Extension of the Numerical Model of Groundwater Flow in the High Plains Aquifer System

Stakeholder Advisory Forum
September 19, 2024

Thank you for signing in early.

The presentation will begin at 10:00 am and end at 11:15 am, Central Daylight Time

Please stay muted during the meeting and use the chat box to submit questions

TEXAS WATER DEVELOPMENT BOARD

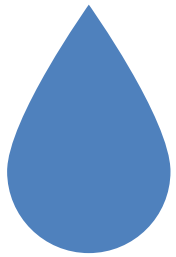
Meeting information

- An audio and video recording of the meeting, presentation, and the report summarizing the meeting will be made available on the project's TWDB webpage

- https://www.twdb.texas.gov/groundwater/models/gam/hpas/hpas.asp

Why Stakeholder Advisory Forums?

Keep stakeholders updated about progress of the modeling project



Inform how the groundwater model can, should, and should not be used

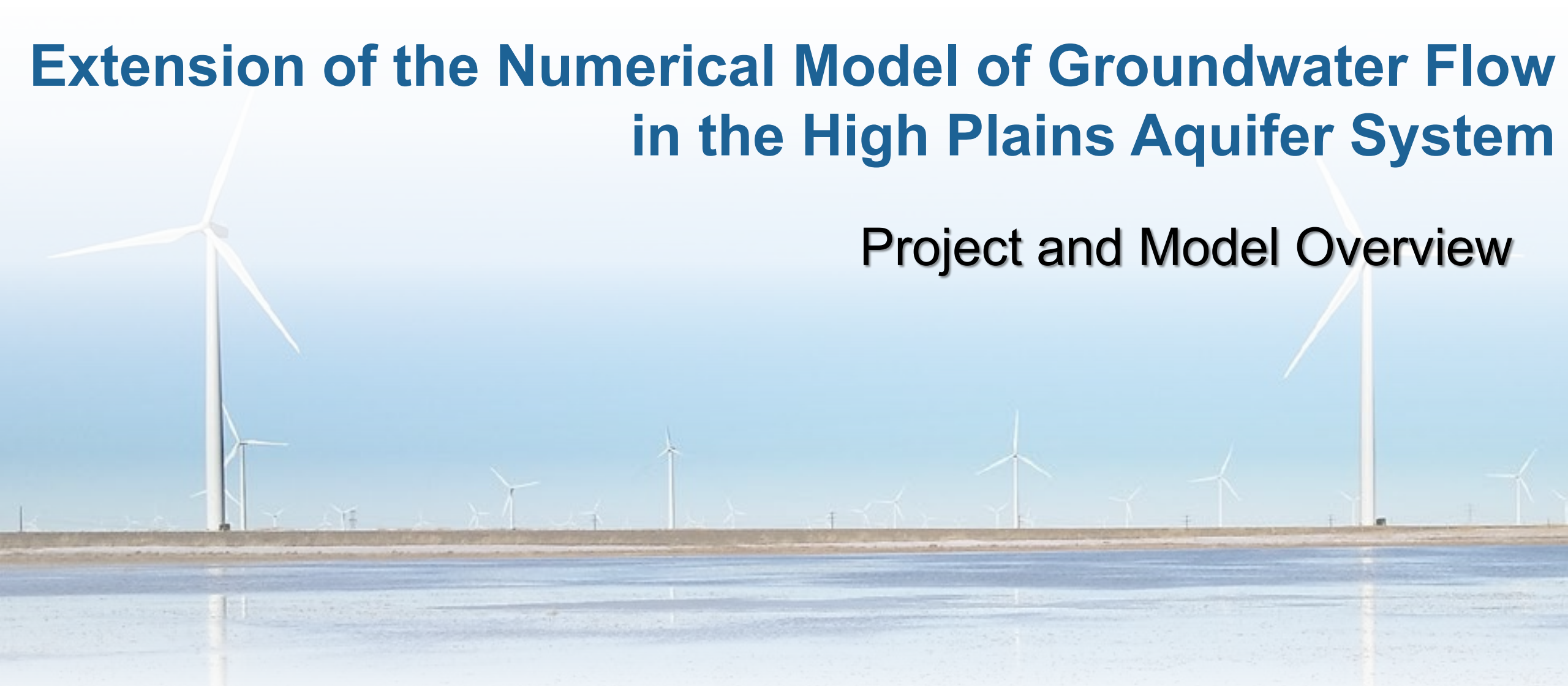
Provide stakeholders with the opportunity to provide input and data to assist with model development

Agenda

- Extension of the Numerical Model of Groundwater Flow in the High Plains Aquifer System
- Question and Answer

Extension of the Numerical Model of Groundwater Flow in the High Plains Aquifer System

Project and Model Overview



Lead Modeler : Tim Cawthon, P.G.
Modeler: Shirley Wade, Ph.D., P.G.
Modeler: Sofia Avendaño, GIT

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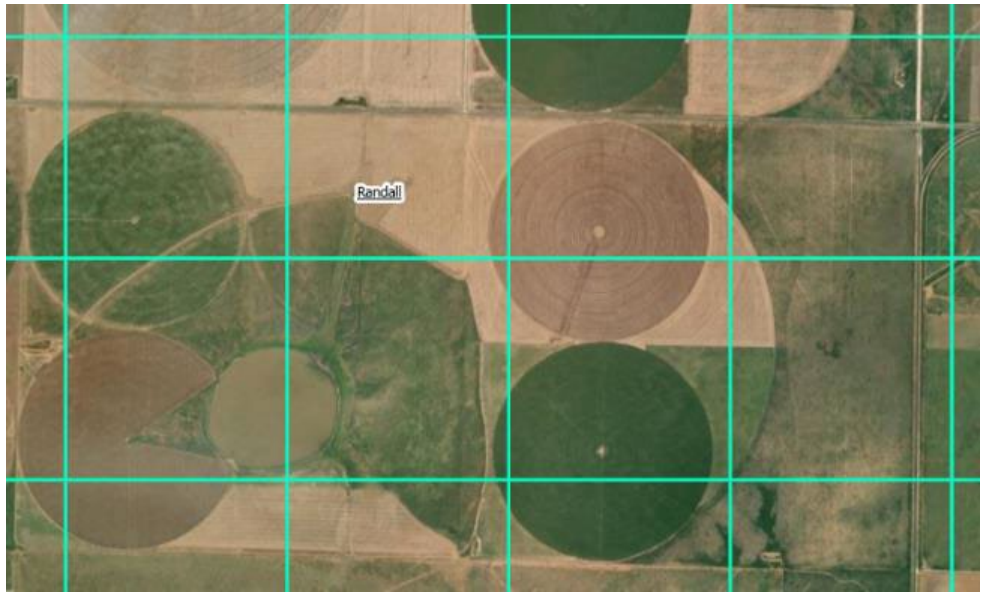
Original Model

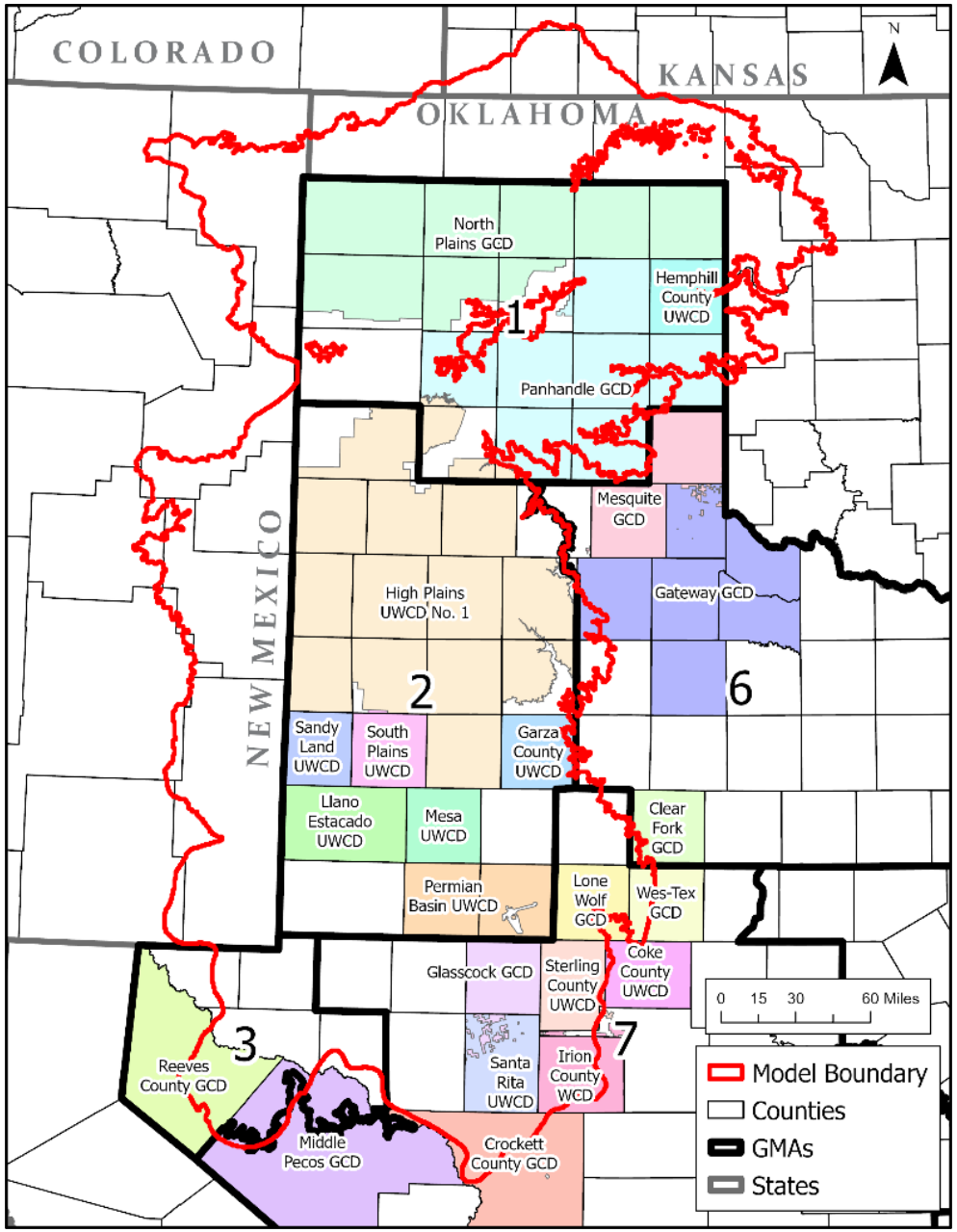
- Completed in 2015 by INTERA
- MODFLOW-NWT
- ½ mile grid spacing
- 4 layers
- 84 years (1929 – 2012)
- Used for 2016 and 2021 Joint Planning cycles

