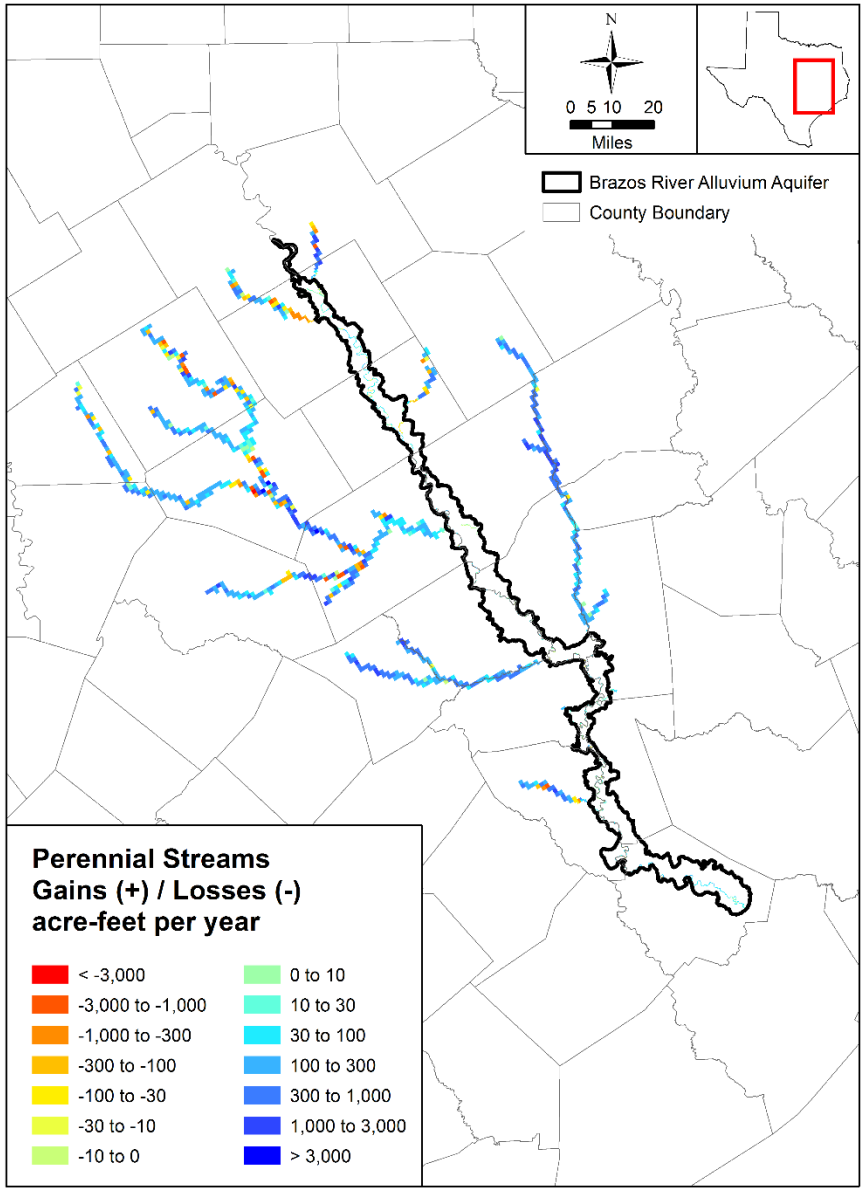


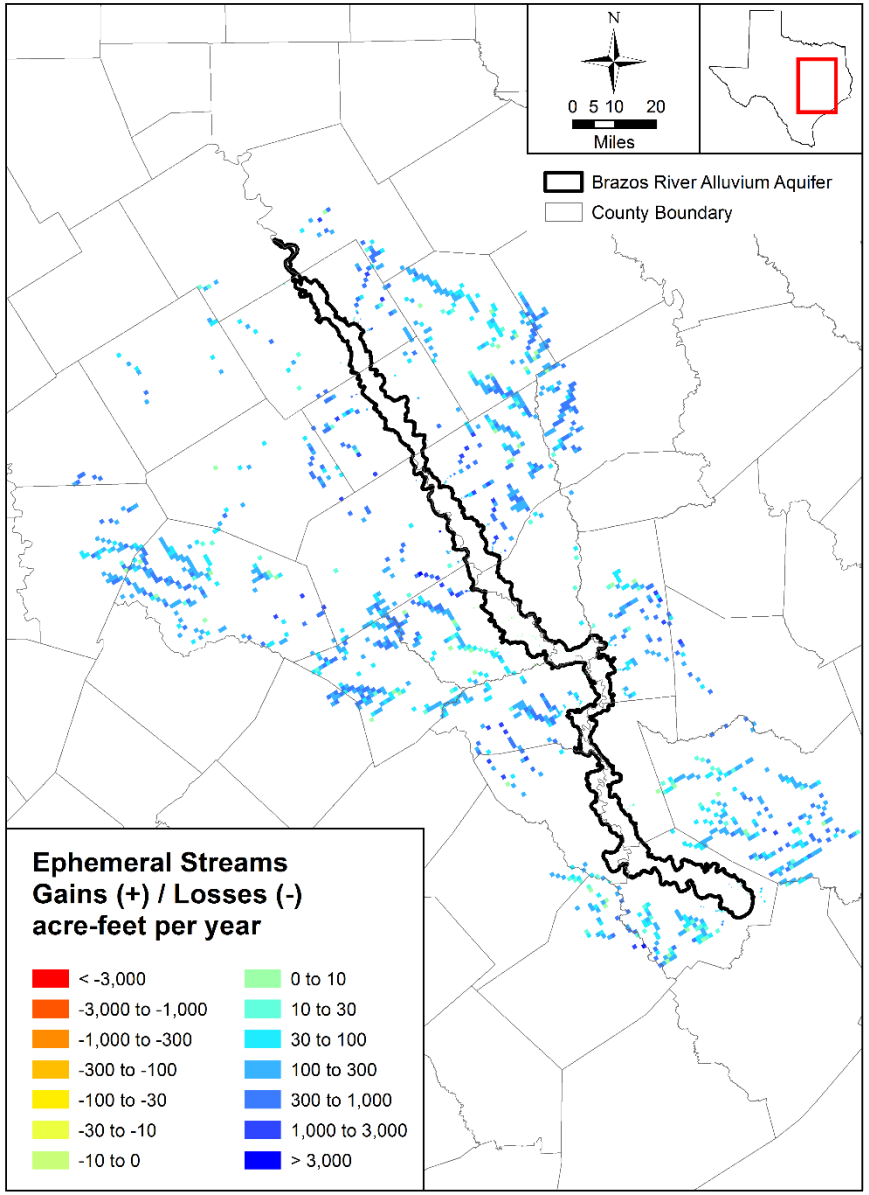
# Cross-Formational Flow



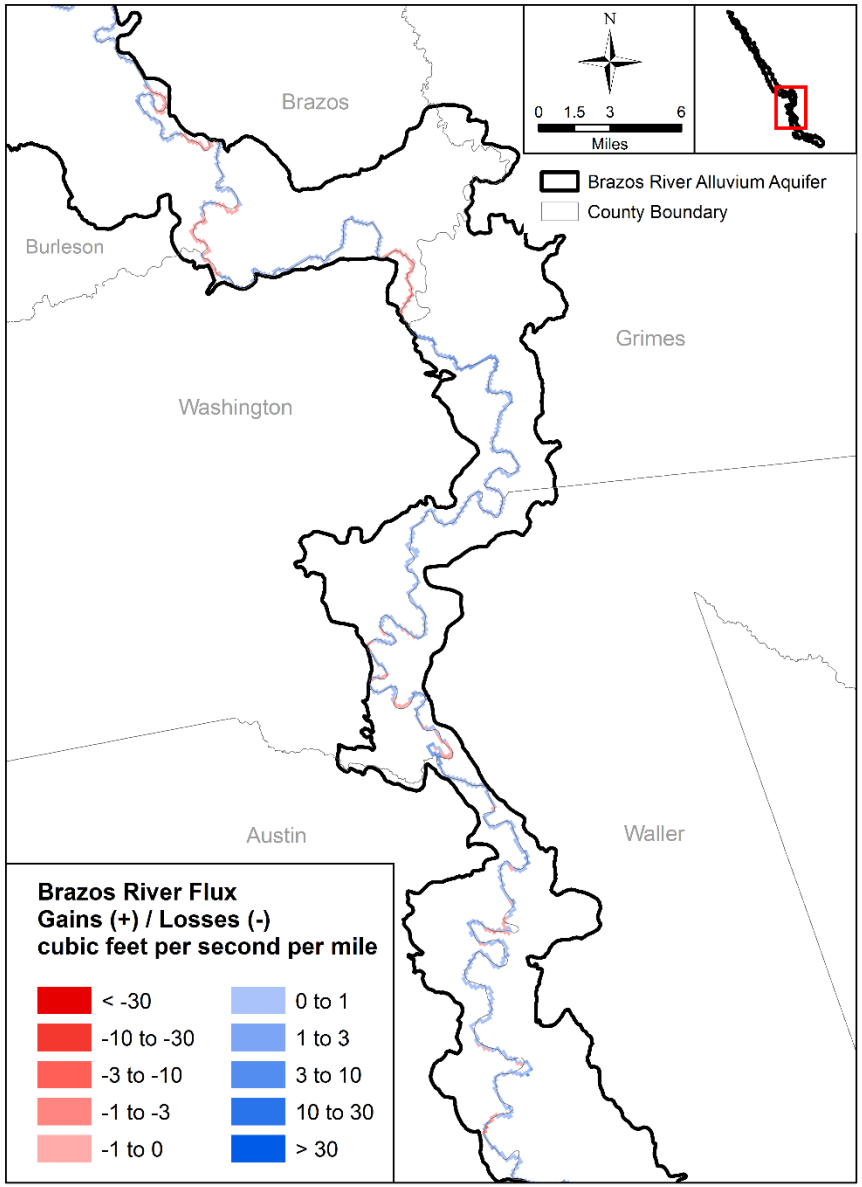



