Stakeholder Advisor Forum for the High Plains Aquifer GAM

Numerical Model Construction and Calibration

Presented at PRPC
Amarillo, TX

Presented By:

INTERA
GEOSCIENCE & ENGINEERING SOLUTIONS

Texas Water Development Board

February 18, 2015

Presentation Outline

- Introduction to the Groundwater Availability Program by Cindy Ridgeway (TWDB)
- High Plains Aquifer System Background and Conceptual Model Review
- Model construction
  - Structure
  - Head boundaries
  - Properties
  - Flux boundaries
- Model Calibration
- Schedule

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

Cindy Ridgeway, P.G.

Manager of Groundwater Availability Modeling

Texas Water Development Board

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.

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Groundwater Availability Modeling Program

- **Aim**: 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.

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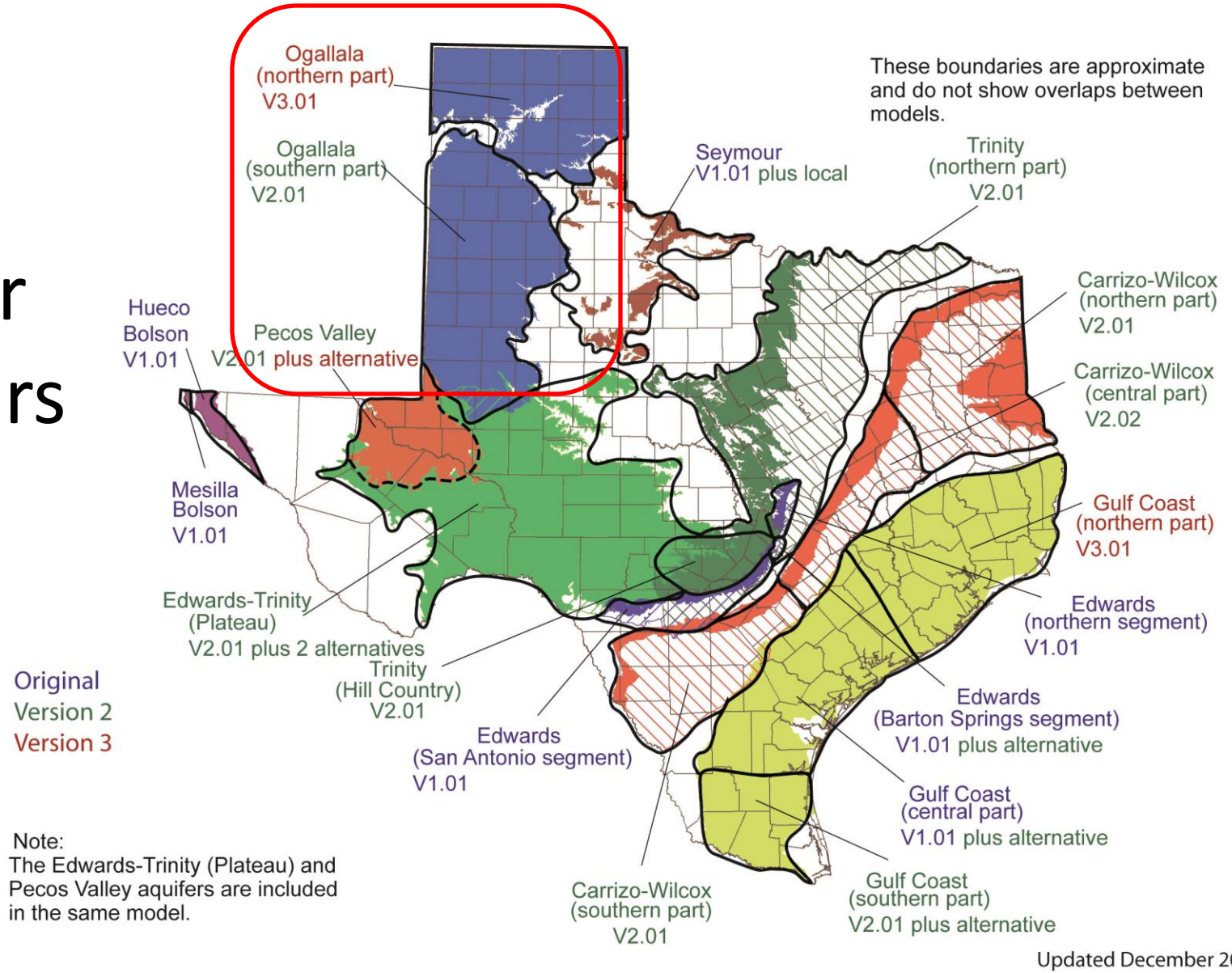
Major Aquifers



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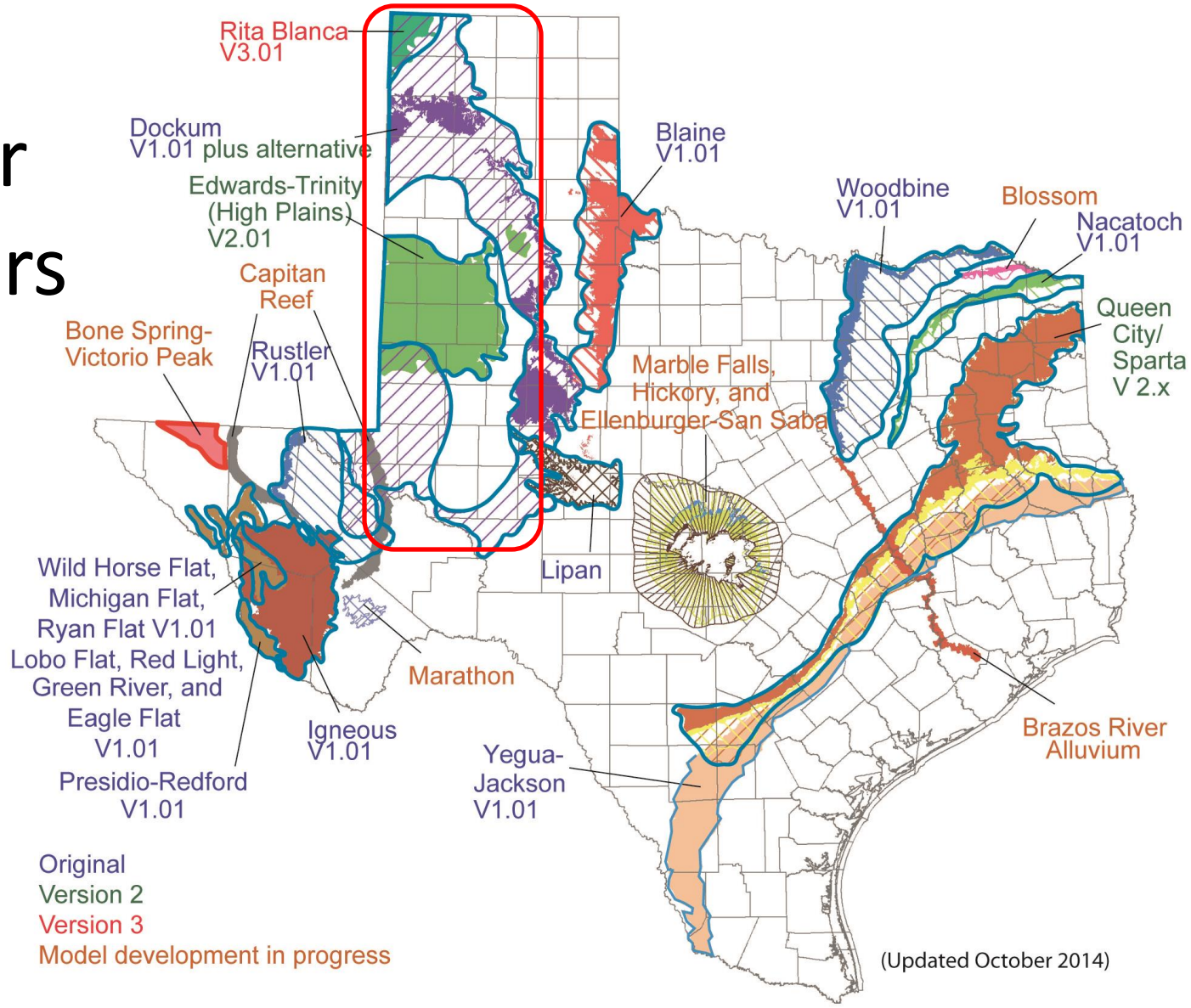
Minor Aquifers



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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.

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Why Stakeholder Advisory Forums?

- Keep stakeholders updated about progress of the model
- Inform how the groundwater model can, should, and should not be used
- Provide stakeholders with the opportunity to provide input and data to assist with model development

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Contact Information

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Texas Water Development Board
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Austin, Texas 78711-3231

Web information:
http://www.twdb.texas.gov/groundwater/models/gam/hpas/hpas.asp

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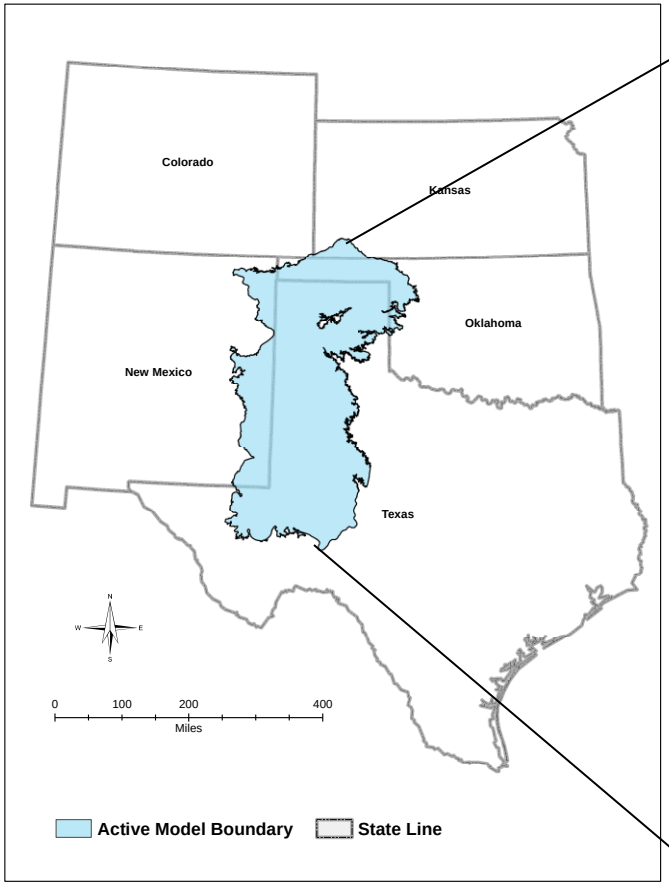
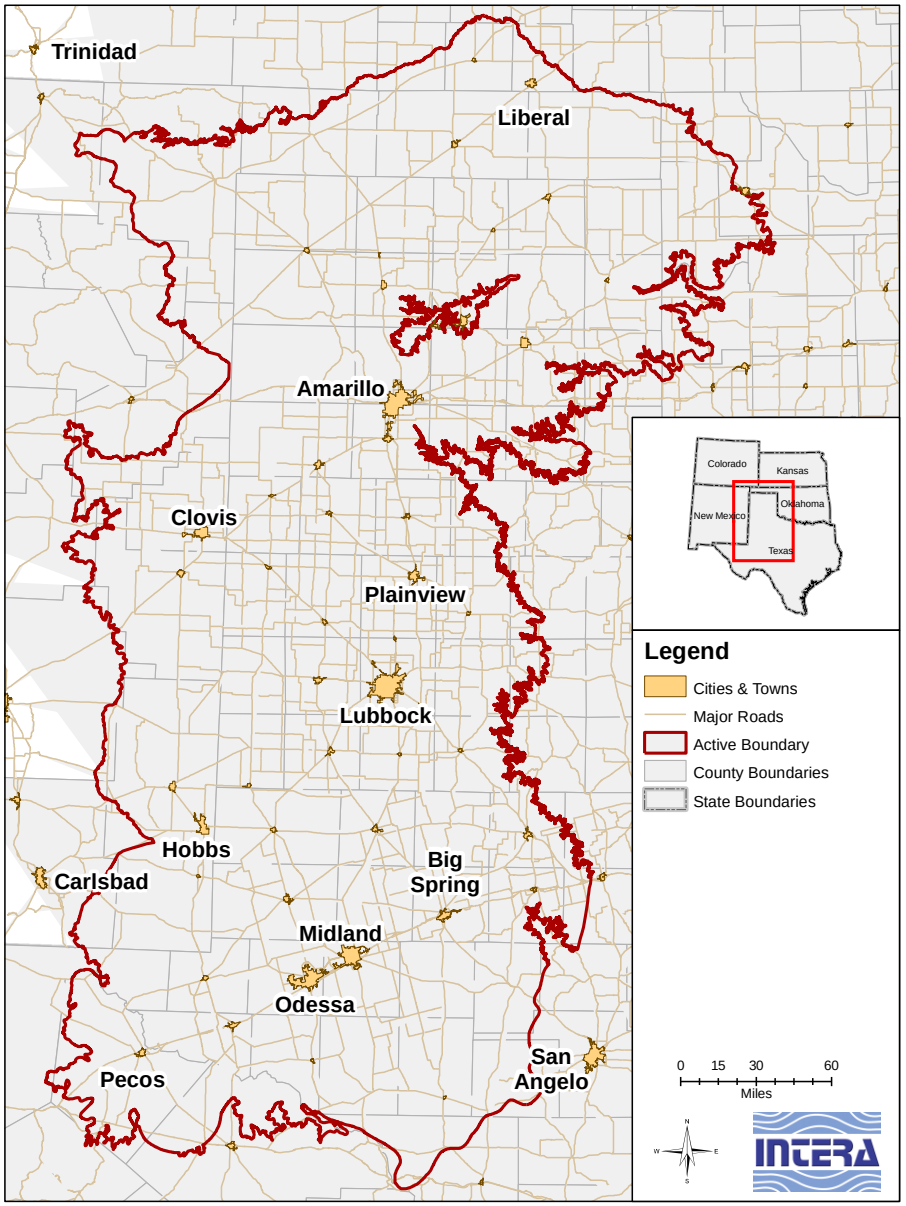
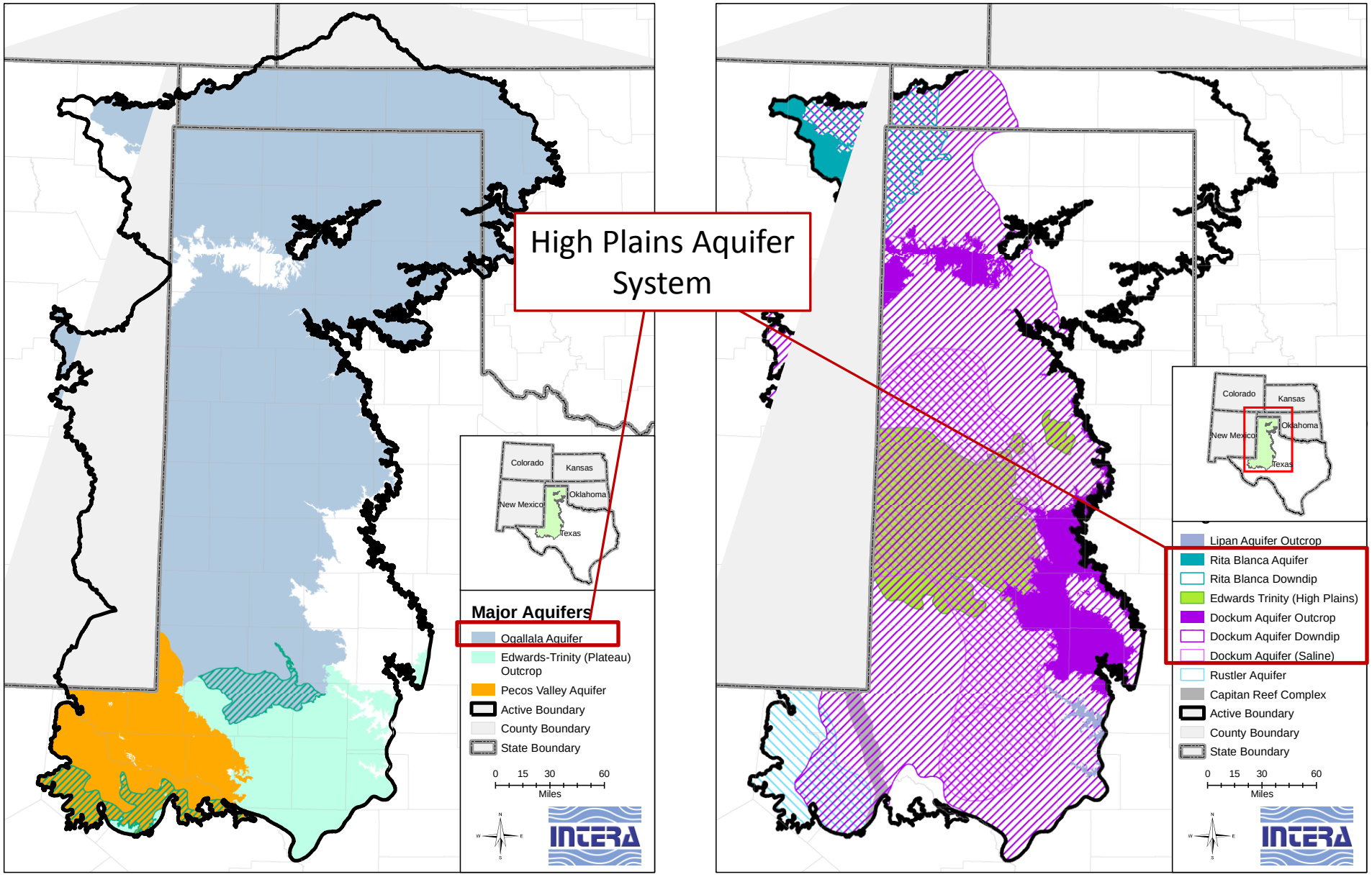
Study Area


Colorado
Kansas
Oklahoma
New Mexico
Texas
0
100
200
400
Miles
Active Model Boundary
State Line


Trinidad
Liberal
Amarillo
Clovis
Plainview
Lubbock
Hobbs
Carlsbad
Big Spring
Midland
Odessa
Pecos
San Angelo
Colorado
Kansas
Oklahoma
New Mexico
Texas
Legend
Cities & Towns
Major Roads
Active Boundary
County Boundaries
State Boundaries
0
15
30
60
Miles
INTERA

Aquifers in the Study Area



Model Layer Representation

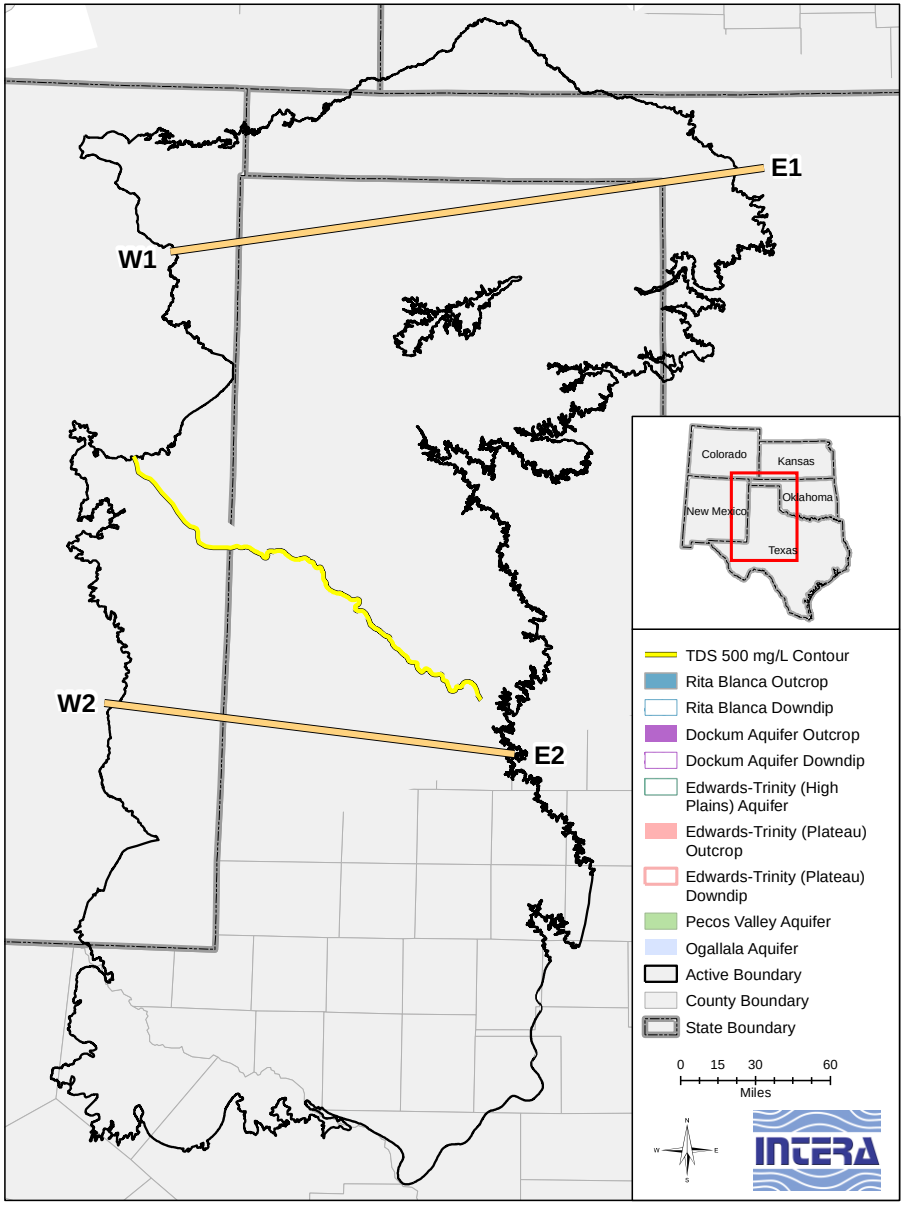
System	Formation		Aquifer	Model Layer		
				North	Central	South
Quaternary	Pecos Valley Alluvium		Pecos Valley			1
Tertiary	Ogallala		Ogallala	1	1	
Cretaceous	Duck Creek II	Boracho*	Edwards – Trinity		2II	2*
	Kiamichi II	Finlay*				
	Edwards II					
	Comanche Peak II					
	Walnut II					
	Antlers					
Jurassic	Morrison		Rita Blanca	2		
	Exeter					
Triassic	Cooper Canyon		Upper Dockum	3	3	3
	Trujillo					
	Tecovas		Lower Dockum	4	4	4
	Santa Rosa					
Permian	Dewey Lake			No Flow		
	Rustler		Rustler			

II Edwards-Trinity (High Plains) Aquifer represented by layer 2 in the central portion of the domain.
* Edwards-Trinity (Plateau) Aquifer represented by layer 2 in the southern portion of the domain.

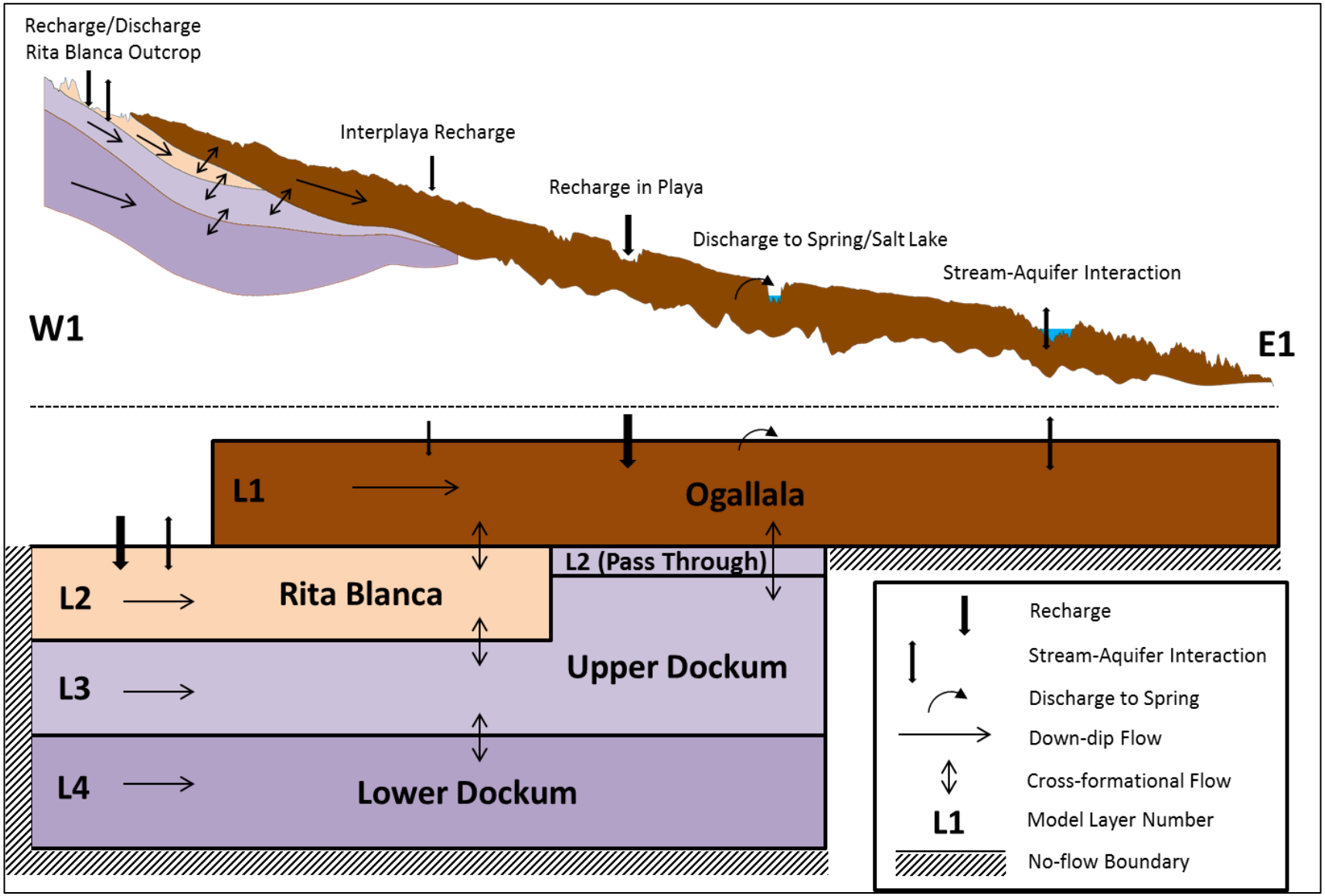
Head Boundaries

Conceptual Model

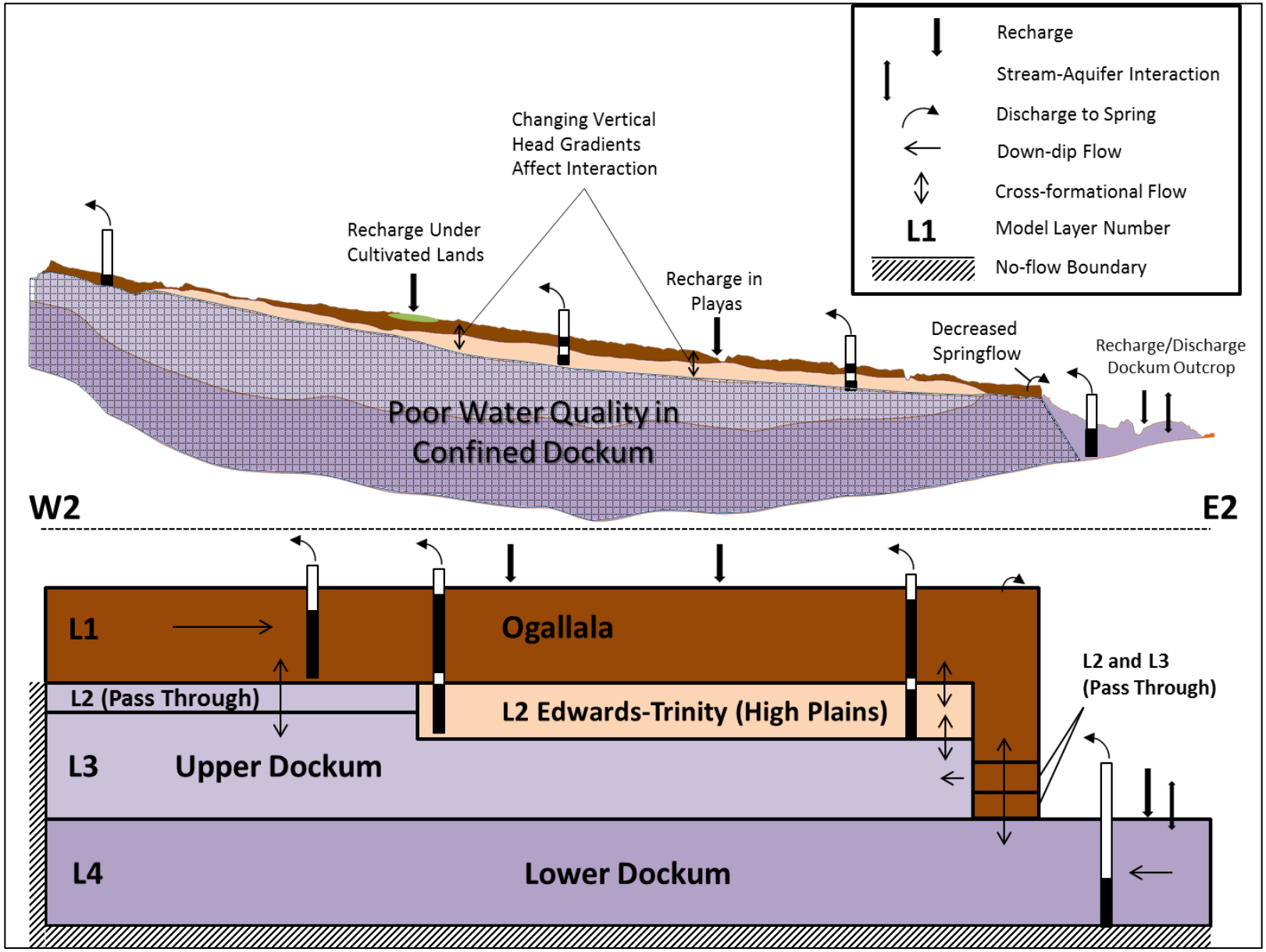
- During Pre-development: recharge balances discharge, no net change in groundwater storage
- During Post-development: Increased discharge from pumping, locally increased recharge from irrigation, overall reduction in natural discharge and GW storage
- Northern and Southern sections have different hydrostratigraphy and recharge patterns.