½ mile grid spacing



Model Boundary

Model Area ≈ 77,000 mi²

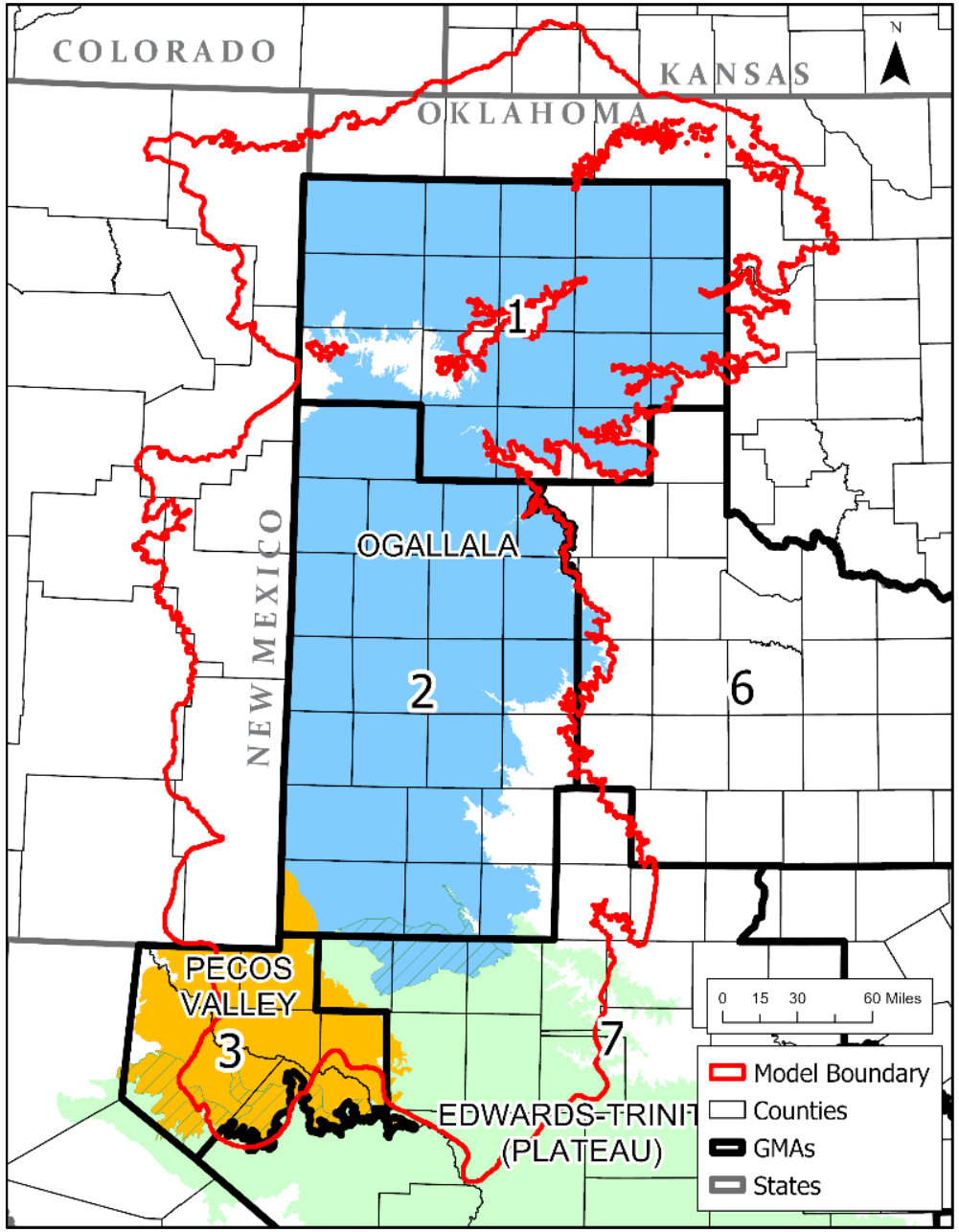


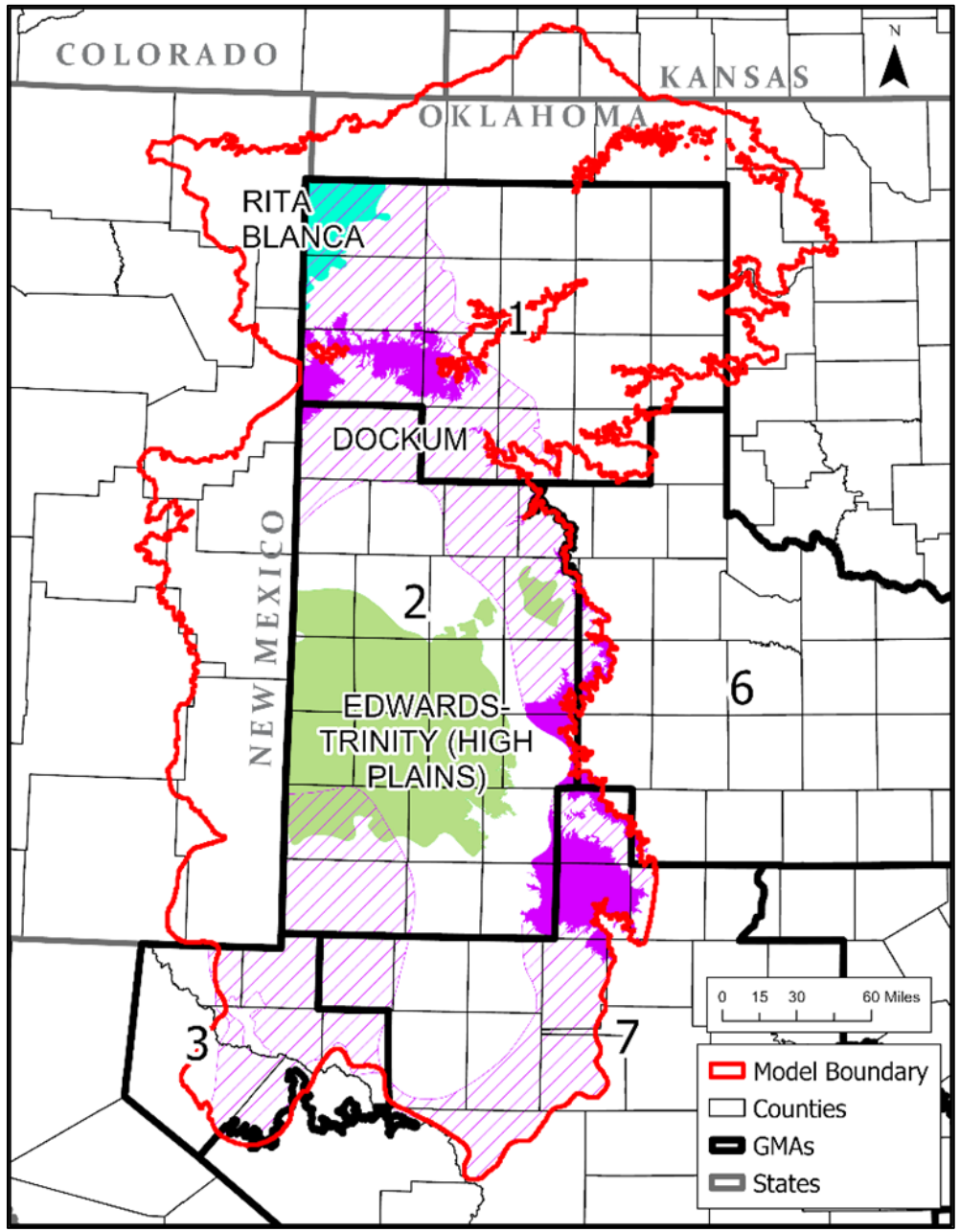
- Clear Fork GCD
- Coke County UWCD
- Crockett County GCD
- Garza County UWCD
- Gateway GCD
- Glasscock GCD
- Hemphill County UWCD
- High Plains UWCD No. 1
- Irion County WCD
- Llano Estacado UWCD
- Lone Wolf GCD
- Mesa UWCD
- Mesquite GCD
- Middle Pecos GCD
- North Plains GCD
- Panhandle GCD
- Permian Basin UWCD
- Reeves County GCD
- Sandy Land UWCD
- Santa Rita UWCD
- South Plains UWCD
- Sterling County UWCD
- Wes-Tex GCD

Model Official Aquifers

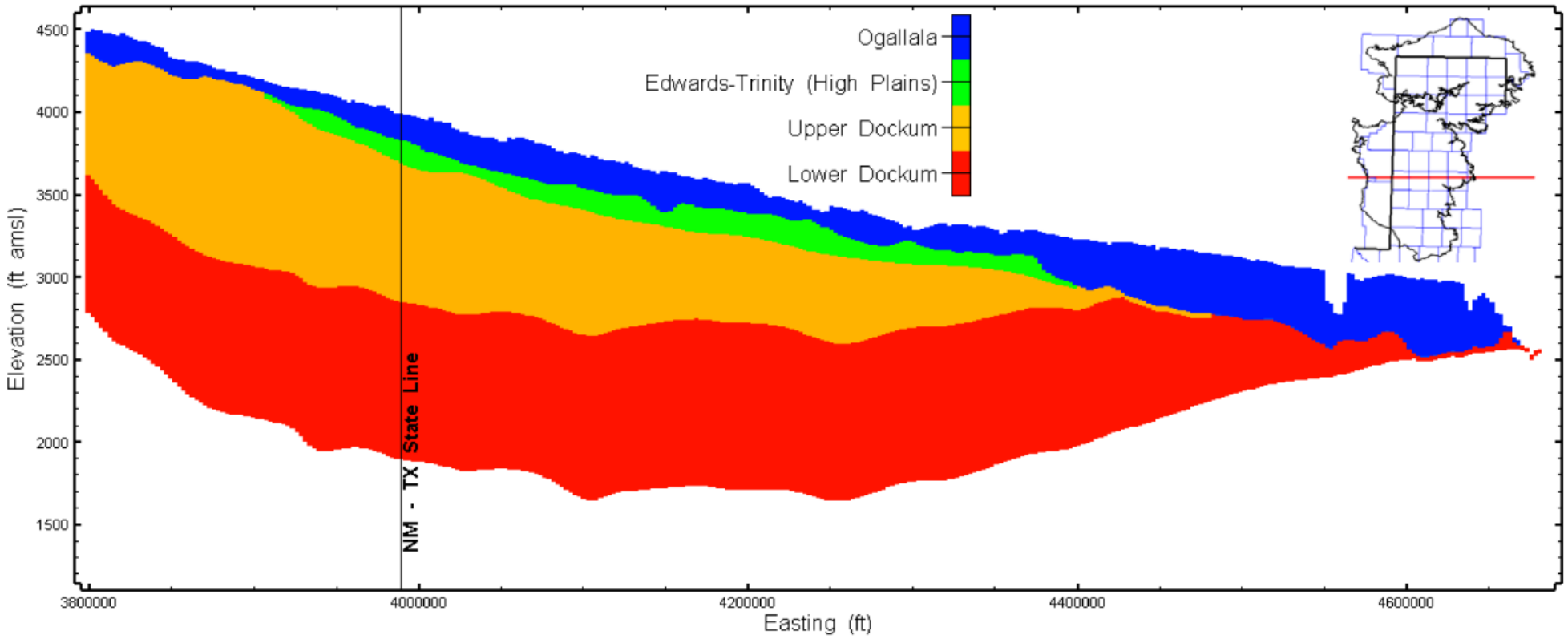
Layer	Aquifers
1	Ogallala
2	Rita Blanca or Edwards-Trinity (High Plains)
3	Upper Dockum
4	Lower Dockum

Layer	General Head Boundaries
1	Pecos Valley Alluvium
2	Edwards-Trinity (Plateau)
3	
4	



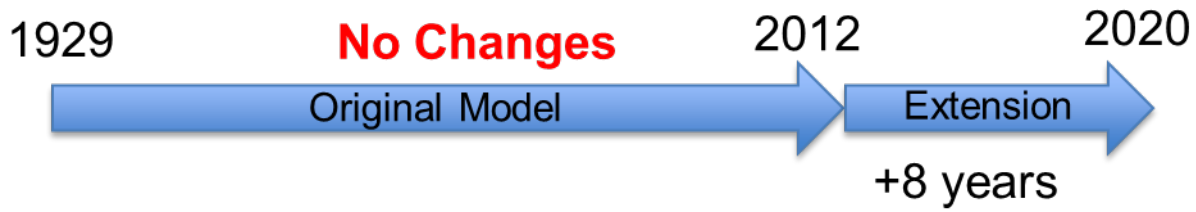


Model Layers



Layer	Aquifer 1	Aquifer 2	General Head Boundary
1	Ogallala		Pecos Valley Alluvium
2	Rita Blanca	Edwards-Trinity (High Plains)	Edwards-Trinity (Plateau)
3	Upper Dockum		
4	Lower Dockum		

Model Extension



- Extend model (through December 31, 2020)
  - Well Package - Add new wells and pumping
  - Other Packages – Same values as 2012
  - Recharge Package - Adjustment to Howard County recharge
- Run model and evaluate performance
  - Verify still meets original project goals
- Develop report

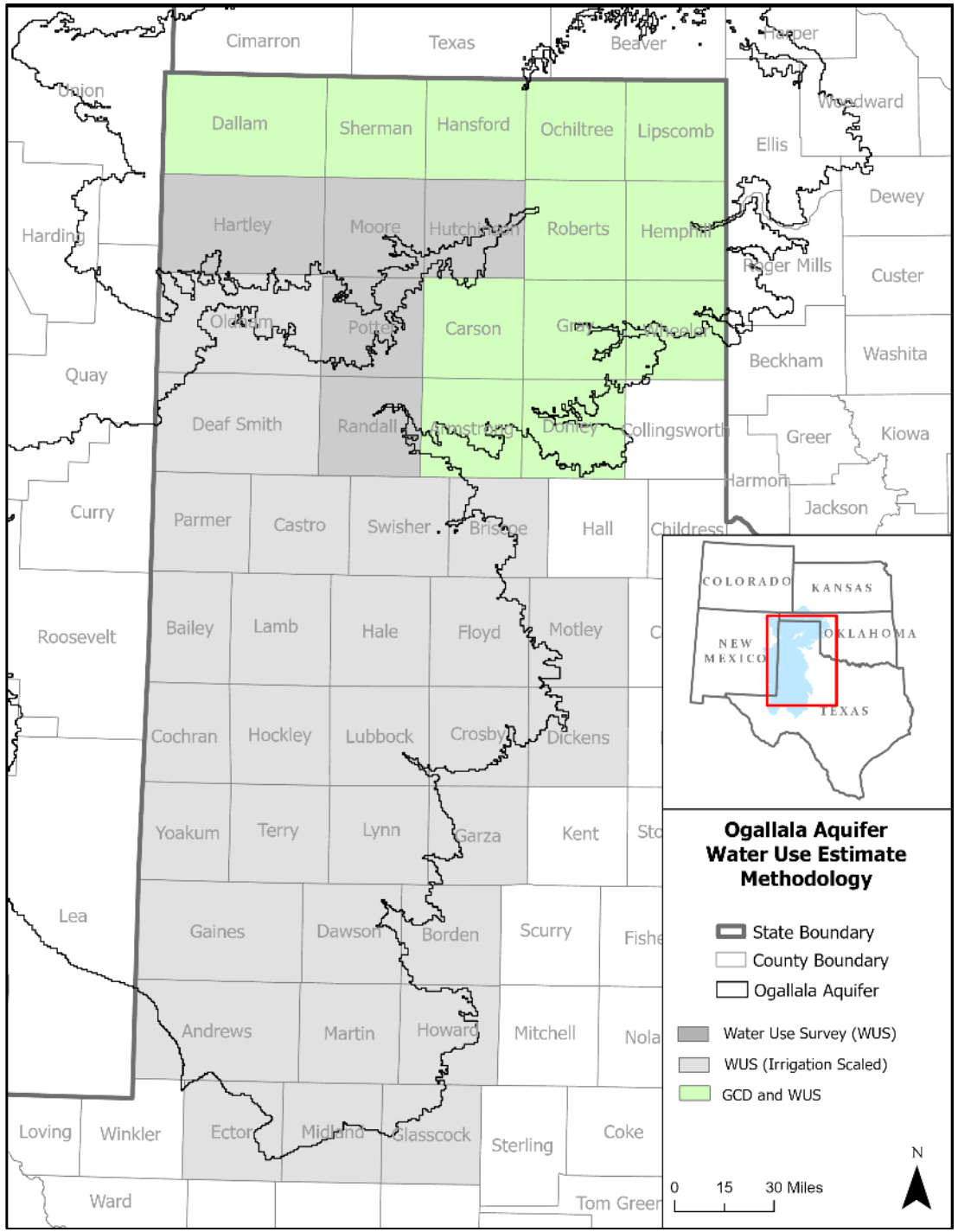
Well Package Extension

1) Pumping Estimates
2) Well Dataset
3) Distribute Pumping to Wells

Pumping Estimates

- TWDB Water Use Survey
  - Surveyed Pumping
    - Municipal and Industrial
  - Non-Surveyed County Pumping
    - Rural Domestic, Livestock, Irrigation, and Mining
- Local GCD Data
  - Meter data (Irrigation, Municipal, and Industrial)
  - County Estimates (Irrigation, Municipal, and Industrial)
  - Only if GCD covered entire county
- Original Model
  - No Dockum WUS or GCD pumping data for some counties
- Other States
  - New Mexico 2015 county estimates by pumping category
  - Oklahoma and Kansas: Same as 2012