# Steady-State Stream Gains/Losses

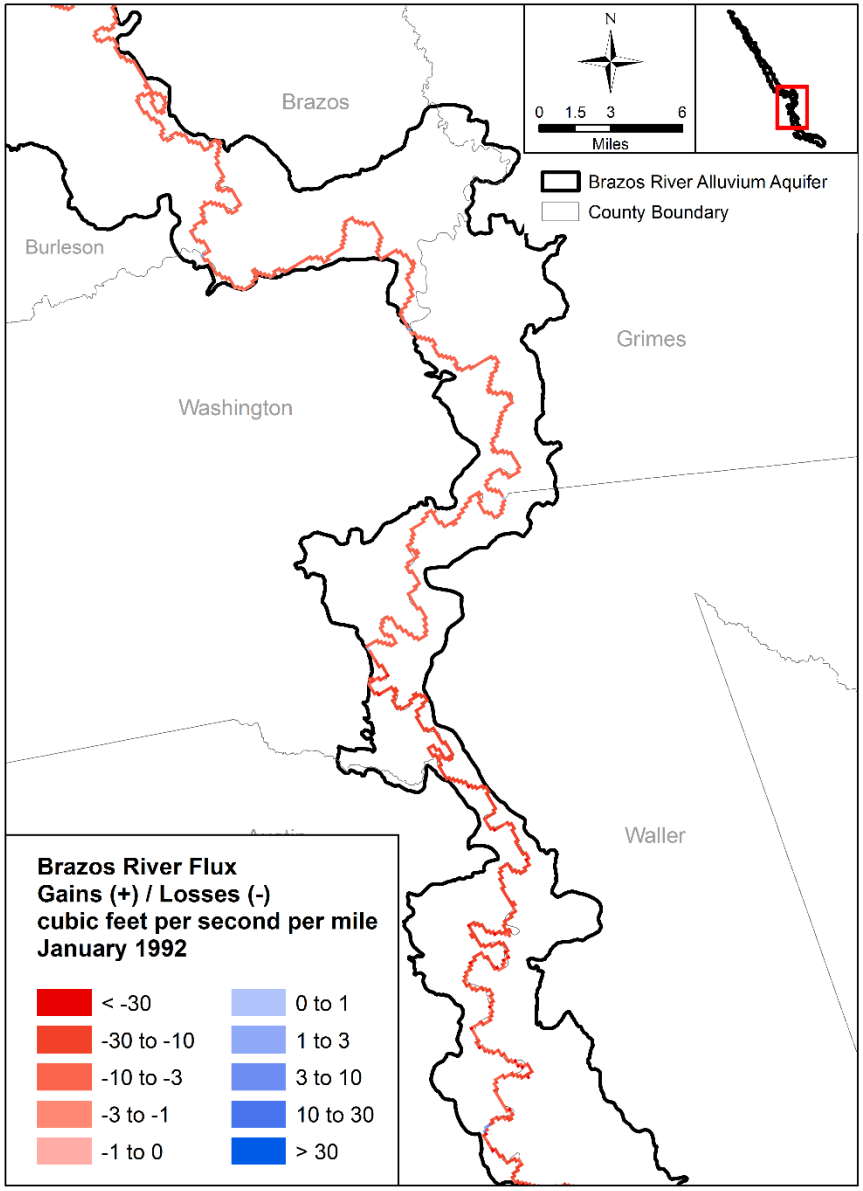


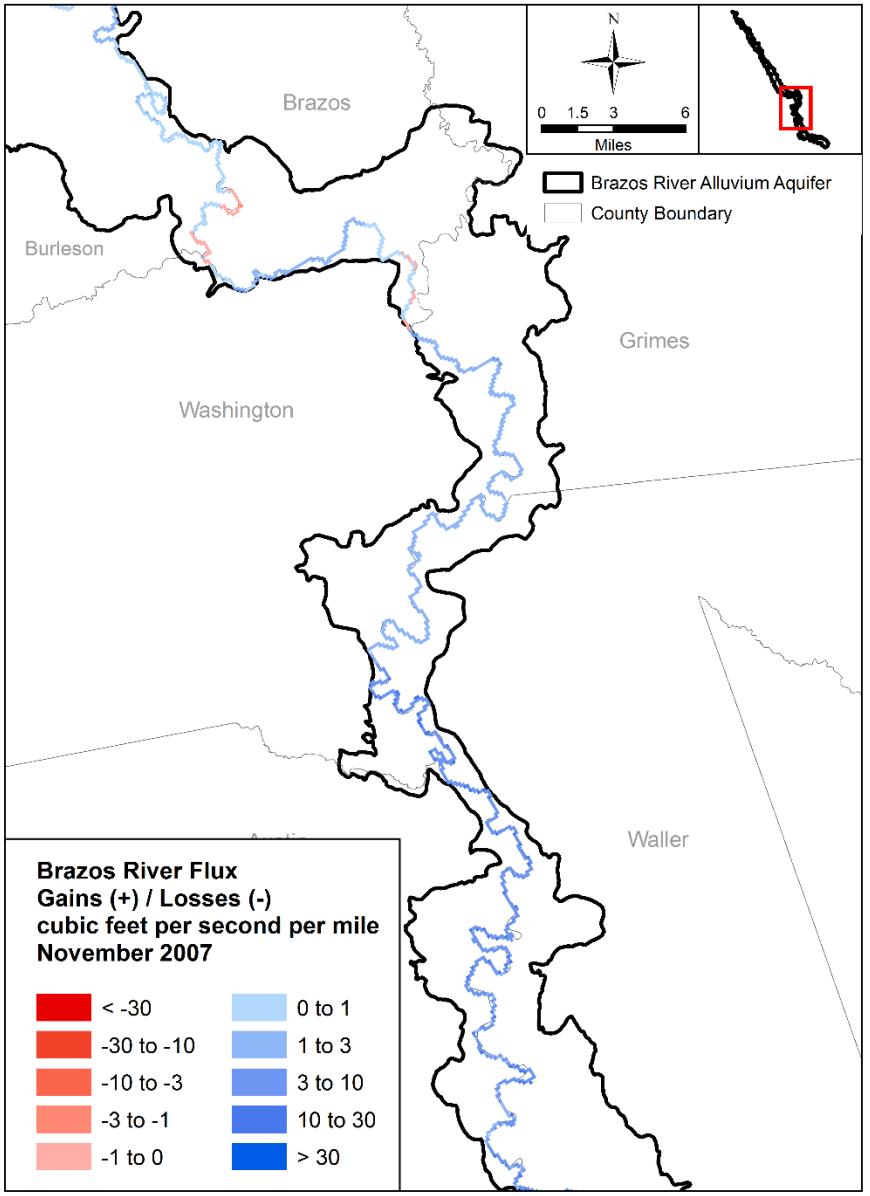



# Steady-State Stream Gains/Losses in Brazos River