Conceptual Model: Predevelopment

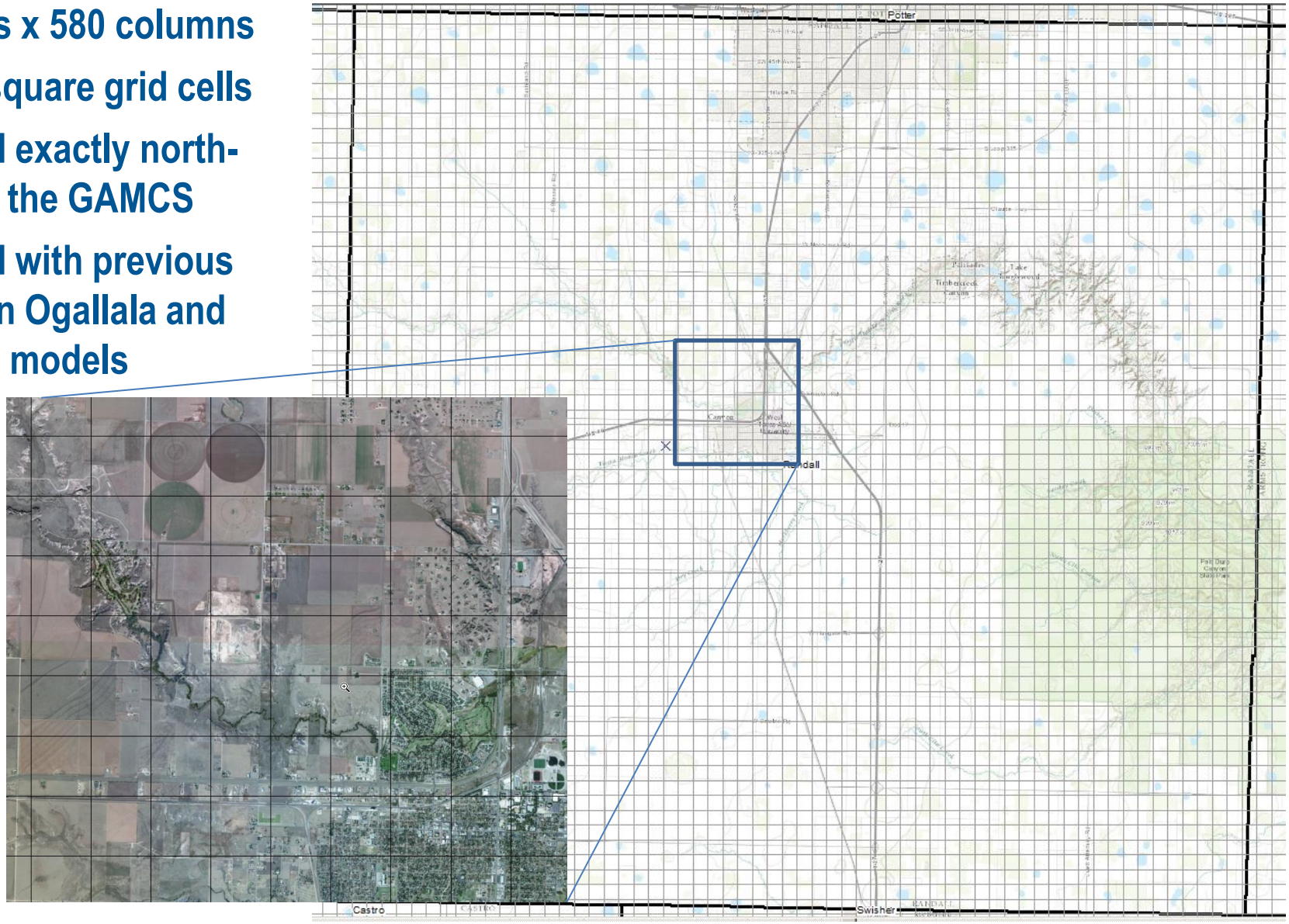


Conceptual Model: Post Development



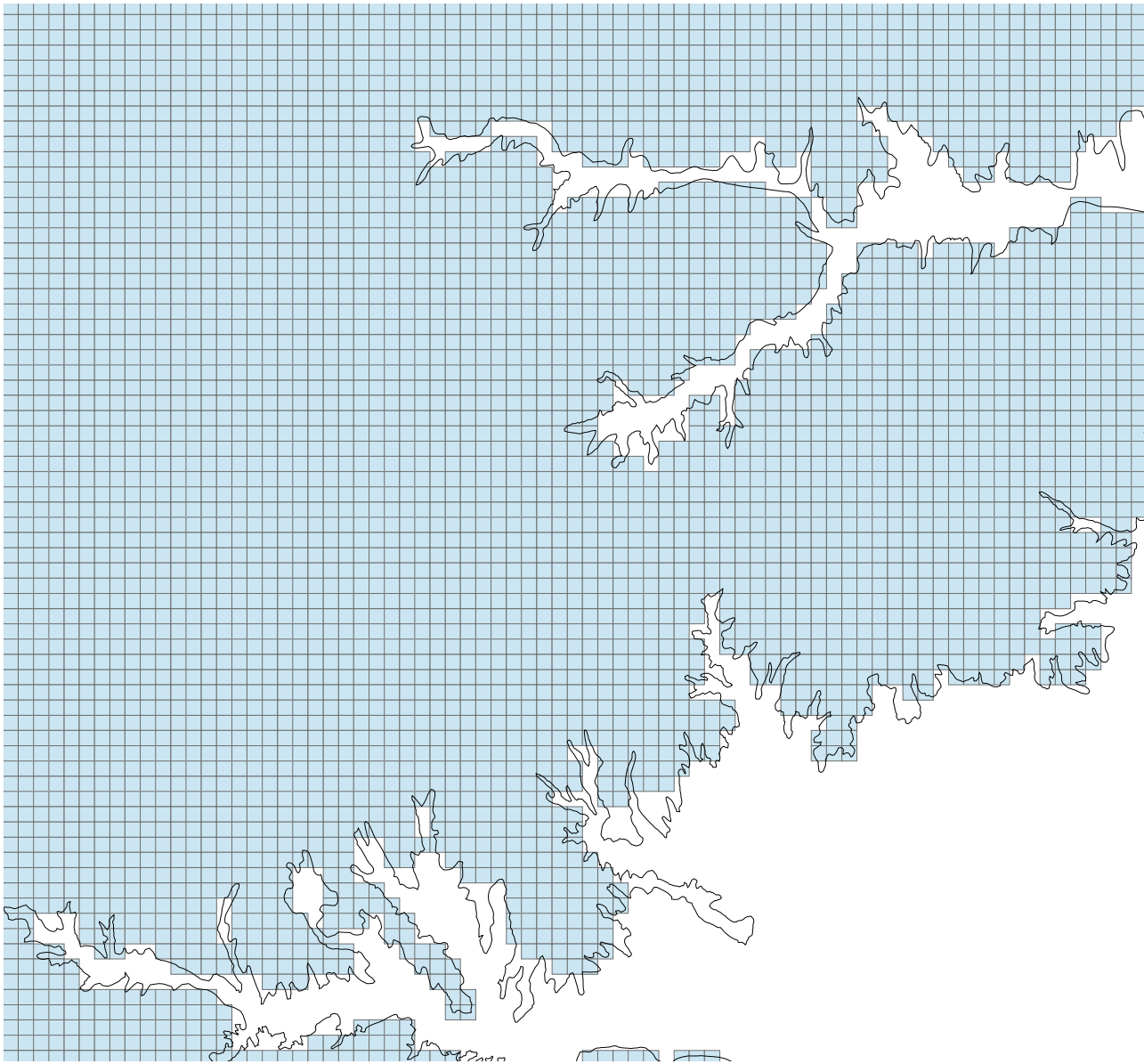
Model Grid

- 932 rows x 580 columns
- 2640 ft square grid cells
- Oriented exactly north-south in the GAMCS
- Oriented with previous Southern Ogallala and Dockum models



Model Grid

- Base active areas based on grid centroids
- Smoothing to remove corner connections, small islands and peninsulas
- Without smoothing, steady-state model does not converge



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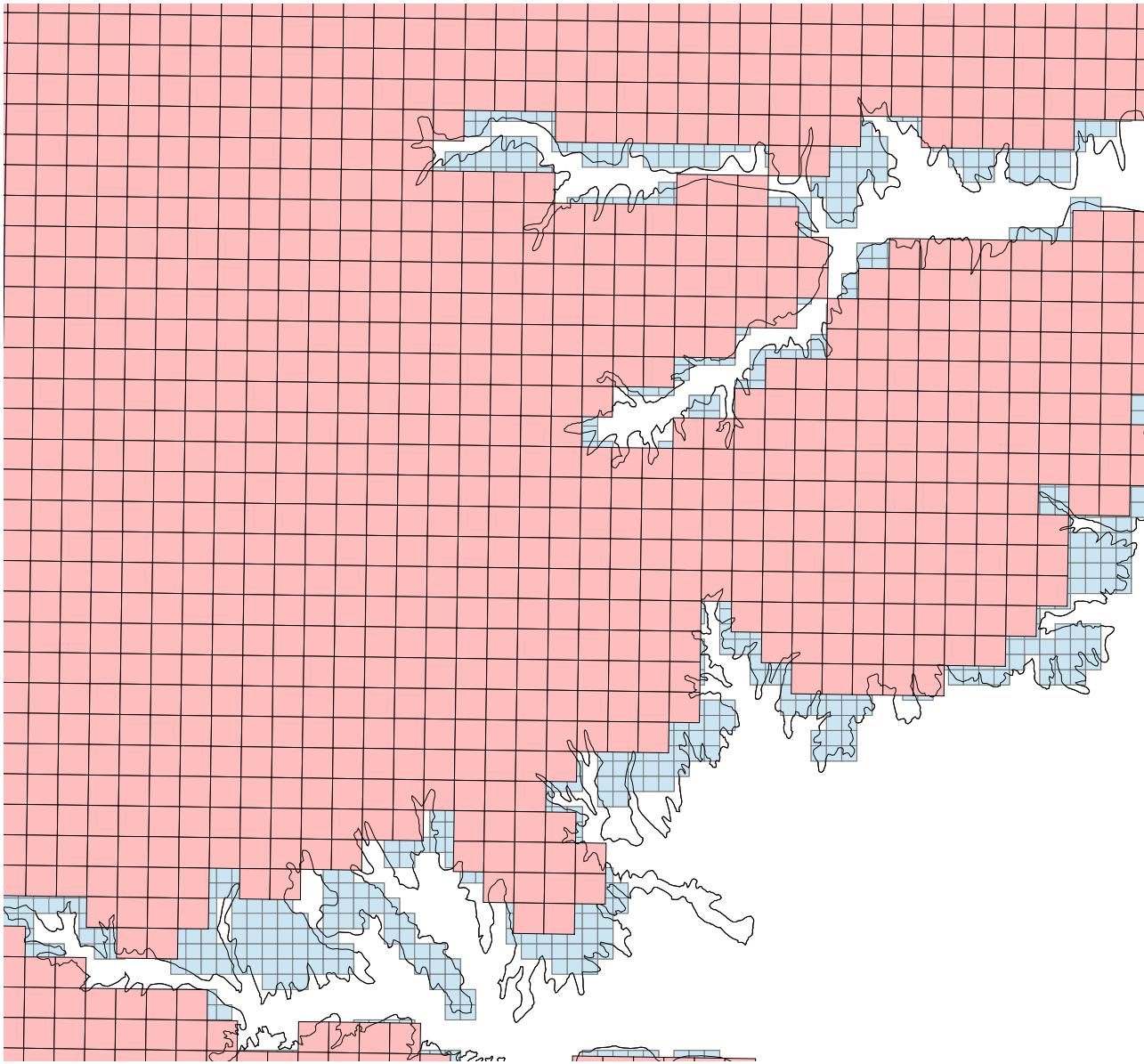
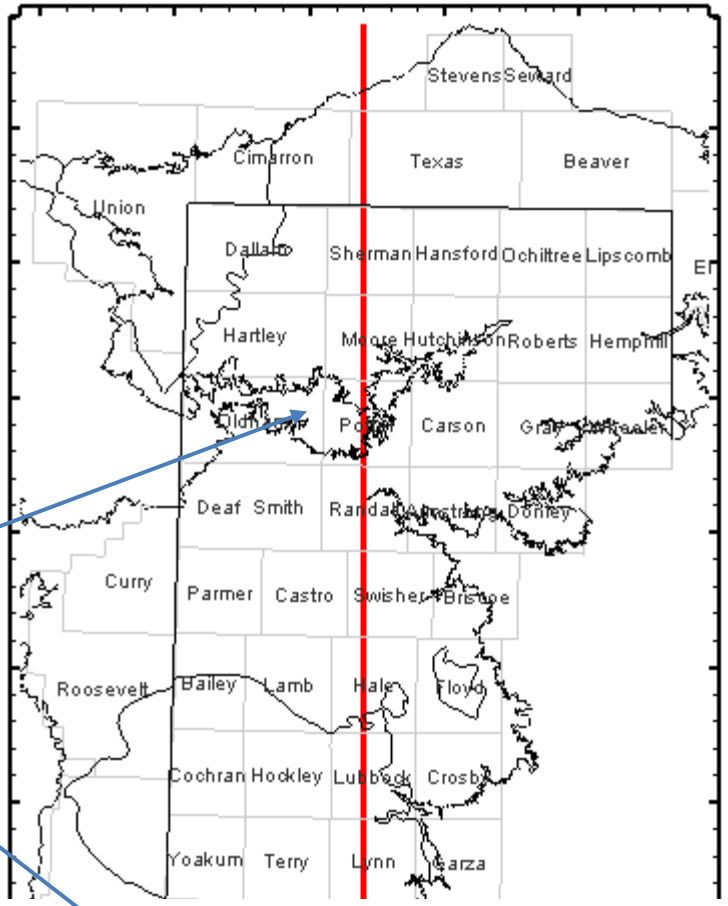
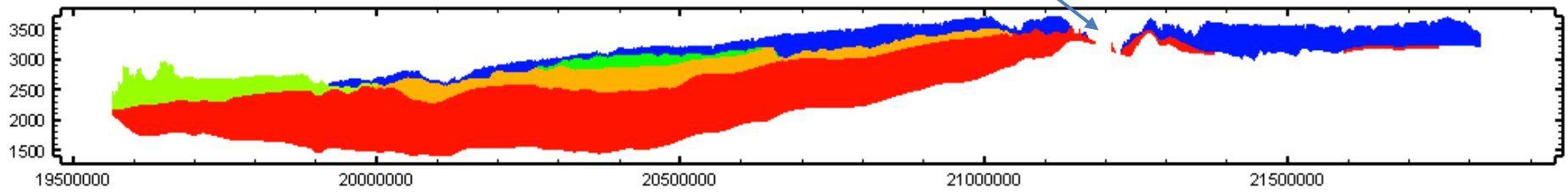


Structure on Grid

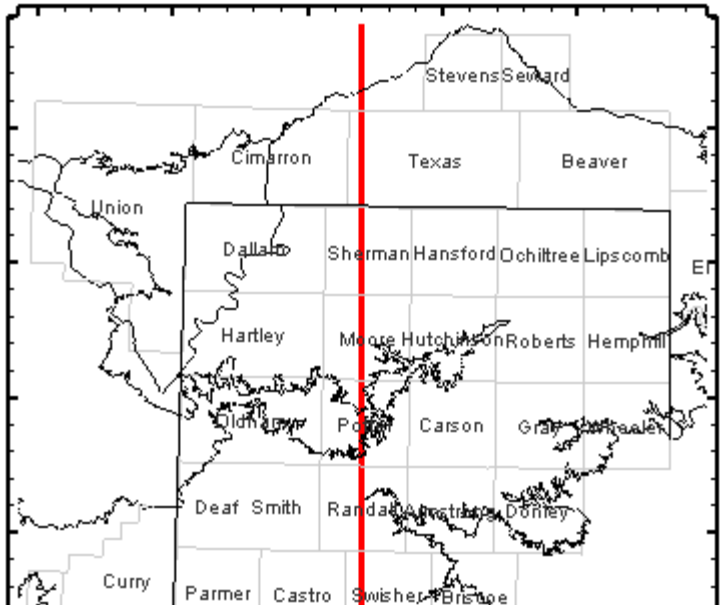
- "Pass throughs" required where Ogallala directly overlays Upper or Lower Dockum
- IBOUND carries key for what model cells represent
- Where Permian is at surface, model is inactive for all layers

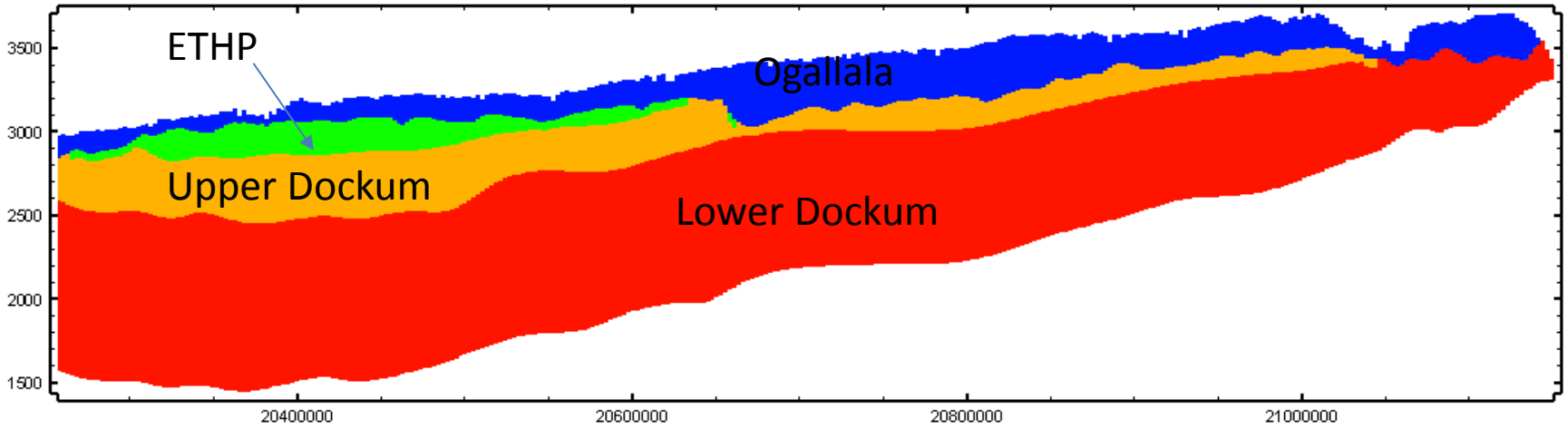




Structure on Grid

- "Pass throughs" required where Ogallala directly overlays Upper or Lower Dockum, and a few other places where aquifers have pinched out
- IBOUND carries key for what model cells represent
- Where Permian is at surface, model is inactive for all layers





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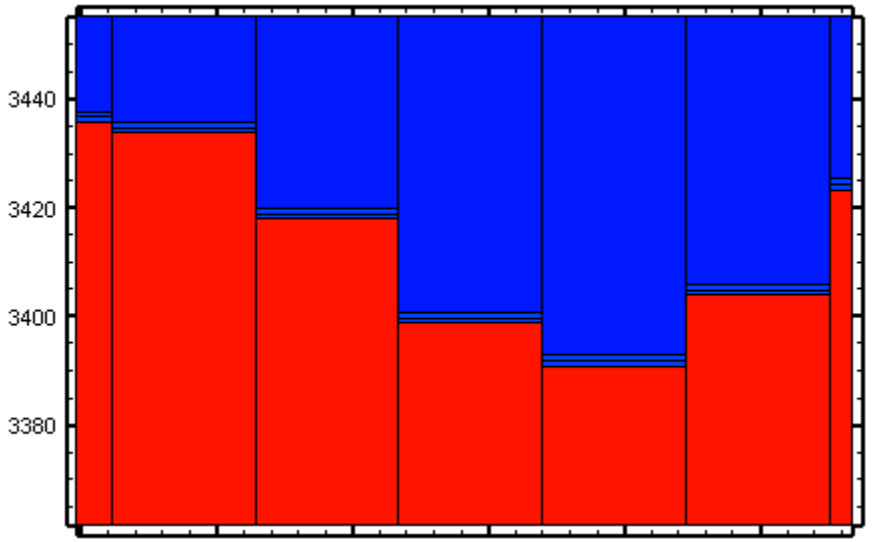
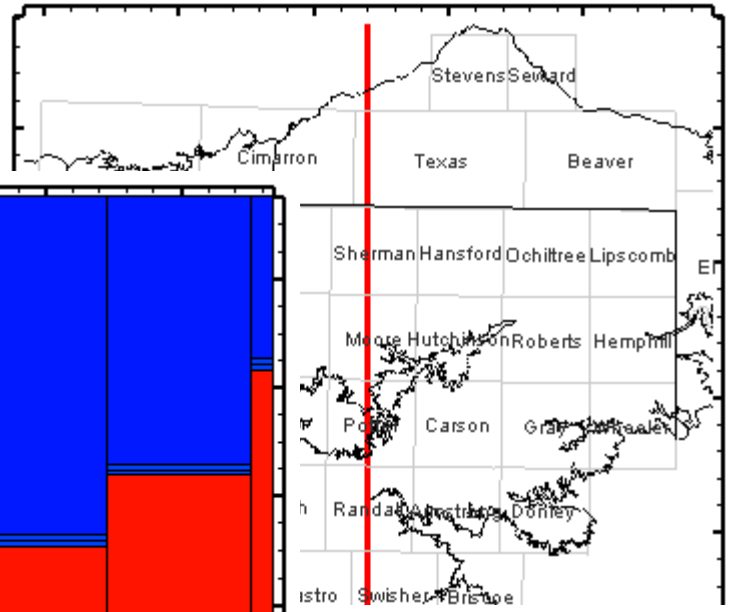
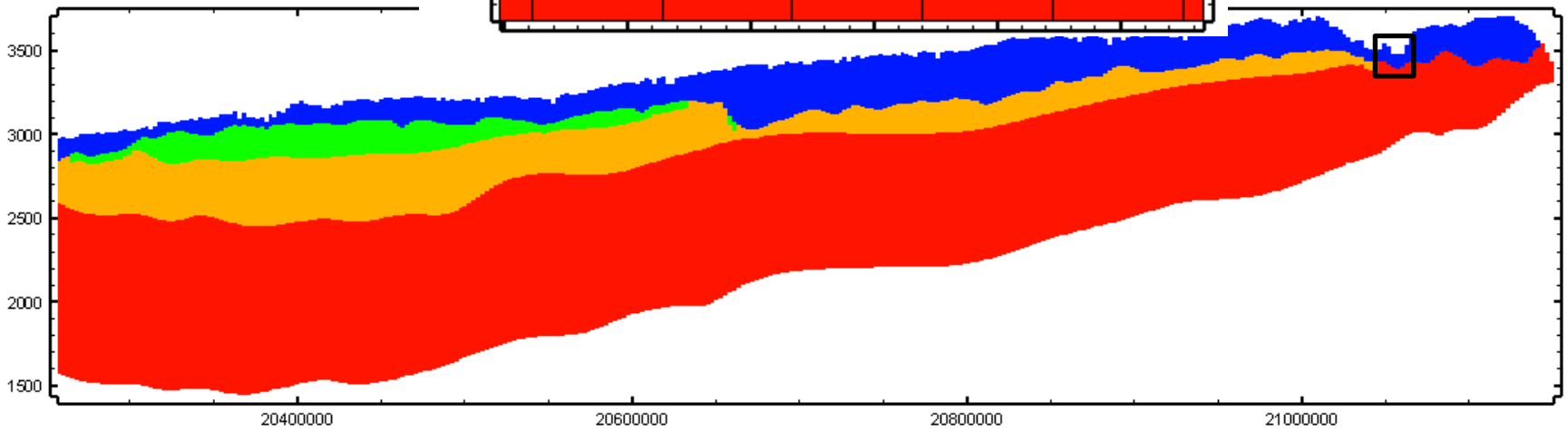
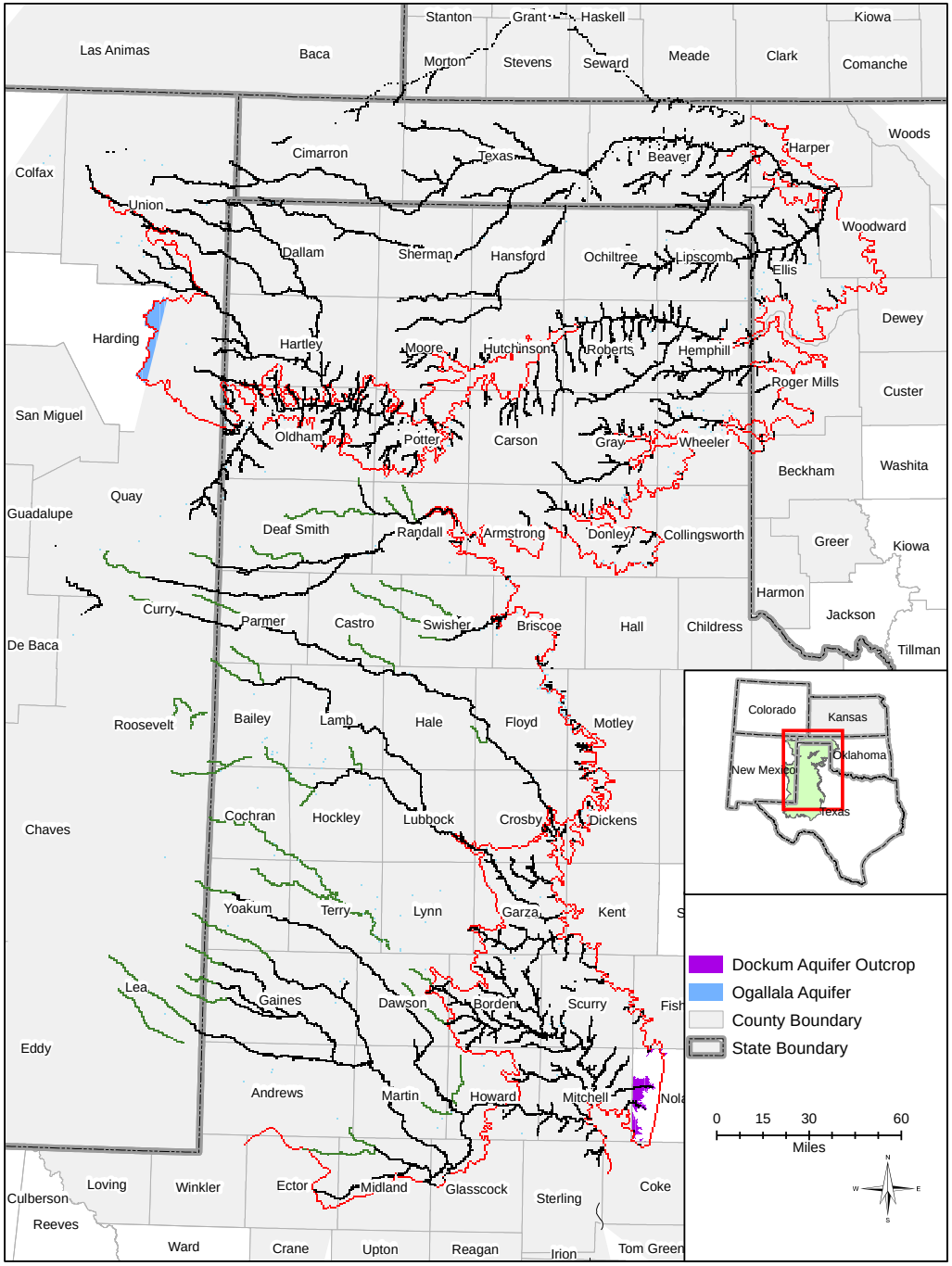






Head boundaries: DRN and RIV

- Drains represent springs, draws, and seeps along escarpment
- RIV cells represent rivers, streams, and reservoirs



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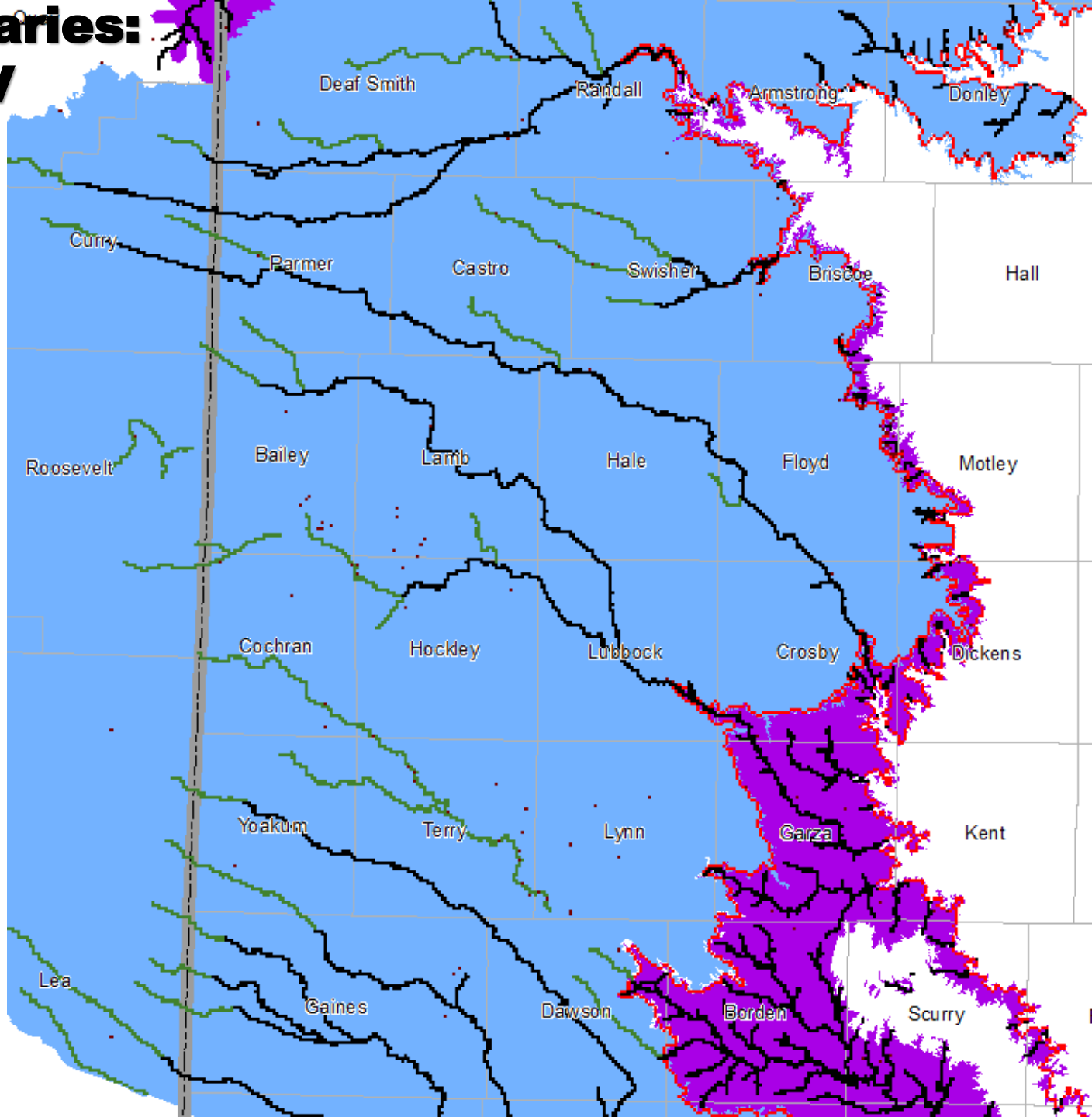
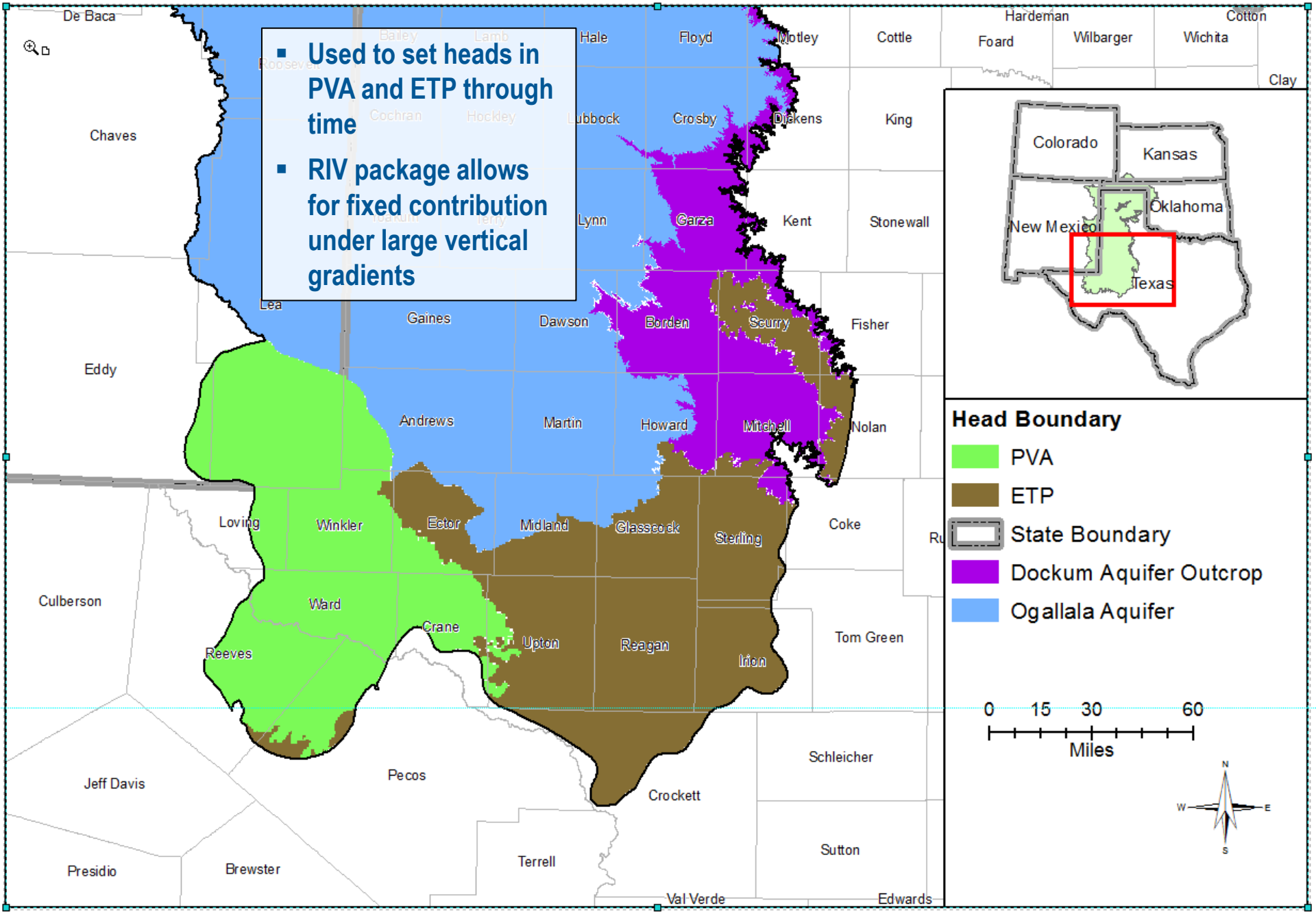
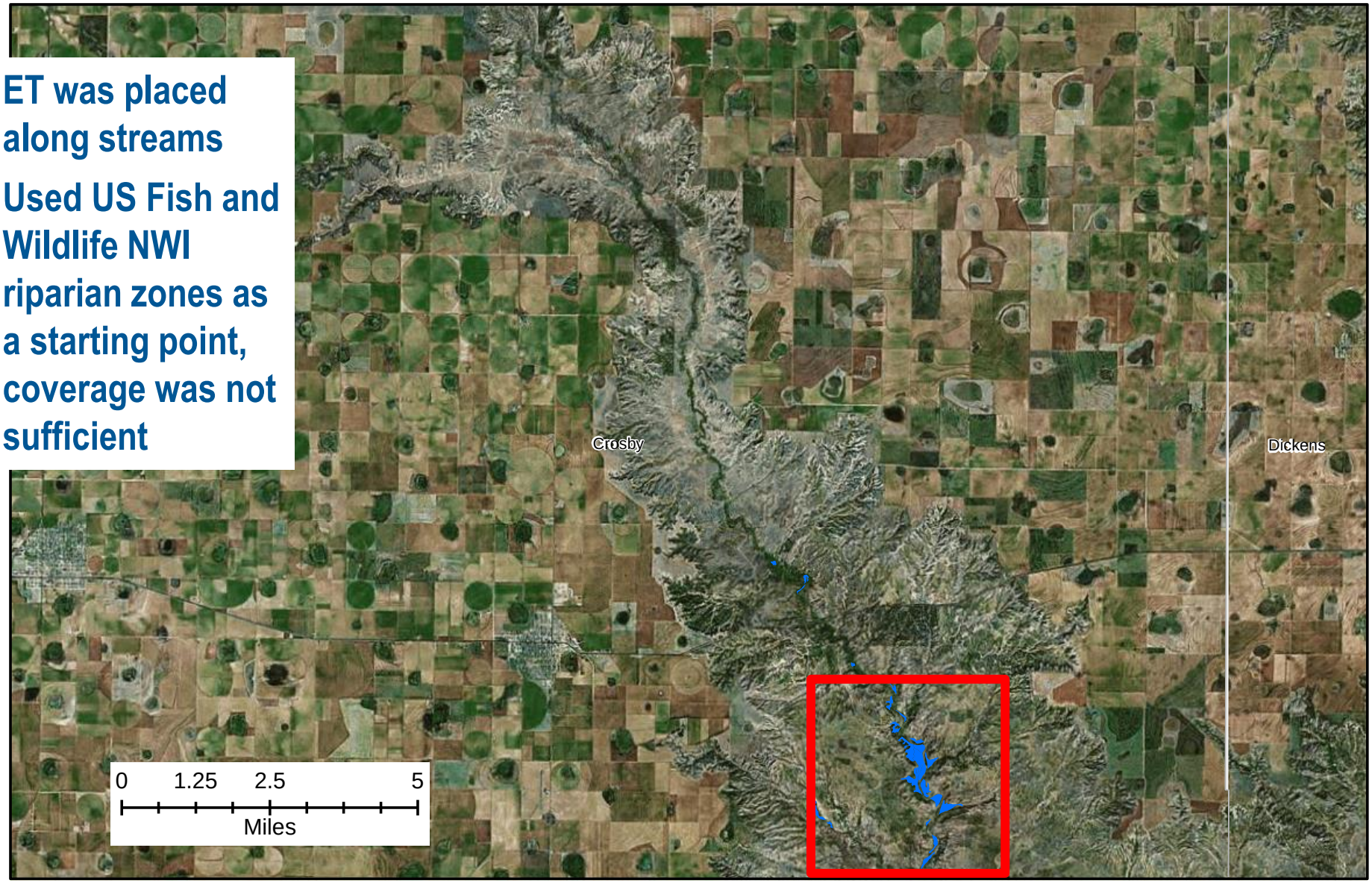


Head boundaries: RIV as "GHB"