Ogallala Aquifer Pumping Estimates



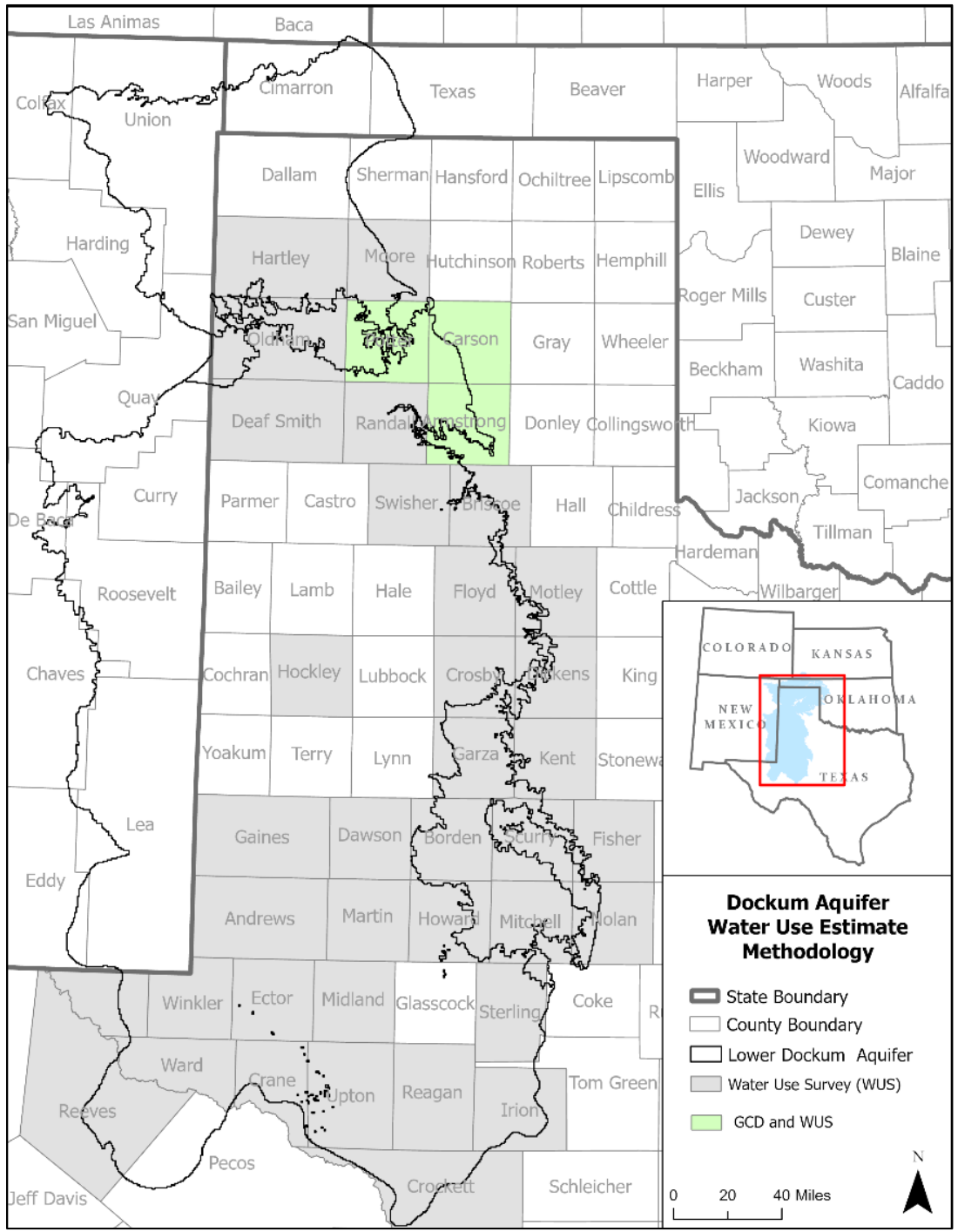
Water Use Survey (WUS)

WUS (Irrigation Scaled)

GCD and WUS

* GCD data was not used for Hartley, Moore, Hutchinson, and Potter counties because one GCD did not cover the entire county.

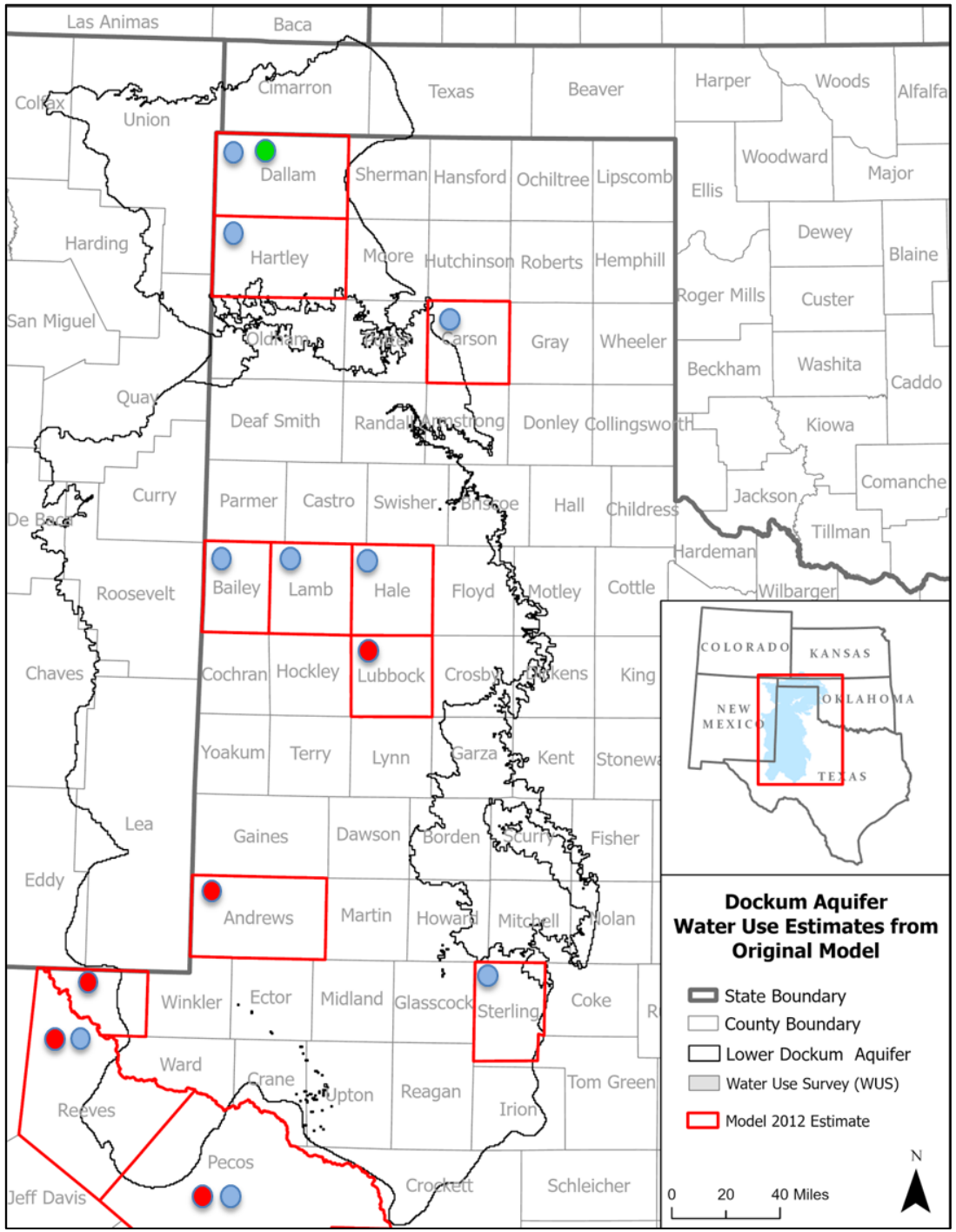
Dockum Aquifer Pumping Estimates



Water Use Survey (WUS)

GCD and WUS

Dockum Aquifer Pumping Estimates

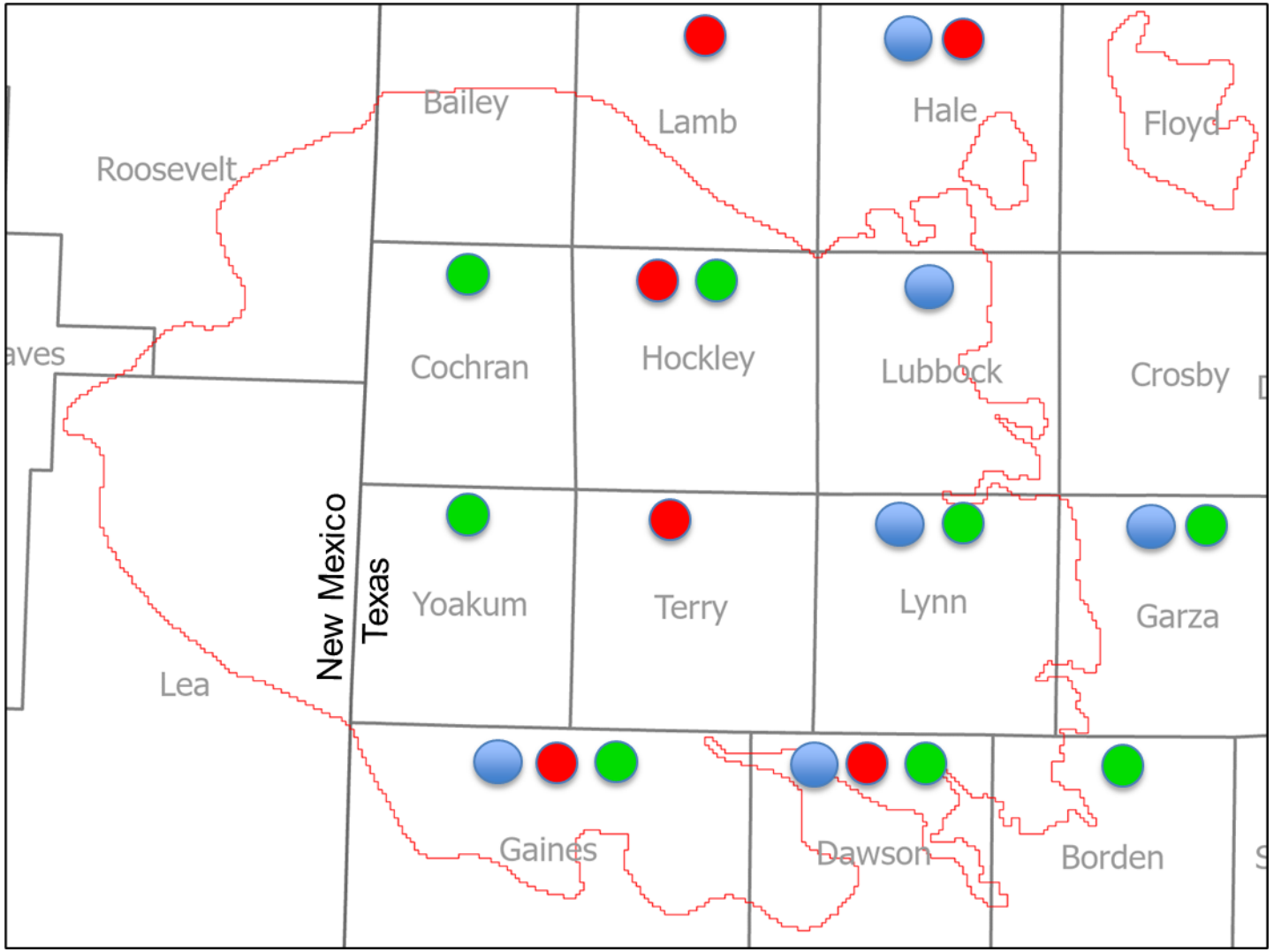


Model 2012 Estimate

WUS or GCD estimate **is not** available but Original Model includes pumping

- Irrigation (9)
- Rural Domestic (5)
- Livestock (1)

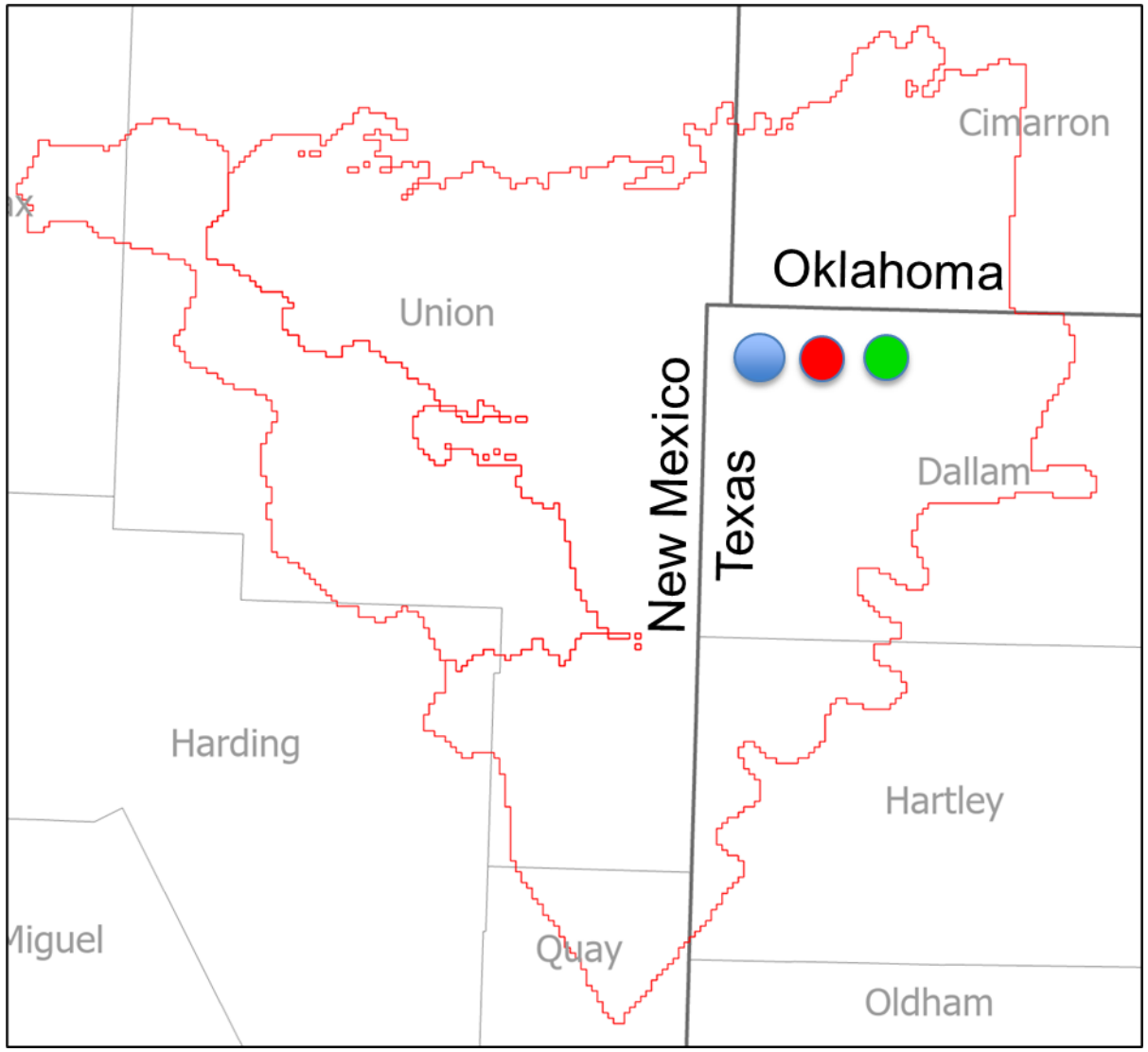
Edwards-Trinity (High Plains) Aquifer



Water Use Survey Estimate **is** Available

- Irrigation (6)
- Rural Domestic (6)
- Livestock (8)