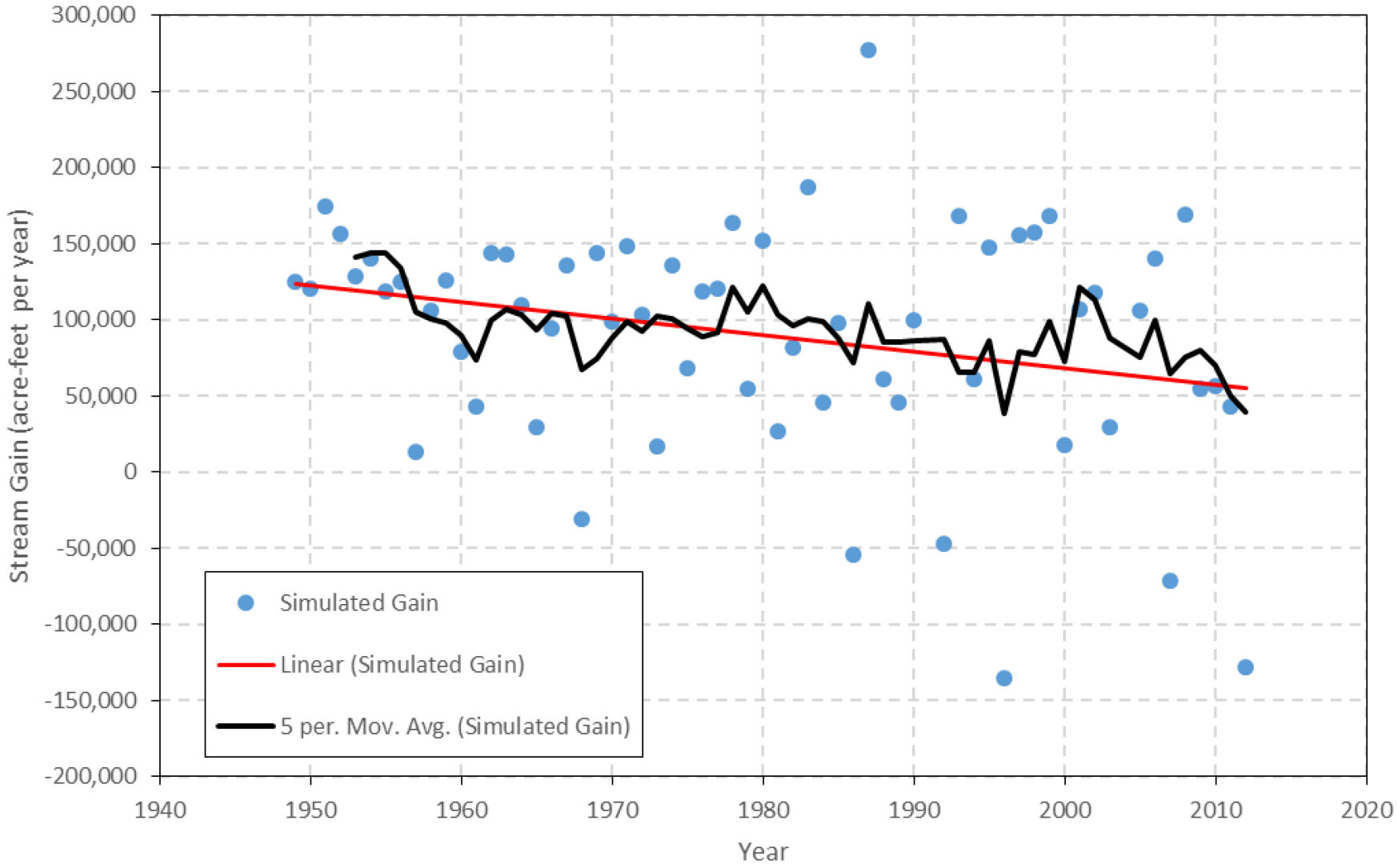


# Transient Stream Gains/Losses in Brazos River

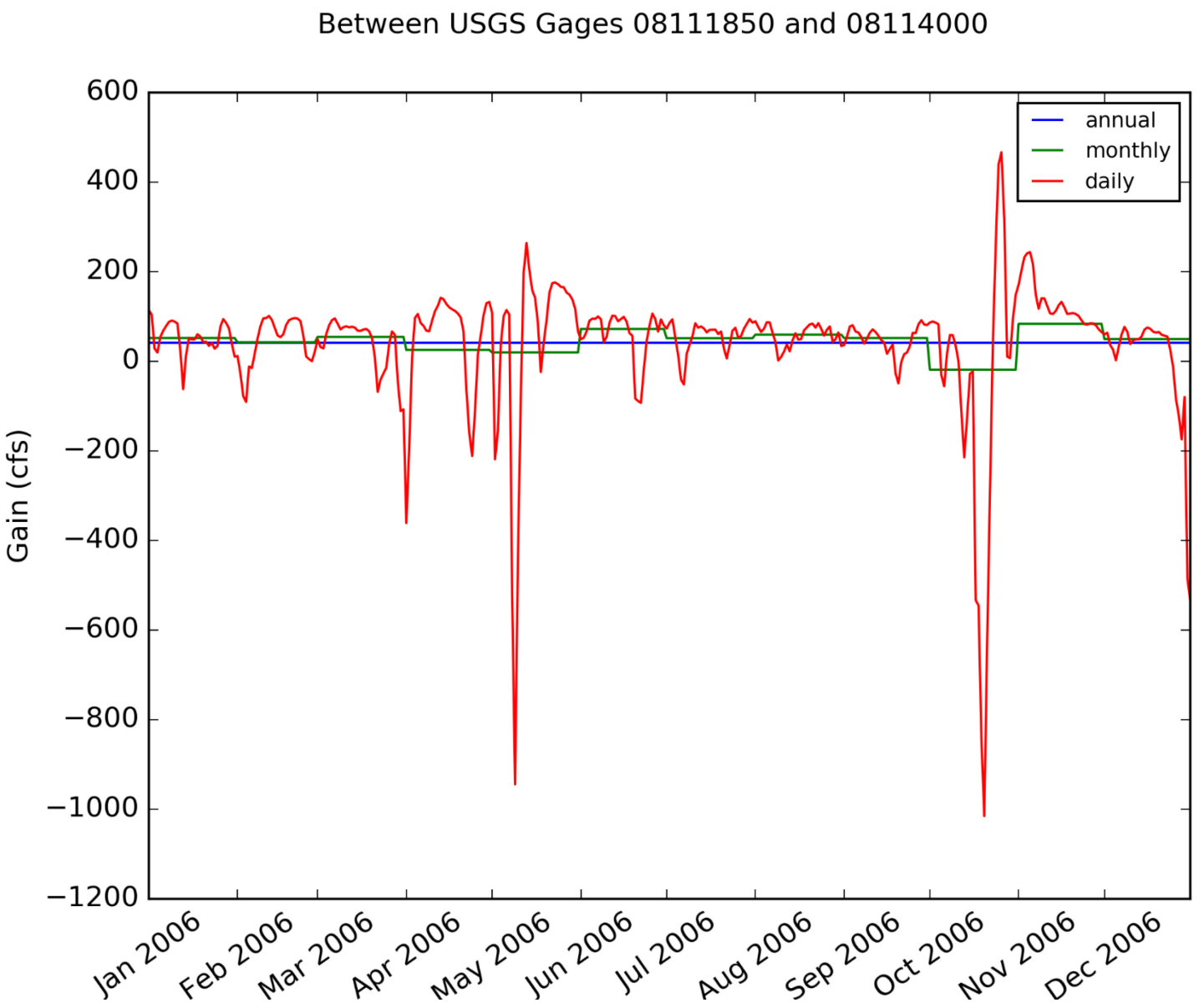


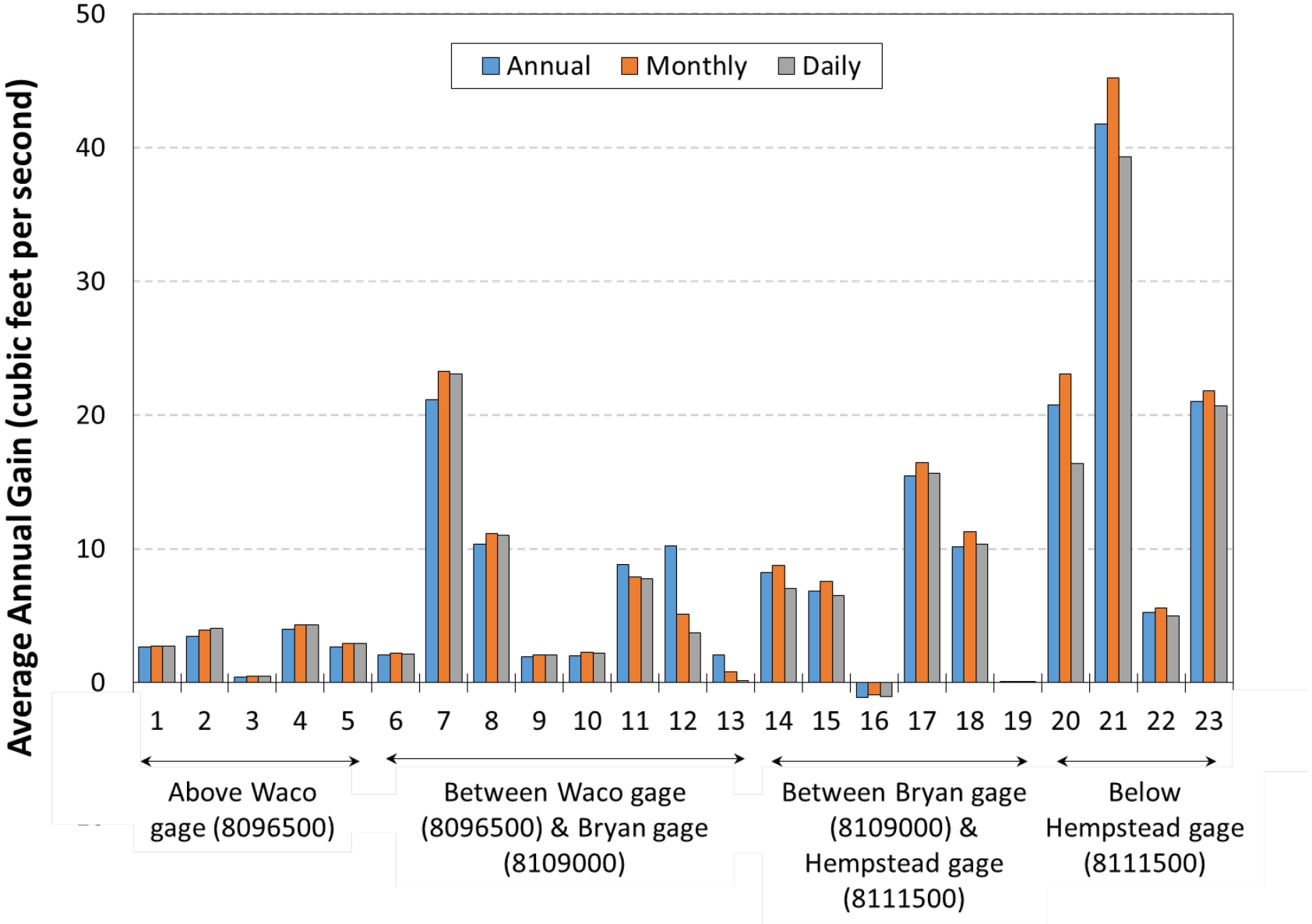