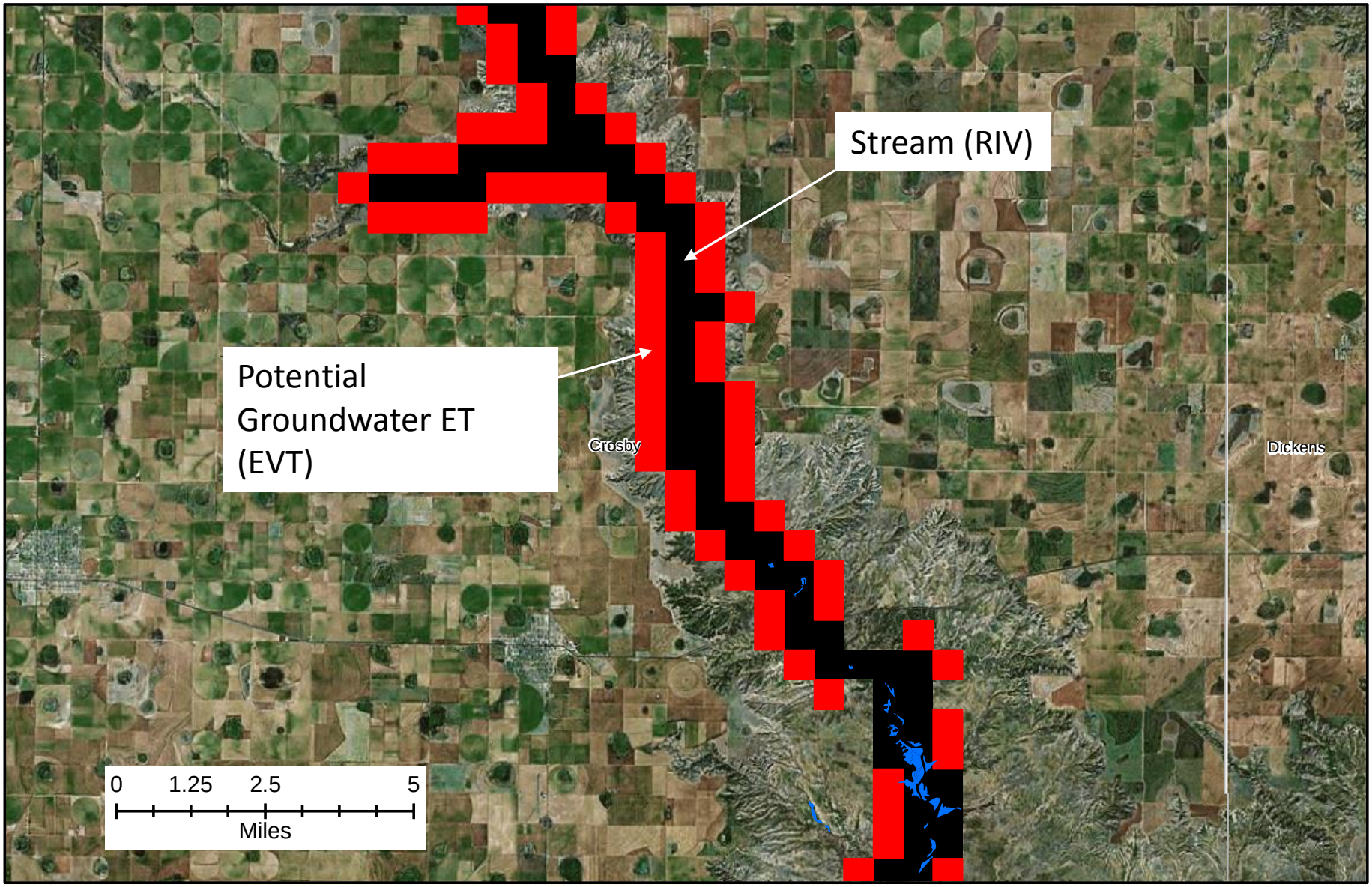


Head boundaries: EVT

- ET was placed along streams
- Used US Fish and Wildlife NWI riparian zones as a starting point, coverage was not sufficient

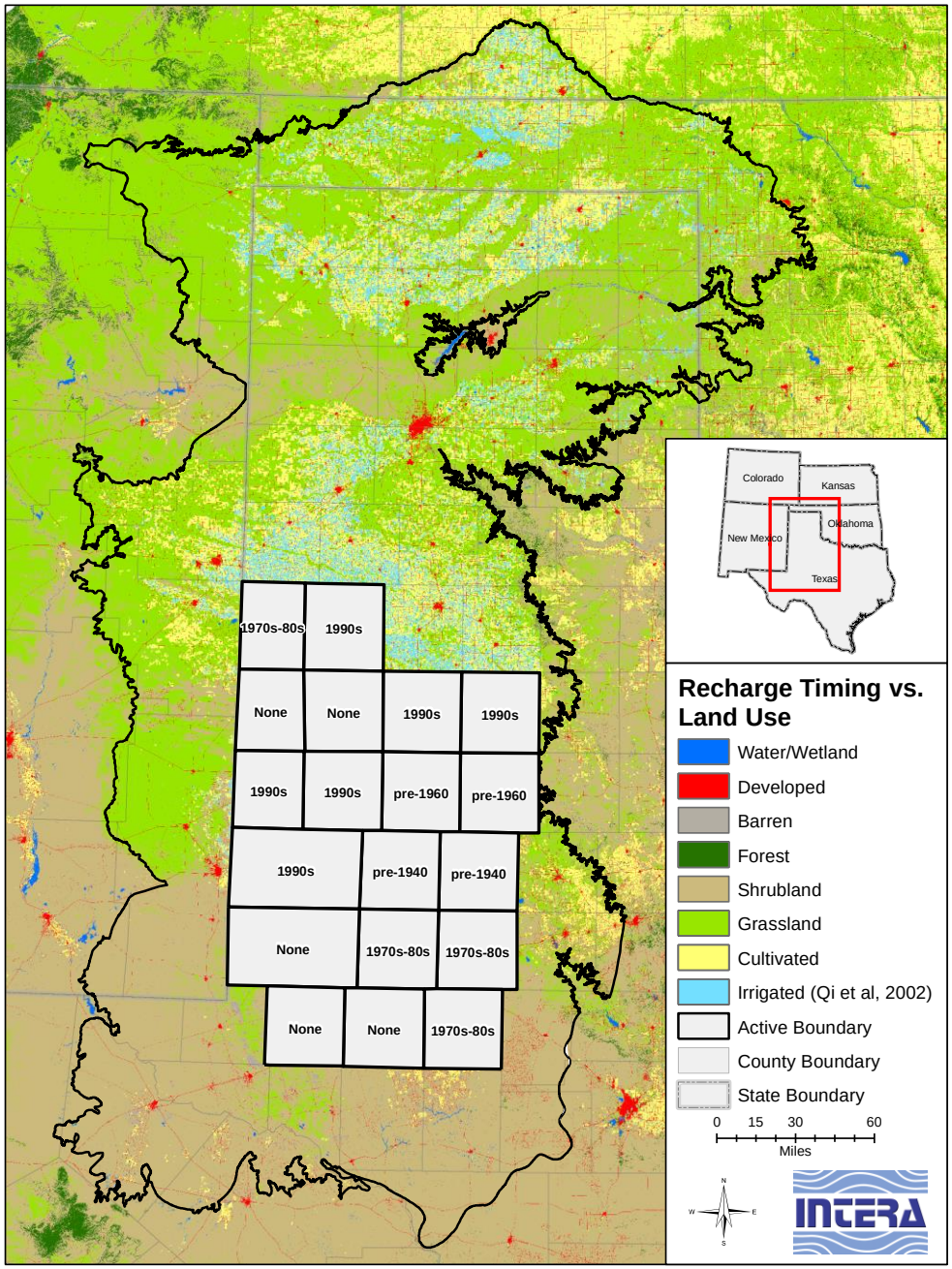


Head dependent flux: EVT



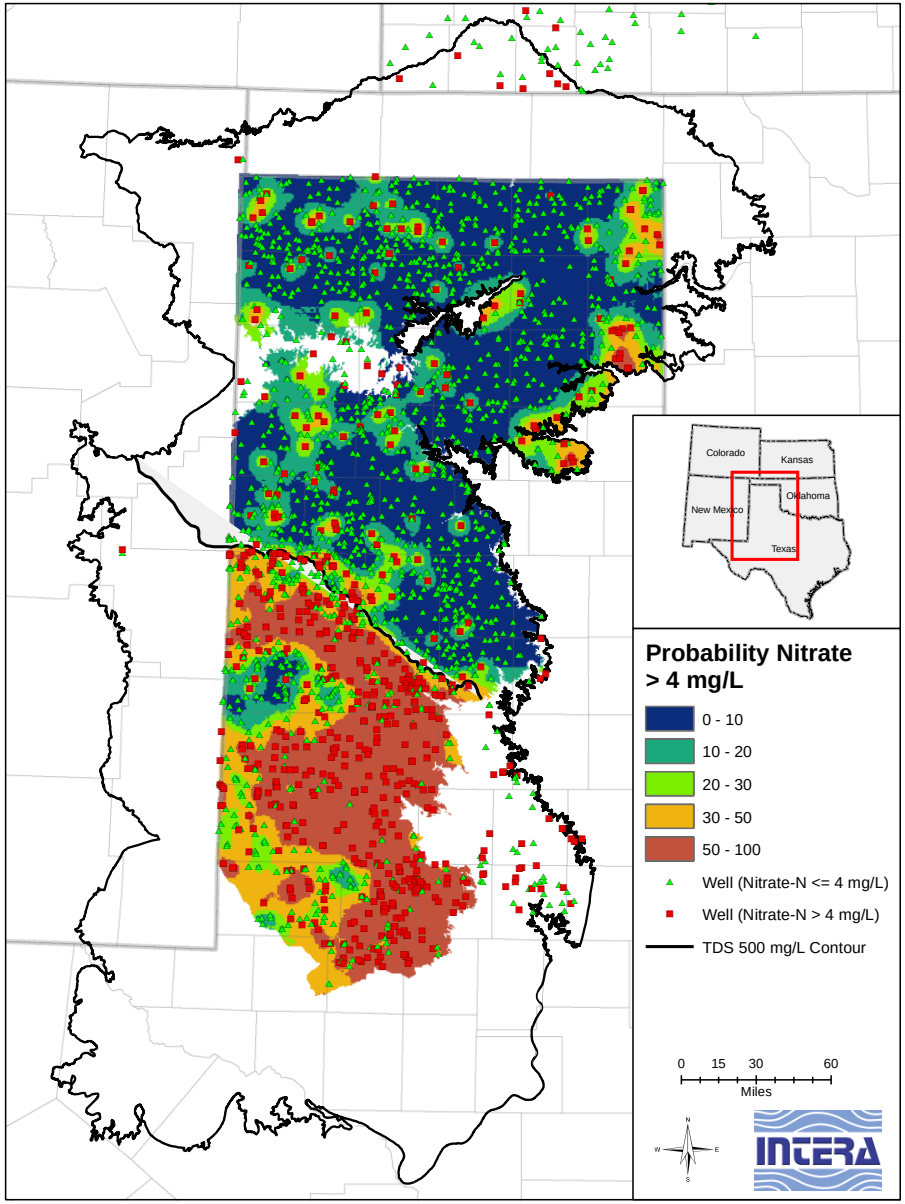
Flux Boundary: RCH

- Initialized steady-state with Reedy/Scanlon estimates
- Transitioned to post-agriculture estimates based on breakthrough map



Flux Boundary: RCH

- Areas with no evidence of agriculturally-enhanced recharge were kept at steady-state values



Flux Boundary: Pumping

- Created combined database of all known wells from all sources
  - TWDB GWDB
  - Driller databases
  - TCEQ PWS
  - GCD Databases
- Used actual wells for pumping assignment when possible
- Located wells vertically based on screen location or well depth, and transmissivity weighted allocation to the wells
- Had meter data for only a few wells (primarily CRMWA)
- “Fuzzy” matched owner name and survey type (MIN, MUN, etc) when possible for survey data pumping (i.e. >= year 1980)

Flux Boundary: Pumping

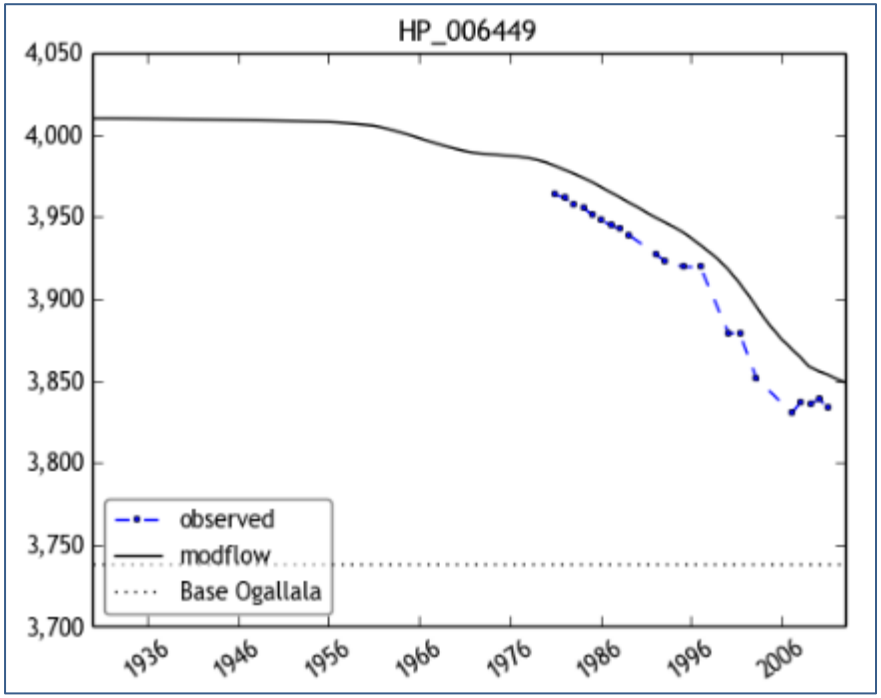
- For irrigation pumping (the bulk of the pumping), used irrigation well locations
- Estimated maximum pumping rates based on saturated thickness
- Added “ghost” wells in places where pumping exceeded the number of wells available in the database
- Added wells in locations where pivot circles were recorded, but no wells were in place

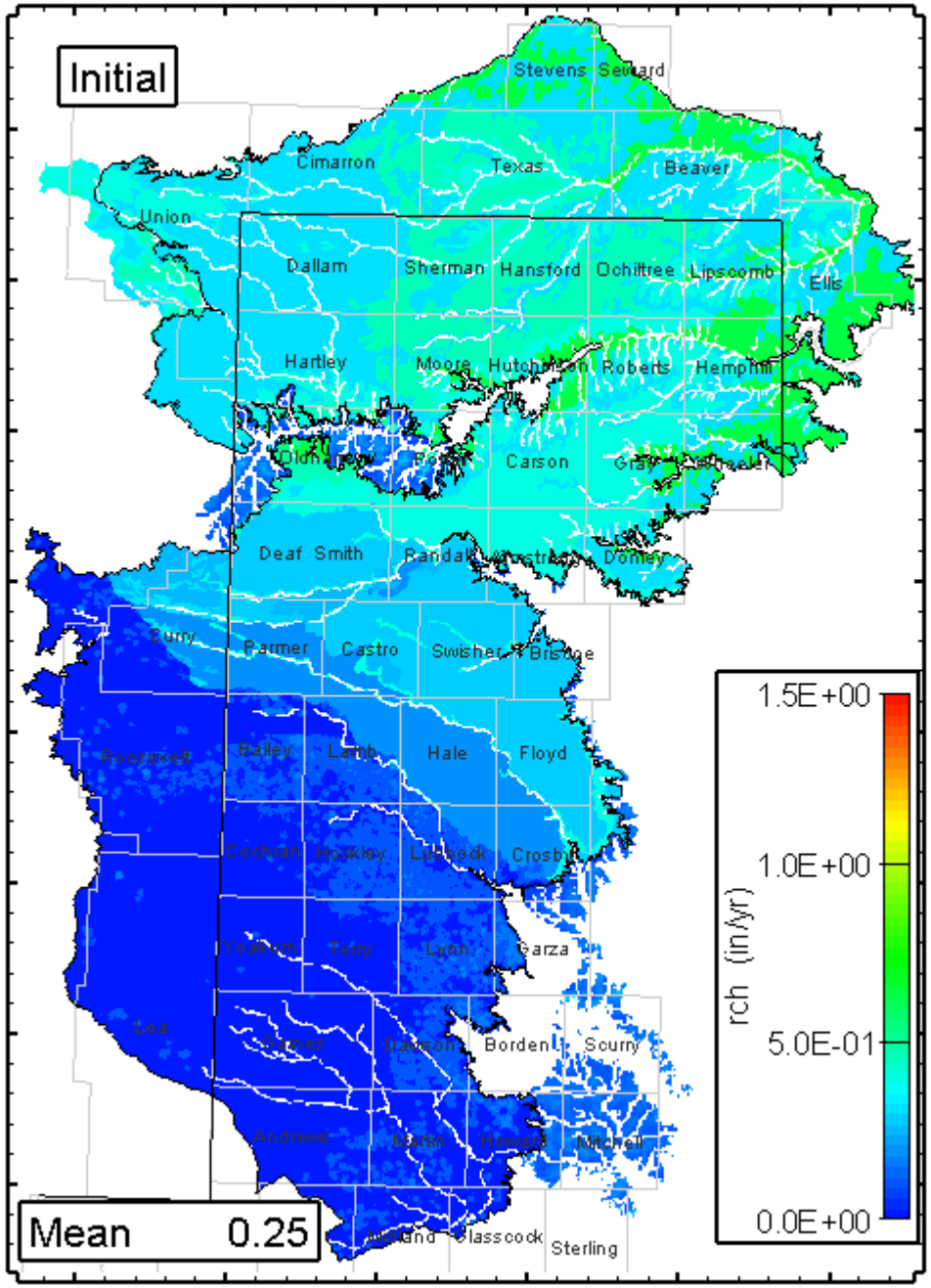
Flux Boundary: Pumping

- Added wells in locations where pivot circles were recorded, but no wells were in place
- Attempted to honor estimated pumping post-1980 by county
- Pumping prior to 1980 was reduced in some cases (more later)

Model Calibration

- Model calibration is the adjustment of parameter values within well-defined bounds to improve the fit between simulated and measured or estimated results
- Model is calibrated to both steady-state (prior to development) and transient conditions
- Calibrating to both conditions helps constrain parameters, creating a more realistic model
- The steady-state condition represents the starting point for the model
- Primary calibration target is water level measurements




Initial
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Howard
Mitchell
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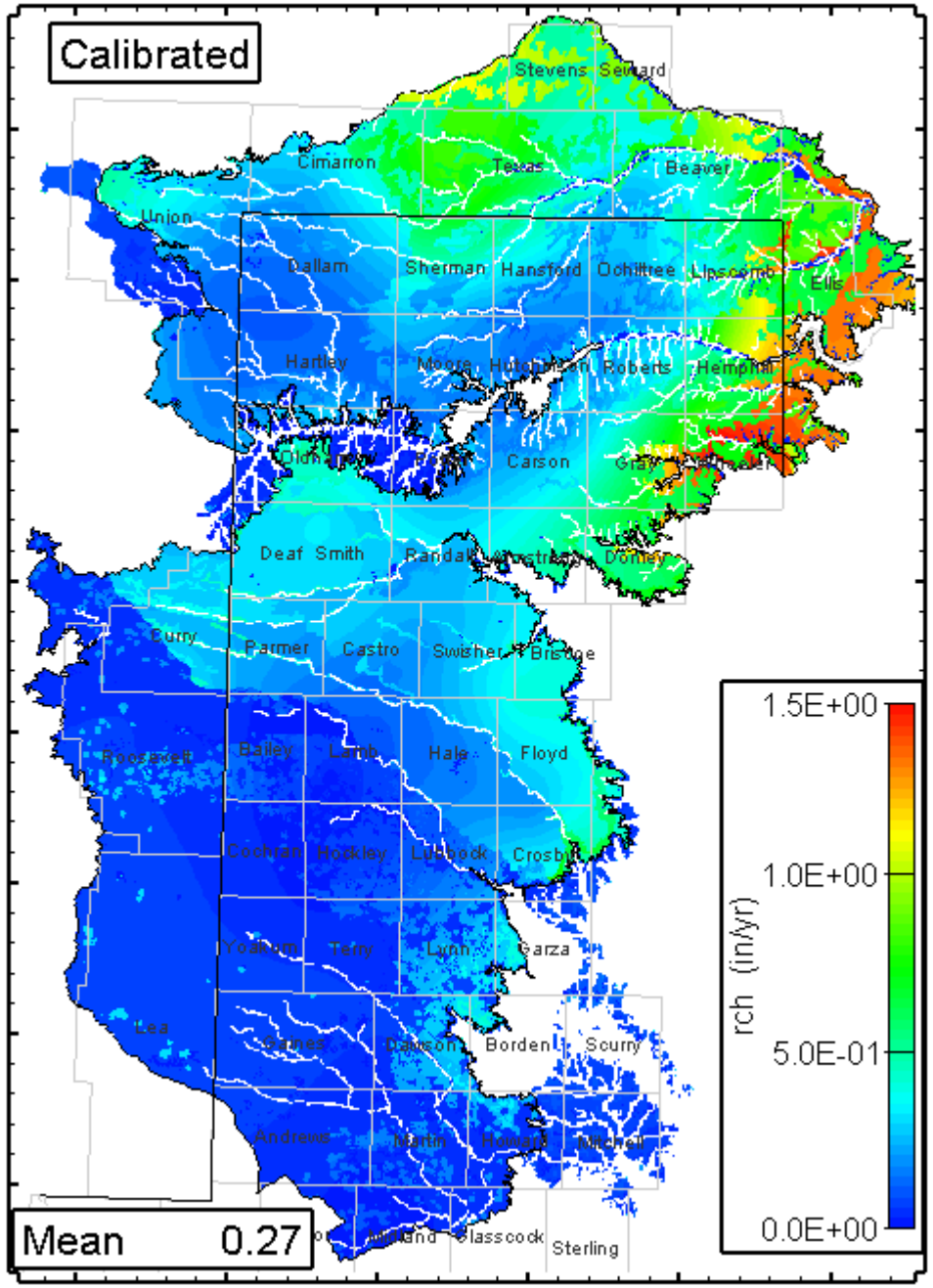
0.0E+00
rch (in/yr)
Mean 0.25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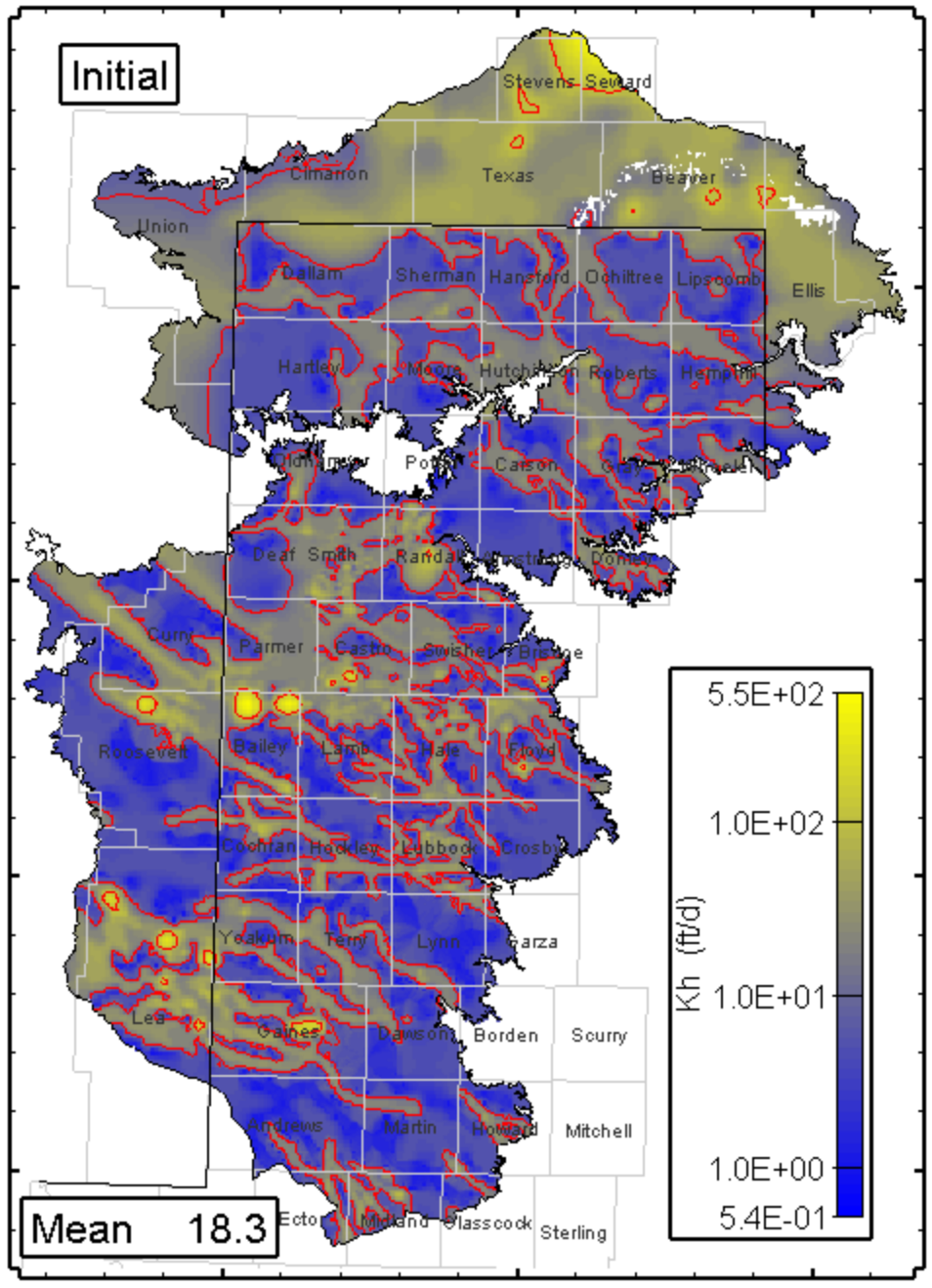
rch (in/yr)
Mean 0.27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Howard
Mitchell
Ector
Midland
Glasscock
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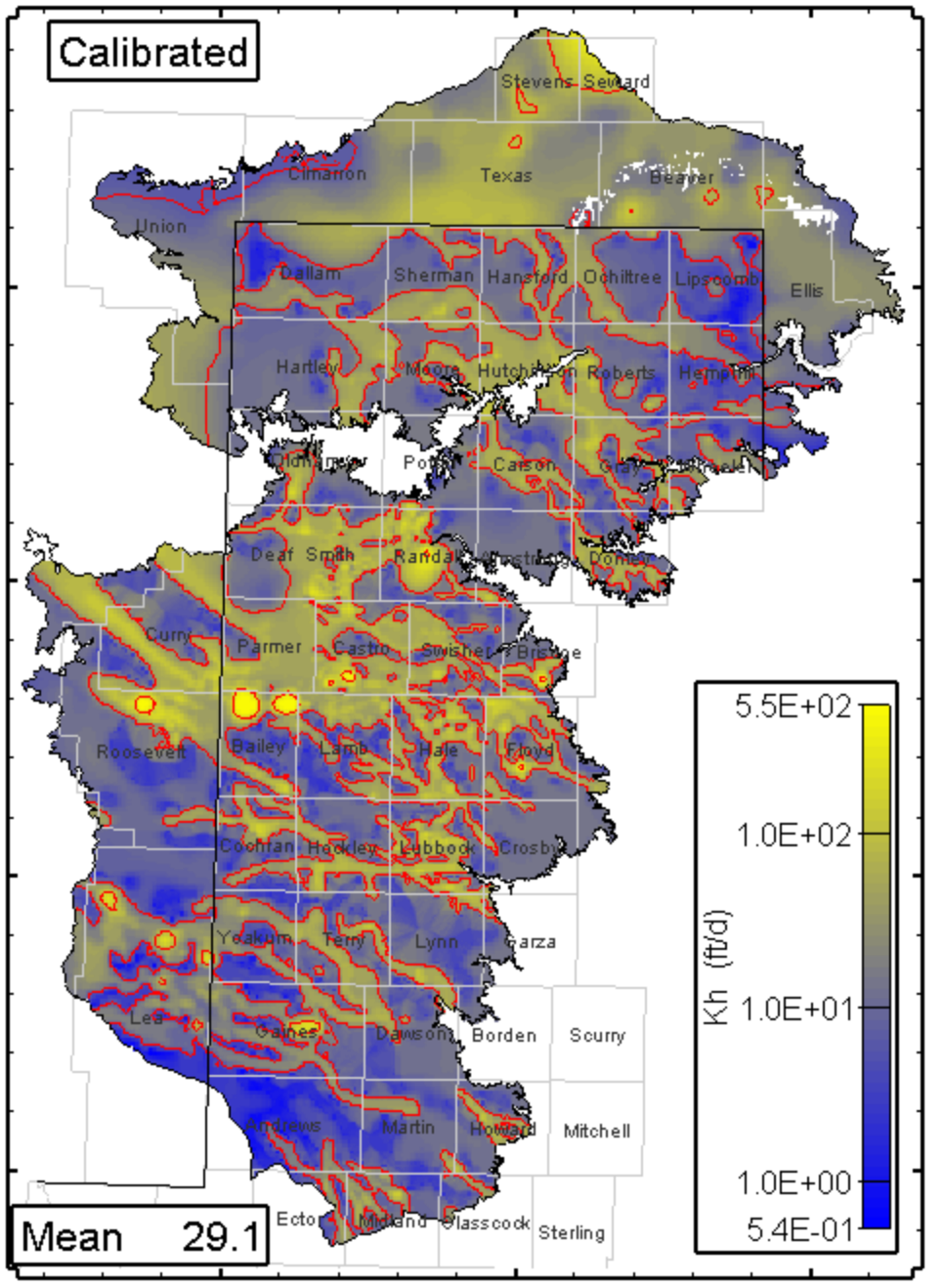
Kh (ft/d)
Mean 18.3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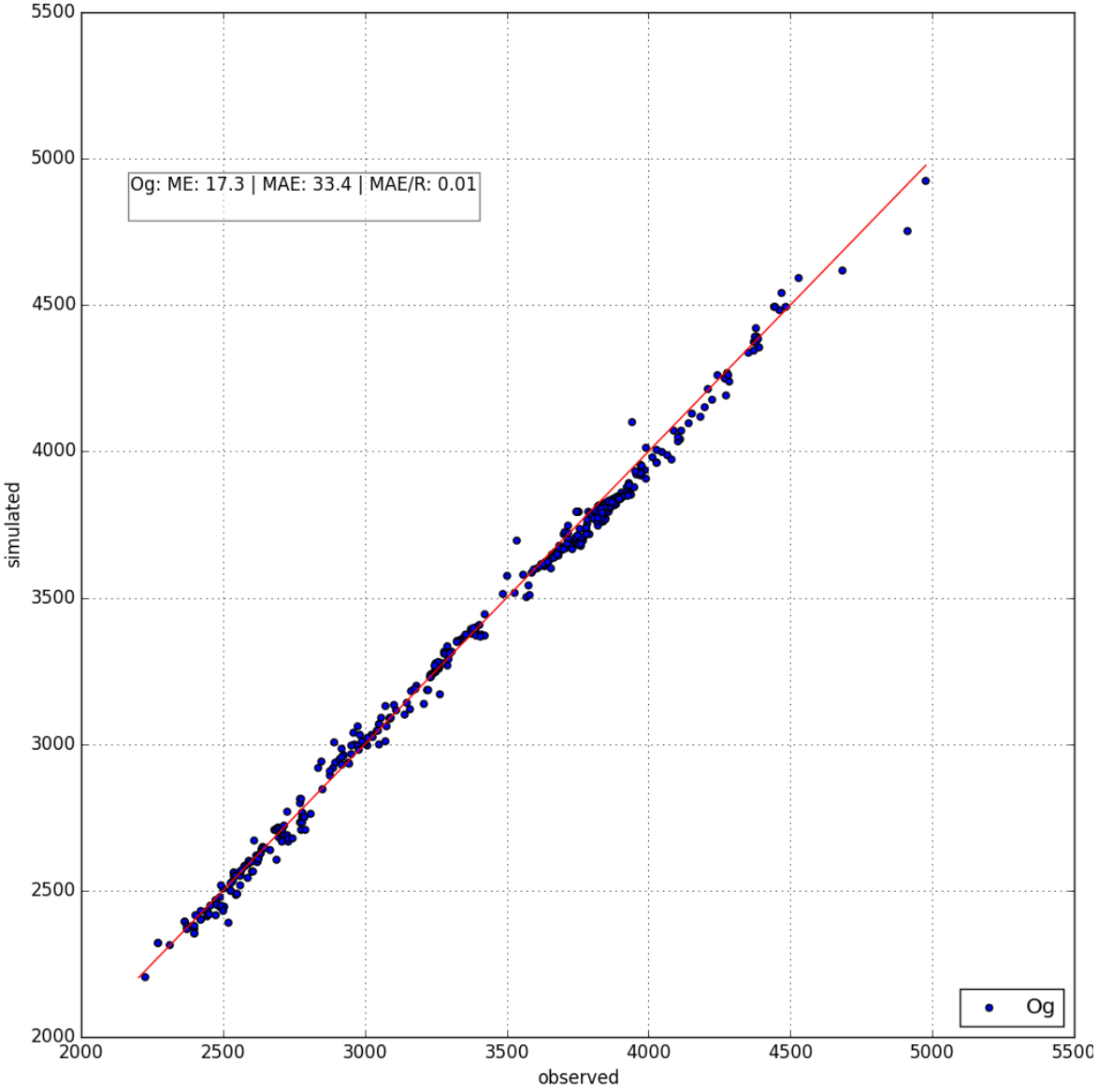
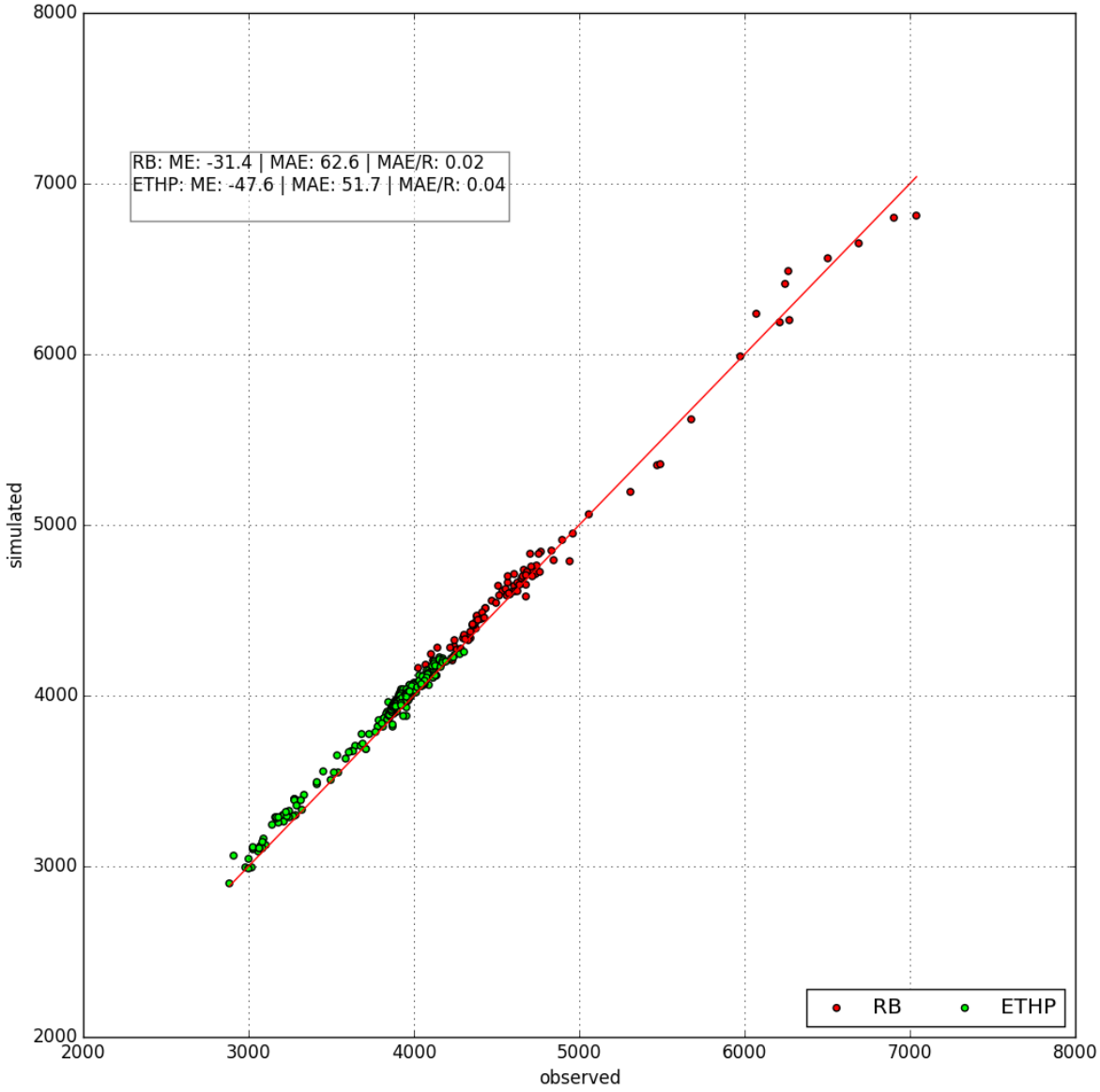
1.0E+01
1.0E+00
5.4E-01
Kh (ft/d)
Mean 29.1