Rita Blanca Aquifer



Water Use Survey Estimate **is** Available

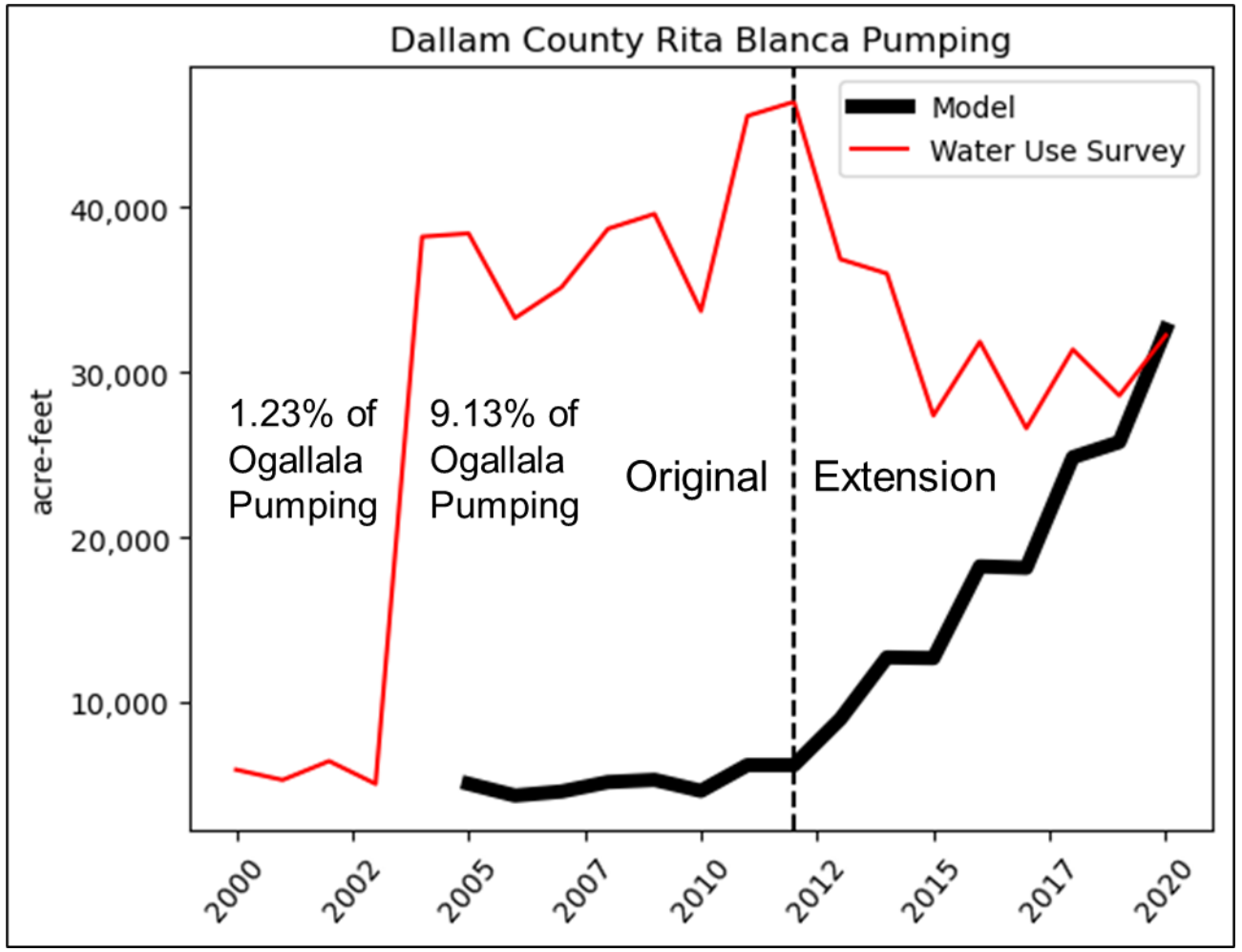
- Irrigation (1)
- Rural Domestic (1)
- Livestock (1)

Rita Blanca Aquifer

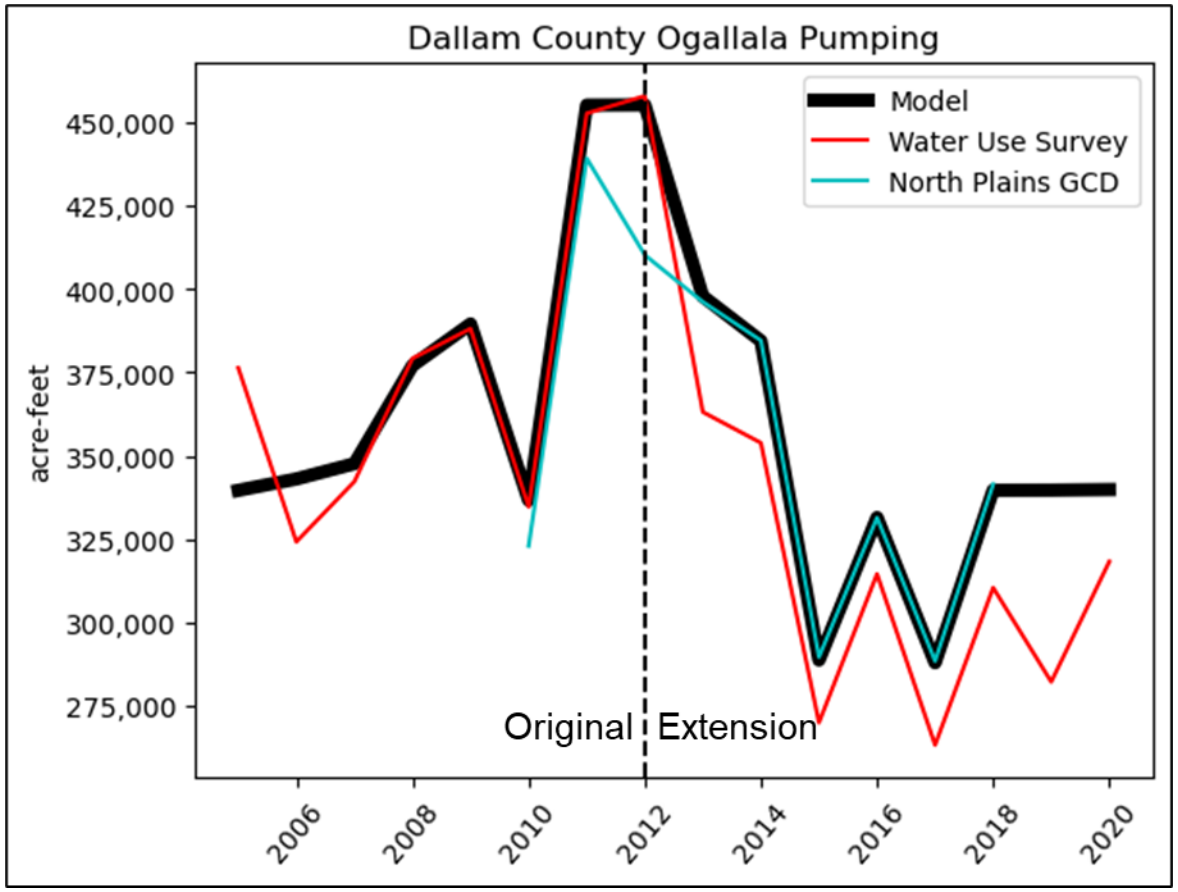
Dallam County
Water Use Survey Aquifer Splits

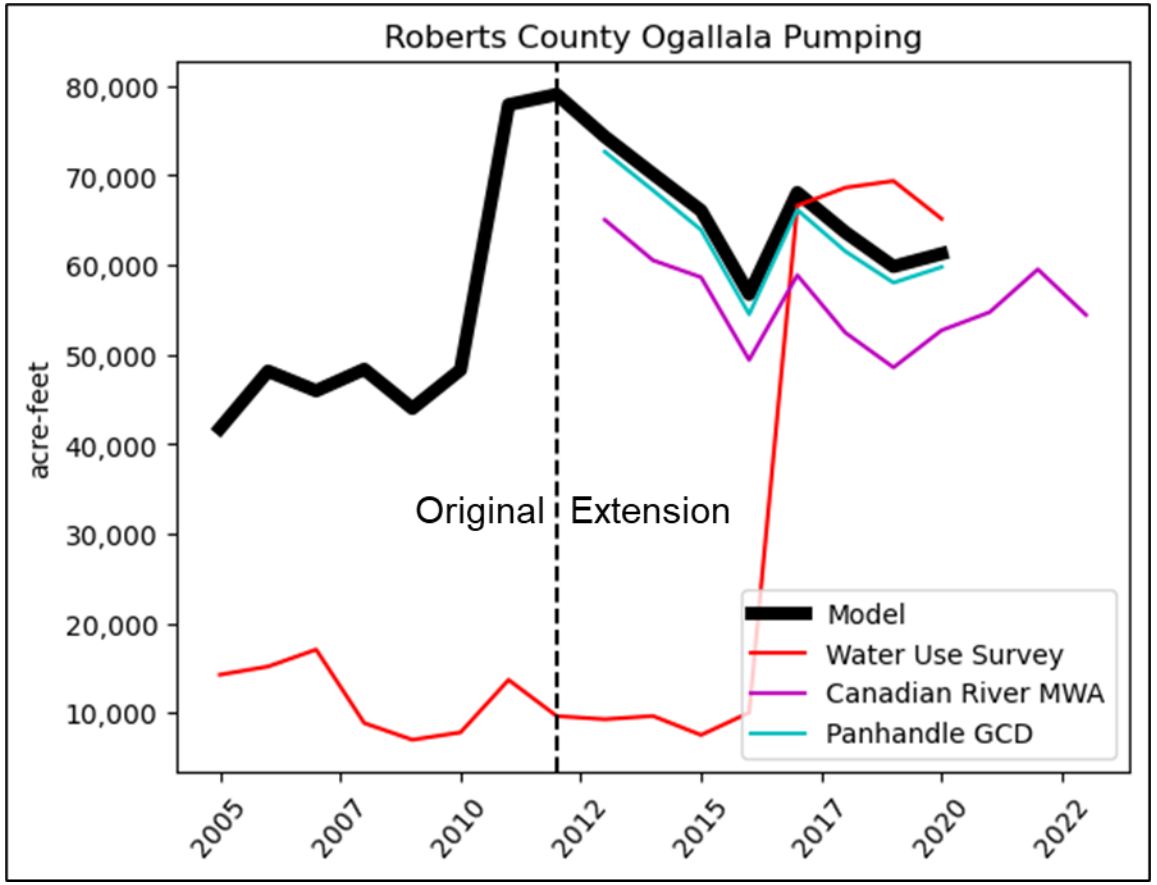
<u>Before 2004</u>
Ogallala = 97.54%
Rita Blanca = 1.23%
Dockum = 1.23%

<u>After 2004</u>
Ogallala = 90.87%
Rita Blanca = 9.13%
Dockum = 0%



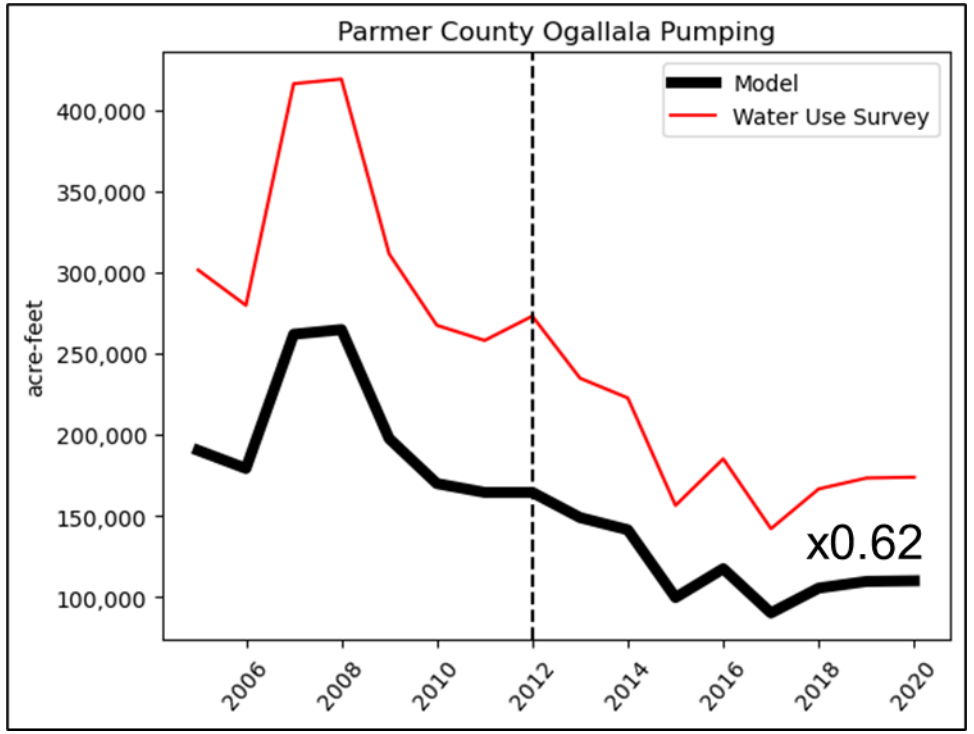
Ogallala Aquifer
Local GCD Example

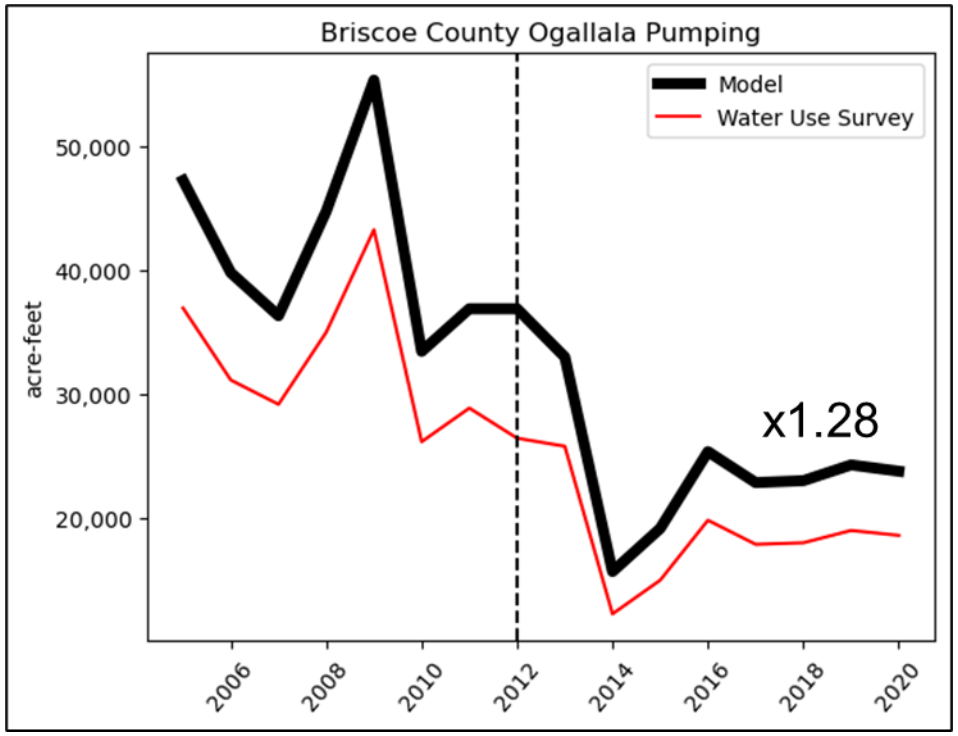




Ogallala Aquifer Irrigation Scaling Ratios

County	Scaling Ratio
Andrews	0.69
Armstrong	0.90
Bailey	0.53
Borden	1.18
Briscoe	1.28
Castro	0.46
Cochran	0.64
Crosby	1.04
Dawson	0.74
Deaf Smith	0.70
Dickens	3.94
Ector	0.29
Floyd	0.77
Gaines	0.65
Garza	1.66
Glasscock	0.71
Hale	0.75
Hockley	0.99
Howard	2.36
Lamb	0.76
Lubbock	0.82
Lynn	0.97
Martin	1.00
Midland	0.22
Motley	1.18
Oldham	2.41
Parmer	0.62
Swisher	0.81
Terry	1.05
Yoakum	0.89