# Transient Stream Gains/Losses in Brazos River Alluvium



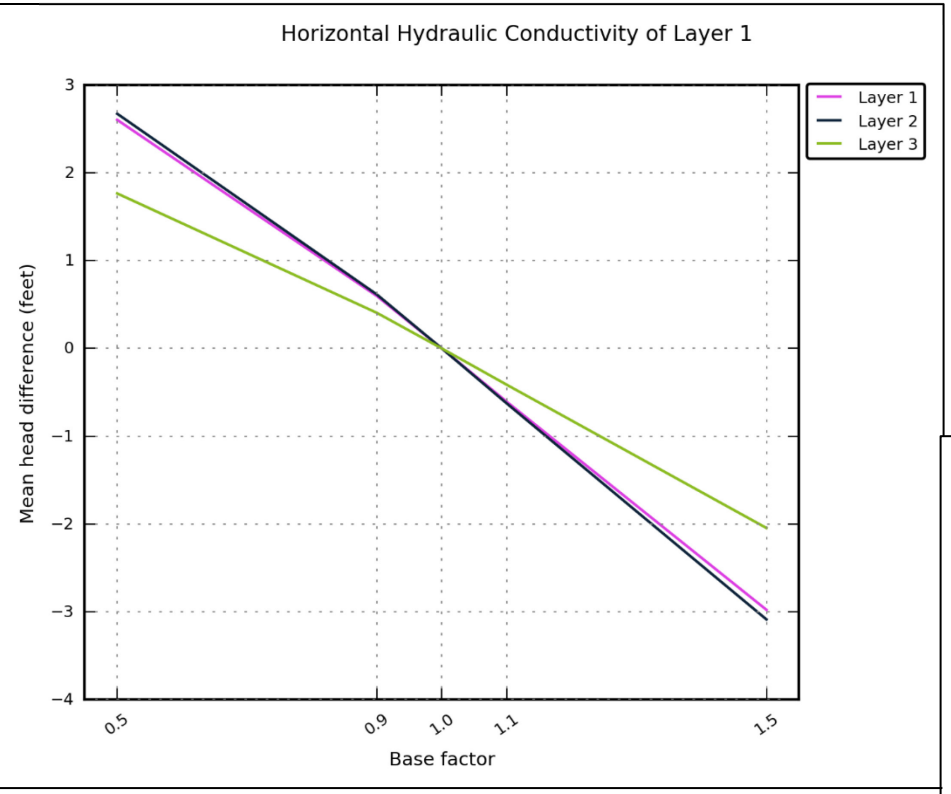
# 2006 Stream Gains/Losses in Brazos River Alluvium