Draft Steady-State Calibration



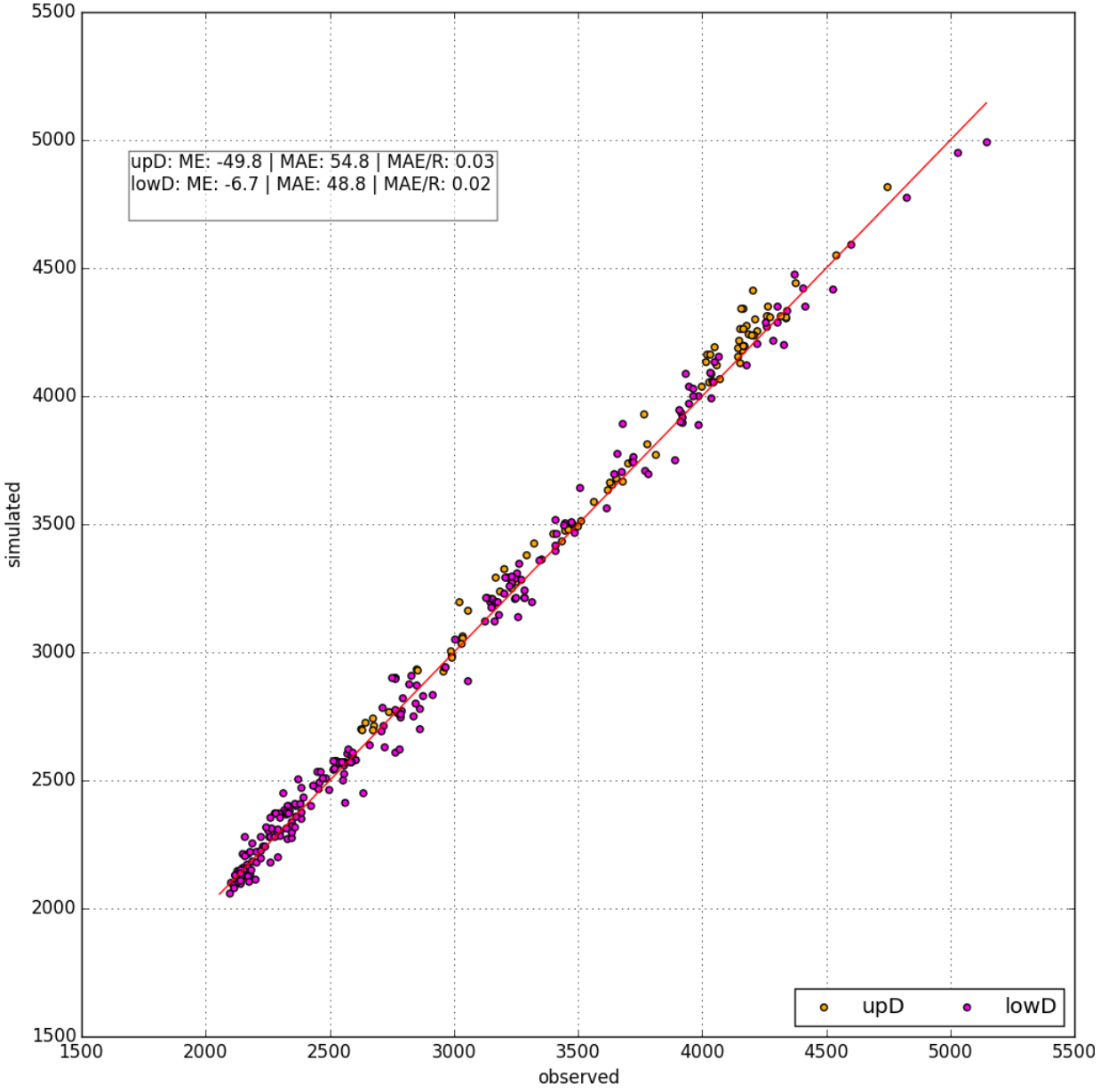
- Biggest challenge was keeping Ogallala “wet” in the west at high topography
- Wet/dry was sensitive to parameterization of underlying units
- Using parameters from current GAMs “as-is” does not work well

Draft Steady-State Calibration

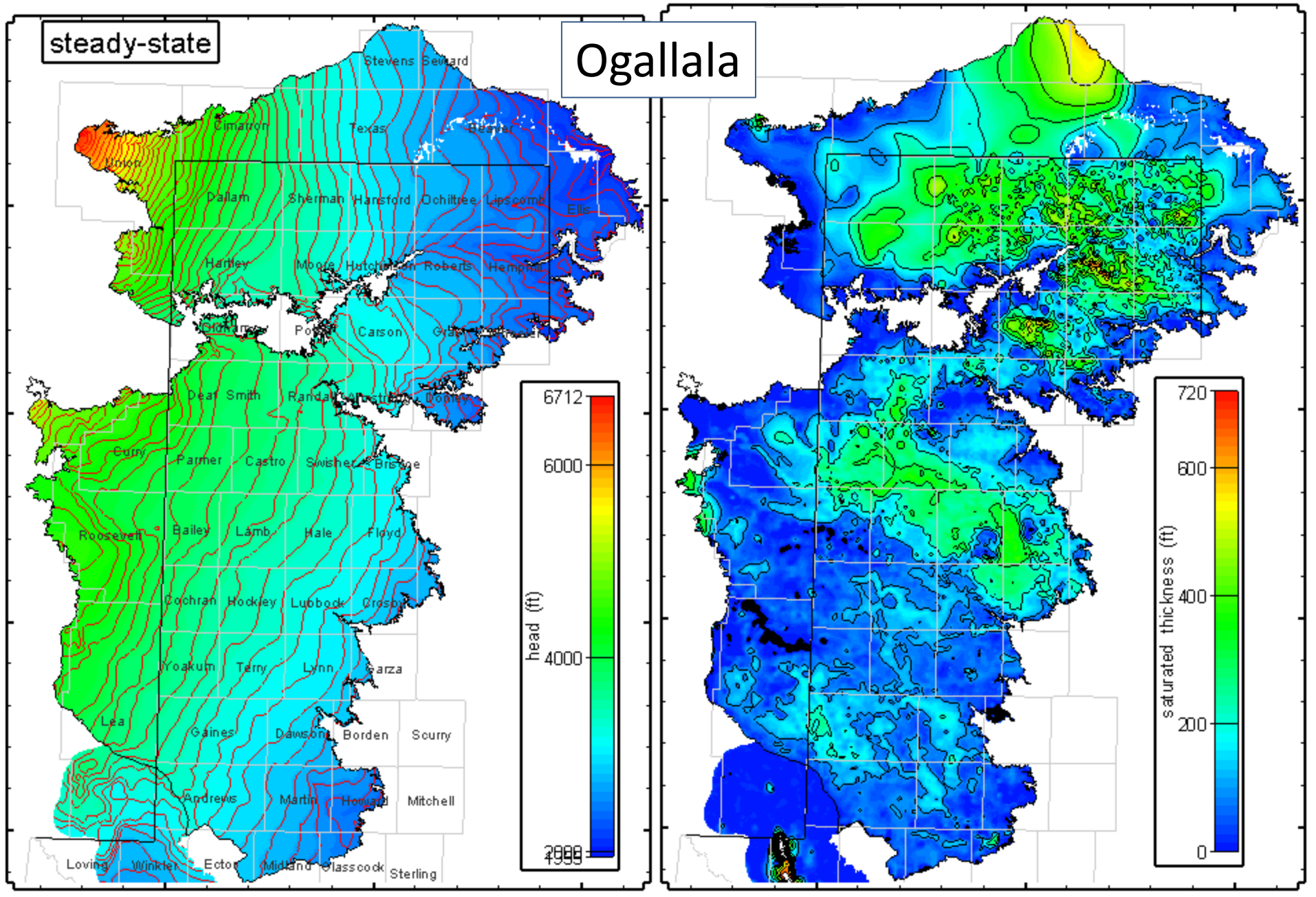


- Some bias in ETHP a compromise with:
  - Keeping Ogallala wet in the west
  - Getting sufficient drawdown in ETHP in transient
- Being on the simulated high-side in steady-state most consistent with water levels affected by development

Draft Steady-State Calibration



- Dockum shows the most "scatter"
- Few targets in Upper Dockum, probably not worth calibrating it separately


steady-state
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Lipscomb
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Briscoe
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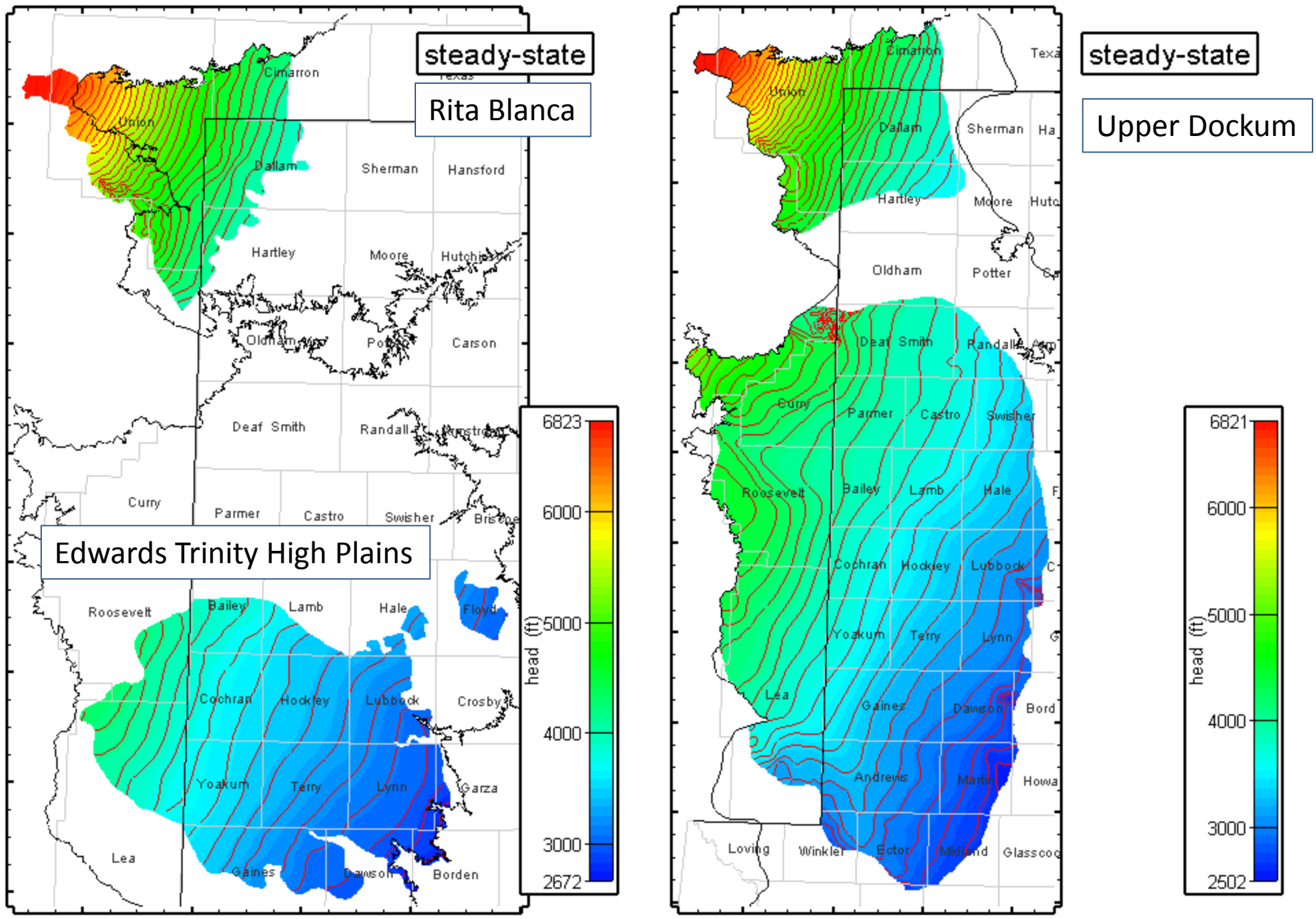
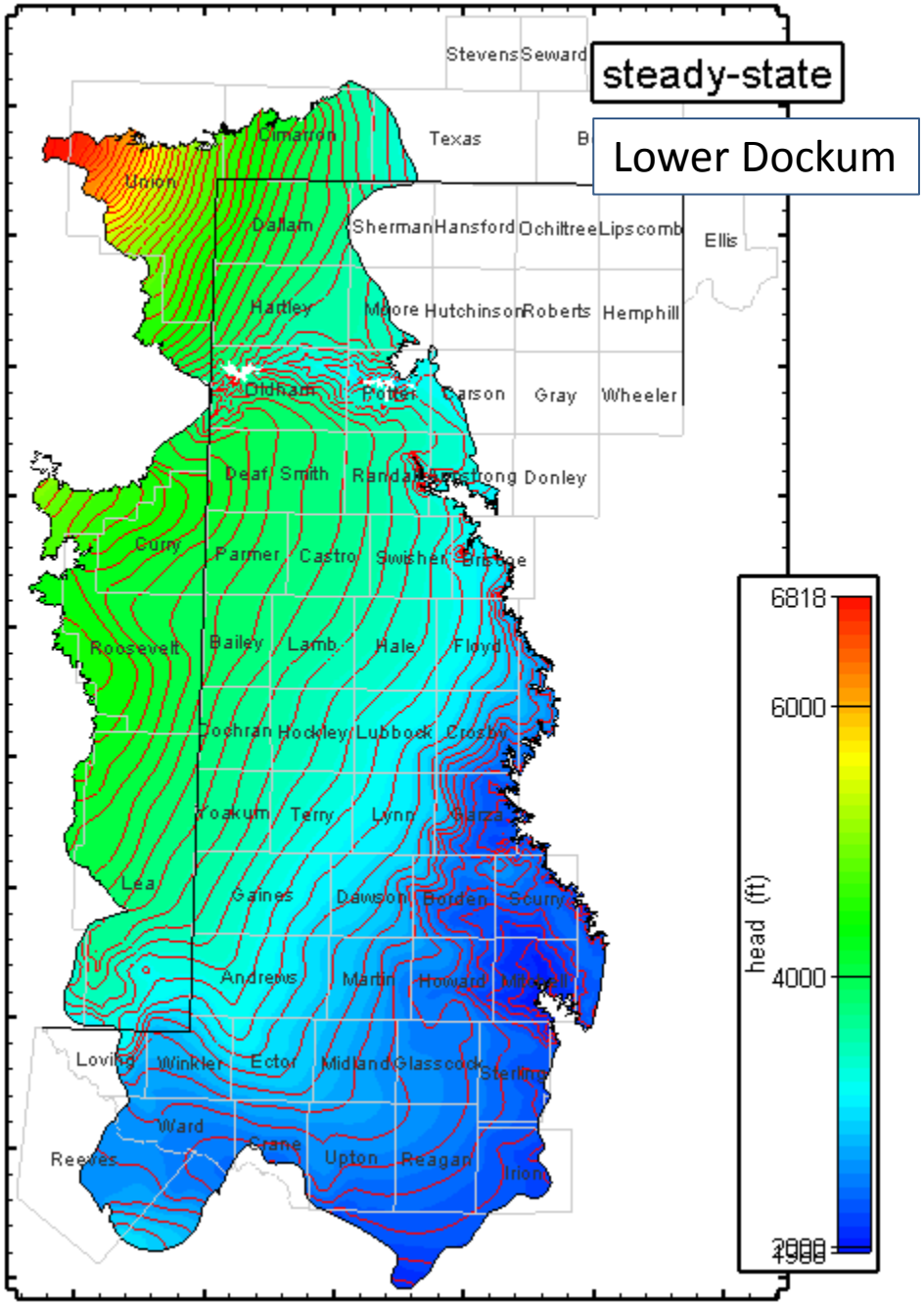
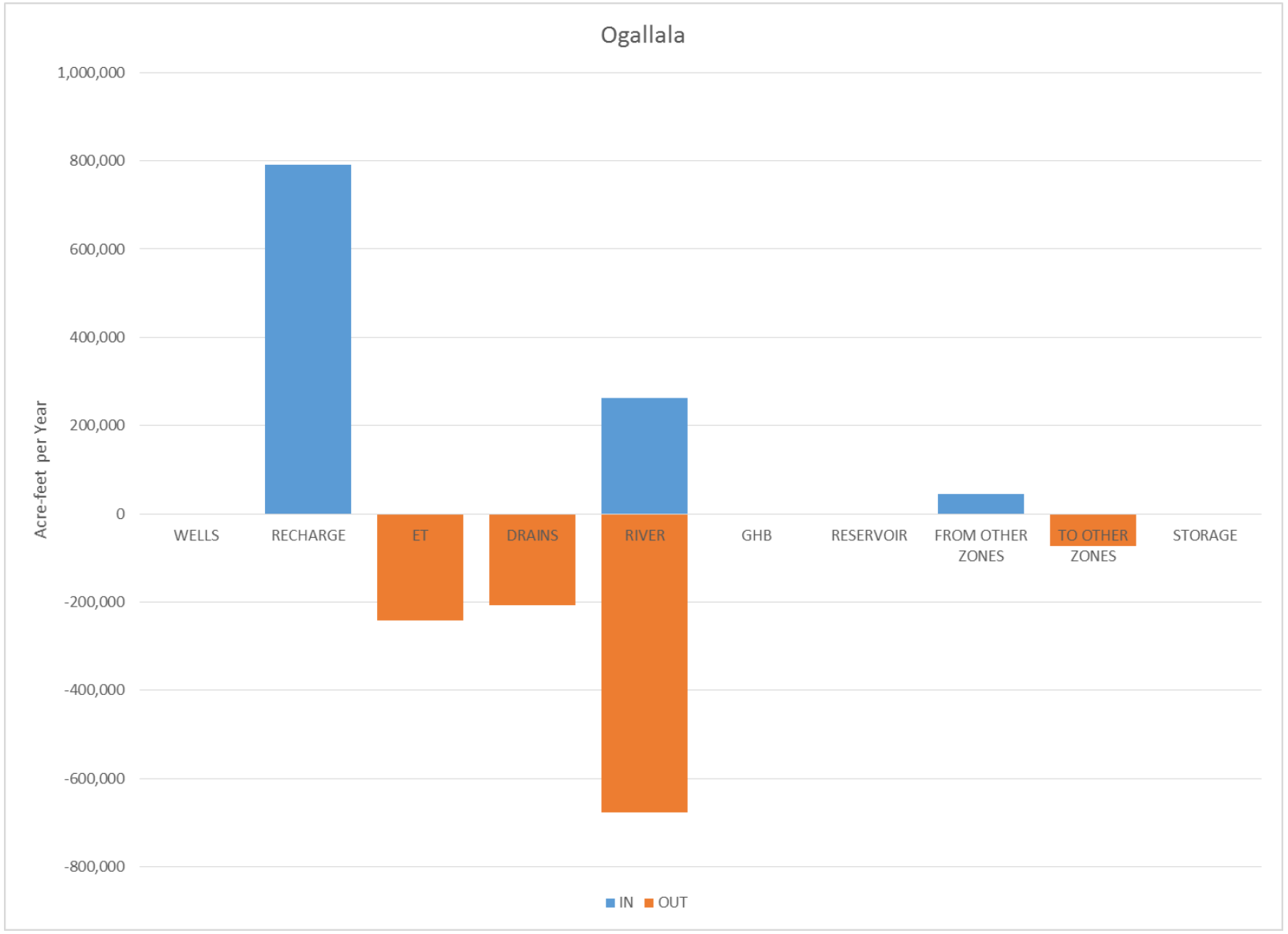
Hockley
Lubbock
Crosby
Yoakum
Terry
Lynn
Garza
Lea
Gaines
Dawson
Borden
Scurry
Andrews
Martin
Howard
Mitchell
Loving
Winkler
Ector
Midland
Glasscock
Sterling
6712
6000
4000
head (ft)
720
600
400
200
0
saturated thickness (ft)


steady-state
Rita Blanca
Edwards Trinity High Plains
Cimarron
Union
Dallam
Sherman
Hansford
Hartley
Moore
Hutchinson
Oldham
Potter
Carson
Deaf Smith
Randall
Armstrong
Curry
Parmer
Castro
Swisher
Bristoe
Roosevelt
Bailey
Lamb
Hale
Floyd
Cochran
Hockley
Lubbock
Crosby
Yoakum
Terry
Lynn
Garza
Lea
Gaines
Dawson
Borden
6823
6000
5000
4000
3000
2672
head (ft)
steady-state
Upper Dockum
Texa
Sherman
Ha
Hartley
Moore
Hutc
Oldham
Potter
Deaf Smith
Randall
Curry
Parmer
Castro
Swisher
Roosevelt
Bailey
Lamb
Hale
Cochran
Hockley
Lubbock
Yoakum
Terry
Lynn
Lea
Gaines
Dawson
Bord
Andrews
Martin
Howa
Loving
Winkler
Ector
Midland
Glasscoc
6821
6000
5000
4000
3000
2502
head (ft)