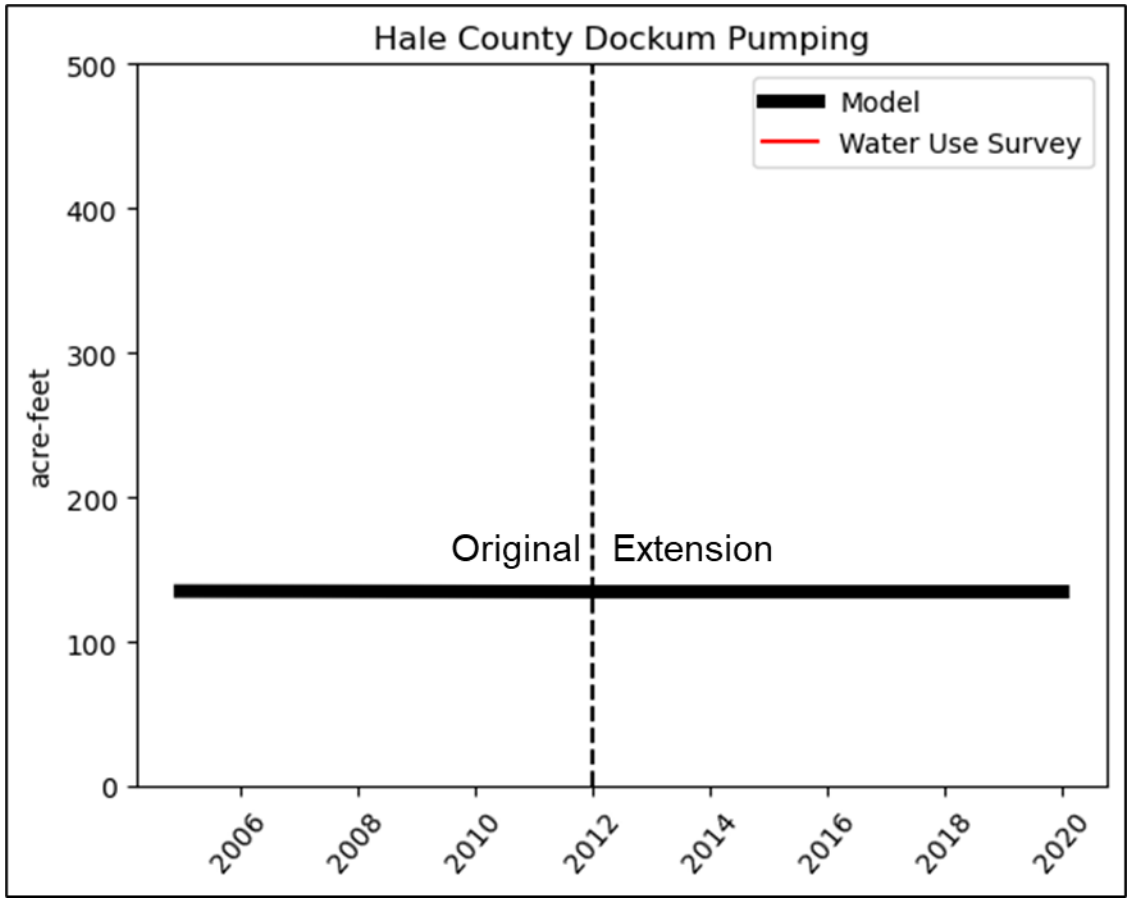
Version 1 Irrigation scaling ratios between the Water Use Survey irrigation estimates and the Amosson and others (2003) estimates were developed for the Southern Ogallala counties. This ratio was kept the same after 1997.

Amosson, S., Marek, T., New, L., Bretz, F., and Almas, L., 2003, Estimated irrigation demand for the Southern Ogallala GAM. Appendix B of the Groundwater Availability of the Southern Ogallala Aquifer in Texas and New Mexico Report.

Dockum Model Estimates

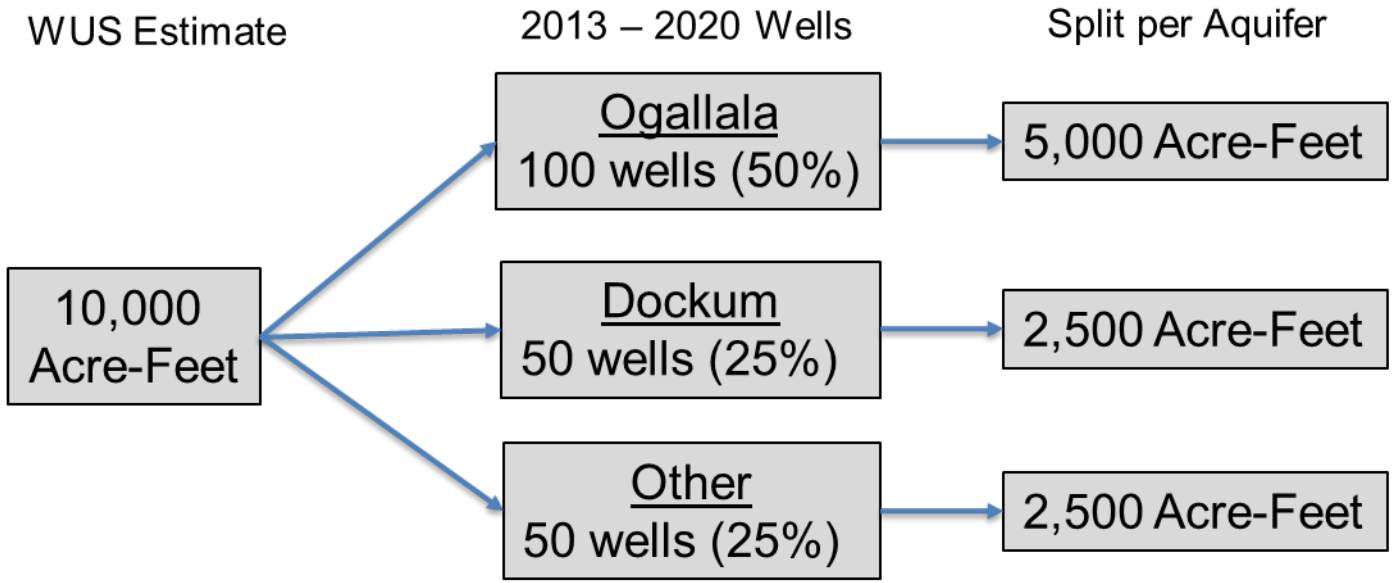
2012 Model pumping with
no GCD or WUS Pumping available

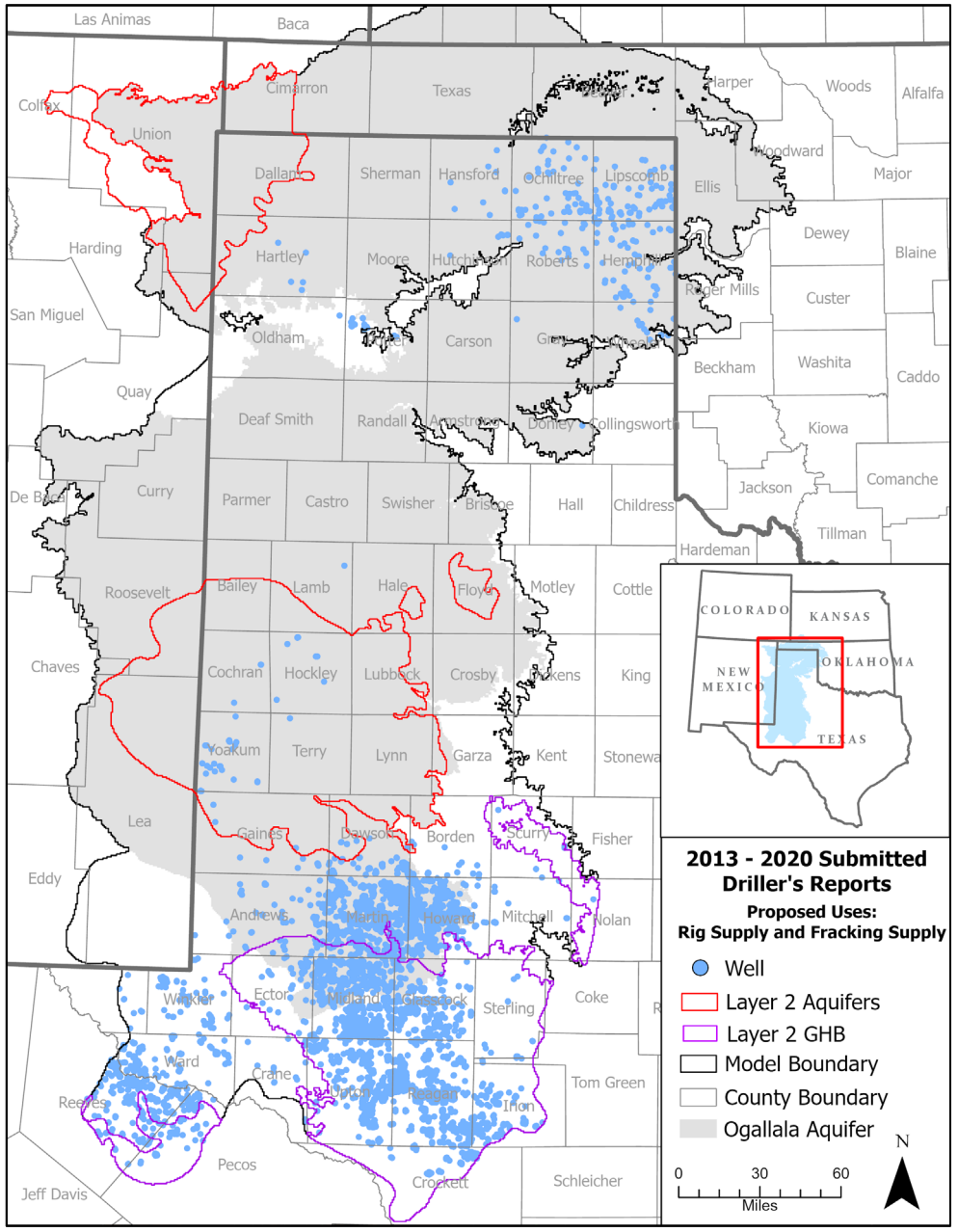
County	Aquifer	Use	Model (Acre-Feet)
Andrews	Dockum	Rural Domestic	1
Bailey	Dockum	Irrigation	5
Carson	Dockum	Irrigation	91
Dallam	Dockum	Irrigation	2,763
Dallam	Dockum	Livestock	8
Hale	Dockum	Irrigation	135
Hartley	Dockum	Irrigation	840
Lamb	Dockum	Irrigation	3
Loving	Dockum	Rural Domestic	2
Lubbock	Dockum	Rural Domestic	3
Pecos	Dockum	Irrigation	772
Pecos	Dockum	Rural Domestic	5
Reeves	Dockum	Irrigation	180
Reeves	Dockum	Rural Domestic	4
Sterling	Dockum	Irrigation	8



Mining County Estimates

- WUS Mining County Pumping
  - Not split between aquifer
- Texas Submitted Drillers Reports (SDR) Database
  - Rig Supply and Fracking Supply wells
  - Assign aquifers
  - Calculate aquifer splits per county





[TWDB Water Use Survey Methodology]

Mining County Estimates

Dockum

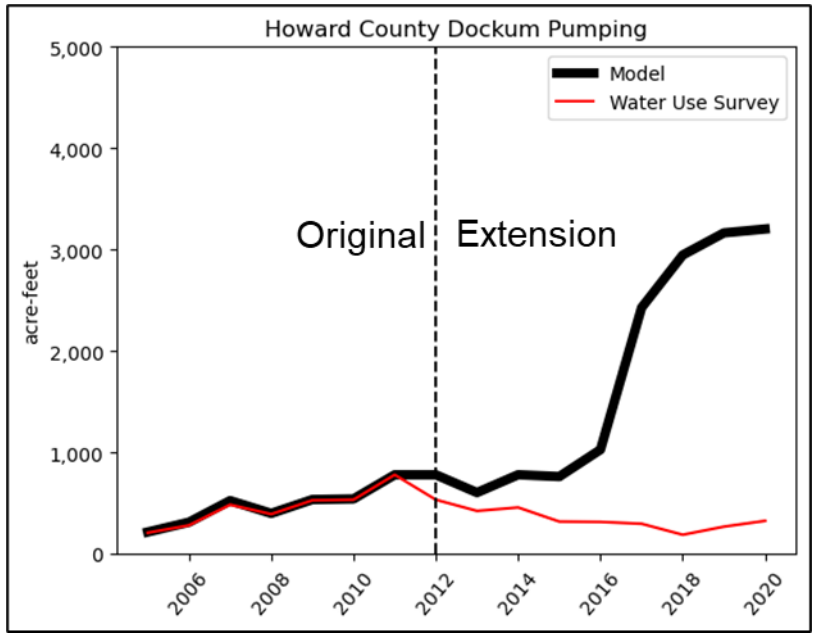
County	Wells	Annual Average (2013-2020) Acre-Feet
Midland	307	3,366
Howard	568	1,541
Martin	264	1,369
Upton	140	1,140
Andrews	37	877
Reagan	146	834
Ward	57	763
Winkler	42	626
Reeves	138	493
Glasscock	70	492
Borden	20	326
Irion	46	316
Loving	5	283
Ector	25	163
Scurry	8	71
Crane	21	58
Pecos	34	38
Potter	27	37
Sterling	7	25
Mitchell	14	24
Gaines	2	21
Yoakum	2	10
Oldham	1	6
Crockett	2	5
Nolan	1	5
Hartley	3	4
Dawson	6	4
Tom Green	2	0