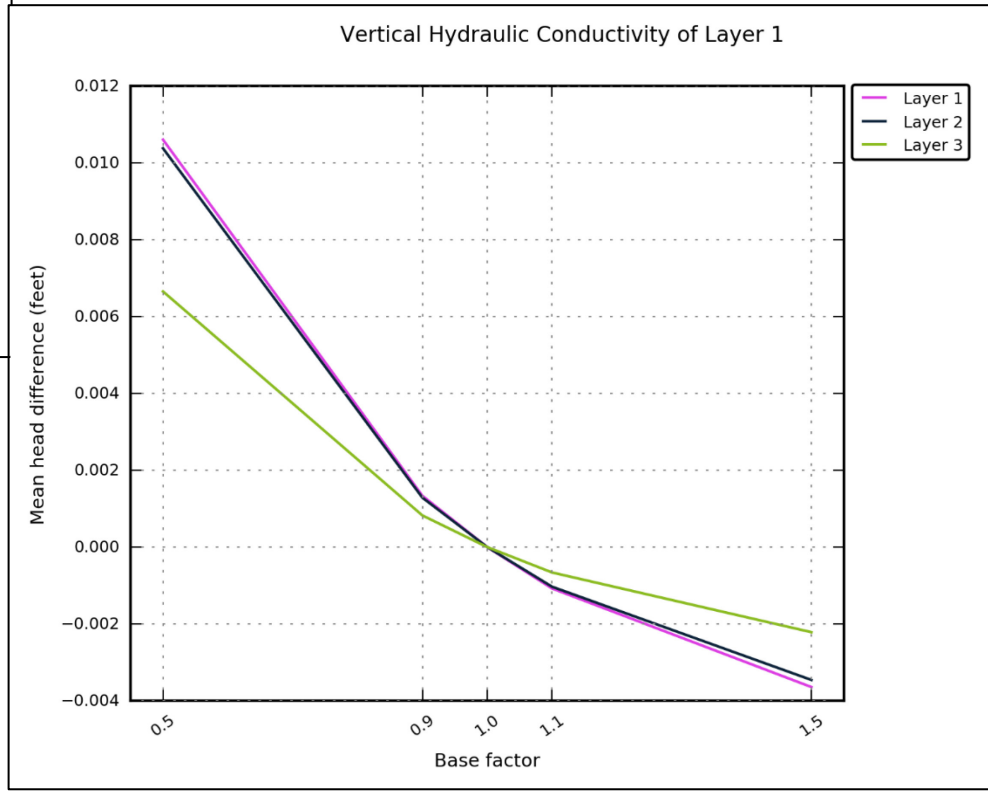


# 2006 Stream Gains/Losses in Brazos River Alluvium

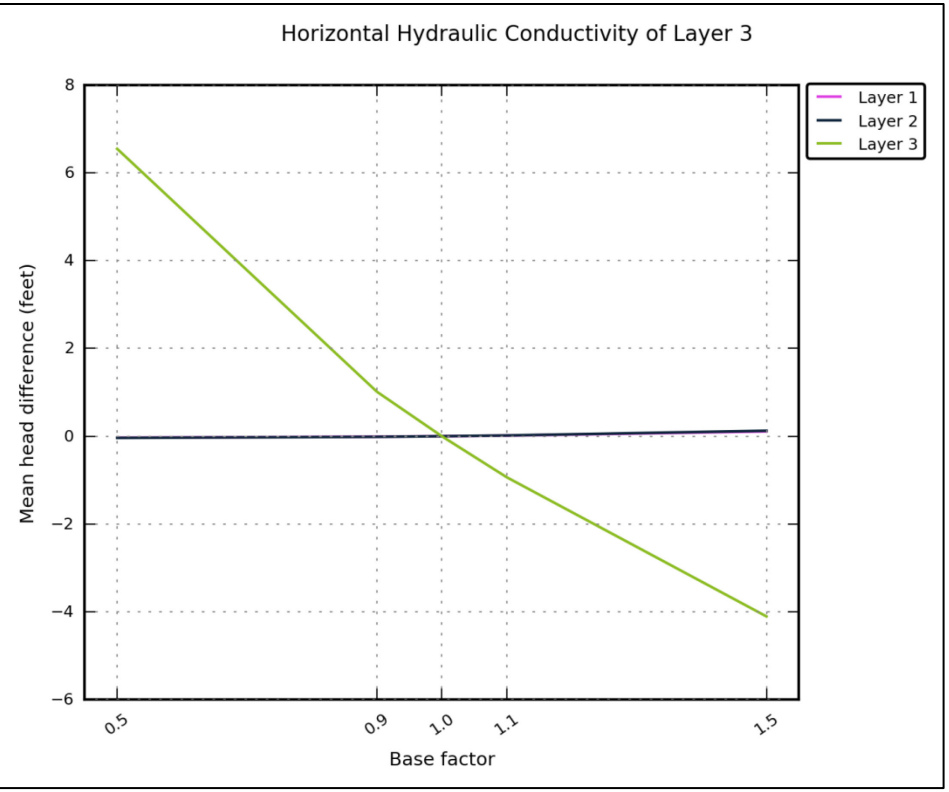


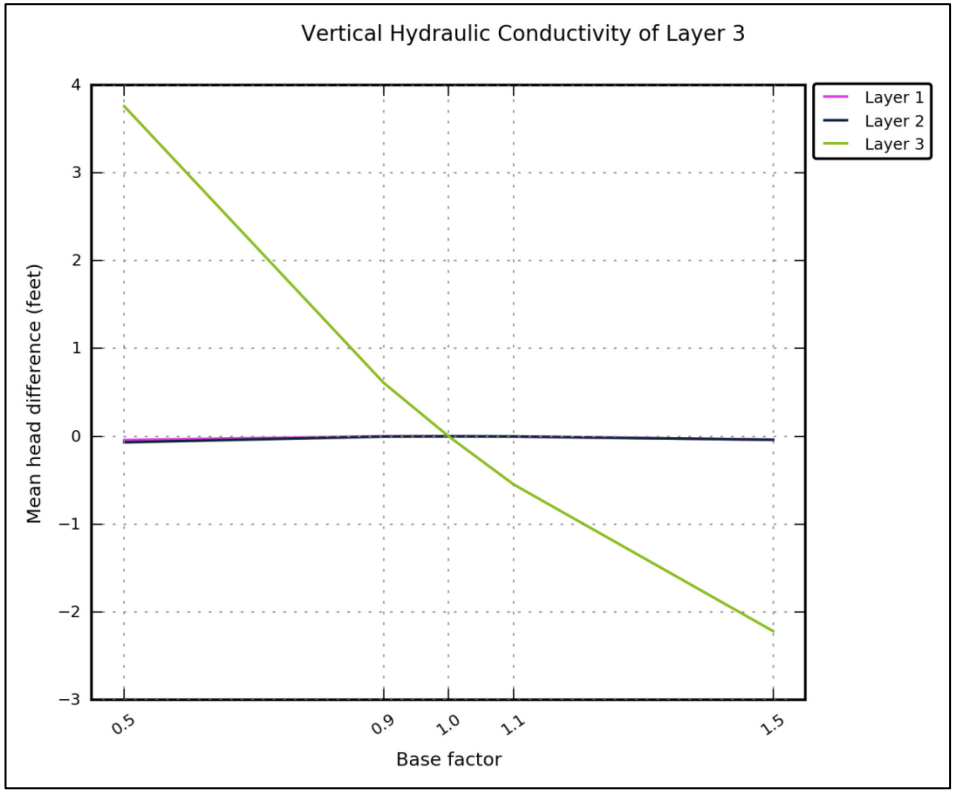
# Steady-State Head Sensitivities



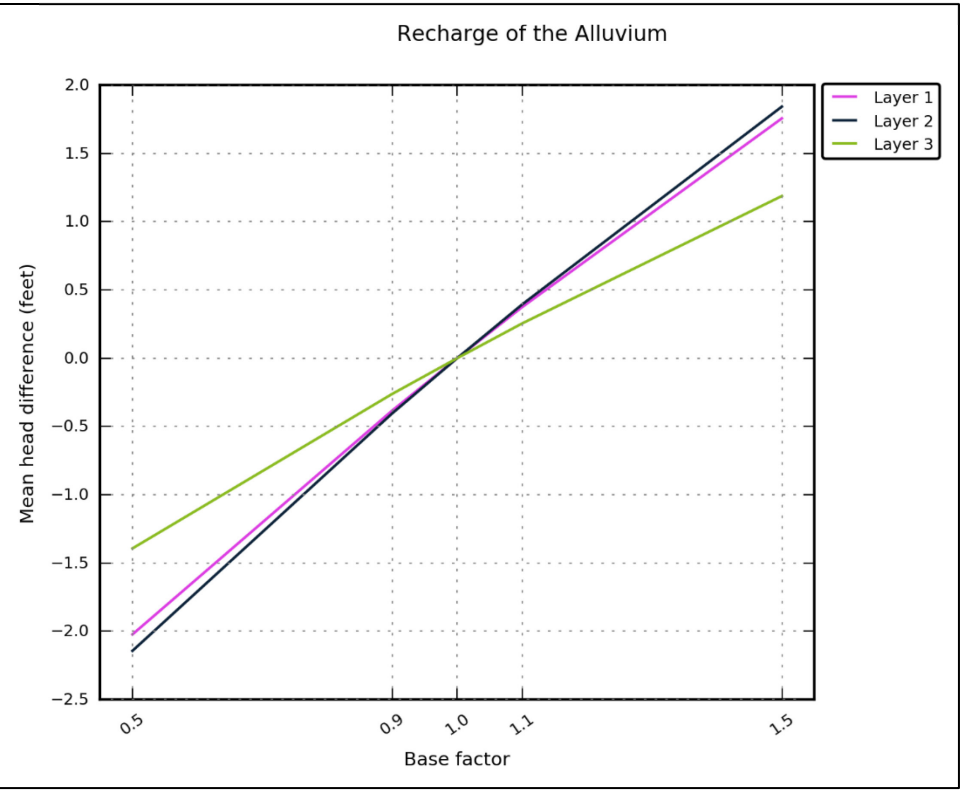



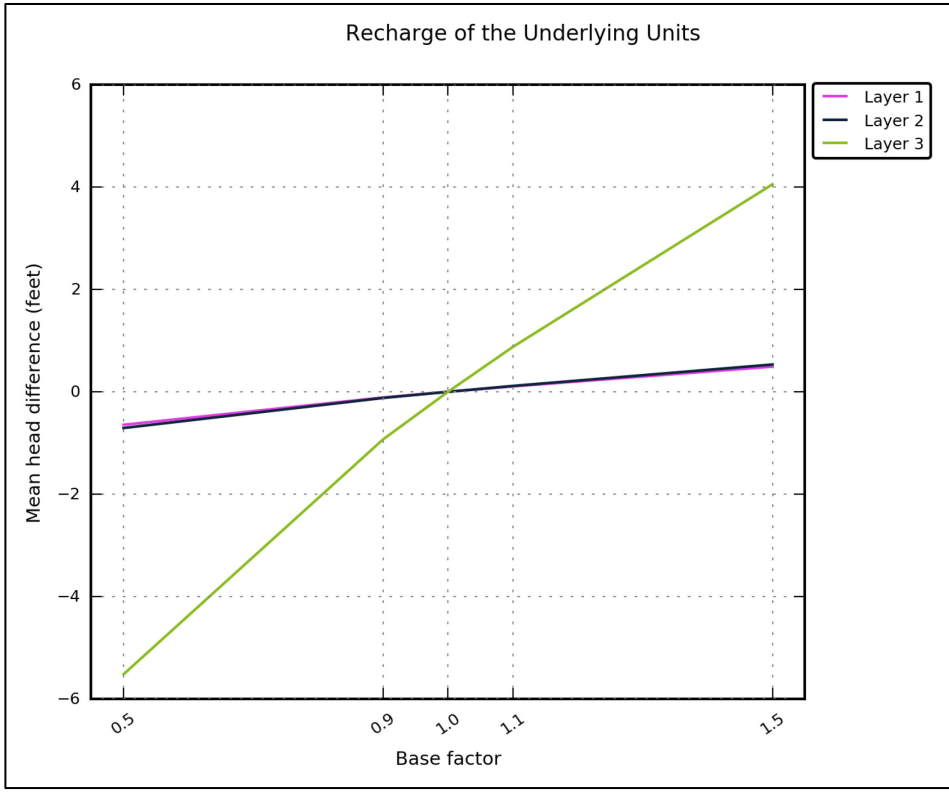
# Steady-State Head Sensitivities



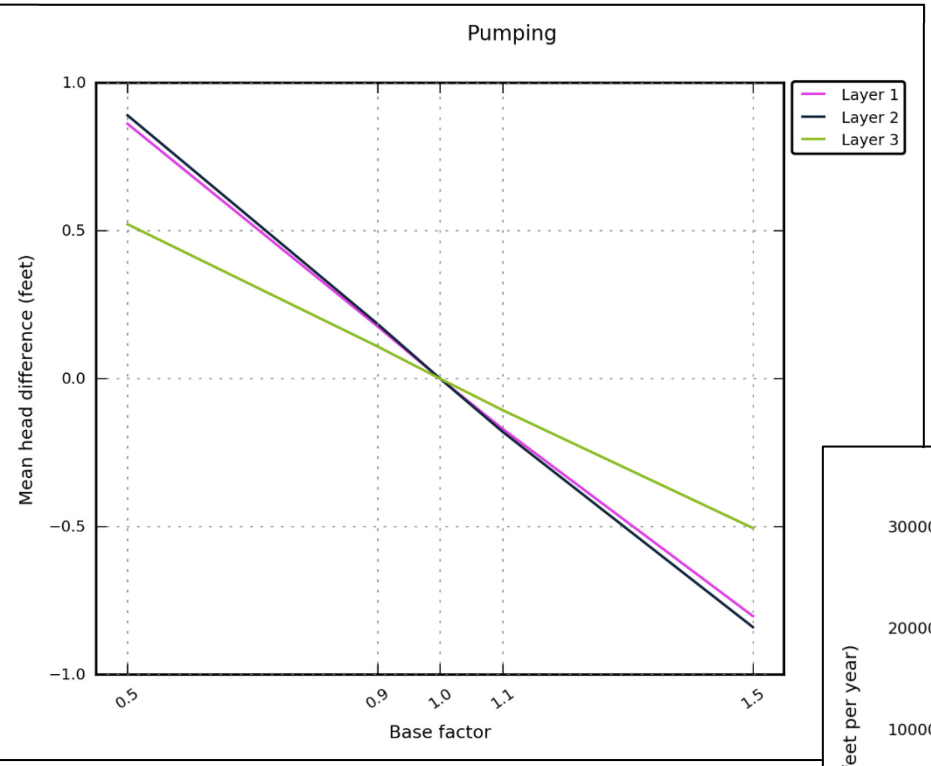



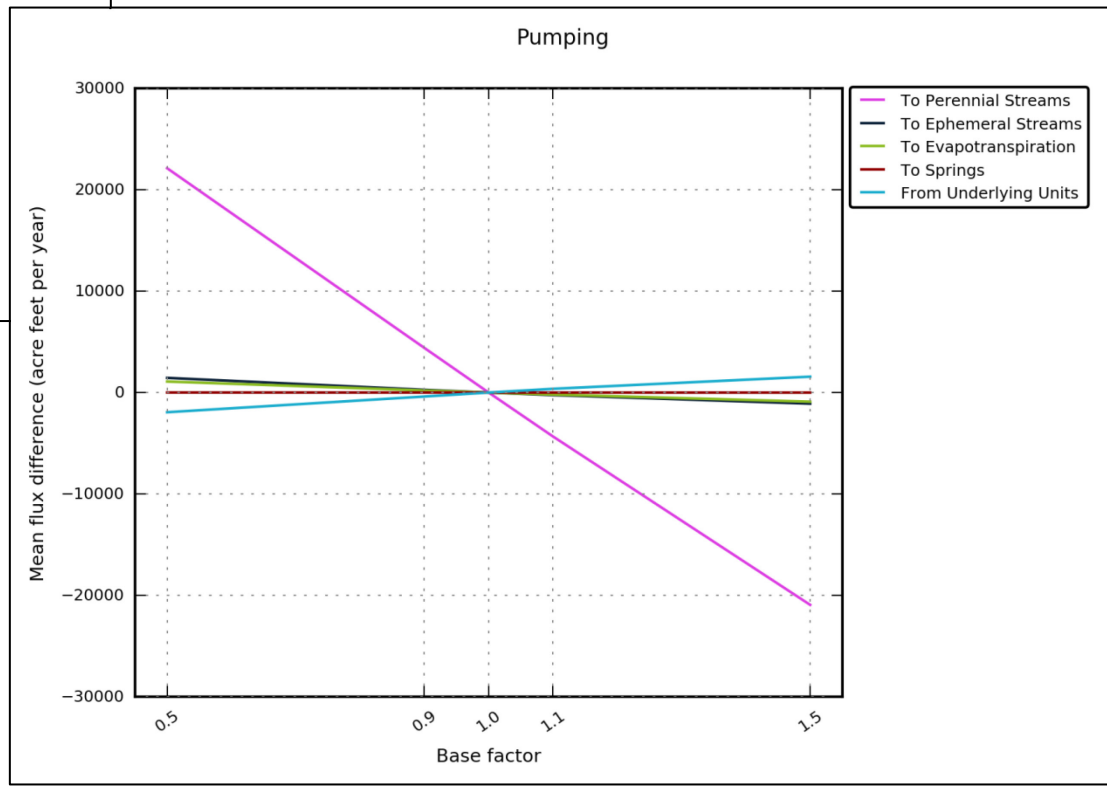
# Steady-State Head Sensitivities



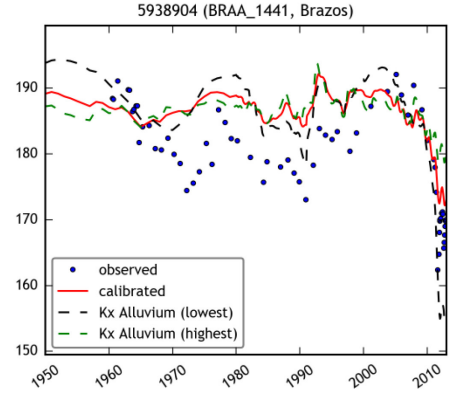



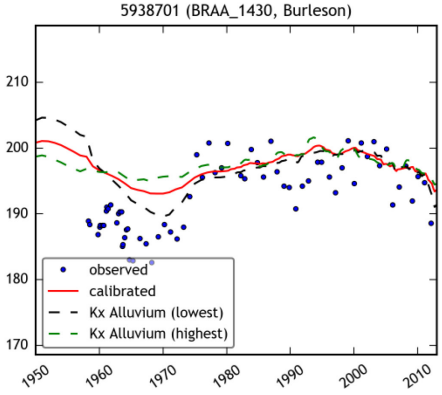
# Transient Head/Flow Sensitivities

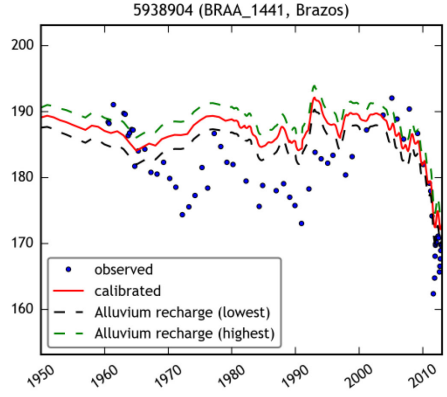


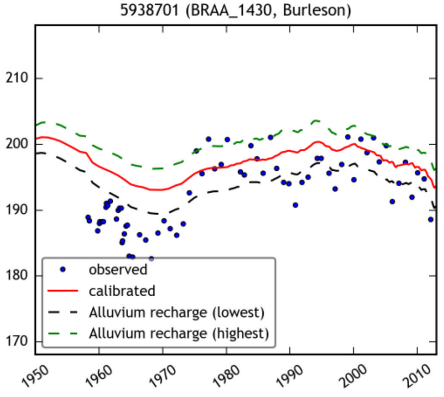



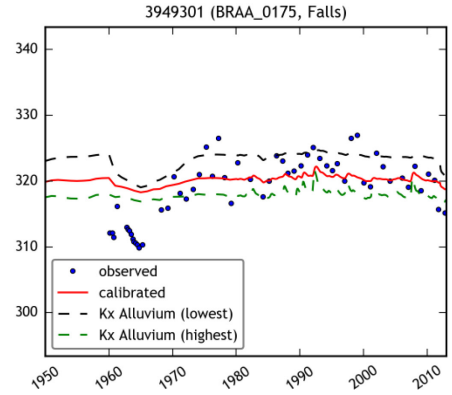
# Transient Hydrograph Sensitivities

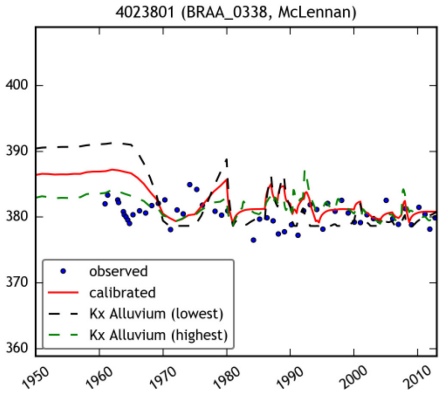


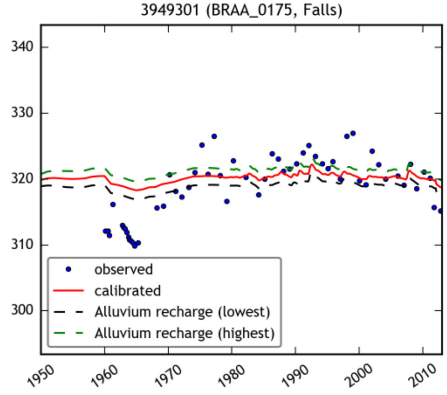



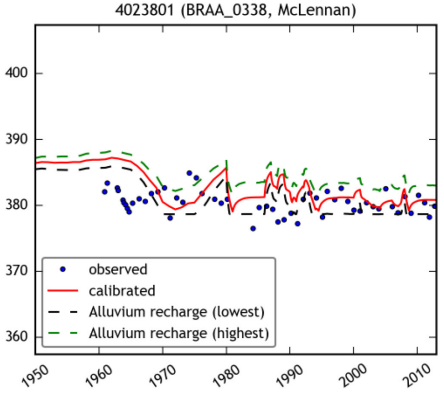



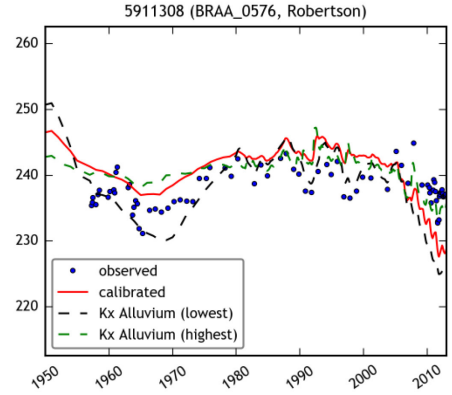



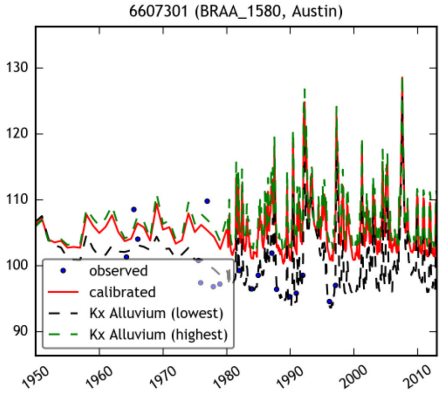



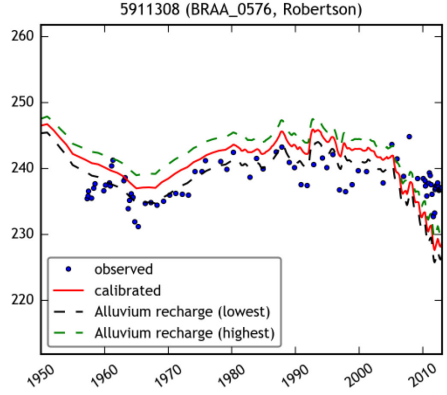



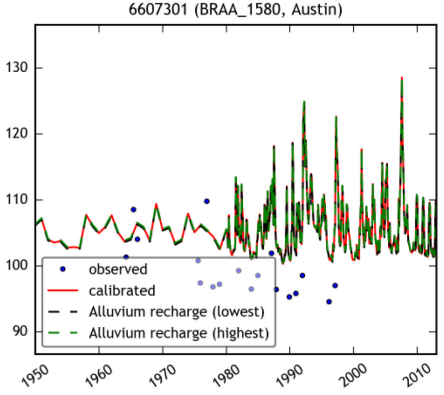



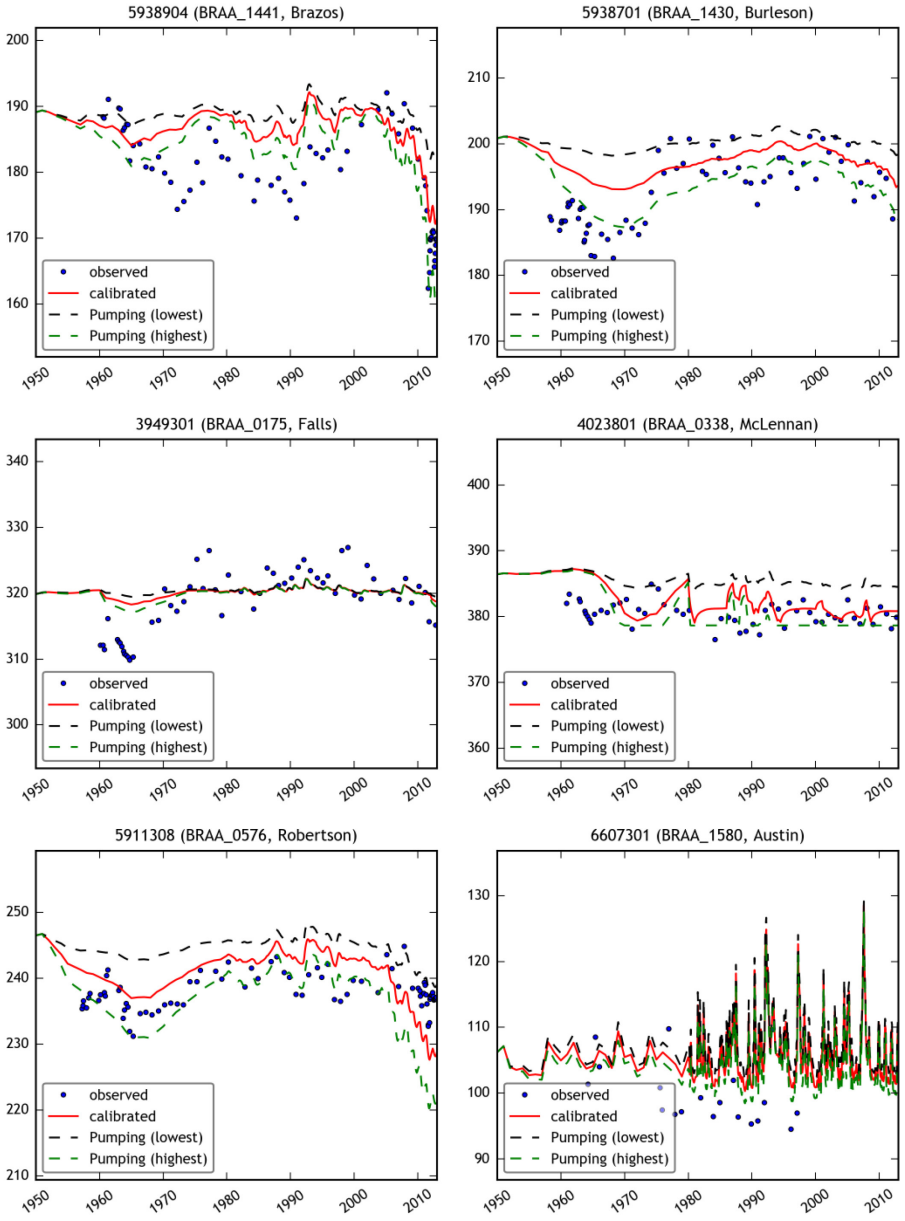



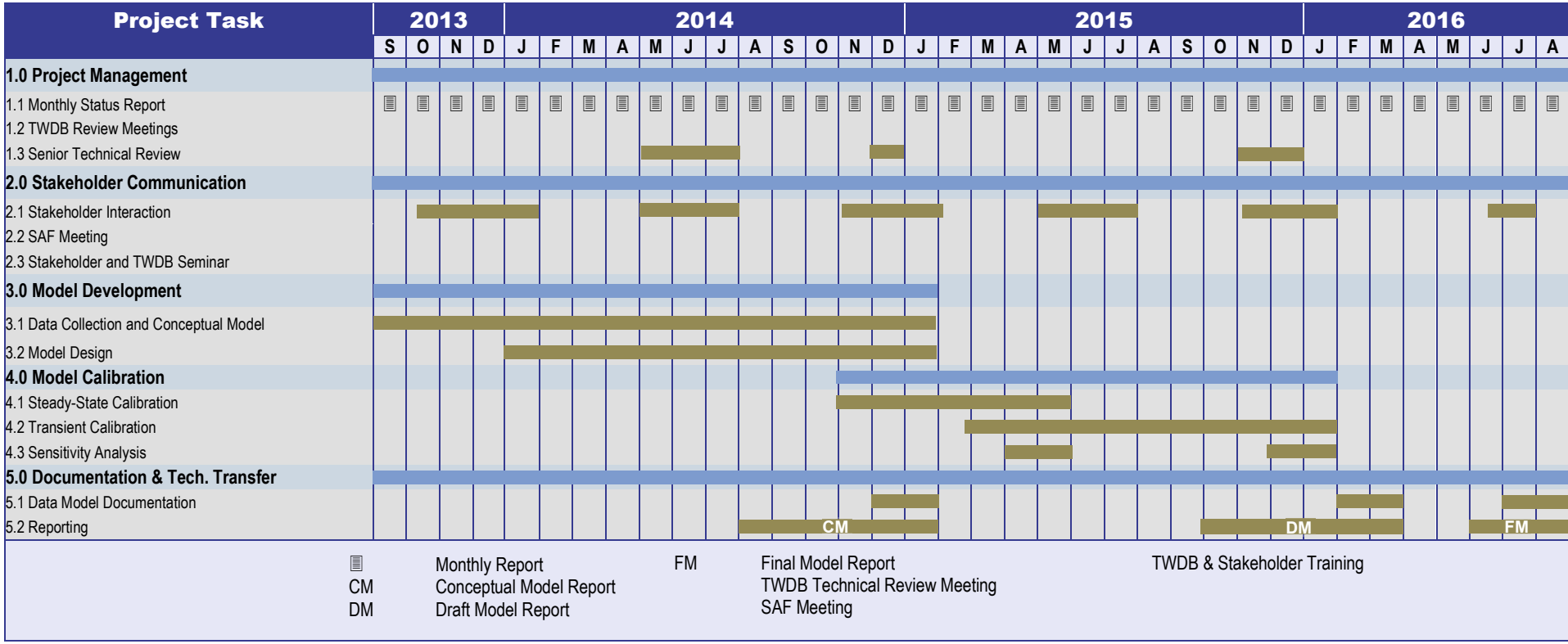



# Transient Hydrograph Sensitivities



# Schedule


Project Task
2013
2014
2015
2016
S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A
1.0 Project Management
1.1 Monthly Status Report
1.2 TWDB Review Meetings
1.3 Senior Technical Review