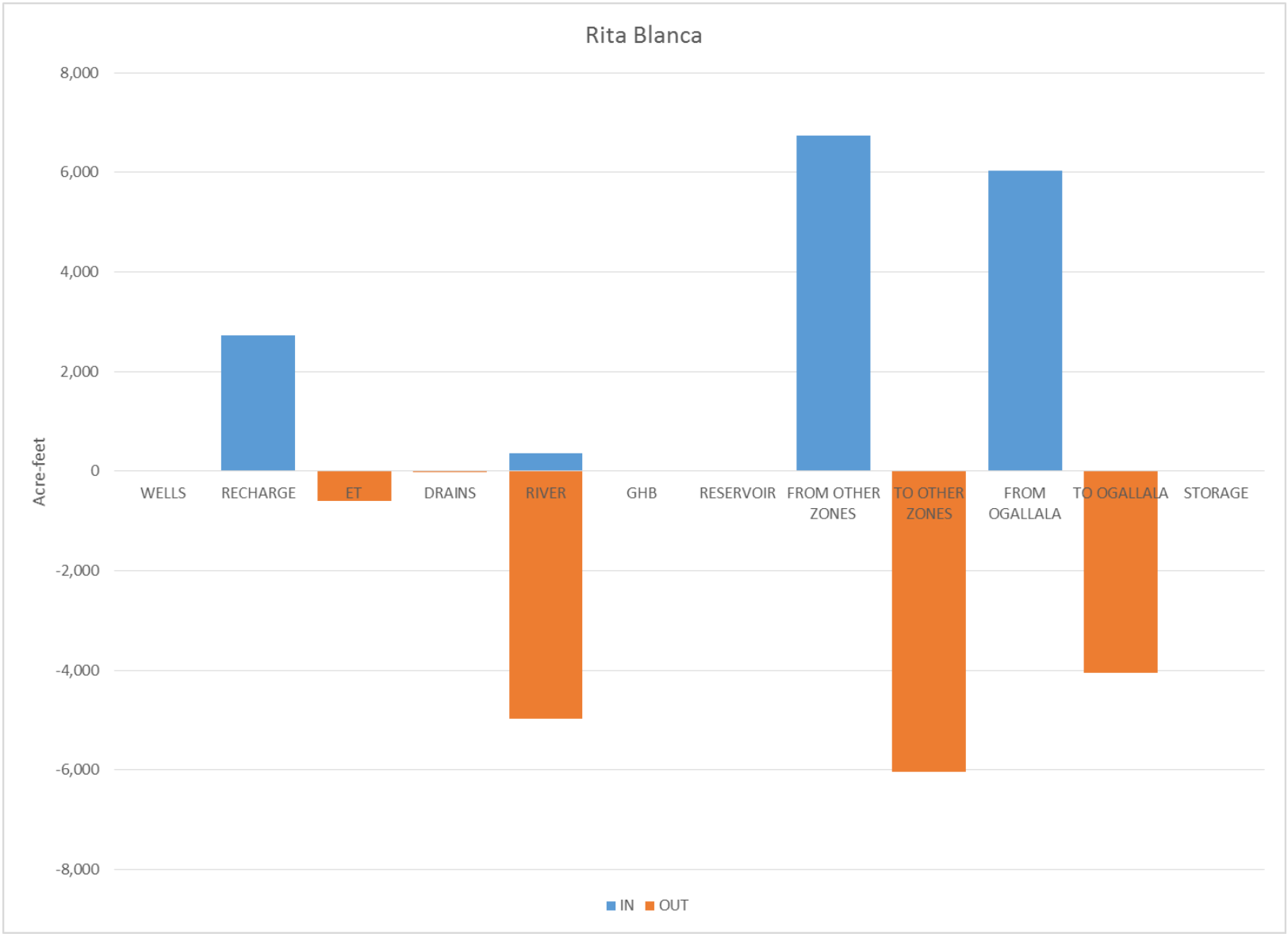
Steady-State Calibration



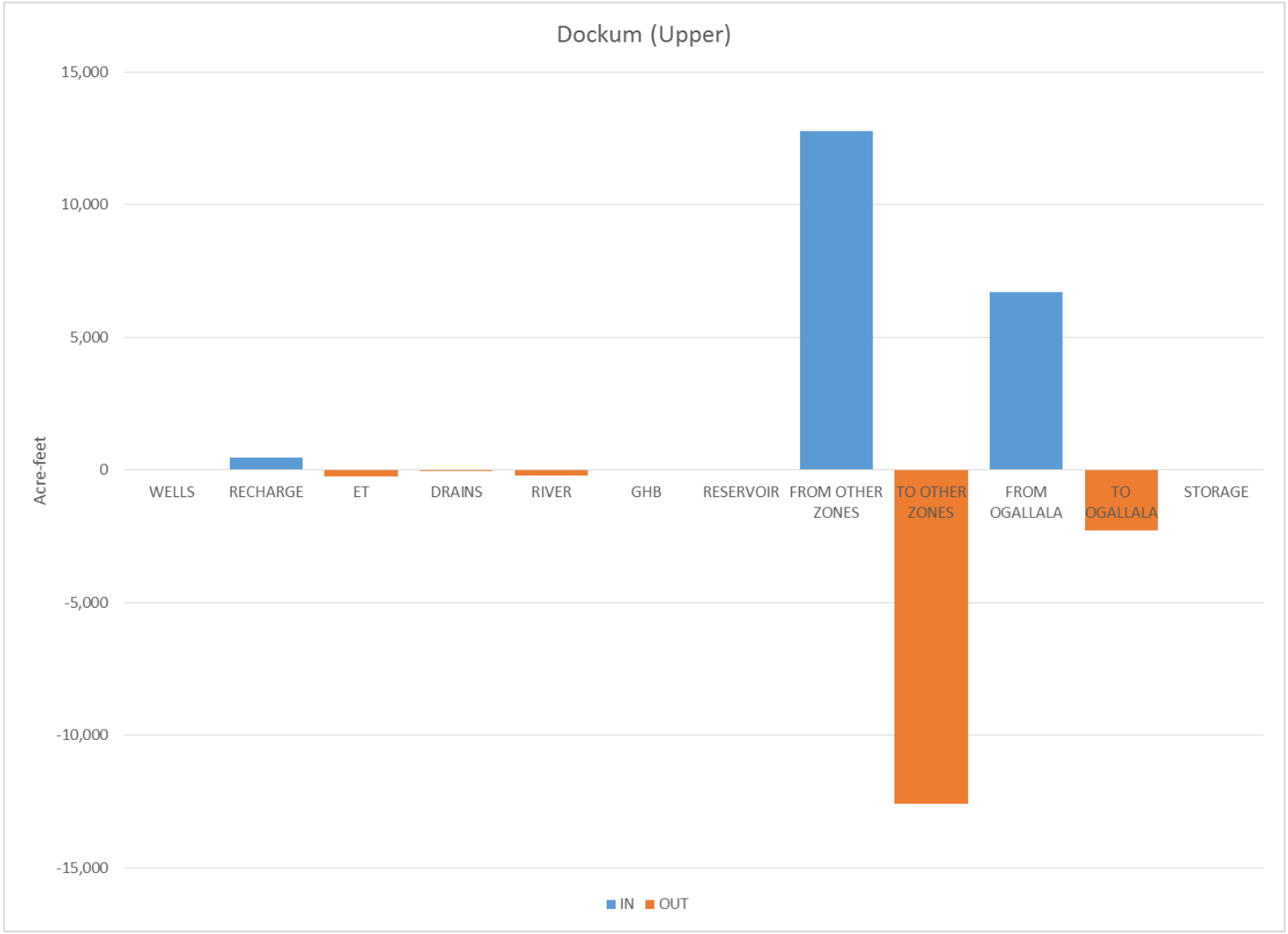
Steady-State Water Balance



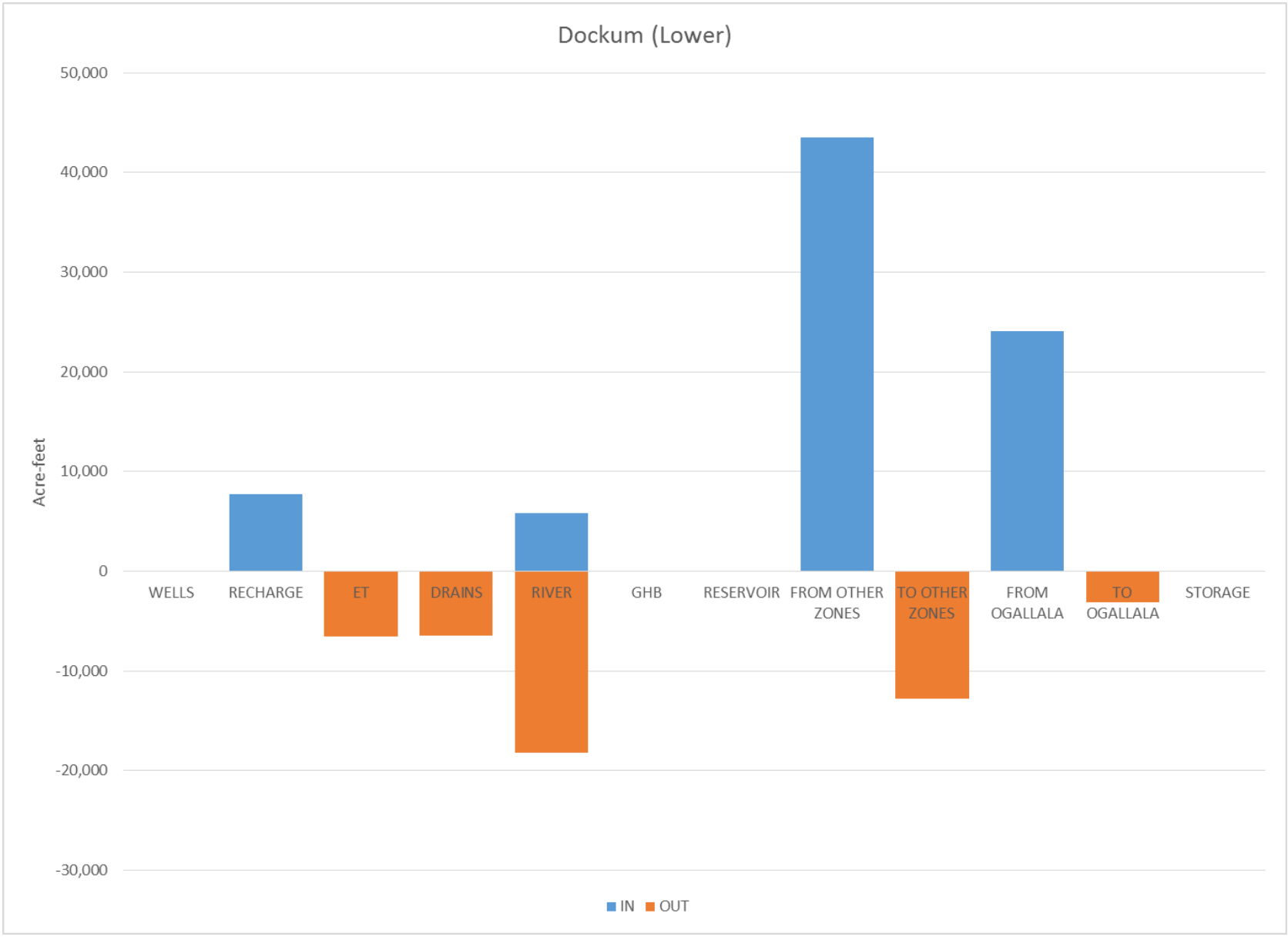
Steady-State Water Balance



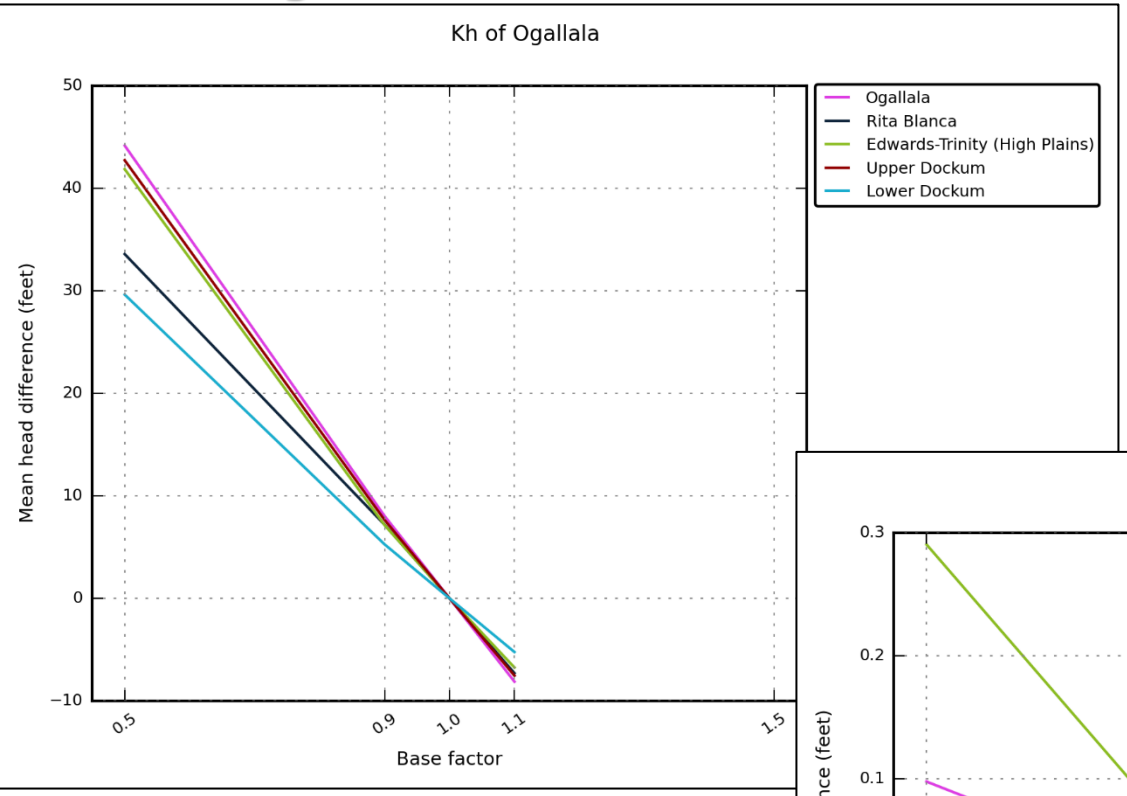
Steady-State Water Balance

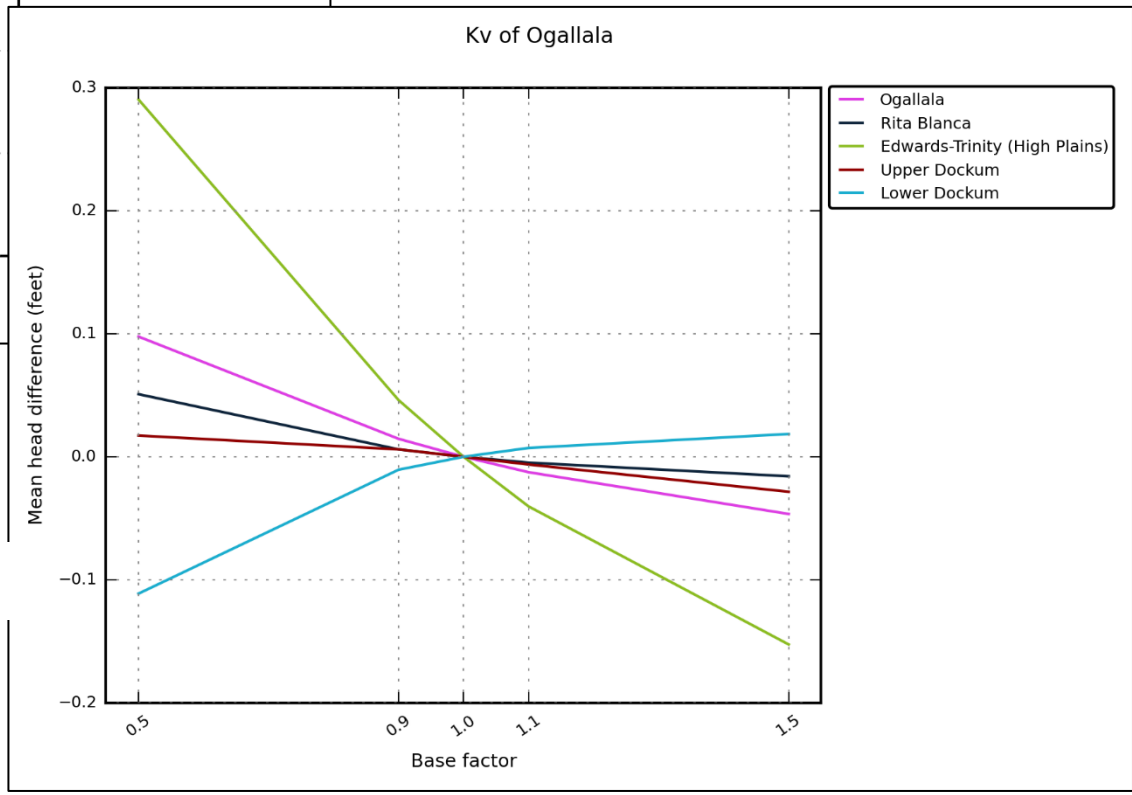


Steady-State Water Balance



Steady-State Sensitivities

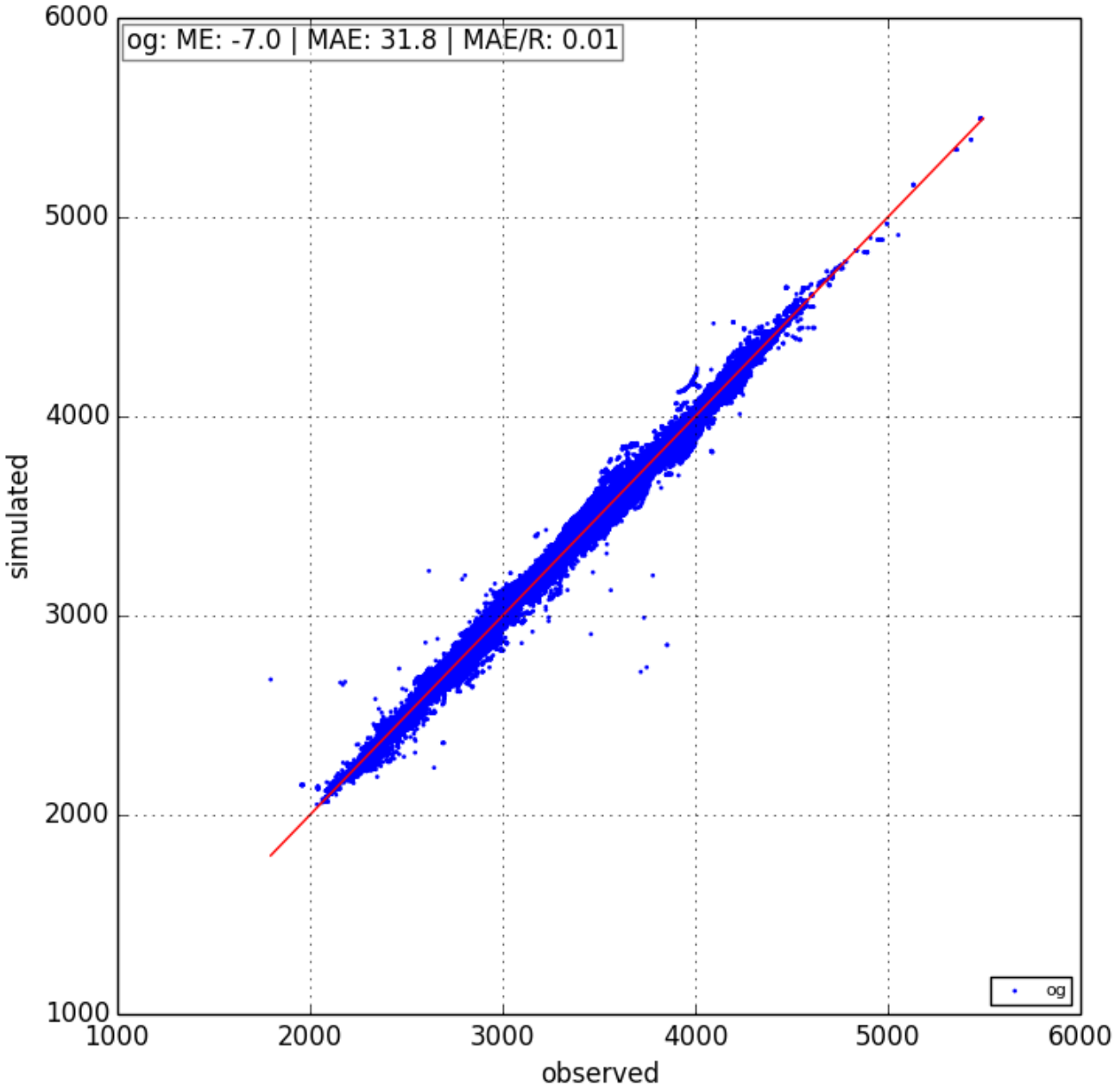




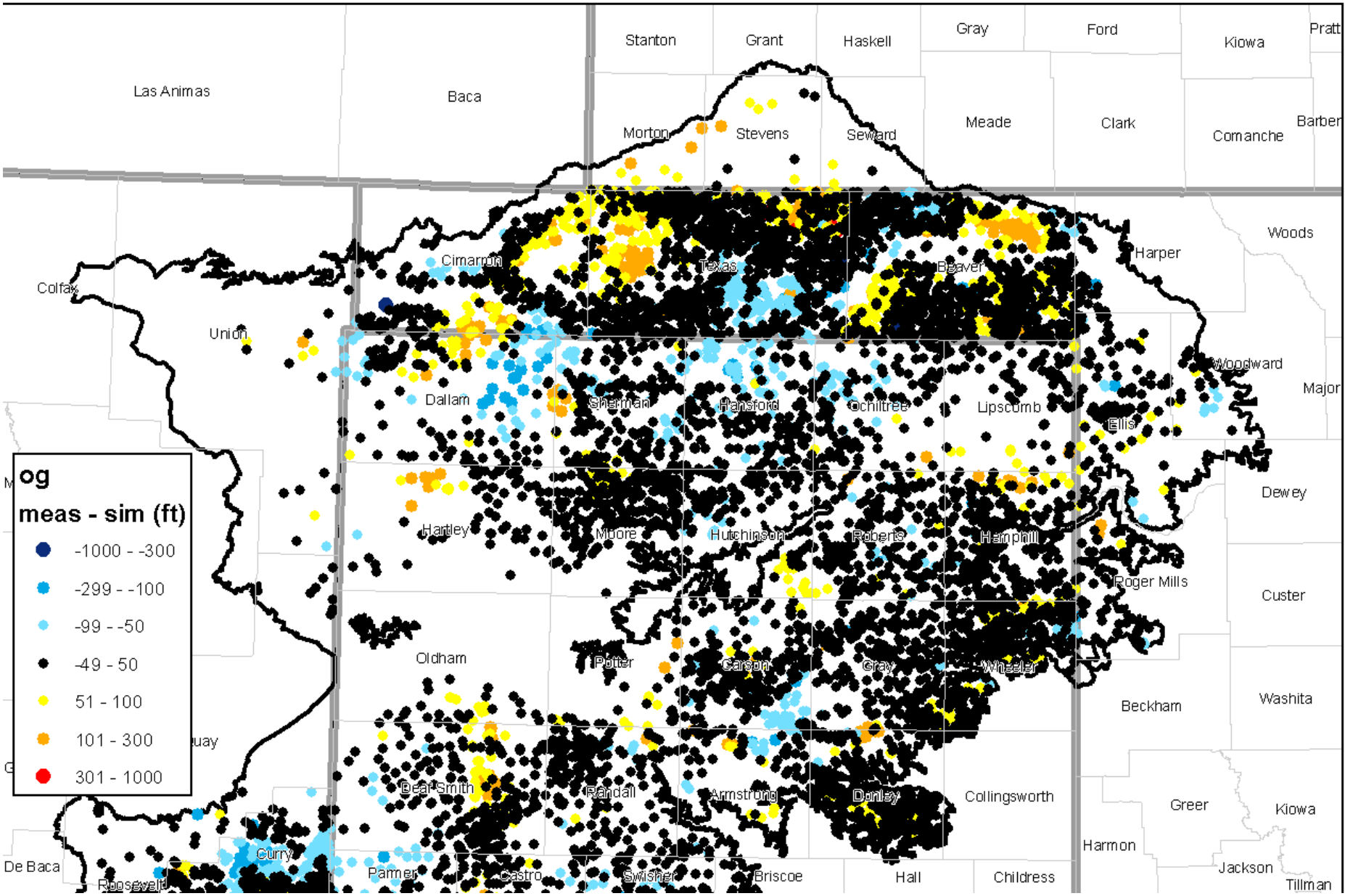
Ogallala lies on lower Kv sediments

Transient Calibration

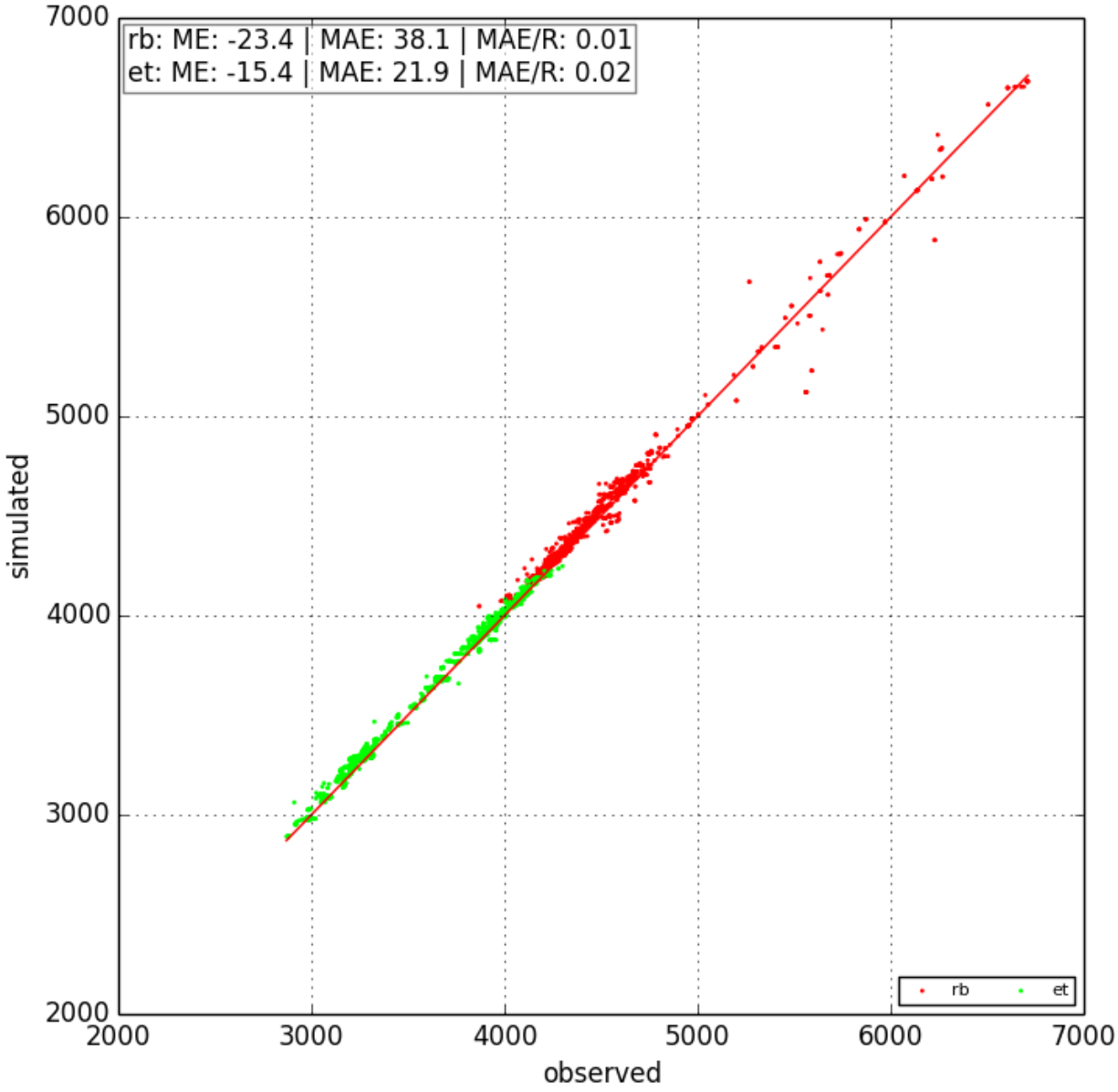
- Model goes from 1929 (SS) to 2012, with 84 annual SPs
- Kh/Kv were modified somewhat from steady-state (fields were shown previously)
- Specific storage not changed
- Sy not changed
- Pumping is the big driver in the Ogallala