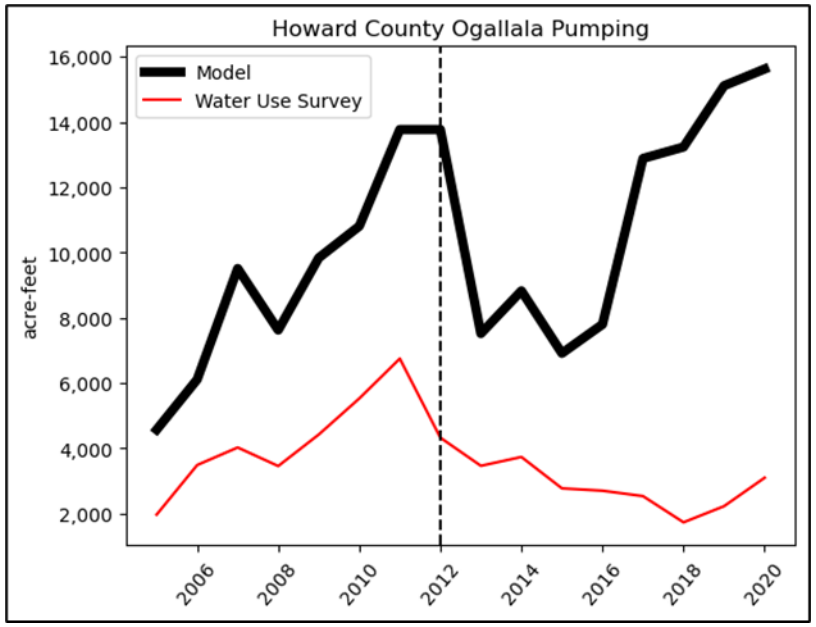
Ogallala

County	Wells	Annual Average (2013-2020) Acre-Feet
Martin	1,563	7,912
Midland	603	6,206
Howard	2,093	5,637
Andrews	73	1,072
Hemphill	71	285
Ector	36	234
Glasscock	34	208
Borden	12	163
Wheeler	12	158
Yoakum	37	152
Ochiltree	174	149
Lipscomb	221	114
Gaines	12	105
Dawson	162	94
Roberts	22	71
Cochran	5	52
Hockley	8	13
Hansford	29	11
Terry	22	5
Hutchinson	15	4
Hartley	6	3

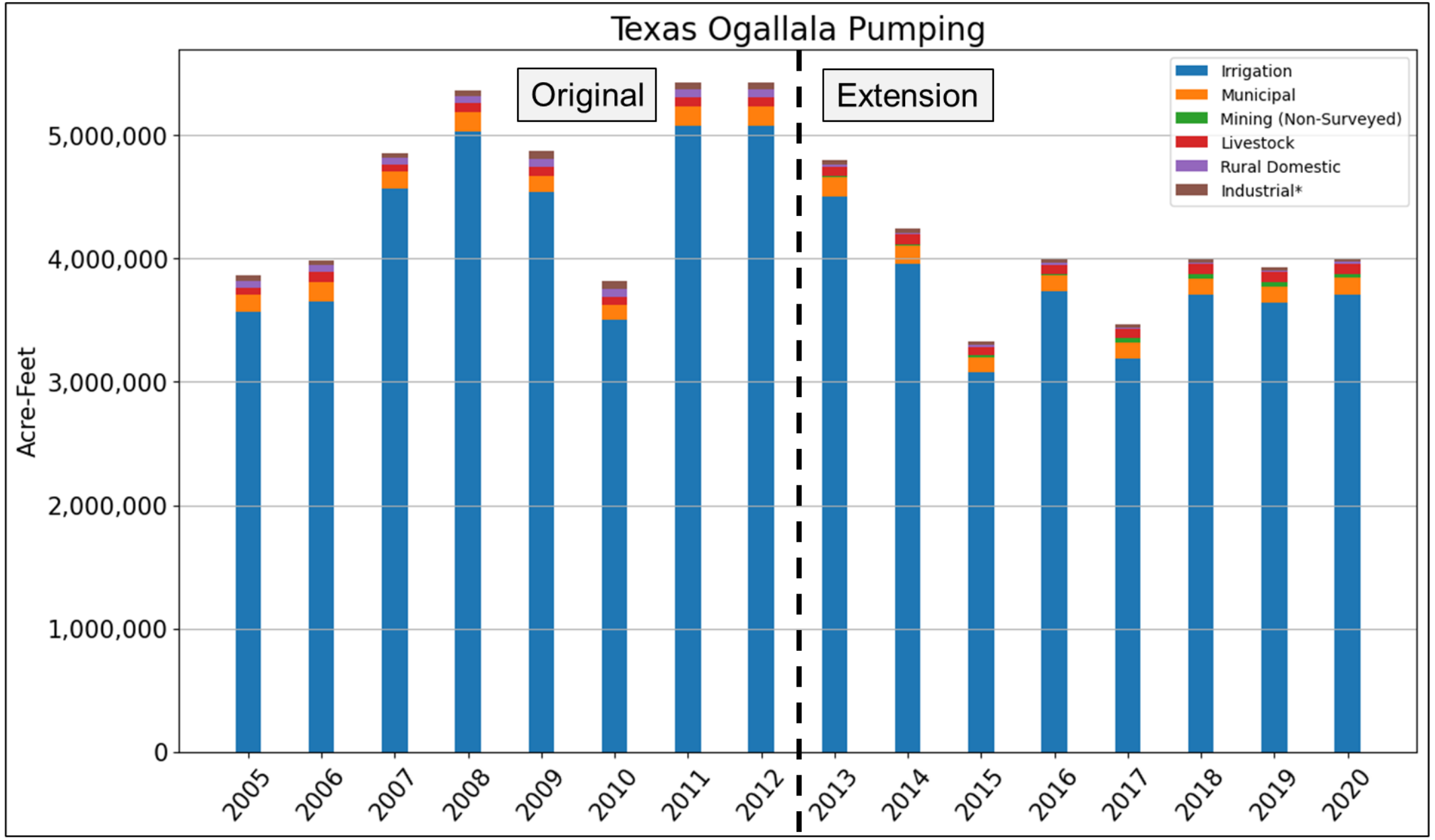
Edwards-Trinity (High Plains)

County	Wells	Annual Average (2013-2020) Acre-Feet
Gaines	2	21
Yoakum	3	15
Dawson	5	3
Hockley	2	3

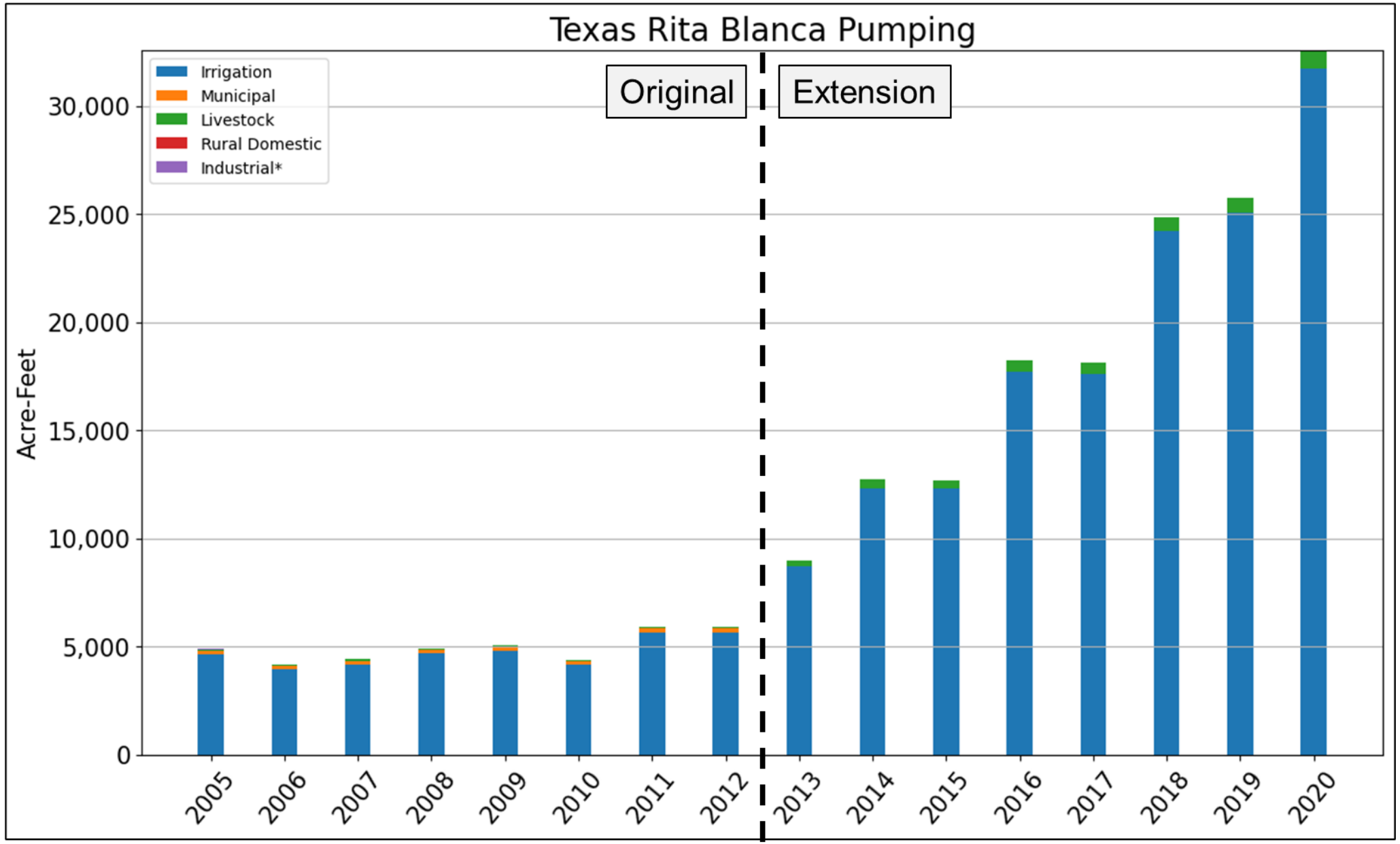




Howard County
77% Ogallala
21% Dockum
2% Edwards-Trinity (Plateau)



*Industrial includes Power, Manufacturing, and Mining (Surveyed)



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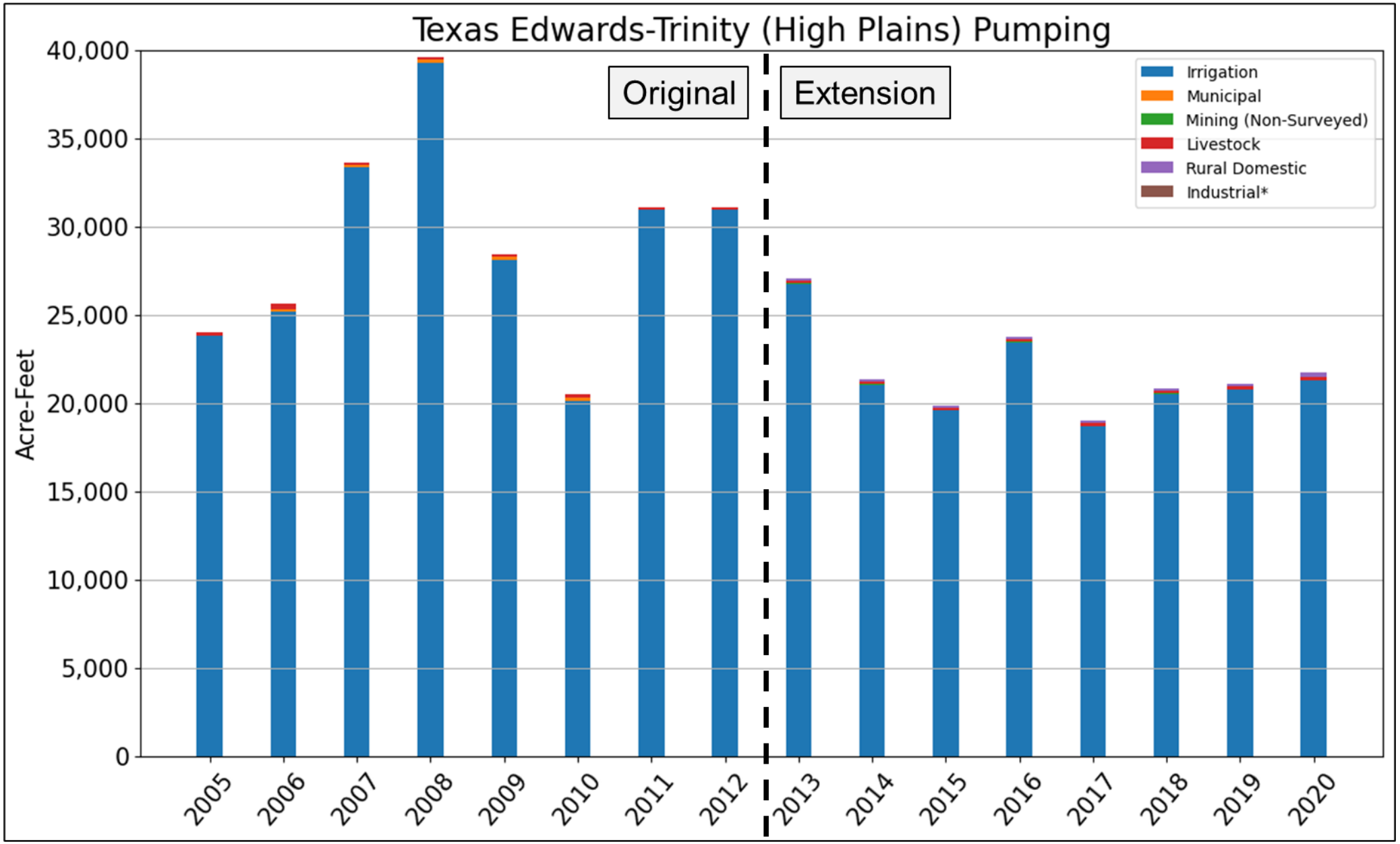