2.0 Stakeholder Communication
2.1 Stakeholder Interaction
2.2 SAF Meeting
2.3 Stakeholder and TWDB Seminar
3.0 Model Development
3.1 Data Collection and Conceptual Model
3.2 Model Design
4.0 Model Calibration
4.1 Steady-State Calibration
4.2 Transient Calibration
4.3 Sensitivity Analysis
5.0 Documentation & Tech. Transfer
5.1 Data Model Documentation
5.2 Reporting
CM
DM
FM
Monthly Report
Conceptual Model Report
Draft Model Report
Final Model Report
TWDB Technical Review Meeting
SAF Meeting
TWDB & Stakeholder Training

# Brazos Alluvium Aquifer GAM -- Stakeholder Advisory Forum #3
# Milano, Texas, May 26th, 2016
# Questions and Answers

Question: Slide 37. Explain Stream Leakage in/out flow.
Answer: "Out" means stream gains and "In" means stream loses. So streams are primarily gaining in predevelopment and they are the largest outflow mechanism in the model.

Question: Slide 39. Explain Stream Leakage in/out flow.
Answer: "Out" means stream gains and "In" means stream loses. So gains and losses are roughly equal in December of 2012.

Question: Slide 40. If line is negative does that mean water is leaving the aquifer (stream leakage)?
Answer: Yes.
Question: What is the difference between River and Stream leakage?
Answer: Ephemeral streams are represented with the River package and are called "Rivers". Perennial streams are represented with the Streamflow Routing package and are called "Streams".