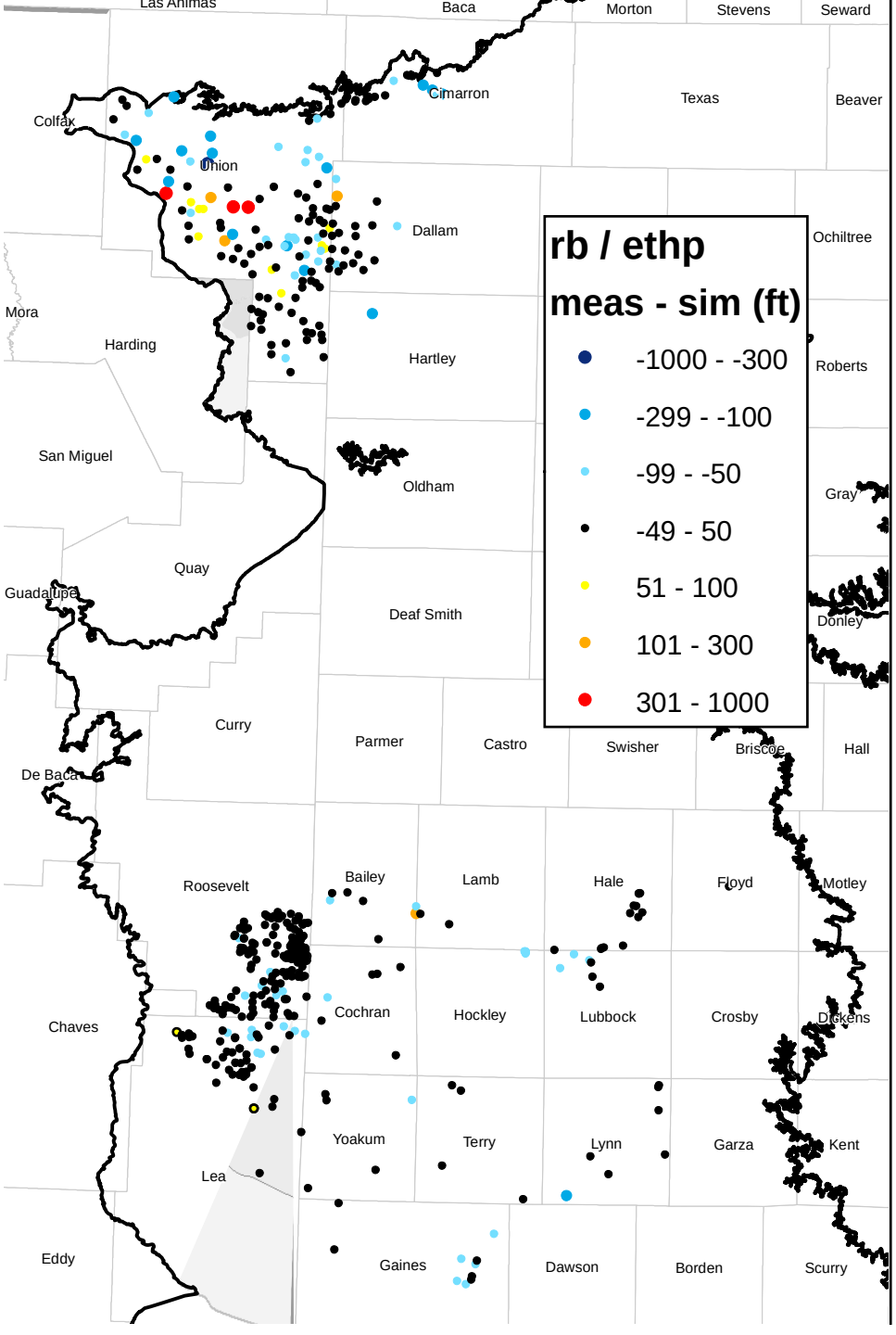
Draft Transient Calibration



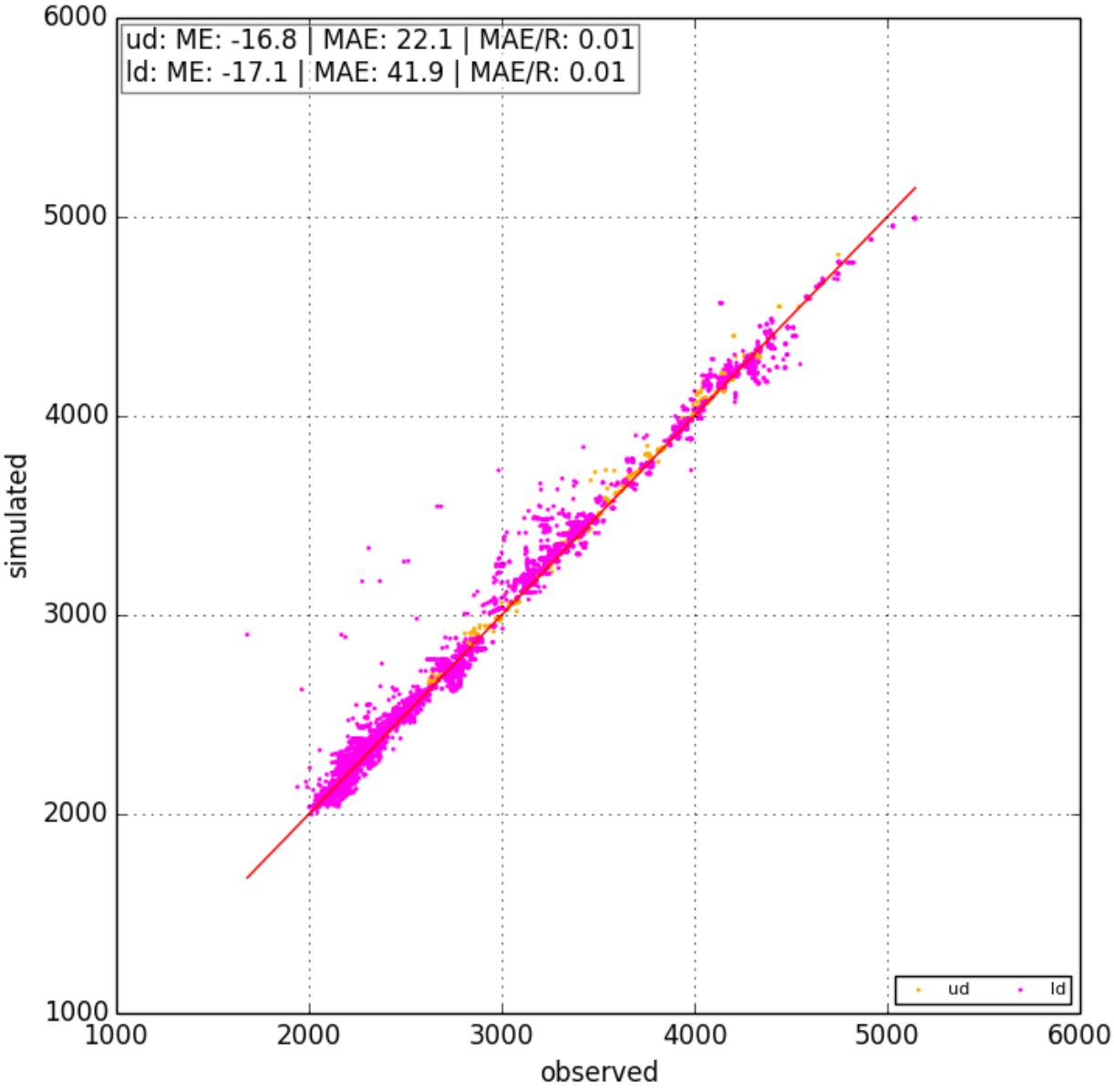
Draft Transient Calibration



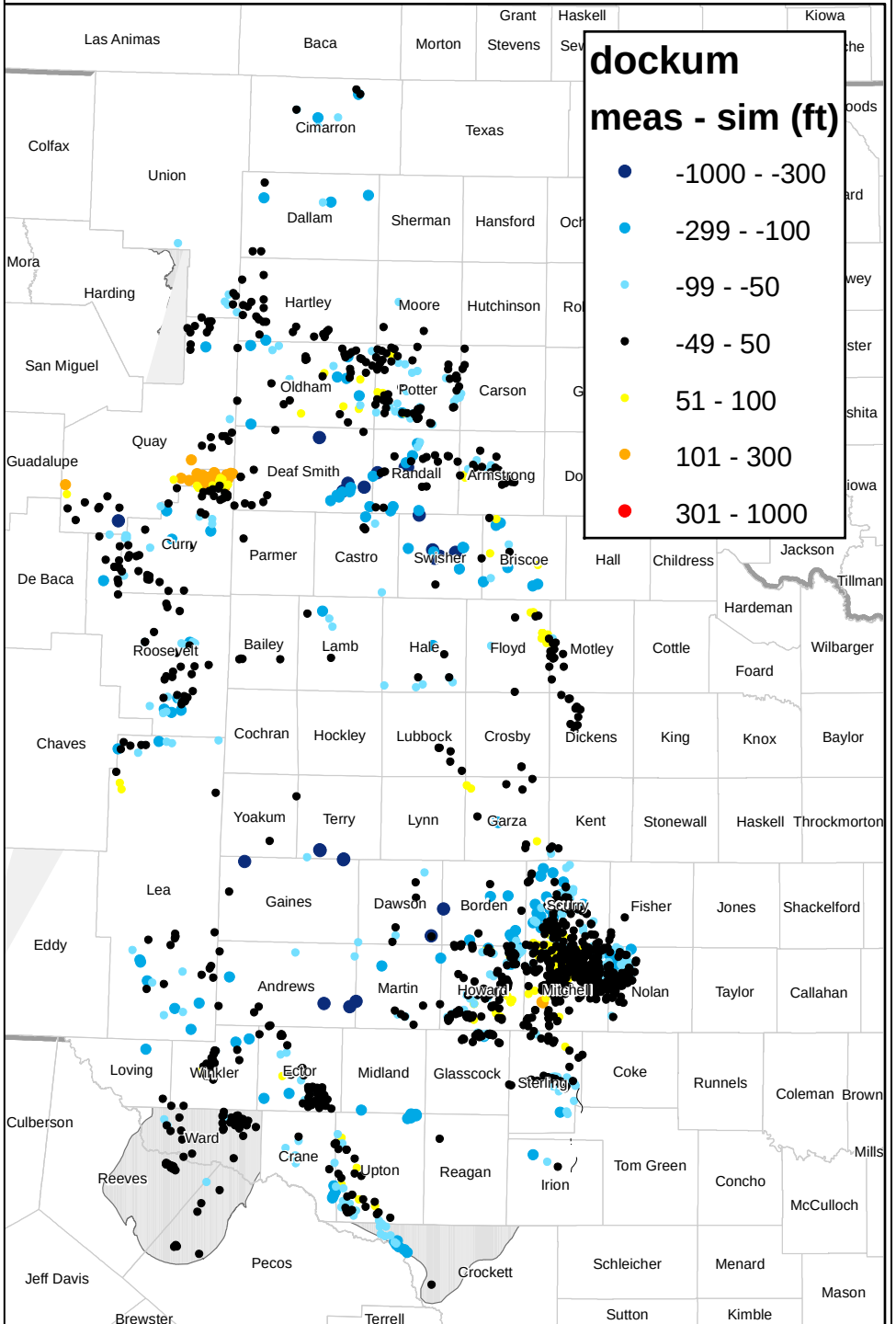
Draft Transient Calibration

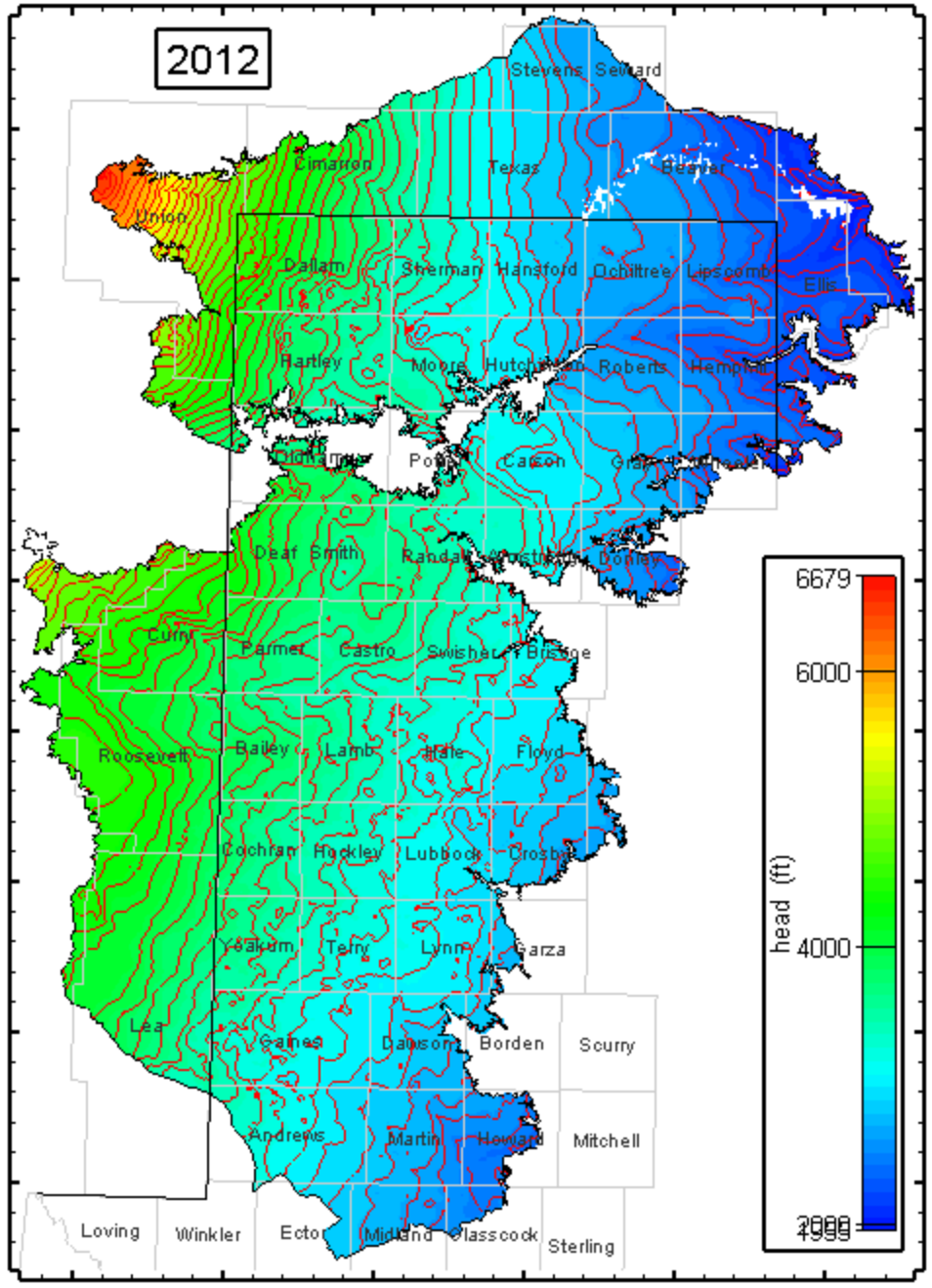


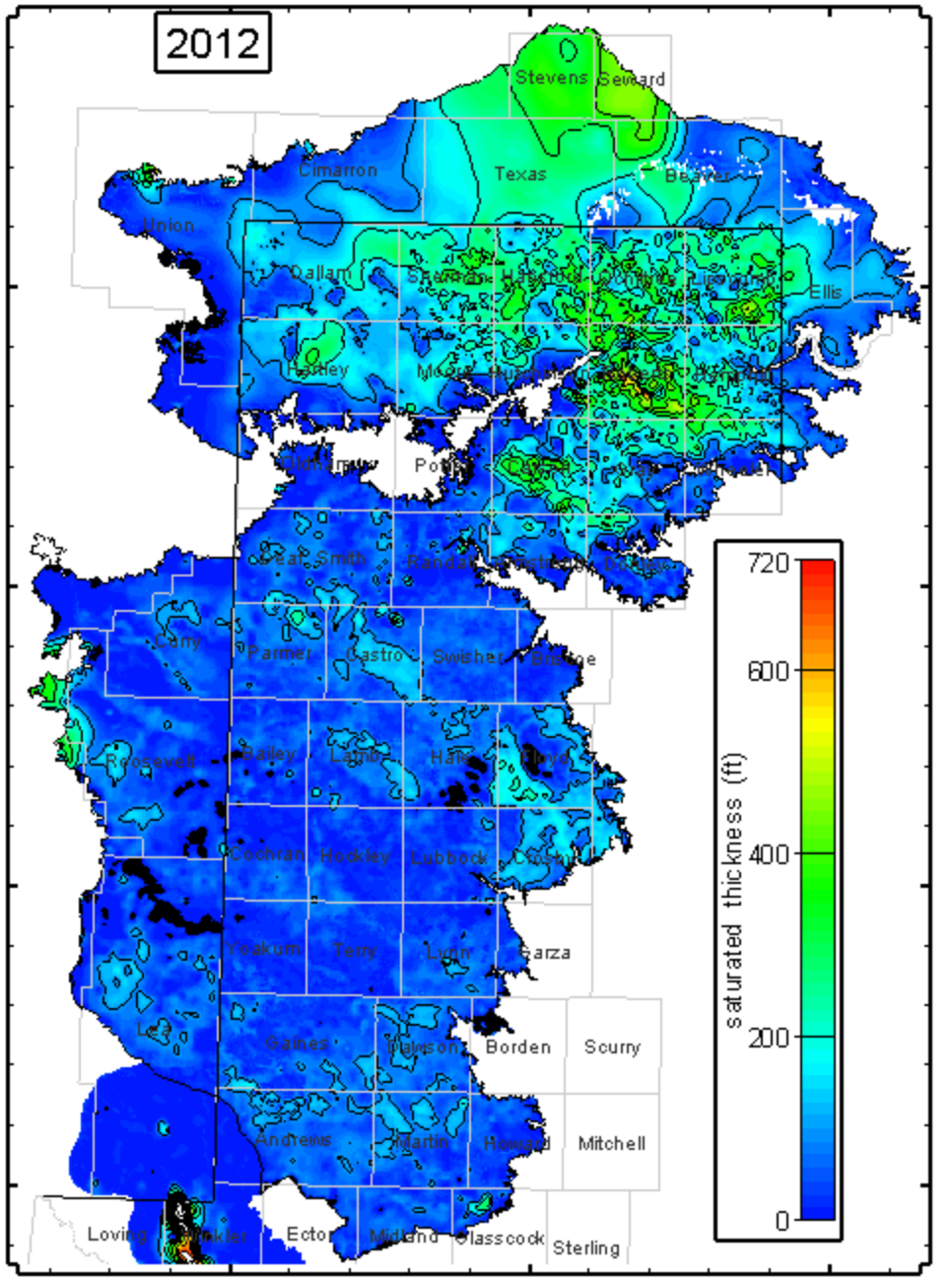
Draft Transient Calibration

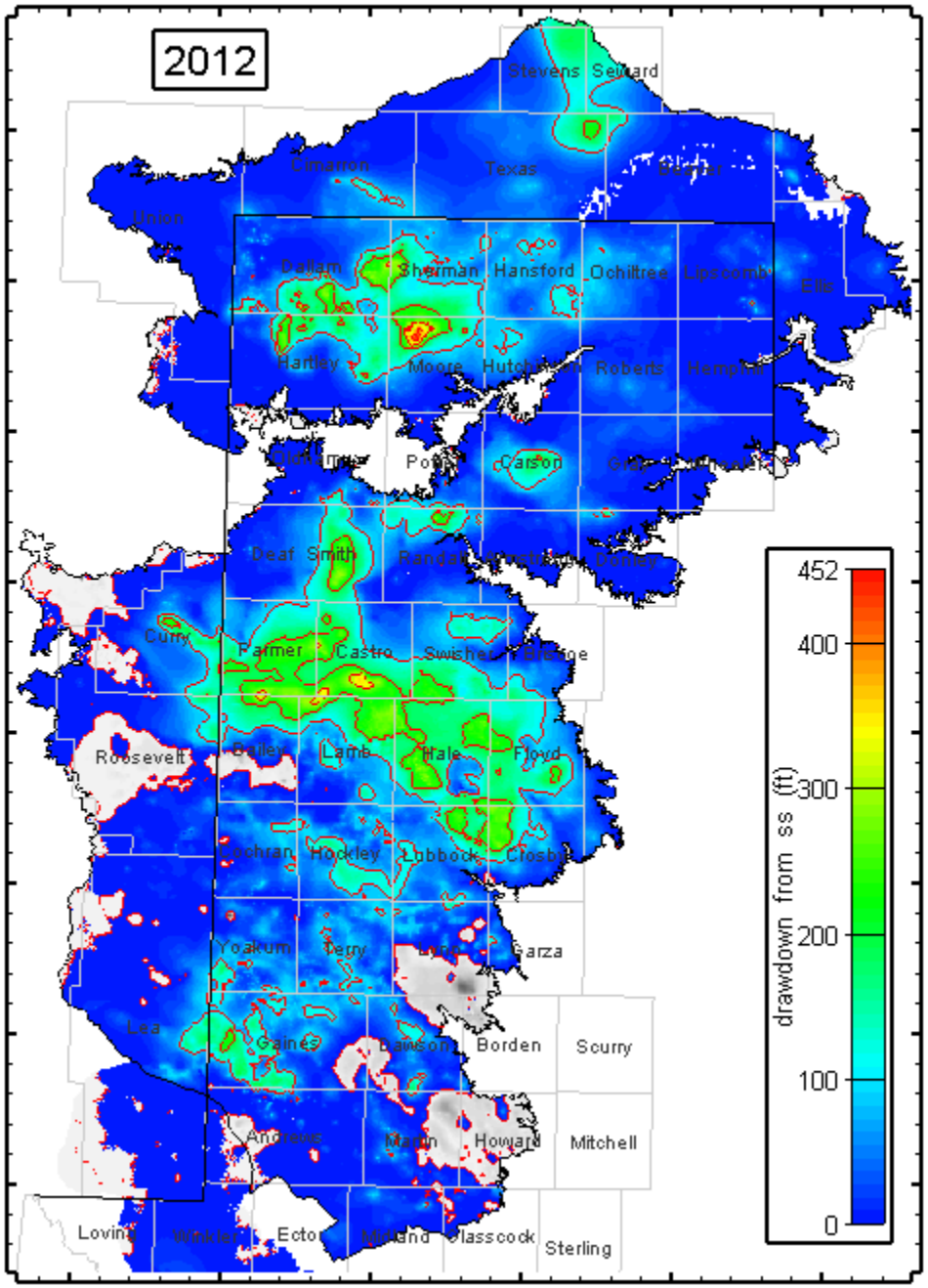


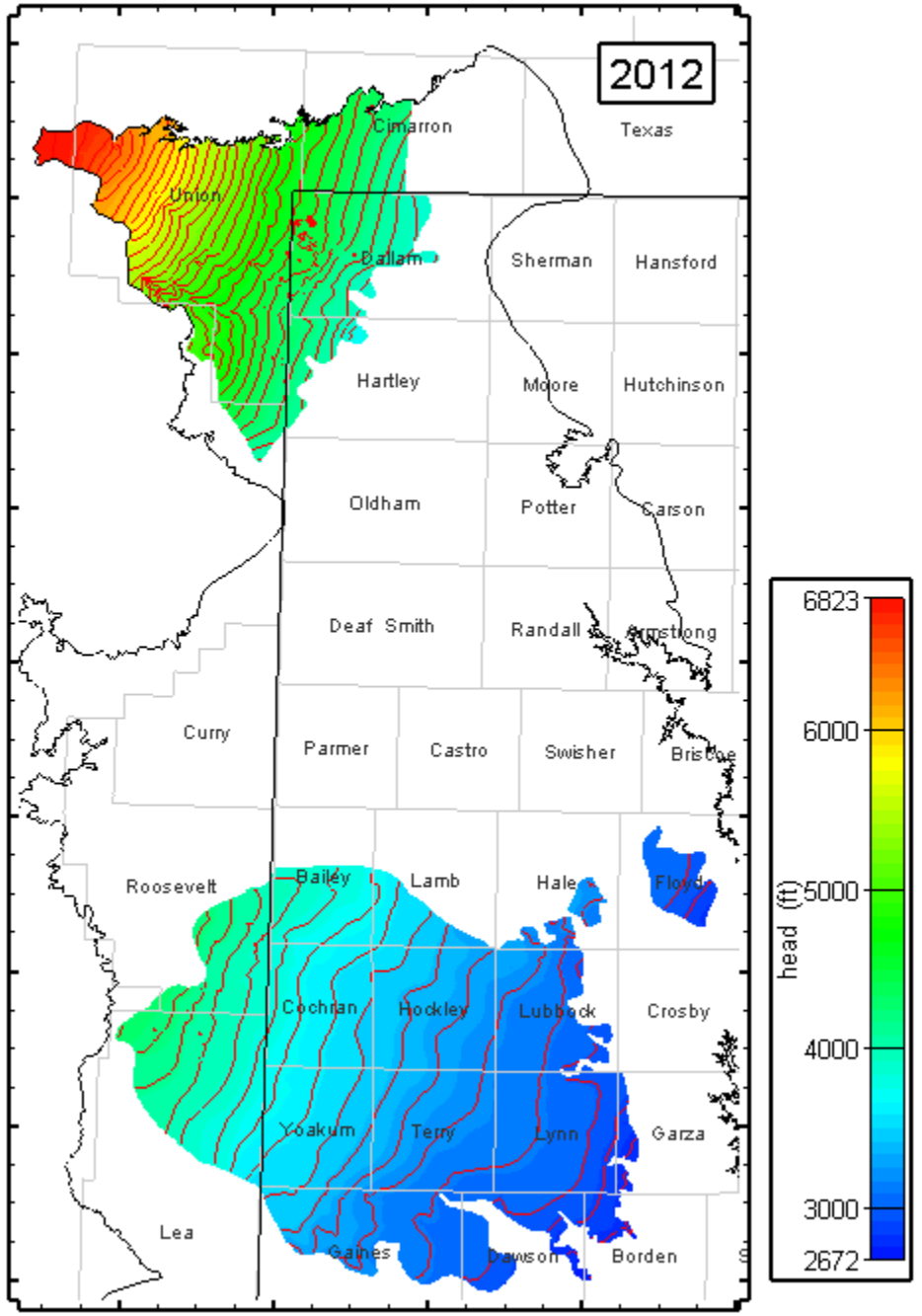
Draft Transient Calibration

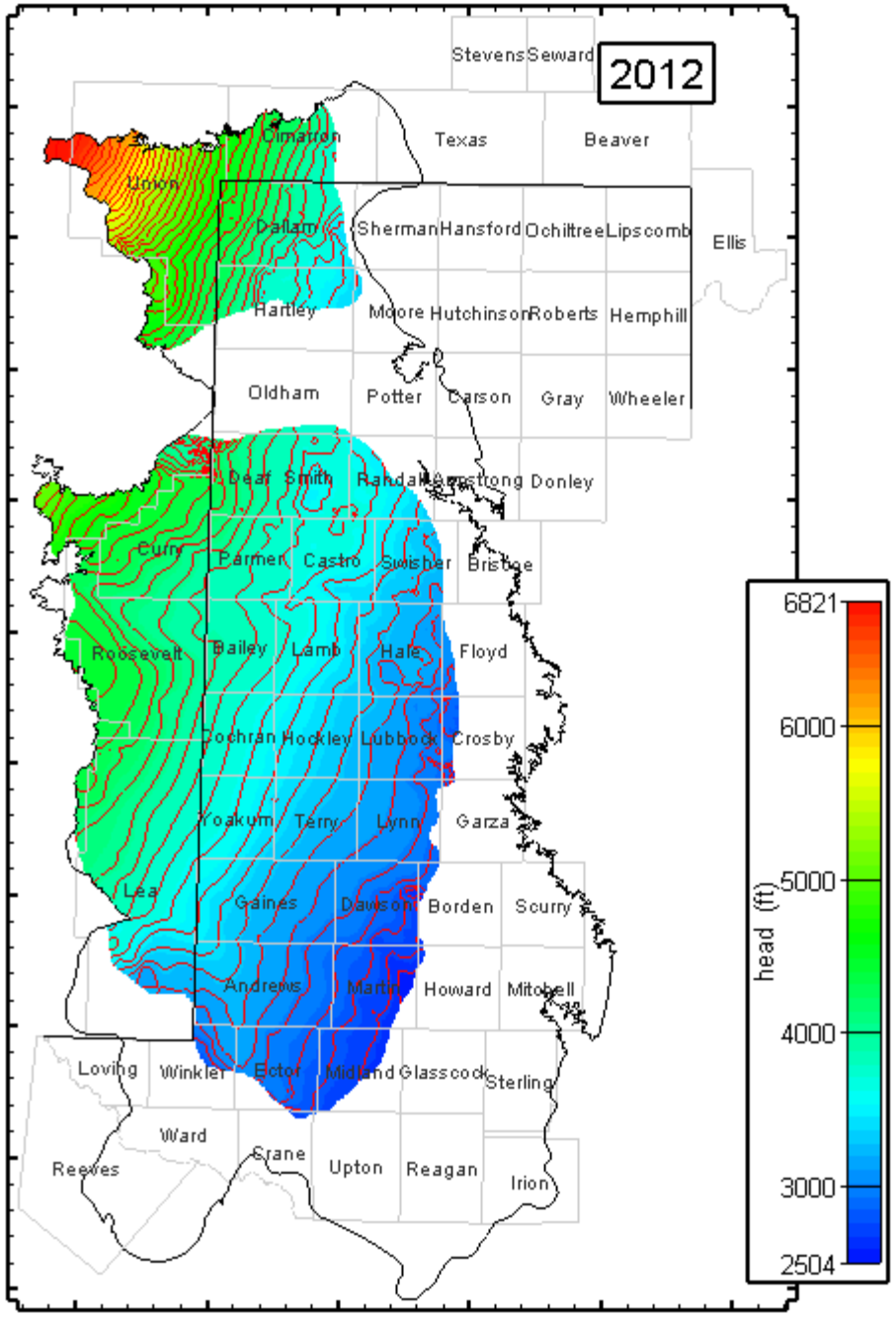


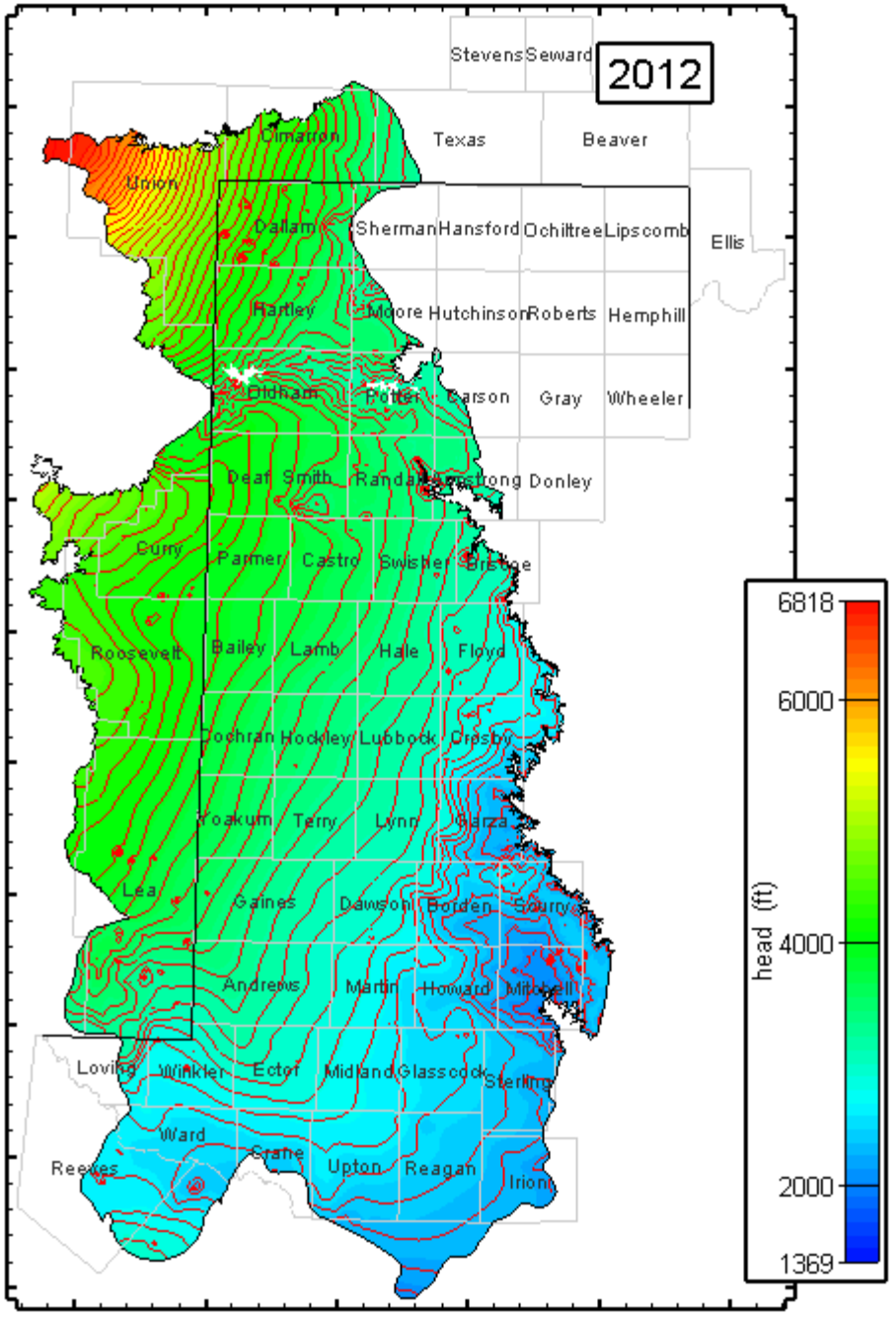

2012
Stevens
Seward
Cimarron
Texas
Beaver
Union
Dallam
Sherman
Hansford
Ochiltree
Lipscomb
Ellis
Hartley
Moore
Hutchinson
Roberts
Hemphill
Oldham
Potter
Carson
Gray
Wheeler
Deaf Smith
Randall
Armstrong
Donley
Curry
Parmer
Castro
Swisher
Briscoe
Roosevelt
Bailey
Lamb
Hale
Floyd
Cochran
Hockley
Lubbock
Crosby
Yoakum
Terry
Lynn
Garza
Lea
Gaines
Dawson
Borden
Scurry
Andrews
Martin
Howard
Mitchell
Loving
Winkler
Ector
Midland
Glasscock
Sterling
head (ft)
6679
6000
4000
2000
1999

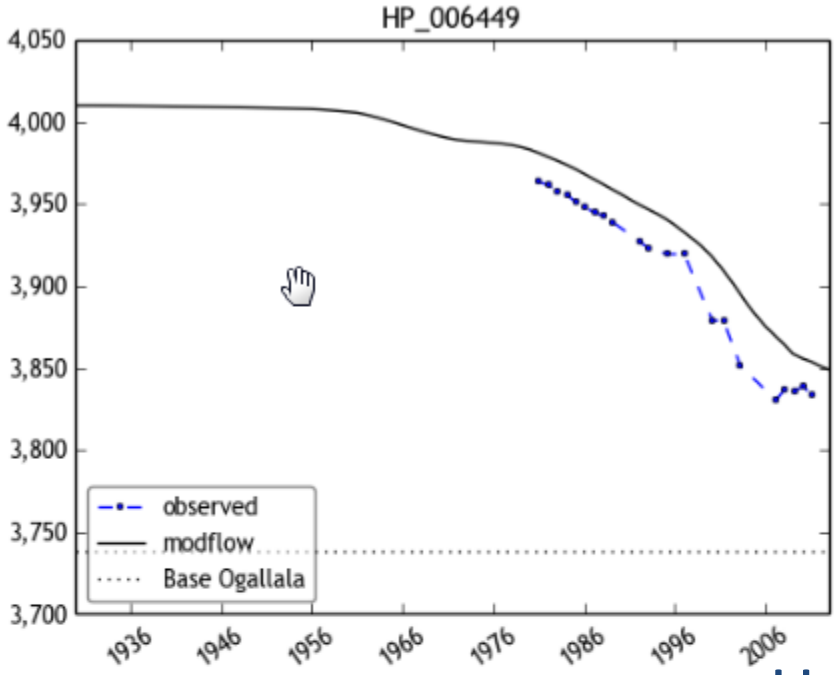

2012
Stevens
Seward
Cimarron
Texas
Beaver
Union
Dallam
Ellis
Hartley
Potter
Deaf Smith
Randall
Curry
Parmer
Castro
Swisher
Roosevelt
Bailey
Lamb
Cochran
Hockley
Lubbock
Yoakum
Terry
Lynn
Garza
Gaines
Dawson
Borden
Scurry
Andrews
Martin
Howard
Mitchell
Loving
Winkler
Ector
Midland
Glasscock
Sterling
saturated thickness (ft)
720
600
400
200
0

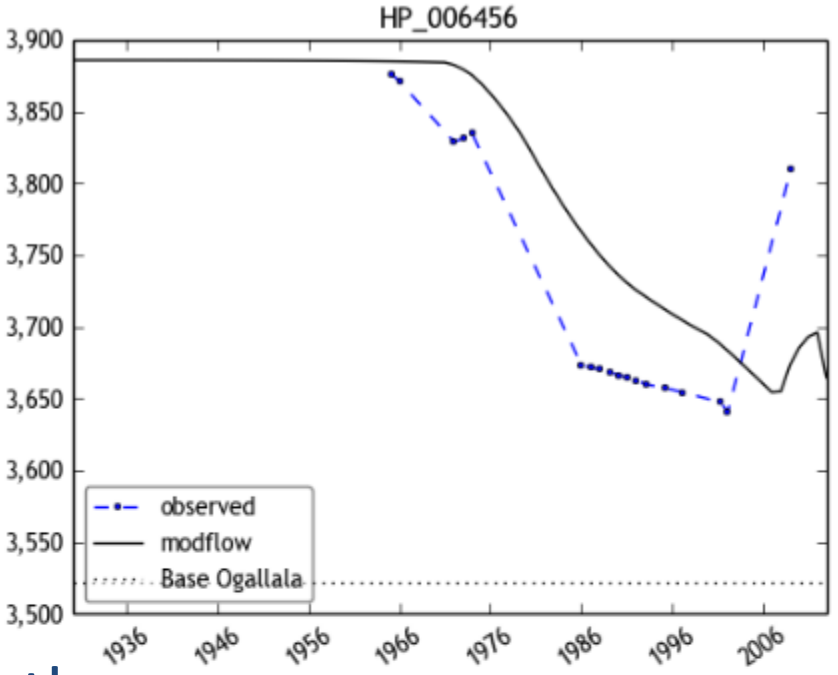

2012
Stevens
Seward
Cimarron
Texas
Union
Dallam
Sherman
Hansford
Ochiltree
Lipscomb
Ellis
Hartley
Moore
Hutchinson
Roberts
Hemphill
Oldham
Potter
Carson
Deaf Smith
Randall
Armstrong
Donley
Curry
Parmer
Castro
Swisher
Briscoe
Roosevelt
Bailey
Lamb
Hale
Floyd
Cochran
Hockley
Lubbock
Crosby
Yoakum
Terry
Lynn
Garza
Lea
Gaines
Dawson
Borden
Scurry
Andrews
Martin
Howard
Mitchell
Lovington
Winkler
Ector
Midland
Glasscock
Sterling
452
400
300
200
100
0
drawdown from ss (ft)


2012
Cimarron
Texas
Union
Dallam
Sherman
Hansford
Hartley
Moore
Hutchinson
Oldham
Potter
Carson
Deaf Smith
Randall
Armstrong
Curry
Parmer
Castro
Swisher
Briscoe
Roosevelt
Bailey
Lamb
Hale
Floyd
Cochran
Hockley
Lubbock
Crosby
Yoakum
Terry
Lynn
Garza
Lea
Gaines
Dawson
Borden
6823
6000
5000
4000
3000
2672
head (ft)

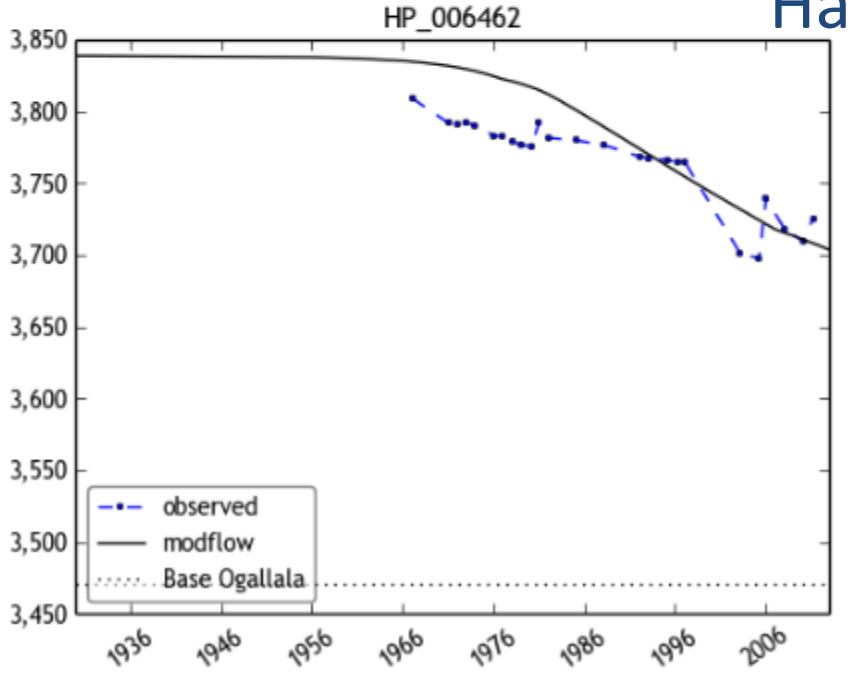

2012
Stevens
Seward
Cimarron
Texas
Beaver
Union
Dallam
Sherman
Hansford
Ochiltree
Lipscomb
Ellis
Hartley
Moore
Hutchinson
Roberts
Hemphill
Oldham
Potter
Carson
Gray
Wheeler
Deaf Smith
Randall
Armstrong
Donley
Curry
Parmer
Castro
Swisher
Briscoe
Roosevelt
Bailey
Lamb
Hale
Floyd
Cochran
Hockley
Lubbock
Crosby
Yoakum
Terry
Lynn
Garza
Lea
Gaines
Dawson
Borden
Scurry
Andrews
Martin
Howard
Mitchell
Loving
Winkler
Ector
Midland
Glasscock
Sterling
Ward
Crane
Upton
Reagan
Irion
Reeves
head (ft)
6821
6000
5000
4000
3000
2504

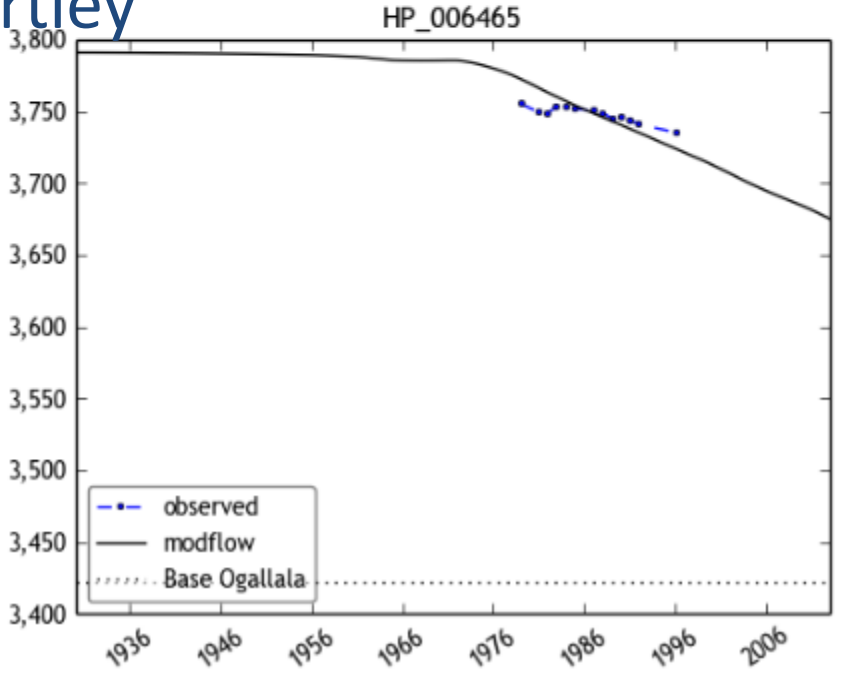

2012
Stevens
Seward
Cimarron
Texas
Beaver
Union
Dallam
Sherman
Hansford
Ochiltree
Lipscomb
Ellis
Hartley
Moore
Hutchinson
Roberts
Hemphill
Oldham
Potter
Carson
Gray
Wheeler
Deaf Smith
Randall
Armstrong
Donley
Curry
Parmer
Castro
Swisher
Briscoe
Roosevelt
Bailey
Lamb
Hale
Floyd
Cochran
Hockley
Lubbock
Crosby
Yoakum
Terry
Lynn
Garza
Lea
Gaines
Dawson
Borden
Scurry
Andrews
Martin
Howard
Mitchell
Loving
Winkler
Ector
Midland
Glasscock
Sterling
Ward
Crane
Upton
Reagan
Irion
Reeves
head (ft)
6818
6000
4000
2000
1369