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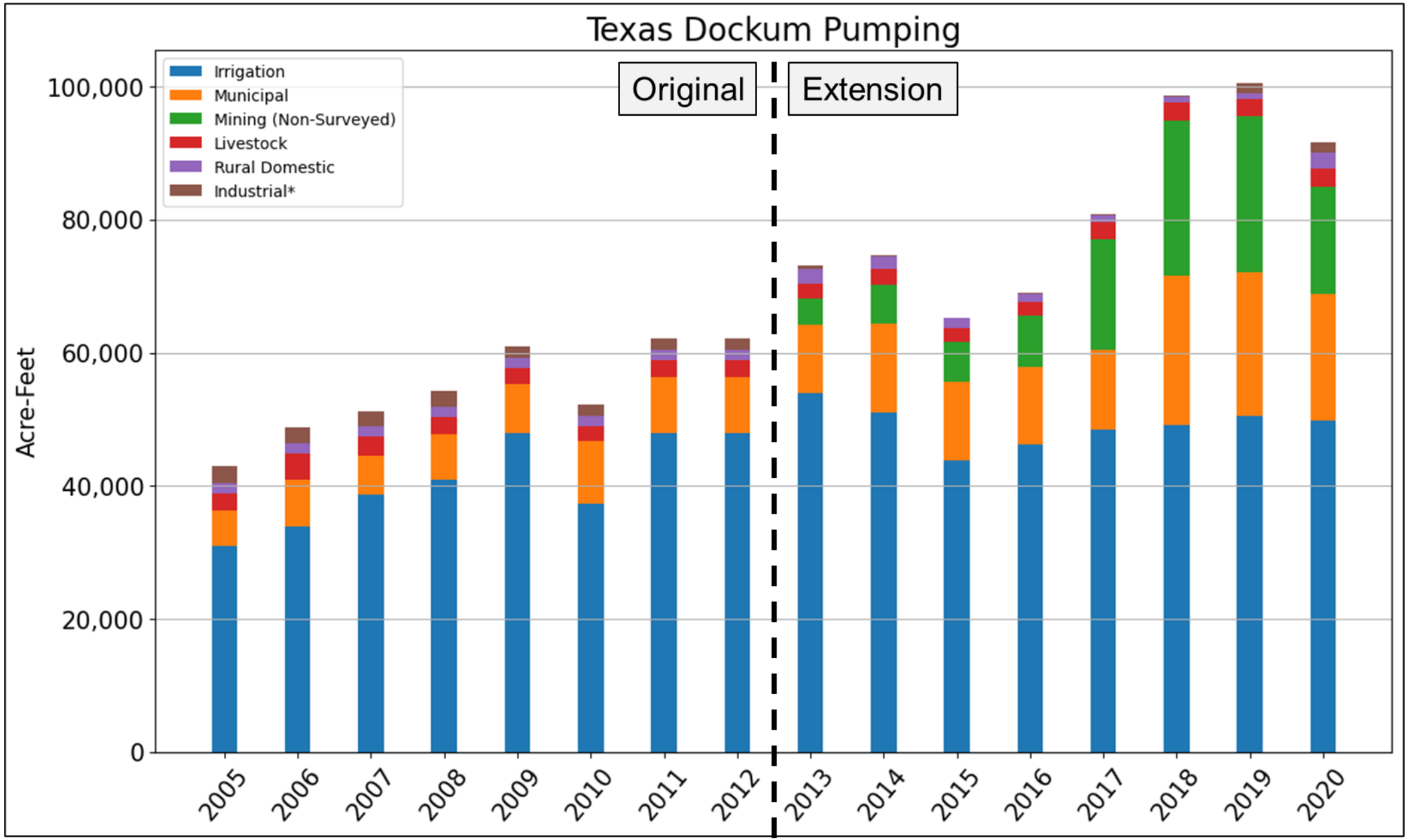


*Industrial includes Power, Manufacturing, and Mining (Surveyed)

Well Package Extension

1) Pumping Estimates
2) **Well Dataset**
3) Distribute Pumping to Wells

Well Point Dataset

- Texas Submitted Drillers Report (SDR) Database
  - Filtered by well proposed use category
  - Added wells drilled from 2013 through 2020
  - Assigned aquifers
- North Plains GCD Well Dataset
- Original Model Active Wells
- Other States
  - New Mexico Points of Diversion
  - Oklahoma and Kansas: No changes

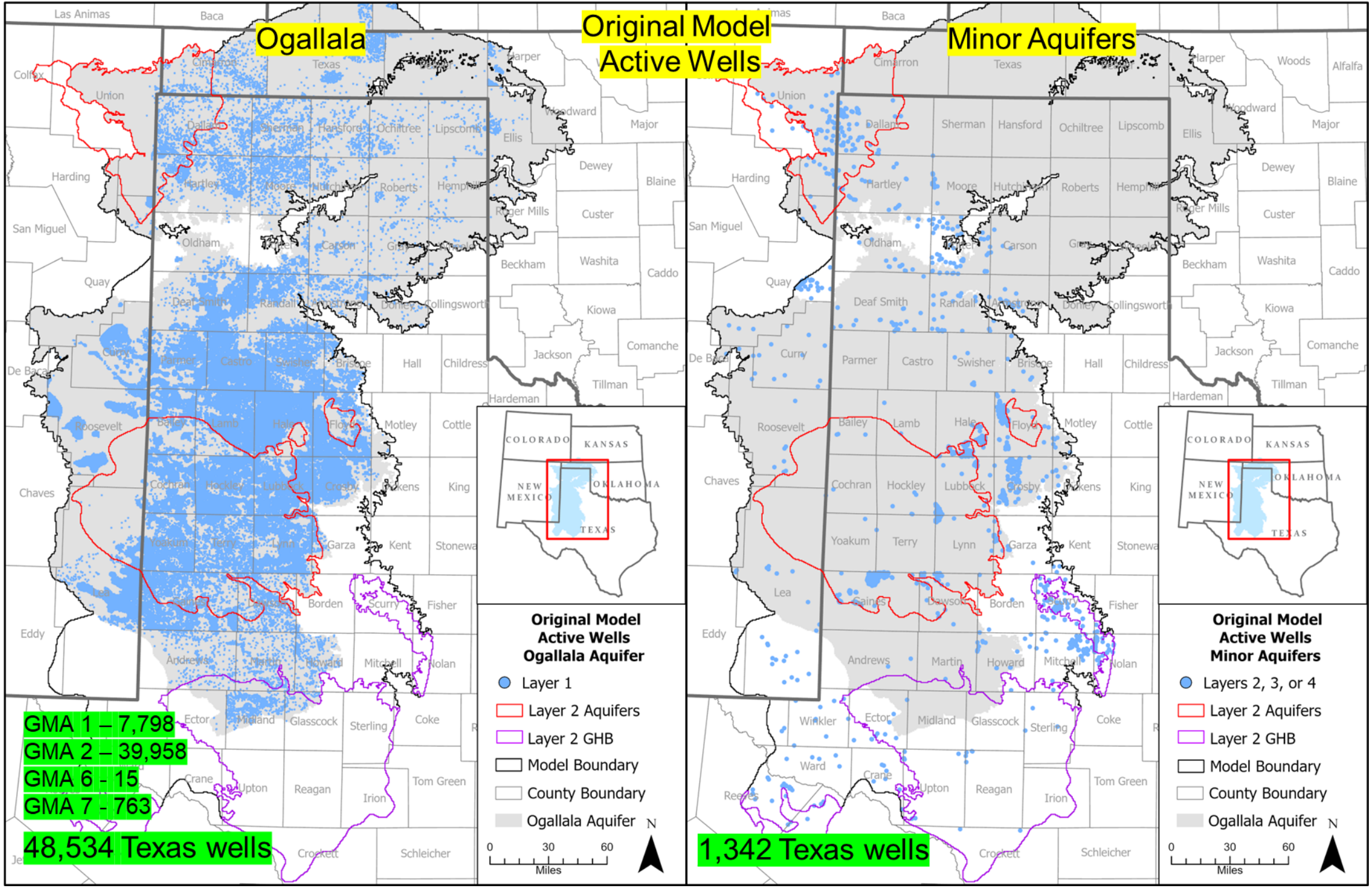
SDR Database Categories

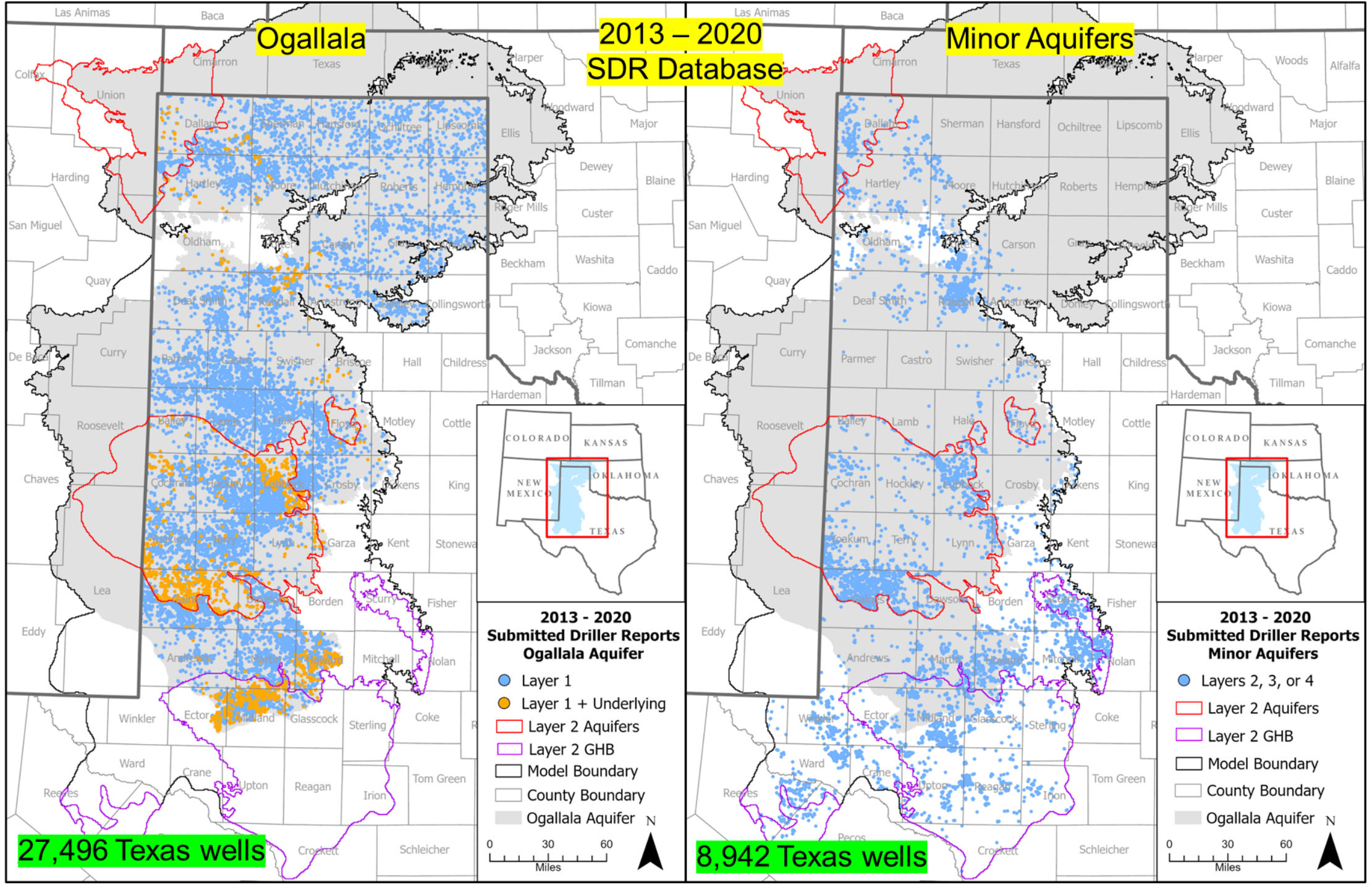
Domestic
Stock
Irrigation
Rig Supply
Fracking Supply
Public Supply
Industrial
Other uses* Not used

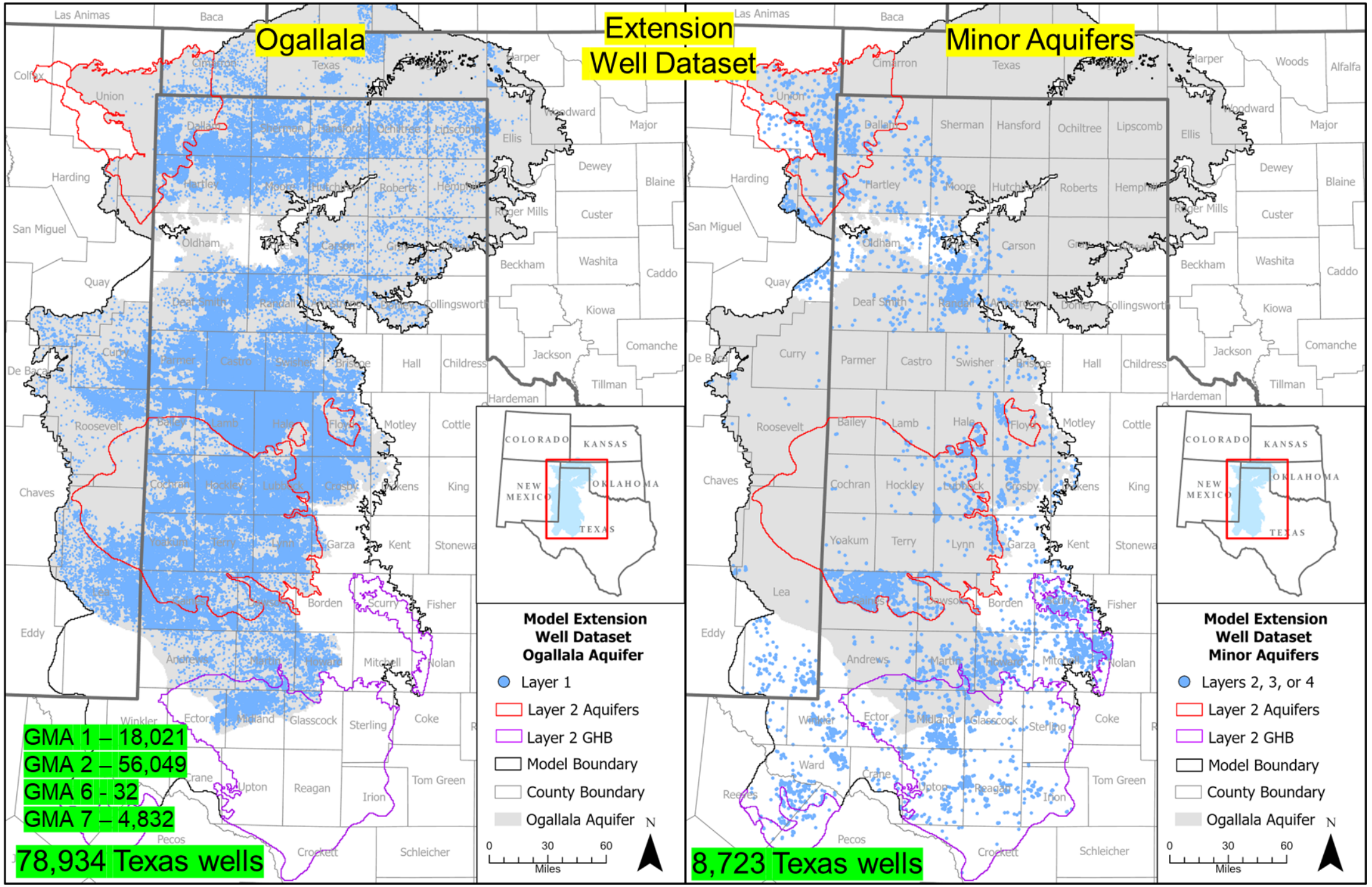
*Other Uses Include: Test Well, Monitor, Environmental Soil Boring, Closed-Loop Geothermal, Extraction, Injection, De-watering, Other, Unknown