Question: Why?
Answer: We actually route flow in the Brazos River and other perennial streams. This requires the Streamflow Routing package.
Question: Slide 40 (lower). Explain Spikes?
Answer: The spikes are high stages in the Brazos River which recharge the aquifer. The fact that the water goes into storage and then comes right back out indicates that it is bank storage.

Question: Slide 41. What is the impact of pumping on stream gains/losses?
Answer: Short term, it's hard to say. Long term there appears to be an impact from pumping.

Question: Slide 42. Why is there more (downward) flow in the south over the Gulf Coast Aquifer?
Answer: Hard to say. It's upward beneath the Brazos River and the downward flow may just indicate more local circulation of water at depth.

Question: Slide 44. Was gain/loss based on studies or data?
Answer: Yes. The steady-state model was calibrated to long-term estimates of base-flow from data. The figure shows the model results.

Question: Slide 46. In more recent times, losses increase. Why?
Answer: Losses typically mean more high stream flows. Not sure about recent increases.
Question: Could 2012 be lower because 2011 was a dry year?
Answer: Maybe, if water table was lower that could also increase losses.

Question: Slide 47. Where are the two gages located?

Answer: Don't know. I don't actually have a map with gage locations with me.

Question: Slide 48. What is 16?
Answer: The x-axis numbers are just arbitrary numbers for segments to order them from upstream to downstream. The fact that it is negative indicates that it is a losing segment.

Question: Slide 52 (lower). Does it mean pumping water from the Brazos River?
Answer: It means wells capturing water before it discharges to the Brazos River.

Question: Slide 54. Does the early dip represent the drought of record?
Answer: Well it occurs more in the 1960s. There is not much data on early time (1950s) pumping.

Question: What will this model be used for?
Answer: for DFCs and MAGs.

Question: What new data is needed?
Answer: Metered pumping, spring flows, a well with a transducer near a stream gage, data from well pairs completed in alluvium and shallow underlying formations.

Question: What is the next step?
Answer: Review of the report, final comments on the report, response to comments, acceptance, and distribution of the model.

Question: Why is Layer 3 200 feet thick?
Answer: This is meant to approximate the shallow flow system and is somewhat of a best guess.

## Brazos River Alluvium Aquifer GAM Stakeholder Advisory Forum III

## May 26th, 2016

## Attendance

| Name | Affiliation |
|---|---|
| Cindy Ridgeway | TWDB |
| John Ewing | Intera |
| Bobby Bazan | POSGCD |
| Tiffany Proffitt | BGCD |
| Philip Price | BRA |