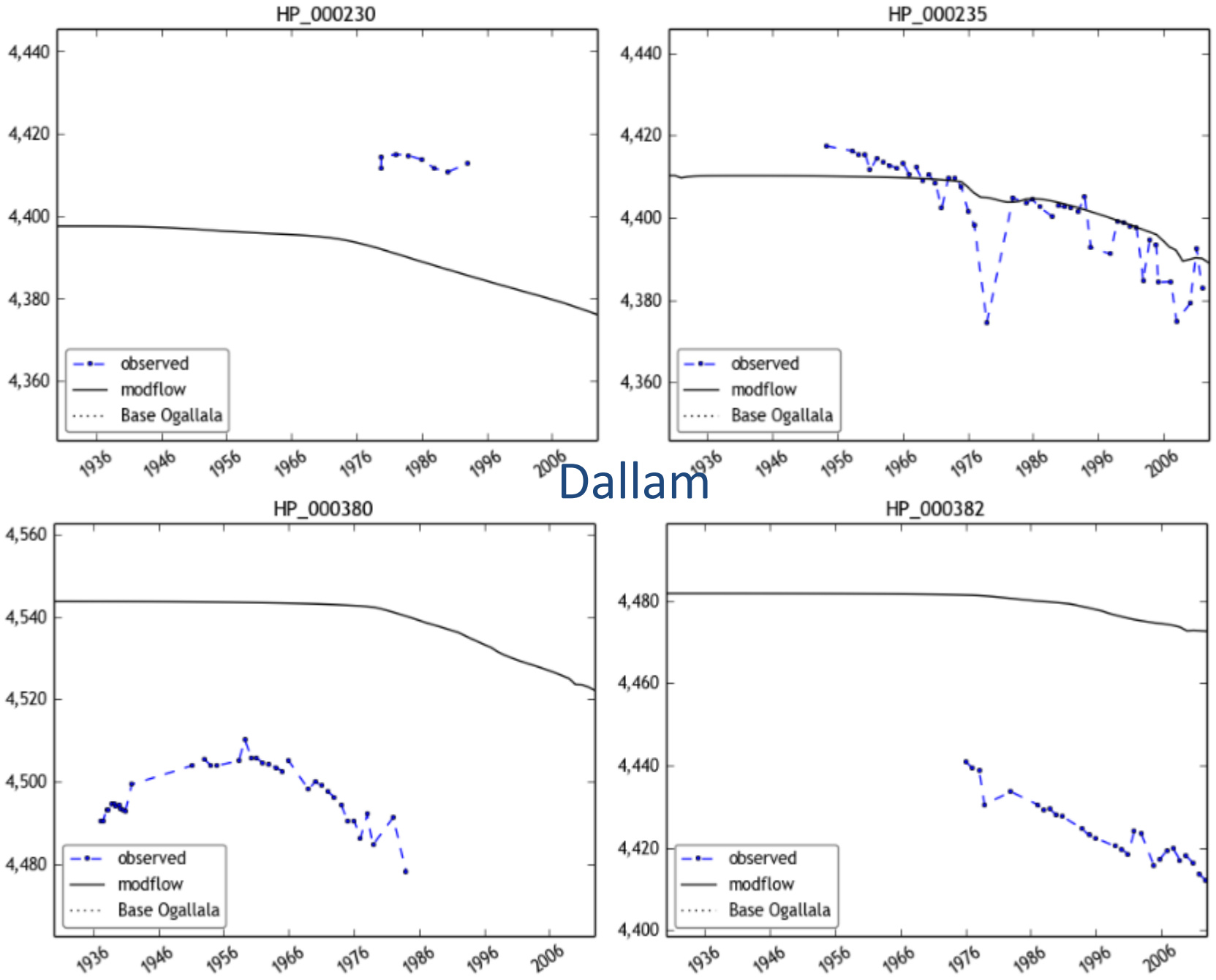

HP_006449
observed
modflow
Base Ogallala

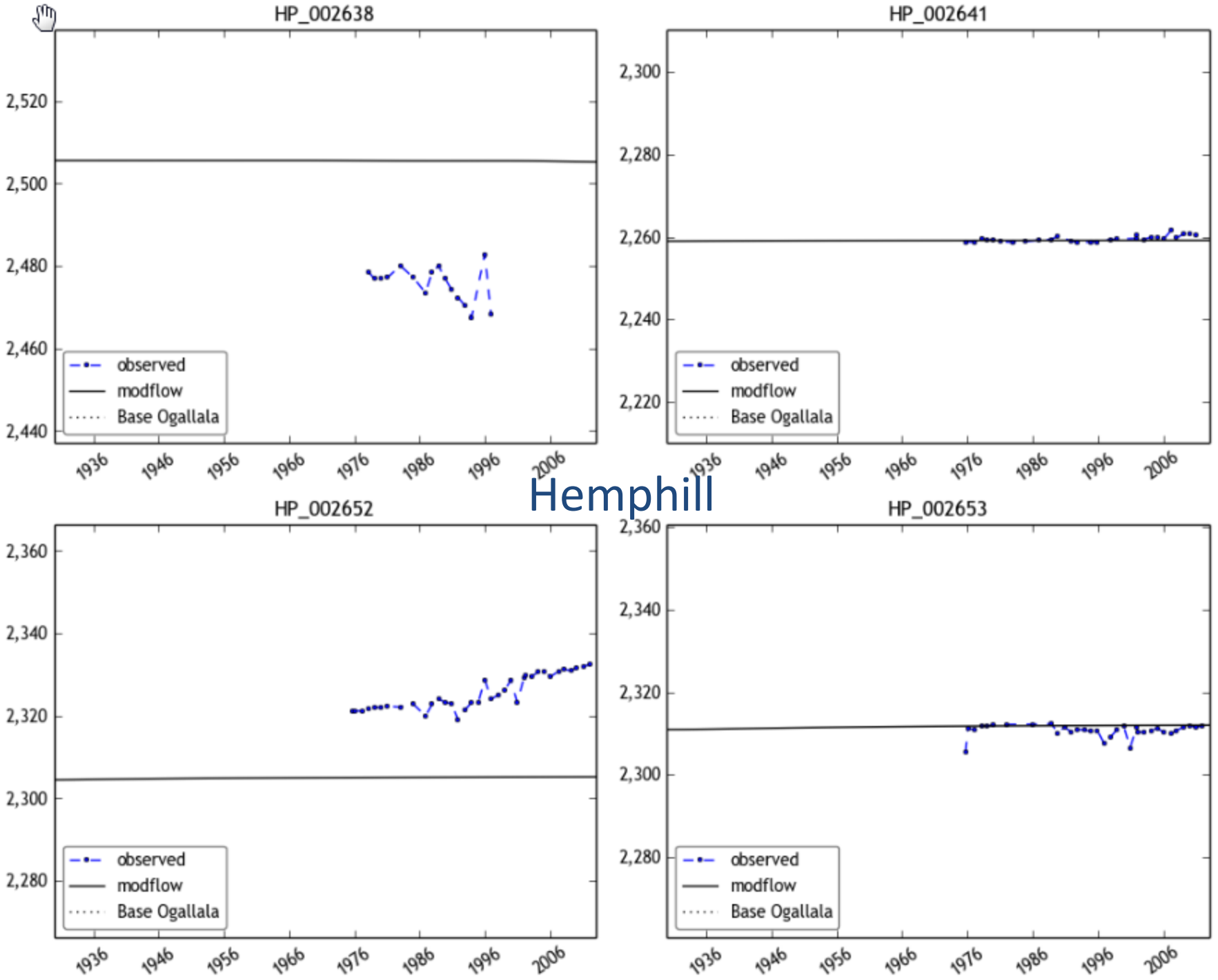

HP_006456
observed
modflow
Base Ogallala

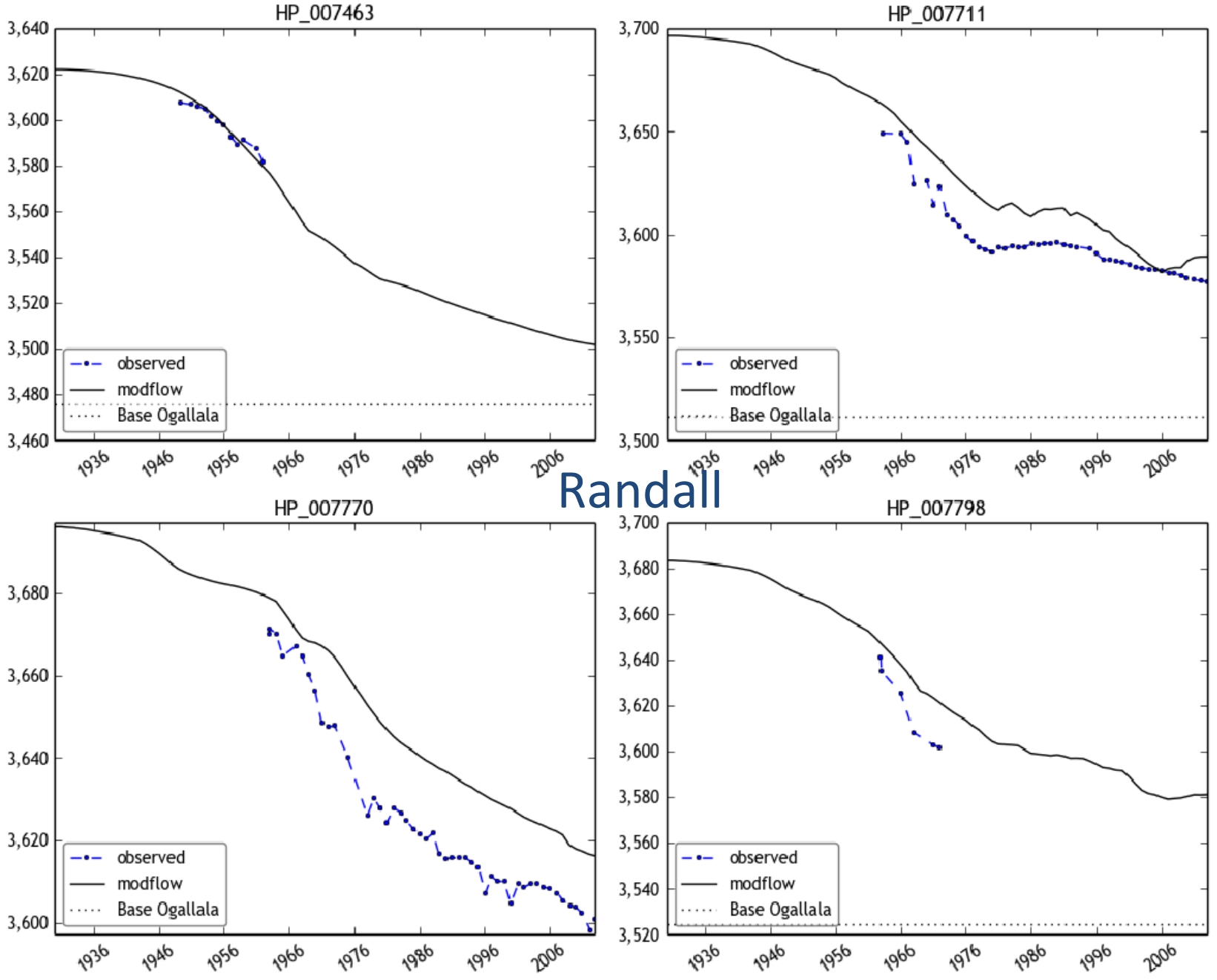
Hartley

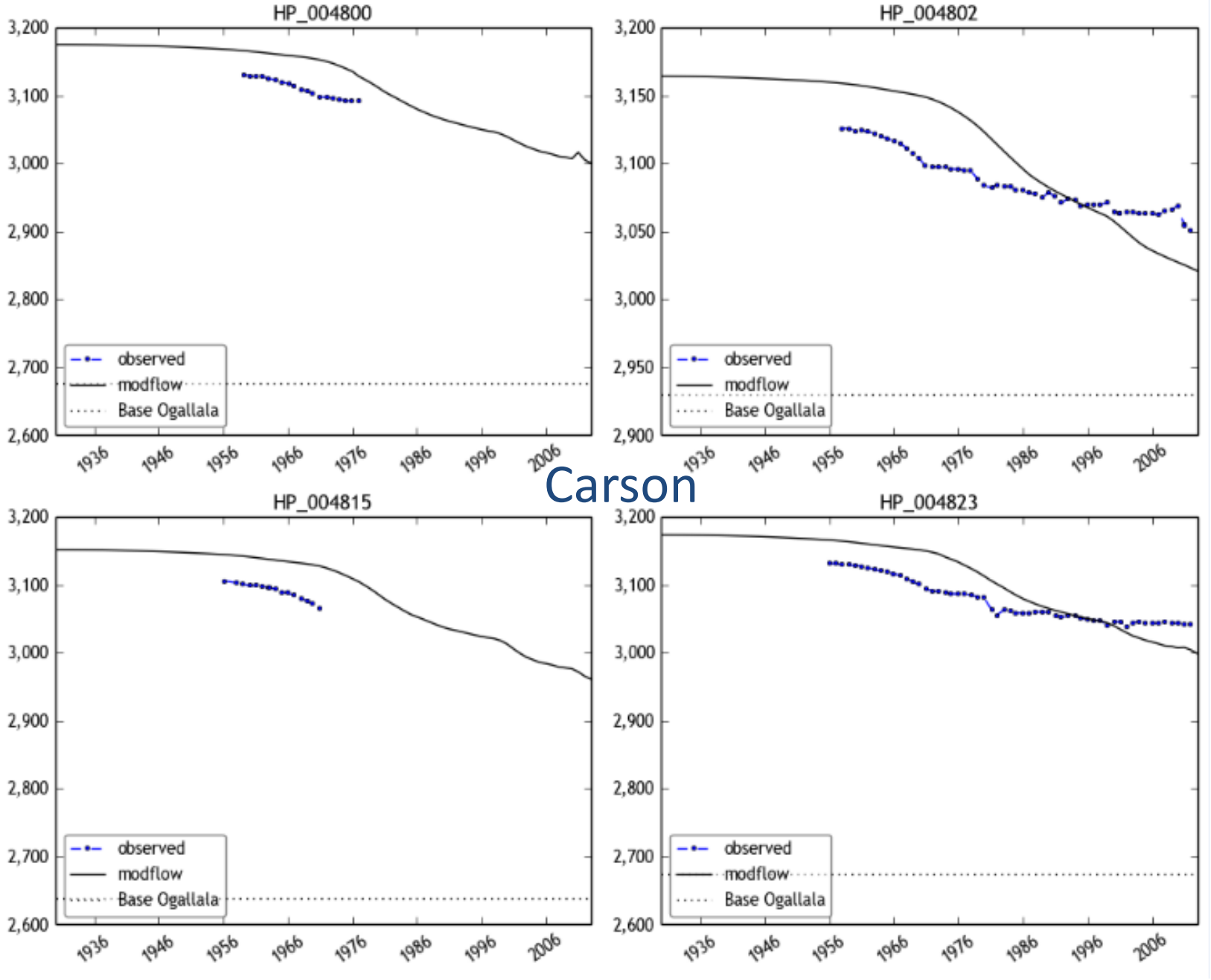

HP_006462
observed
modflow
Base Ogallala

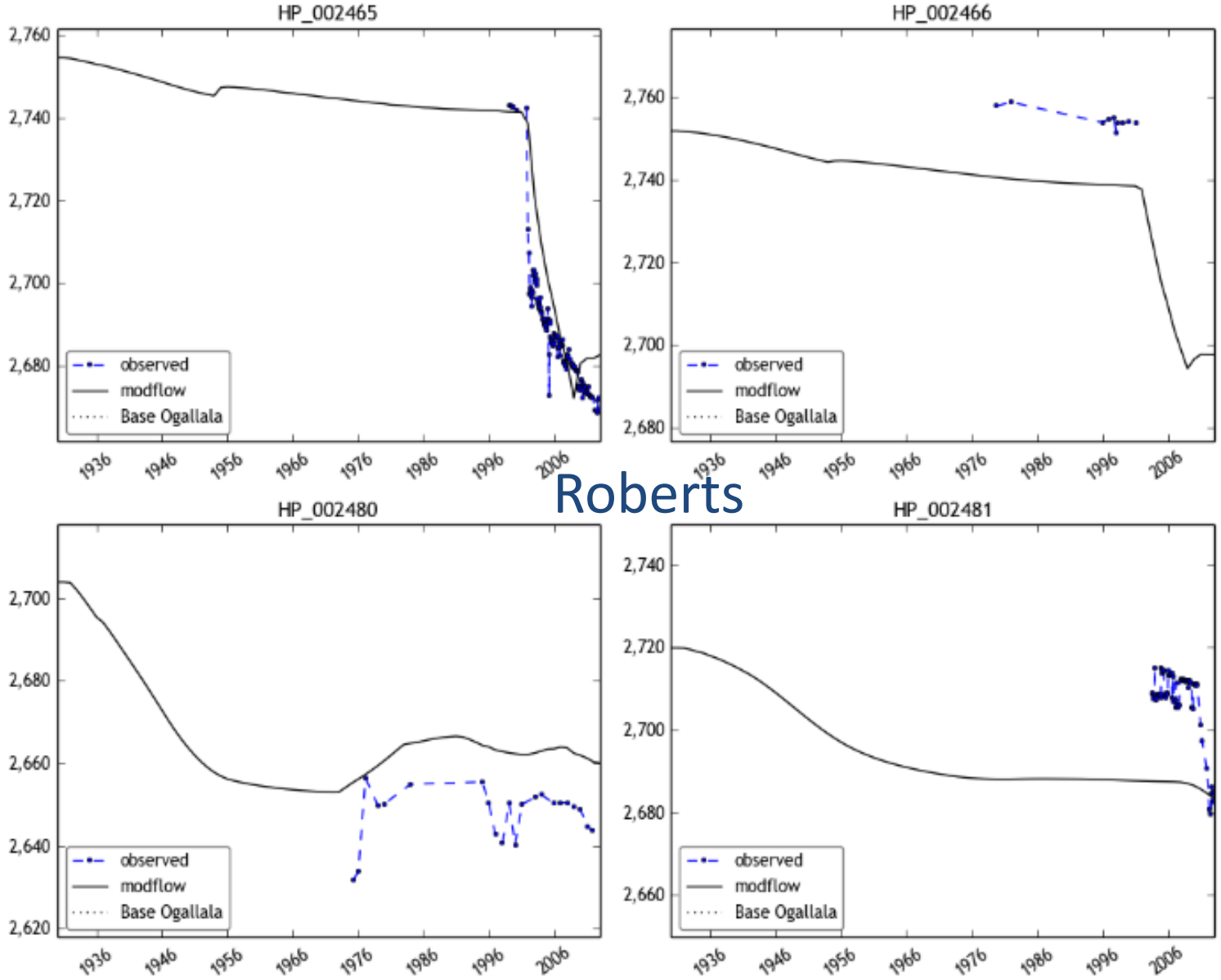

HP_006465
observed
modflow
Base Ogallala


HP_000230
HP_000235
HP_000380
HP_000382
observed
modflow
Base Ogallala
4,440
4,420
4,400
4,380
4,360
4,560
4,540
4,520
4,500
4,480
4,460
1936
1946
1956
1966
1976
1986
1996
2006
Dallam


HP_002638
2,520
2,500
2,480
2,460
2,440
observed
modflow
Base Ogallala
1936
1946
1956
1966
1976
1986
1996
2006
HP_002641
2,300
2,280
2,260
2,240
2,220
observed
modflow
Base Ogallala
1936
1946
1956
1966
1976
1986
1996
2006
Hemphill
HP_002652
2,360
2,340
2,320
2,300
2,280
observed
modflow
Base Ogallala
1936
1946
1956
1966
1976
1986
1996
2006
HP_002653
2,360
2,340
2,320
2,300
2,280
observed
modflow
Base Ogallala
1936
1946
1956
1966
1976
1986
1996
2006


HP_007463
3,640
3,620
3,600
3,580
3,560
3,540
3,520
3,500
3,480
3,460
observed
modflow
Base Ogallala
1936
1946
1956
1966
1976
1986
1996
2006
HP_007711
3,700
3,650
3,600
3,550
3,500
observed
modflow
Base Ogallala
1936
1946
1956
1966
1976
1986
1996
2006
Randall
HP_007770
3,680
3,660
3,640
3,620
3,600
observed
modflow
Base Ogallala
1936
1946
1956
1966
1976
1986
1996
2006
HP_007798
3,700
3,680
3,660
3,640
3,620
3,600
3,580
3,560
3,540
3,520
observed
modflow
Base Ogallala
1936
1946
1956
1966
1976
1986
1996
2006

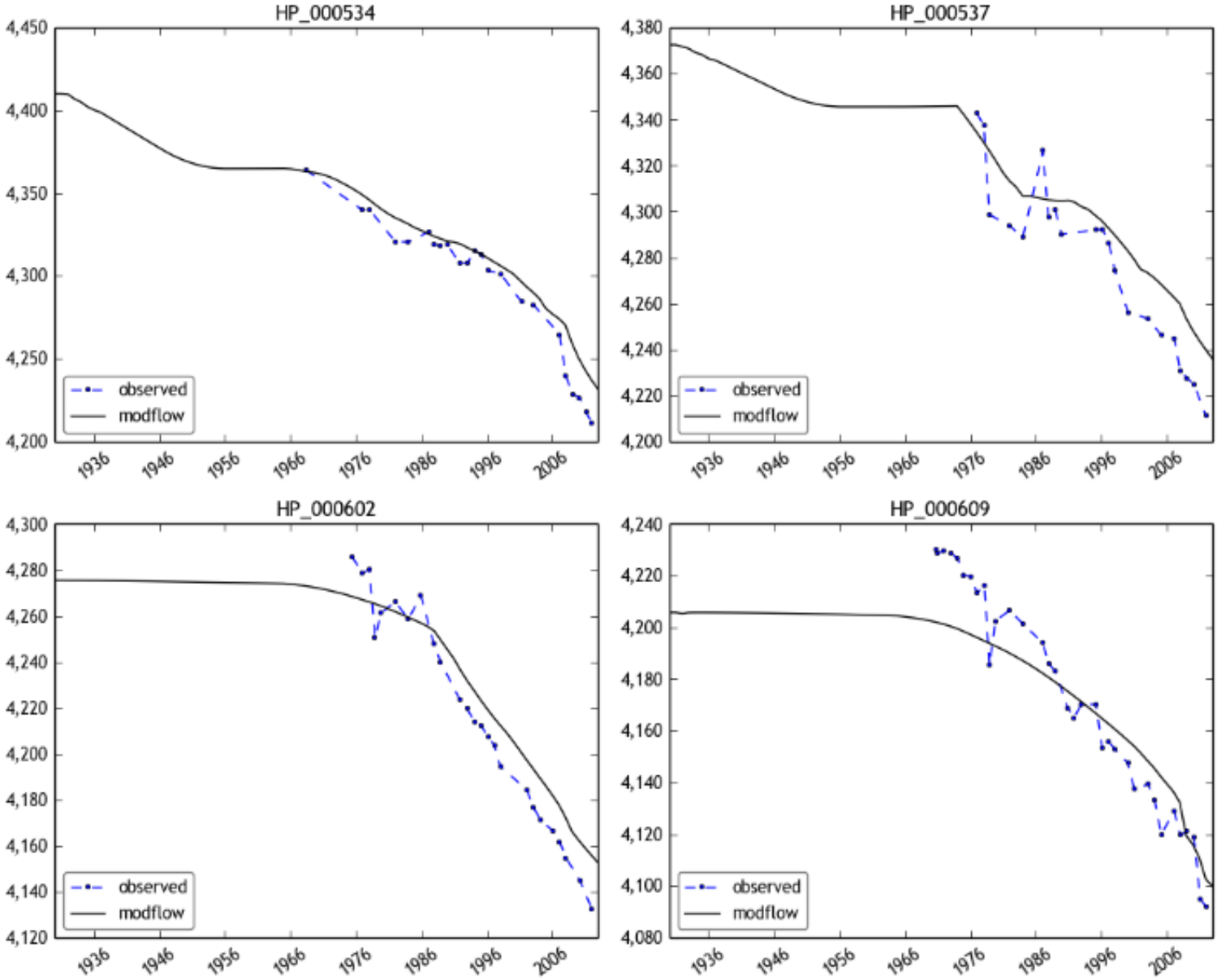

HP_004800
3,200
3,100
3,000
2,900
2,800
2,700
2,600
observed
modflow
Base Ogallala
1936
1946
1956
1966
1976
1986
1996
2006
HP_004802
3,200
3,150
3,100
3,050
3,000
2,950
2,900
observed
modflow
Base Ogallala
1936
1946
1956
1966
1976
1986
1996
2006
Carson
HP_004815
3,200
3,100
3,000
2,900
2,800
2,700
2,600
observed
modflow
Base Ogallala
1936
1946
1956
1966
1976
1986
1996
2006
HP_004823
3,200
3,100
3,000
2,900
2,800
2,700
2,600
observed
modflow
Base Ogallala
1936
1946
1956
1966
1976
1986
1996
2006

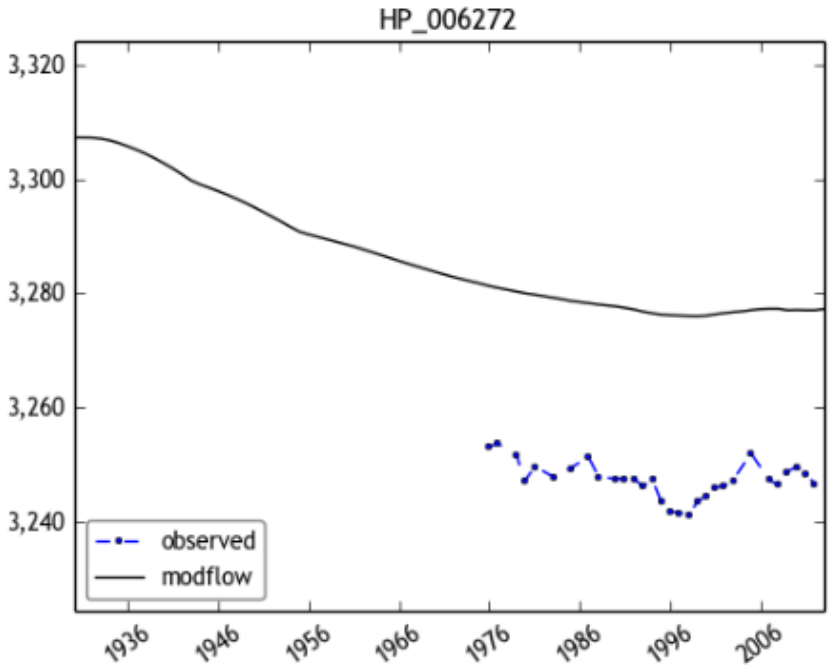

HP_002465
HP_002466
HP_002480
HP_002481
observed
modflow
Base Ogallala
Roberts

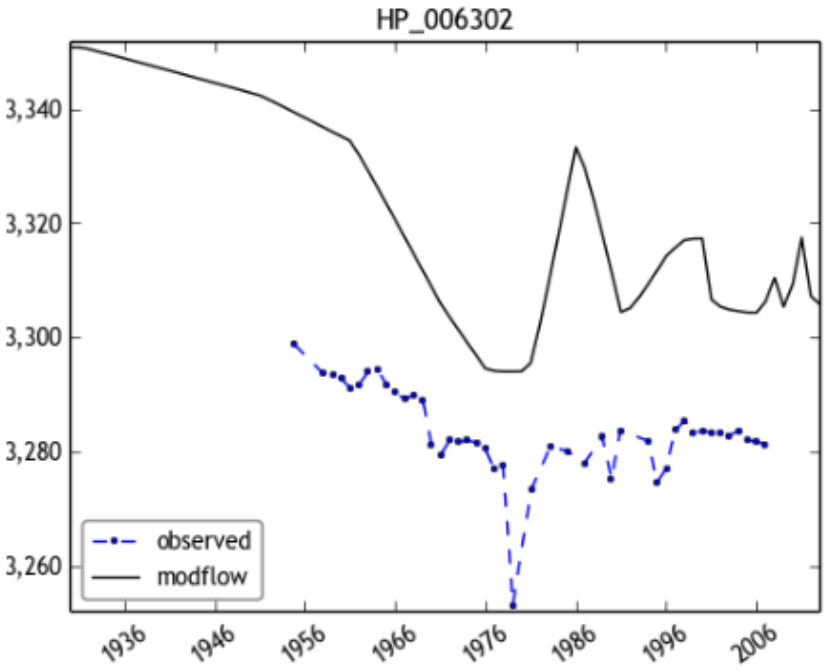
Transient Calibration

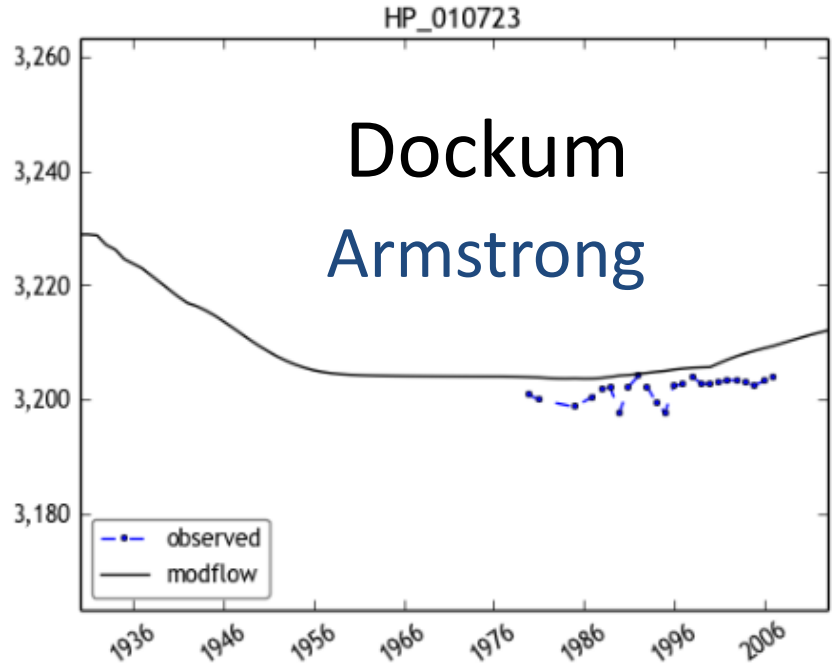
Rita Blanca

Dallam



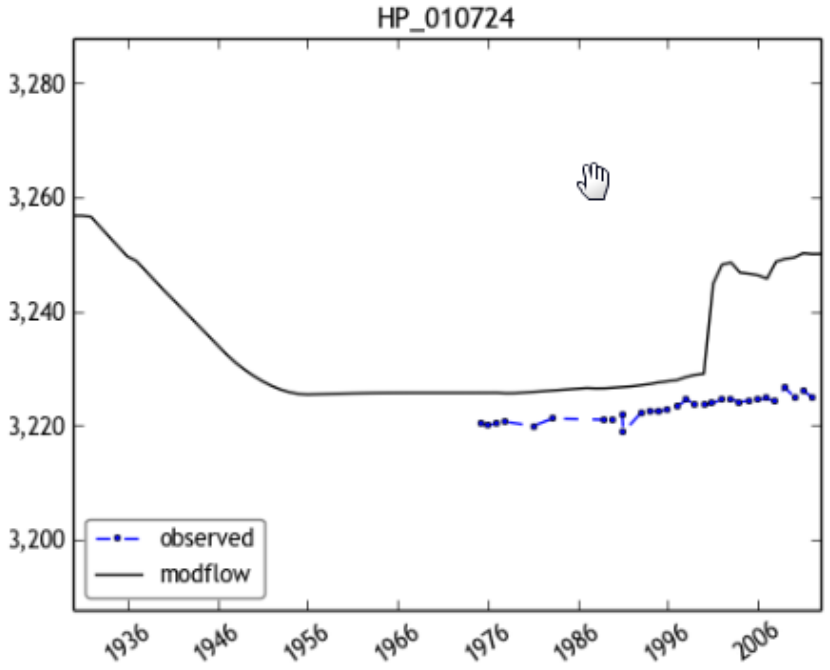


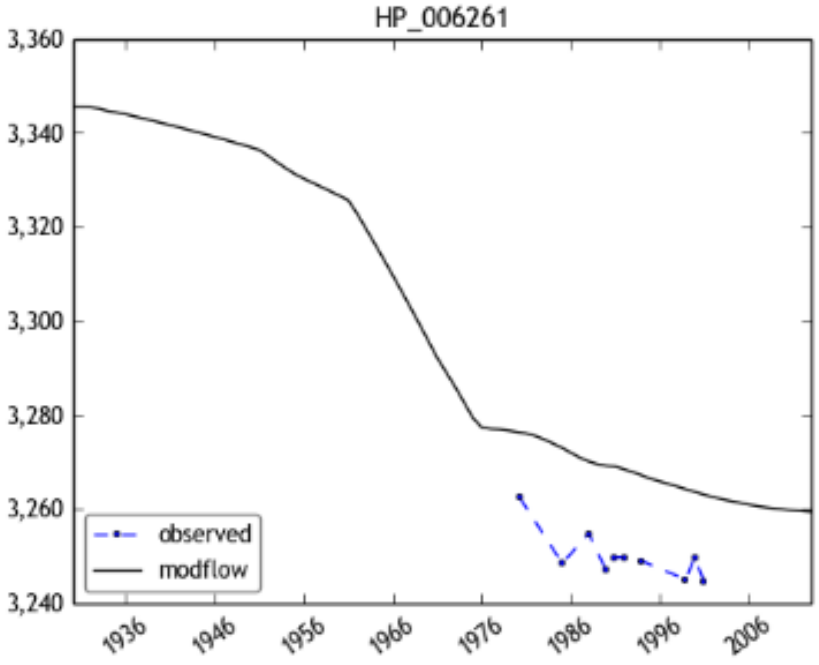




Dockum

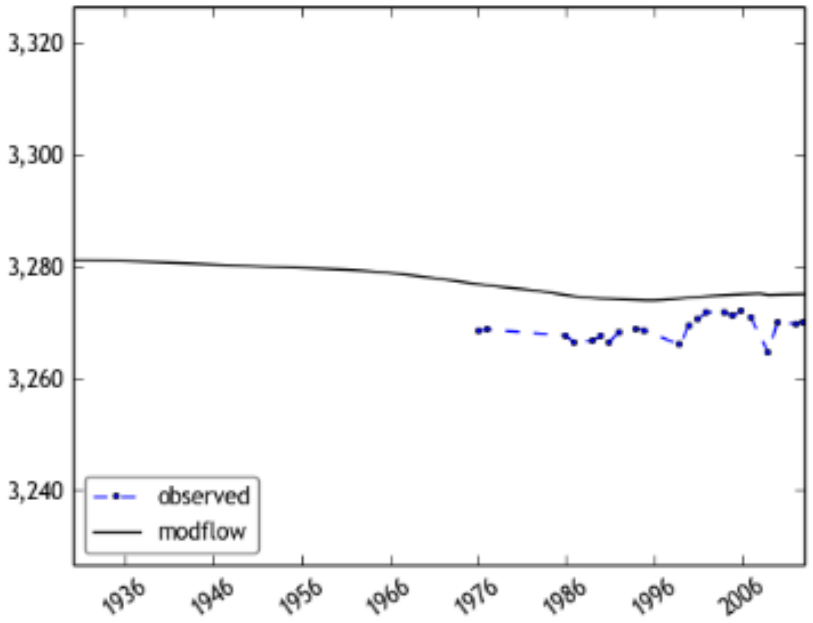
Armstrong

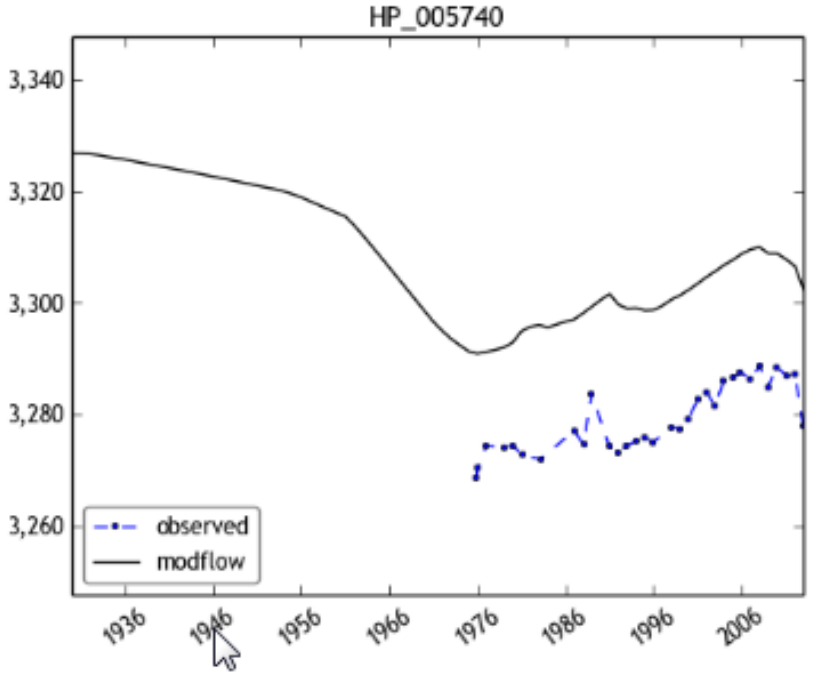


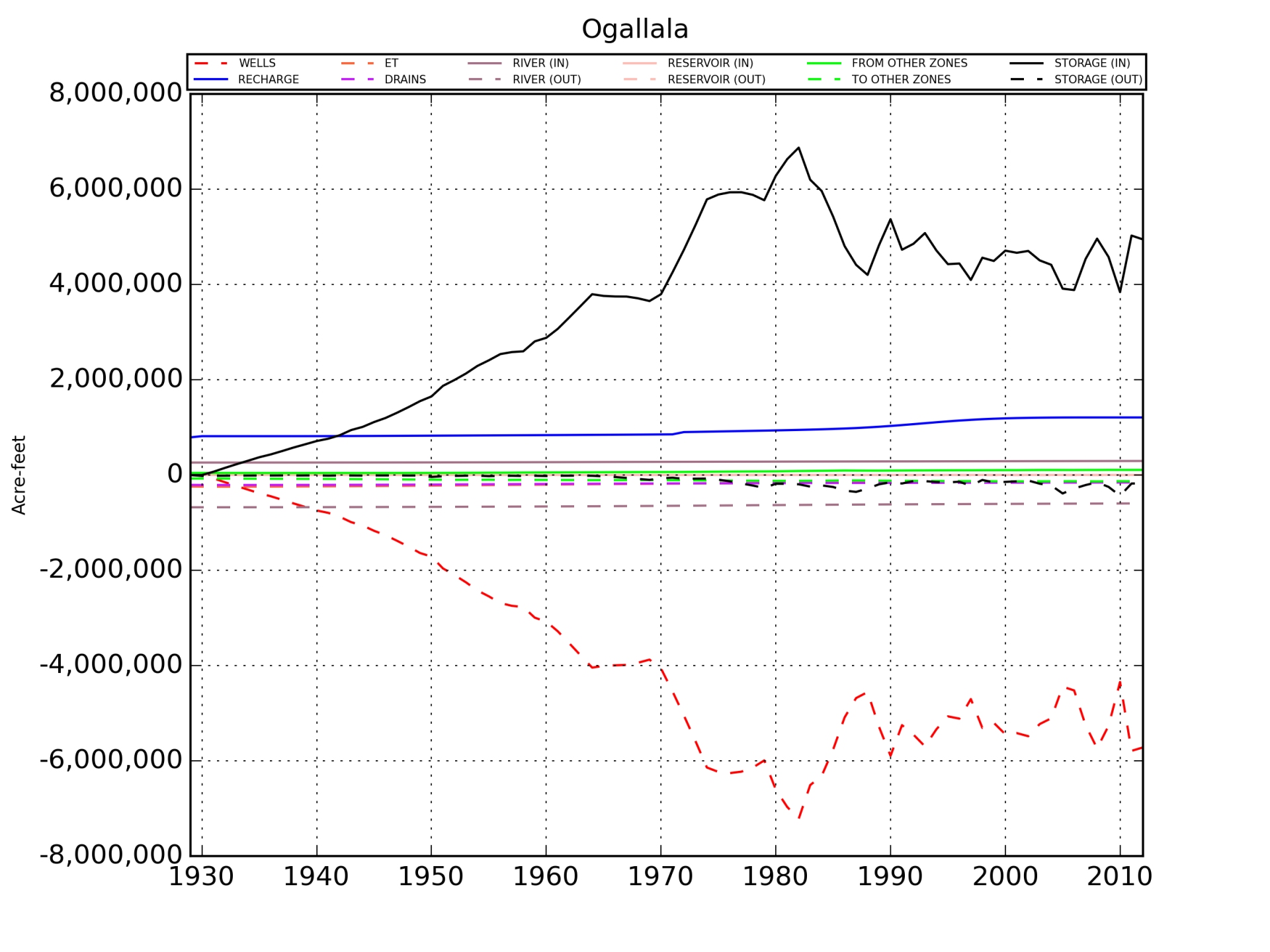


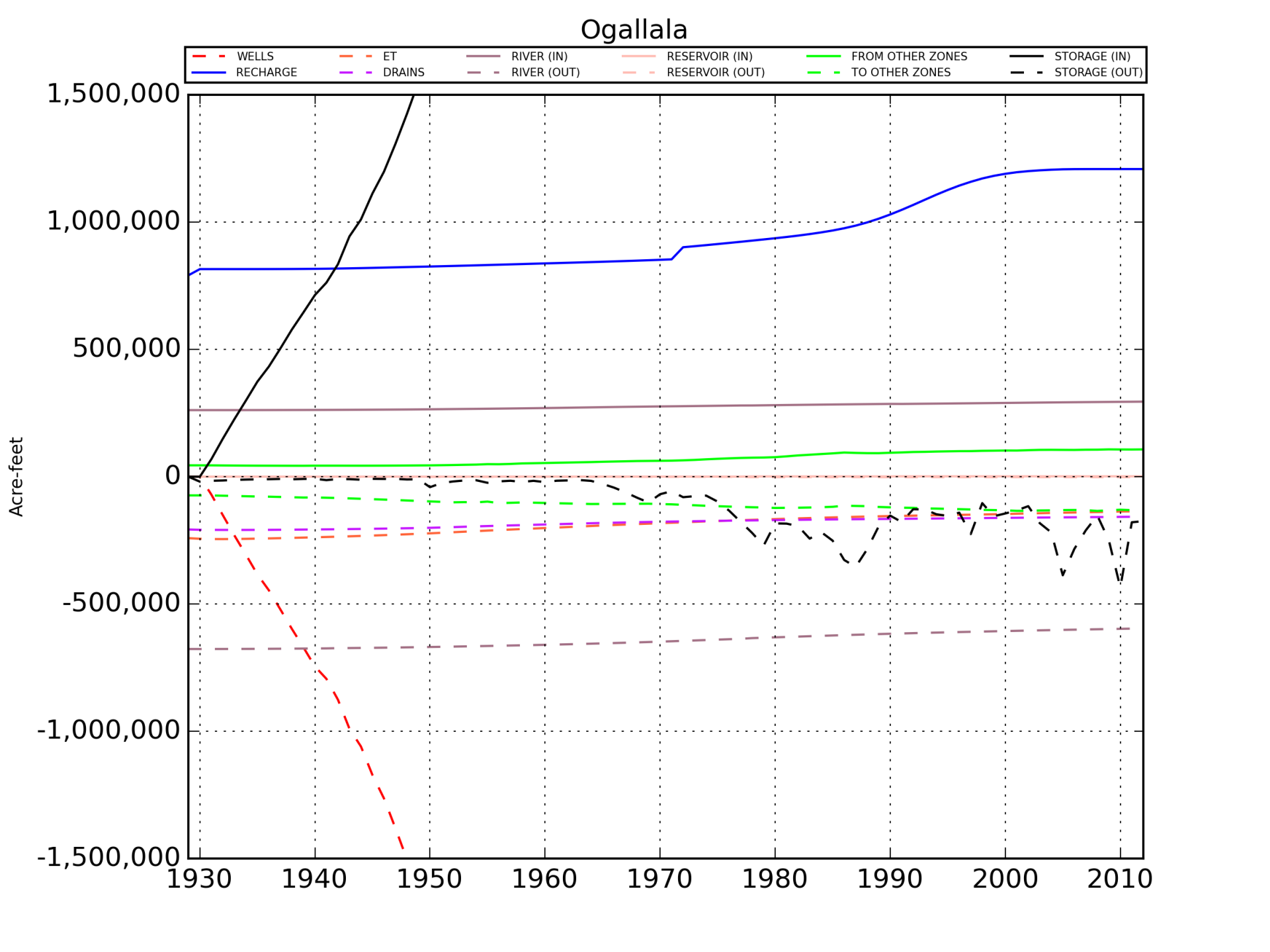
Dockum

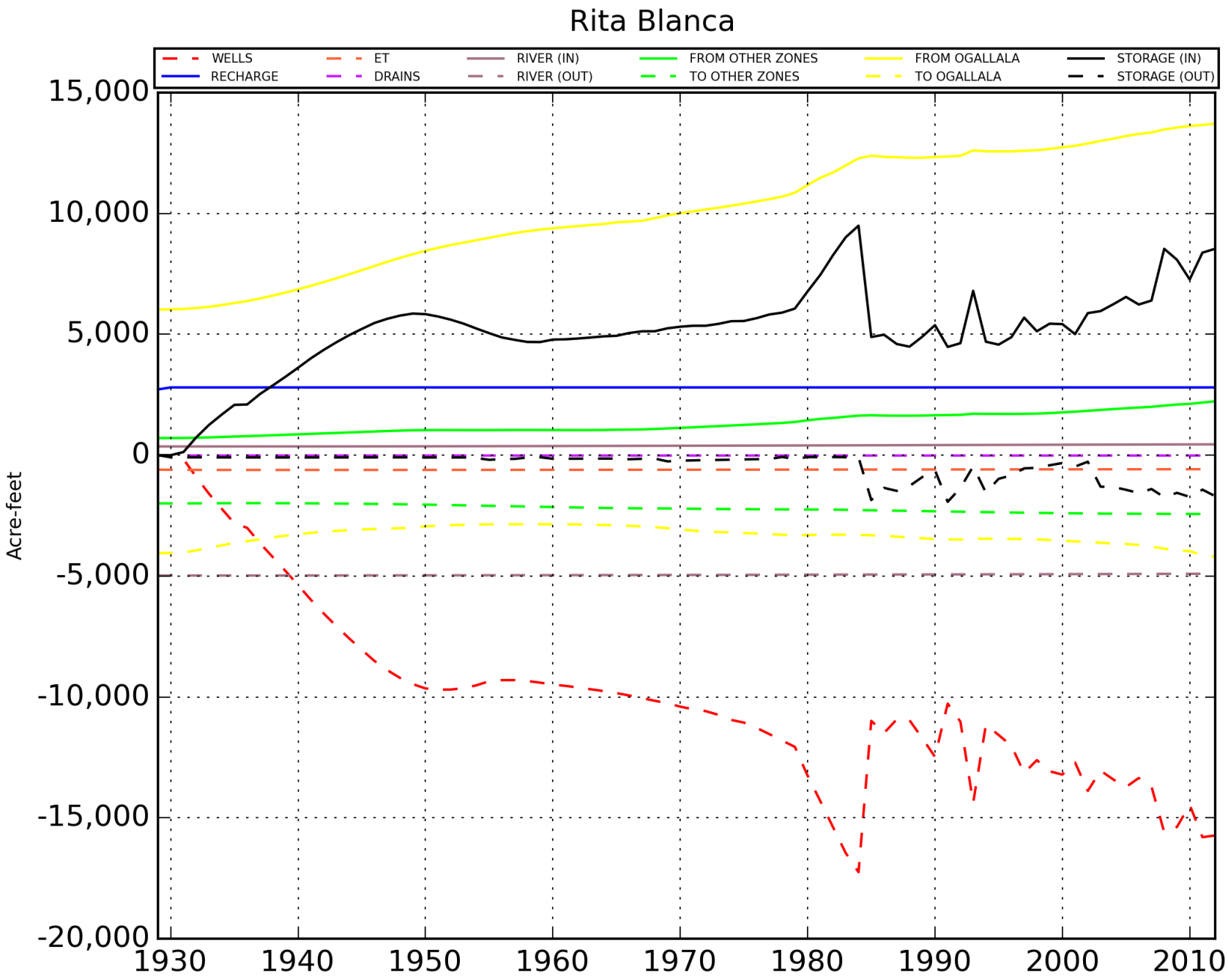
Randall

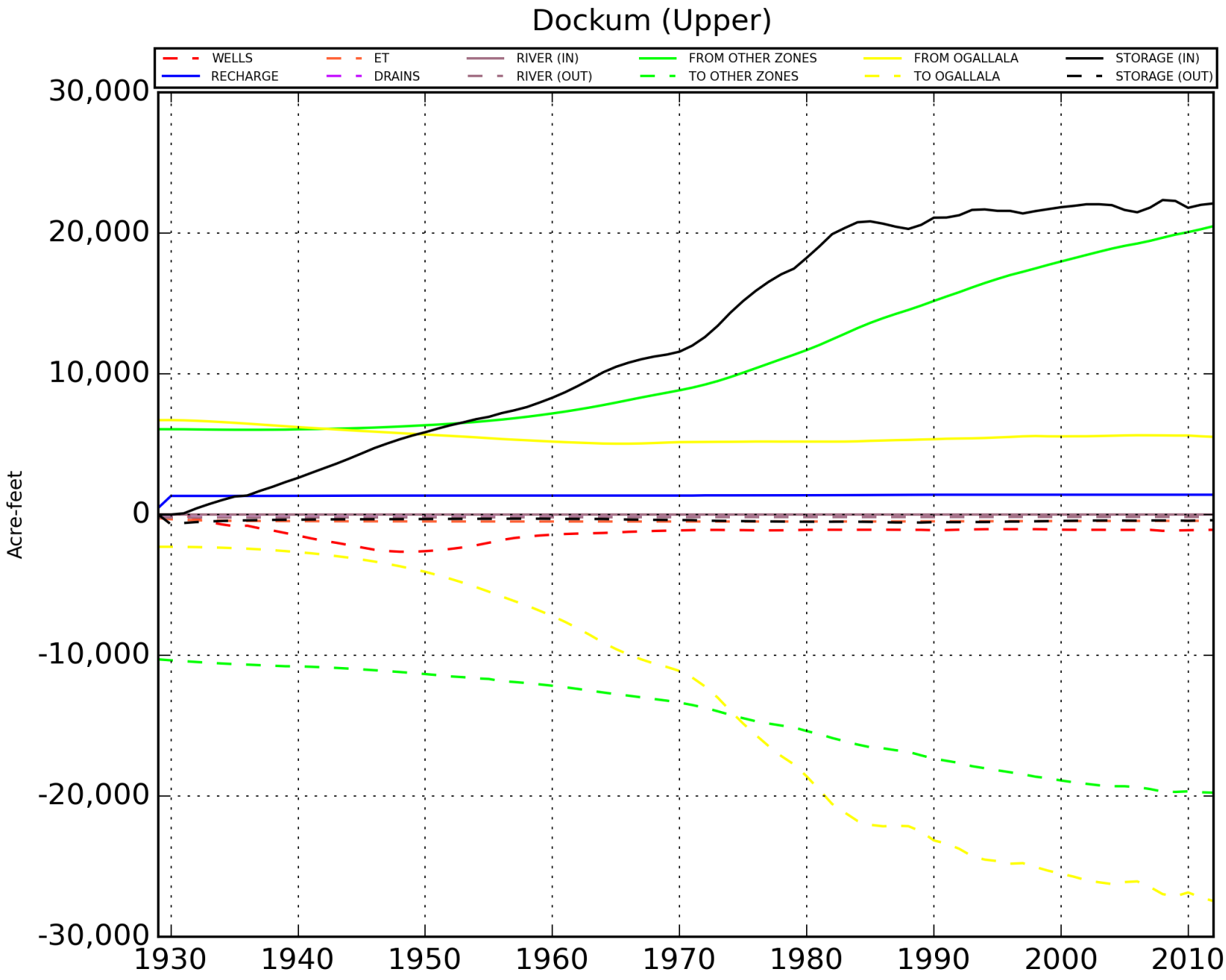


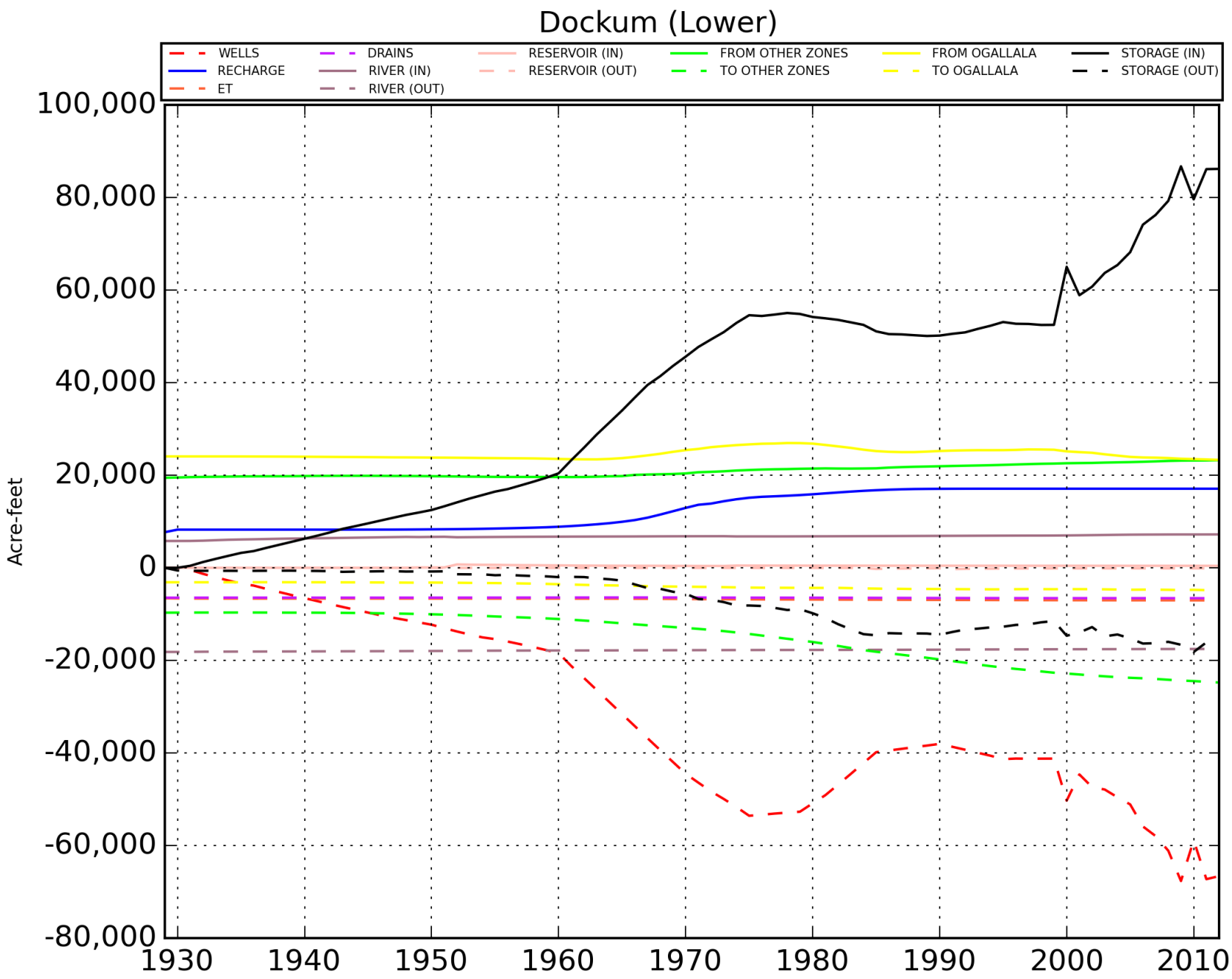



Ogallala
WELLS
RECHARGE
ET
DRAINS
RIVER (IN)
RIVER (OUT)
RESERVOIR (IN)
RESERVOIR (OUT)
FROM OTHER ZONES
TO OTHER ZONES
STORAGE (IN)
STORAGE (OUT)
Acre-feet
8,000,000
6,000,000
4,000,000
2,000,000
0
-2,000,000
-4,000,000
-6,000,000
-8,000,000
1930
1940
1950
1960
1970
1980
1990
2000
2010


Ogallala
WELLS
RECHARGE
ET
DRAINS
RIVER (IN)
RIVER (OUT)
RESERVOIR (IN)
RESERVOIR (OUT)
FROM OTHER ZONES
TO OTHER ZONES
STORAGE (IN)
STORAGE (OUT)
Acre-feet
1,500,000
1,000,000
500,000
0
-500,000
-1,000,000
-1,500,000
1930
1940
1950
1960
1970
1980
1990
2000
2010


Rita Blanca
WELLS
RECHARGE
ET
DRAINS
RIVER (IN)
RIVER (OUT)
FROM OTHER ZONES
TO OTHER ZONES
FROM OGALLALA
TO OGALLALA
STORAGE (IN)
STORAGE (OUT)
Acre-feet
15,000
10,000
5,000
0
-5,000
-10,000
-15,000
-20,000
1930
1940
1950
1960
1970
1980
1990
2000
2010


Dockum (Upper)
WELLS
RECHARGE
ET
DRAINS
RIVER (IN)
RIVER (OUT)
FROM OTHER ZONES
TO OTHER ZONES
FROM OGALLALA
TO OGALLALA
STORAGE (IN)
STORAGE (OUT)
Acre-feet
30,000
20,000
10,000
0
-10,000
-20,000
-30,000
1930
1940
1950
1960
1970
1980
1990
2000
2010


Dockum (Lower)
WELLS
RECHARGE
ET
DRAINS
RIVER (IN)
RIVER (OUT)
RESERVOIR (IN)
RESERVOIR (OUT)
FROM OTHER ZONES
TO OTHER ZONES
FROM OGALLALA
TO OGALLALA
STORAGE (IN)
STORAGE (OUT)
Acre-feet
100,000
80,000
60,000
40,000
20,000
0
-20,000
-40,000
-60,000
-80,000
1930
1940
1950
1960
1970
1980
1990
2000
2010

Transient Calibration: Pumping Prior to 1980

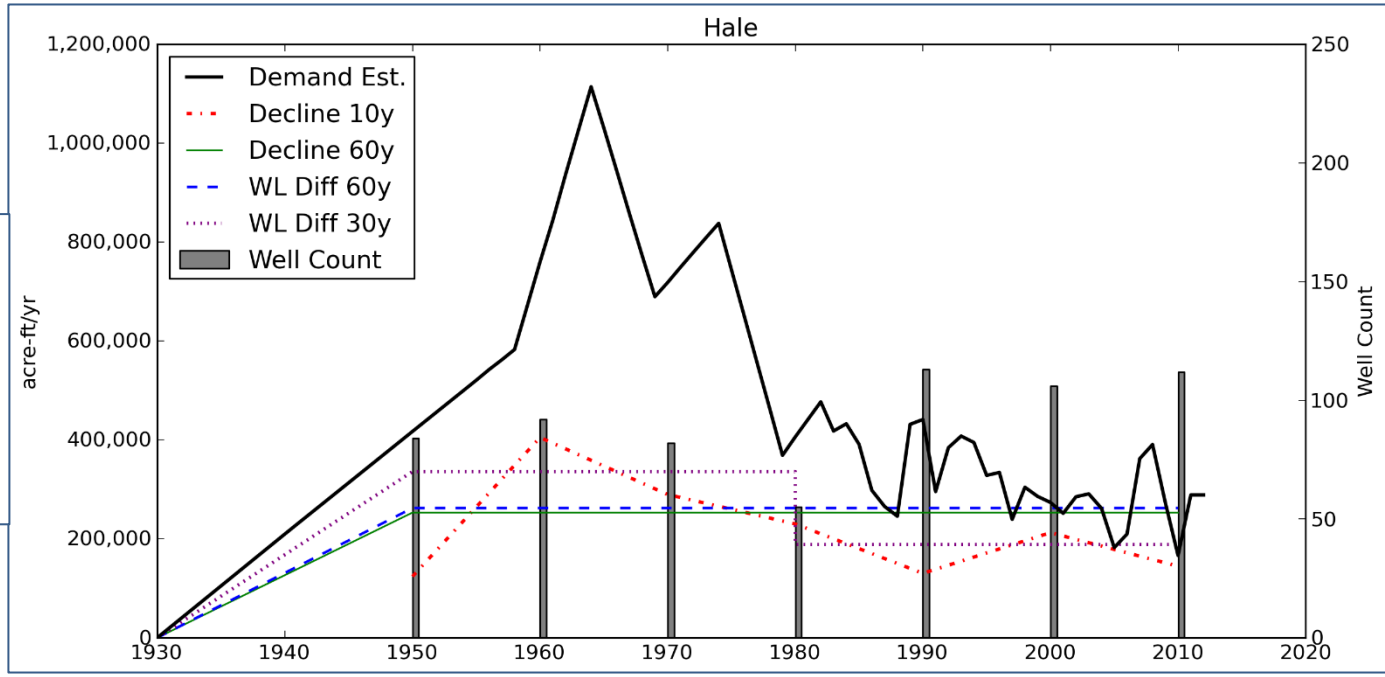
Blandford and others (2004) reduced pumping by factors ranging from 0.45 to 0.9

Table 1: Return Flow Estimates for Texas and New Mexico

Period	Return Flow[a] (%) Texas	New Mexico
1940-1960	55	55
1961-1965	50	50
1966-1970	45	50
1971-1975	40	50
1976-1980	35	40
1981-1985	25	40
1986-1990	20	35
1991-1995	15	25
1996-2000	10	20

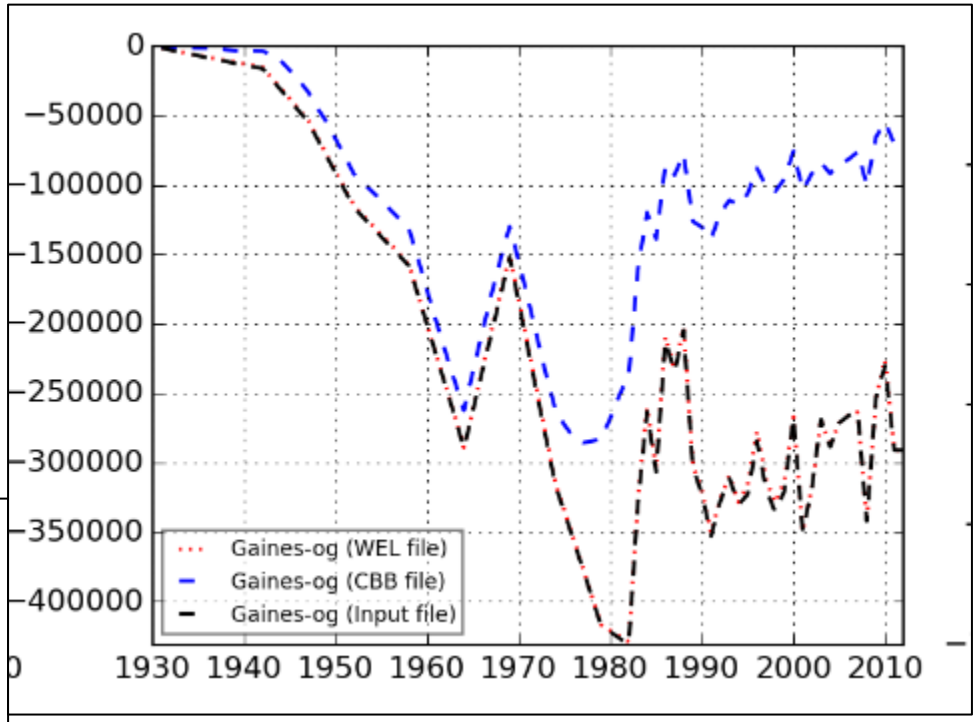
[a] Assumed to occur in same year as pumping.

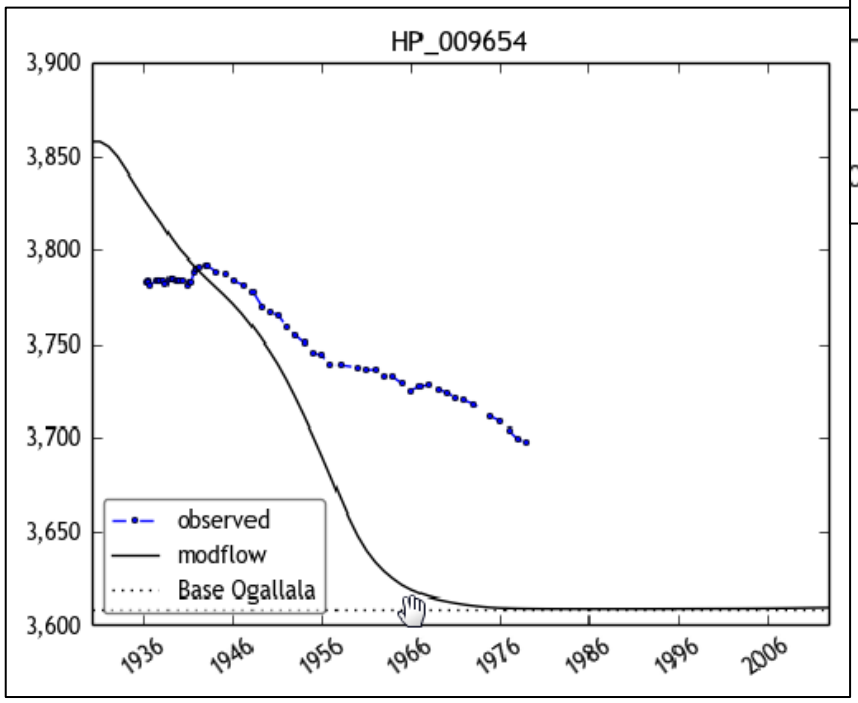
Current study found significant overestimates of pumping based on water level decline



Transient Calibration: Pumping Prior to 1980

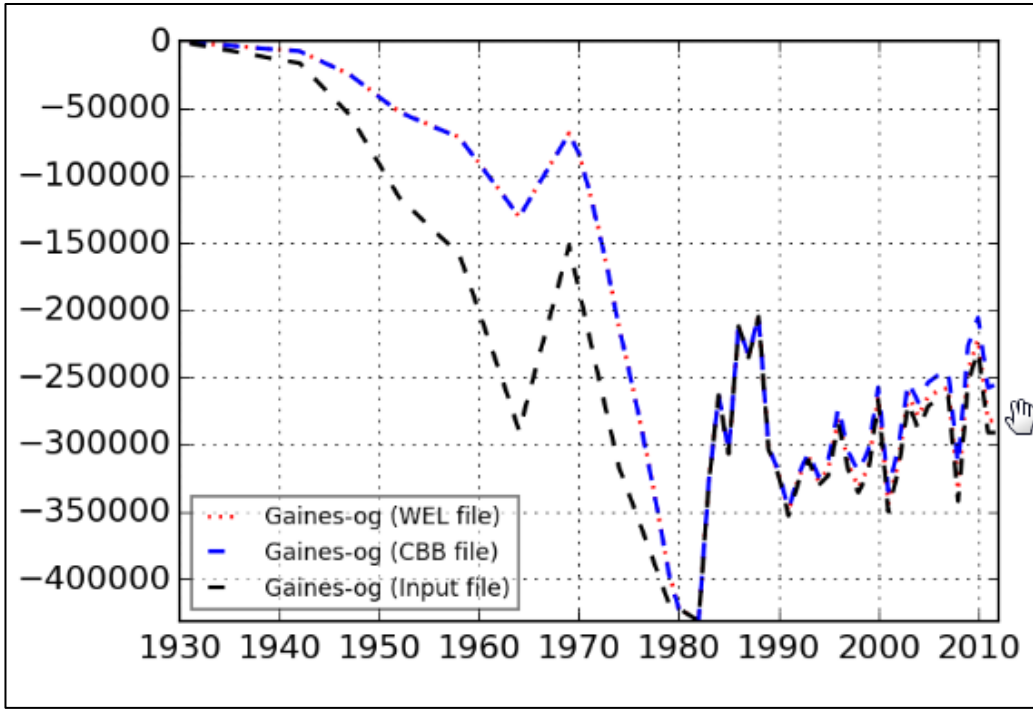
During calibration we found that using unmodified pre-1980 estimates results in dramatically reduced pumping post-1980

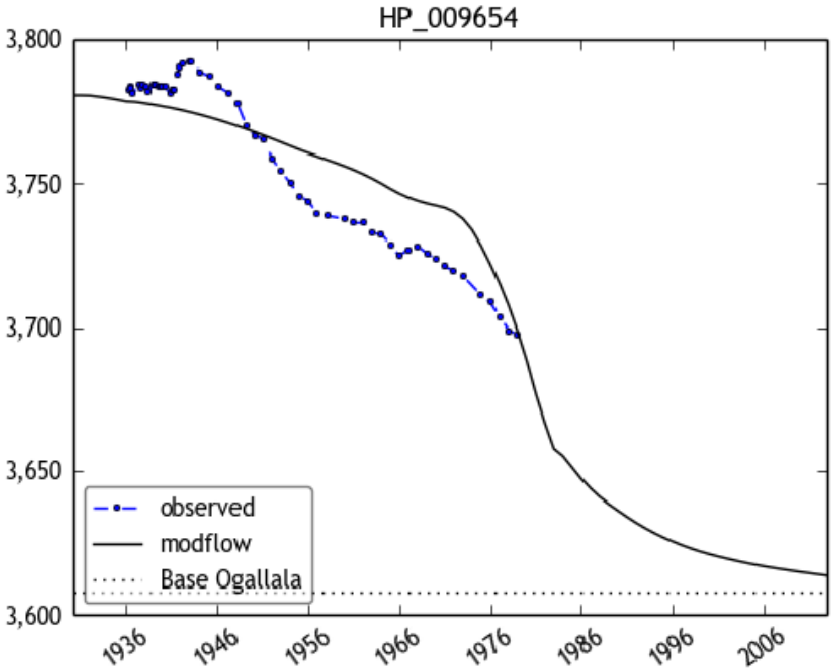




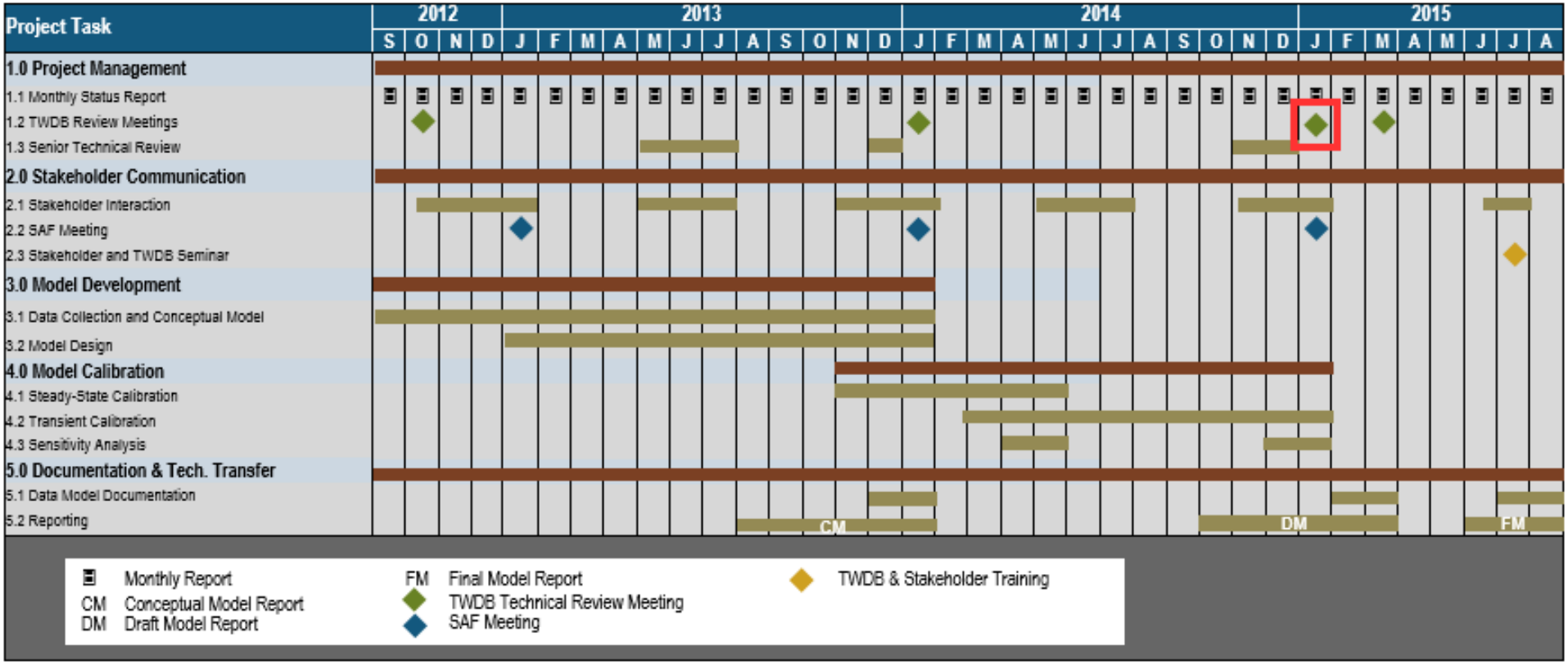
Transient Calibration: Pumping Prior to 1980

Decreasing pumping prior to 1980 allows post-1980 pumping to be nearly matched





This occurs only in the southern Ogallala counties, similar to the current GAM


Project Task
2012
2013
2014
2015
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
CM Conceptual Model Report
DM Draft Model Report
FM Final Model Report
TWDB Technical Review Meeting
SAF Meeting
TWDB & Stakeholder Training

High Plains Aquifer System Groundwater Availability Model

Stakeholder meeting: February 18, 2015,

Panhandle Regional Planning Commission, Amarillo, Texas

1. Question and Answer (Q&A)

Q: If a model gets updated, is an updated total estimated recoverable storage (TERS) automatically sent out?

A: No

Q: Groundwater Management Area would have to send out a request for an update to the total estimated recoverable storage report?

A: Yes

Q: Does the model include all of the Dockum or are the high total dissolved solids areas left out?

A: All of the Dockum is included, although there is not much flow in the high total dissolved solids area, which is consistent with conceptualization.

Q: Where is the demarcation between where irrigation return flow has occurred and where it has not?

A: Slide 29 shows the line, which Bureau of Economic Geology refers to as "500 milligrams per liter total dissolved solids (TDS)" line.

Q: Is there any analysis which indicates when return flow might occur in the north?

A: Per Dutton (2004), the percolation rate is such that infiltration cannot reach the water table given the rate of water table decline. The timing is basically unknown at this point.

Q: How was pumping estimated in New Mexico?

A: Estimates were taken from previous models, which used the New Mexico Office of the State Engineer database as a source.

Q: Slide 39 – what is the black spot in New Mexico?

A: Dry cells, where saturated thickness is zero.

Q: Give an overview of the difference between the Upper and Lower Dockum

A: The Upper Dockum is typically thought to be unproductive and of poor water quality. The Lower Dockum, which contains the most regionally consistent sandstone (Santa Rosa) is the more productive unit, with a significant outcrop area where fresh water can be found.

Q: What is the benefit of splitting the Upper and Lower Dockum in the model?

A: Allows well locations to be better described, since most Dockum wells are in the Lower Dockum and are not screened in the Upper Dockum.

Q: Did the Dockum get extended to the east?

A: Yes, it was extended further into Nolan County based on an existing study in that county.

Q: Will this portion be modeled?

A: Yes, it is active in the model.

Q: What are the units on slide 42?

A: Acre-feet

Q: For the Lower Dockum water budget, what does “other aquifers” mean?

A: Upper Dockum, Rita Blanca, and Edwards-Trinity (High Plains).

Q: [residuals for Groundwater Management Area 1 area are shown] Do you have residuals for the Groundwater Management Area 2 area?

A: Yes [additional figure is shown]

Q: What is the white area on the drawdown map?

A: Areas where mild recovery has occurred, rather than drawdown.

Q: Moore County does not have that 400 feet of historical drawdown that is shown.

A: We will investigate this comment.

Q: What is the starting year on those hydrograph plots, and is it consistent?

A: Yes, it is year 1929 for all plots.

Q: On the Roberts County hydrograph, drawdown appears to occur prior to 2001-2002 when Canadian River Municipal Water Authority started production

A: We will investigate this, but the hydrograph may show 2001 drawdown, difficult to tell because of the coarseness of the scale.

Q: Do you have Dockum hydrographs for Mitchell County?

A: Not in the presentation, but they will be in the report.

Q: Ogallala water budget (zoomed in): Which line shows recharge?

A: The blue line, which shows increases occurring starting in the 1940s, then in several decades after.

Q: Rita Blanca water balance: You mentioned a contribution from the Dockum?

A: Yes [shown on figure].

Q: In the conceptual model, do you have an isopach figure for the Upper Dockum?

A: I don’t remember, but the structure is available in the geodatabase.

Q: Was the Upper Dockum present in the north in the previous Dockum groundwater availability model?

A: No, it was newly added to the current groundwater availability model based on updated information.

Q: How were the irrigation estimates made for the historical surveys?

A: Agricultural extension agents made estimates based on visuals, crop use estimates, etc.

Q: Does the survey show 1,000,000 acre-feet per year in Hale County?

A: Yes, and it seems high.

Q: Where else does this occur?

A: There are at least half a dozen counties that are adjusted downward in the pre-1980 period. Most are in Groundwater Management Area 2, and are the high pumpers in the paleo-valleys.

Q: Do you know how many additional control points were added for this study for the Edwards-Trinity (High Plains) and Dockum?

A: Not offhand, but Figures 4.2.16 through 4.2.19 in the conceptual model report show the control.

Q: The inconsistency between the volume calculations and the irrigation survey estimates makes a statement about assumptions of historical production (and the implications for the Edwards-Trinity (High Plains)). The Natural Resources Conservation Service was basically eyeballing the estimates, which is a difficult task and prone to error. [Group discussion on irrigation pumping estimates].

Q: Did you use the RIV package for focused recharge? How did you vary head with time?

A: Yes, and stage (which was set from minimum Digital Elevation Model) was not varied with time.

Q: What about ephemeral streams?

A: These are represented as discharge features only, using the drain package.

Q: How as Dutton's original hydraulic conductivity used?

A: We modified it slightly based on updated data (from Canadian River Municipal Water Authority—CRMWA and some public water supply—PWS) , and then used it as the initial estimate of hydraulic conductivity.

Q: How would you use the post-development recharge in predictive mode?

A: Best estimate at this point is to just continue the 2012 distribution into the future.

Q: Did you check the sensitivity to recharge?

A: Yes, although only a few counties show sensitivity in the post-development period. Terry, for instance might show that sensitivity.

Q: Did you calculate sensitivity to specific yield (Sy)?

A: Yes, drawdown was highly correlated (when pumping was present).

Q: Why did you keep specific yield constant, when changing it could help explain changing hydrograph slopes?

A: Did not feel that is was justified, since no new measurements were available.

Q: When was the original specific yield study performed?

A: It was performed in the 1970s as part of the United States Geological Survey Regional Aquifer System Analysis (RASA) study in cooperation with the Texas Water Development Board.

Q: How does the volume in place compare between the previous models and the High Plains Aquifer System draft groundwater availability model?

A: We compared 2004 for Groundwater Management Area 1 (i.e. the OGLL_N model). The volume in place was 17,000,000 AF higher for the High Plains Aquifer System draft groundwater availability model, which corresponds to an average of about 10 feet more saturated thickness.

Q: Did you perform water budgets on a per-county basis?

A: Not yet, but we will for the final report. They will be reported decadally.

Q: Is recharge varied annually based on precipitation?

A: No, Bureau of Economic Geology staff indicated that this was not justified for this area.

Comment: Recharge is higher north of the 500 milligrams per liter total dissolved solids line in predevelopment, but can be higher south of the 500 milligrams per liter in post-development, when irrigation return flow occurs.

General discussion of whether water levels the periodically increase are due to cessation of pumping, or increased recharge, or both. One commenter felt that leaving this dynamic recharge out of the model was a mistake. Presenter indicated that in general the data does not support a quick response of the water table to wetter conditions.

Q: Northwest Moore County: don't think the drawdown in the hydrograph shown occurred.

A: Will check against structure.

2. Attendance list

Name	Organization
Neil Deeds	INTERA Incorporated
Cindy Ridgeway	Texas Water Development Board
Steve Walthour	North Plains GCD
C.E. Williams	Panhandle GCD
Janet Guthrie	Hemphill County GCD
Ray Brady	Consultant
Bill Hutchison	Consultant
Jason Coleman	High Plains UWCD No. 1
Kent Sutterwhite	CRMWA
Ben Weinheimer	TCFA
Kody Bessent	High Plains UWCD No. 1
Bill Mullican	Consultant
Zhuping Sheng	TAM Agrilife at El Paso
Jim Haley	HCUWCD