Constructing Well Dataset

SDR Wells	Texas Submitted Drillers Report Database
New Mexico Wells	Office of State Engineer Points of Diversion


Original Model
Active Wells
Ogallala
Minor Aquifers
GMA 1 – 7,798
GMA 2 – 39,958
GMA 6 - 15
GMA 7 - 763
48,534 Texas wells
1,342 Texas wells
Original Model
Active Wells
Ogallala Aquifer
Layer 1
Layer 2 Aquifers
Layer 2 GHB
Model Boundary
County Boundary
Ogallala Aquifer
Original Model
Active Wells
Minor Aquifers
Layers 2, 3, or 4
Layer 2 Aquifers
Layer 2 GHB
Model Boundary
County Boundary
Ogallala Aquifer
COLORADO
KANSAS
NEW MEXICO
OKLAHOMA
TEXAS
0 30 60
Miles
N

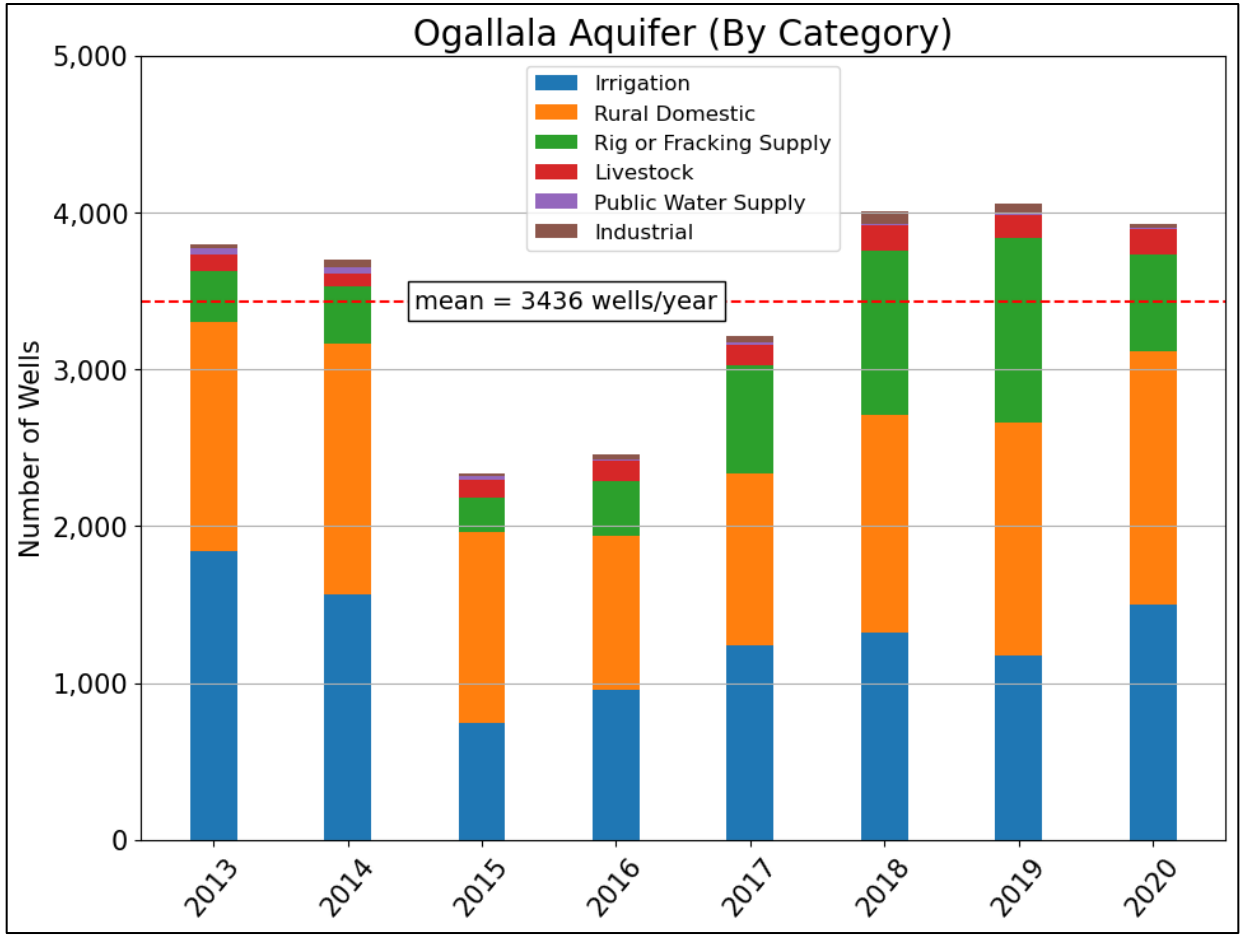

Ogallala
2013 – 2020
SDR Database
Minor Aquifers
27,496 Texas wells
8,942 Texas wells
2013 - 2020
Submitted Driller Reports
Ogallala Aquifer
Layer 1
Layer 1 + Underlying
Layer 2 Aquifers
Layer 2 GHB
Model Boundary
County Boundary
Ogallala Aquifer
2013 - 2020
Submitted Driller Reports
Minor Aquifers
Layers 2, 3, or 4
Layer 2 Aquifers
Layer 2 GHB
Model Boundary
County Boundary
Ogallala Aquifer
COLORADO
KANSAS
OKLAHOMA
NEW MEXICO
TEXAS
0 30 60
Miles
N

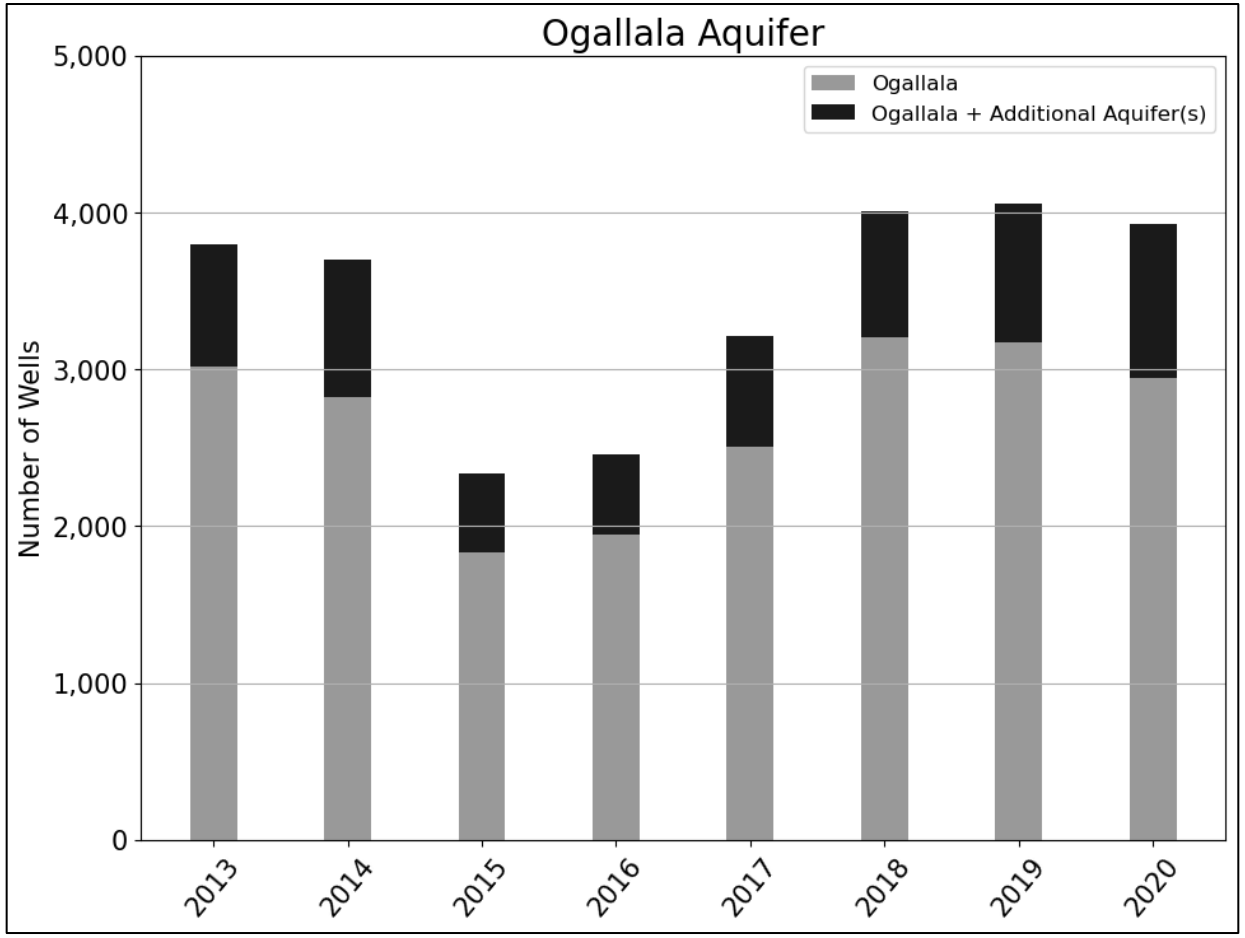

Ogallala
Extension
Well Dataset
Minor Aquifers
GMA 1 – 18,021
GMA 2 – 56,049
GMA 6 - 32
GMA 7 – 4,832
78,934 Texas wells
8,723 Texas wells
Model Extension
Well Dataset
Ogallala Aquifer
Layer 1
Layer 2 Aquifers
Layer 2 GHB
Model Boundary
County Boundary
Ogallala Aquifer
Model Extension
Well Dataset
Minor Aquifers
Layers 2, 3, or 4
Layer 2 Aquifers
Layer 2 GHB
Model Boundary
County Boundary
Ogallala Aquifer
0 30 60
Miles
N
COLORADO
KANSAS
NEW MEXICO
OKLAHOMA
TEXAS

Texas Model Extension Wells

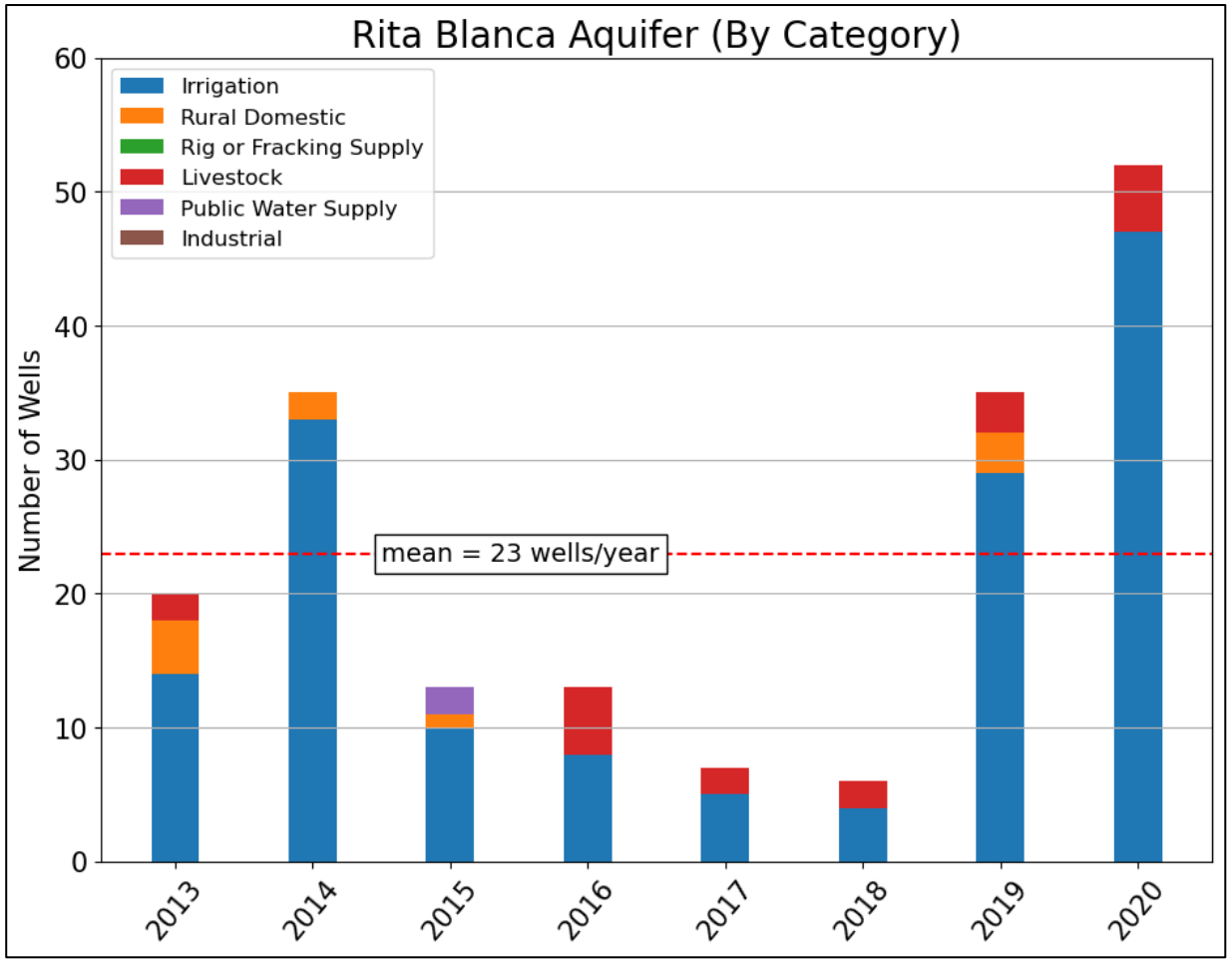
Aquifer	Original	Extension	Increase
Ogallala	48,534	78,934	1.6x
Rita Blanca	34	161	
Edwards-Trinity (High Plains)	534	2,685	
Dockum	774	5,875	
Total Minor Aquifer Wells	**1,342**	**8,723**	**6.5x**
Total	**49,876**	**87,657**	
Multi-Aquifer Wells	**-260**	**-2,686**	
Total Wells	**49,616**	**84,971**	

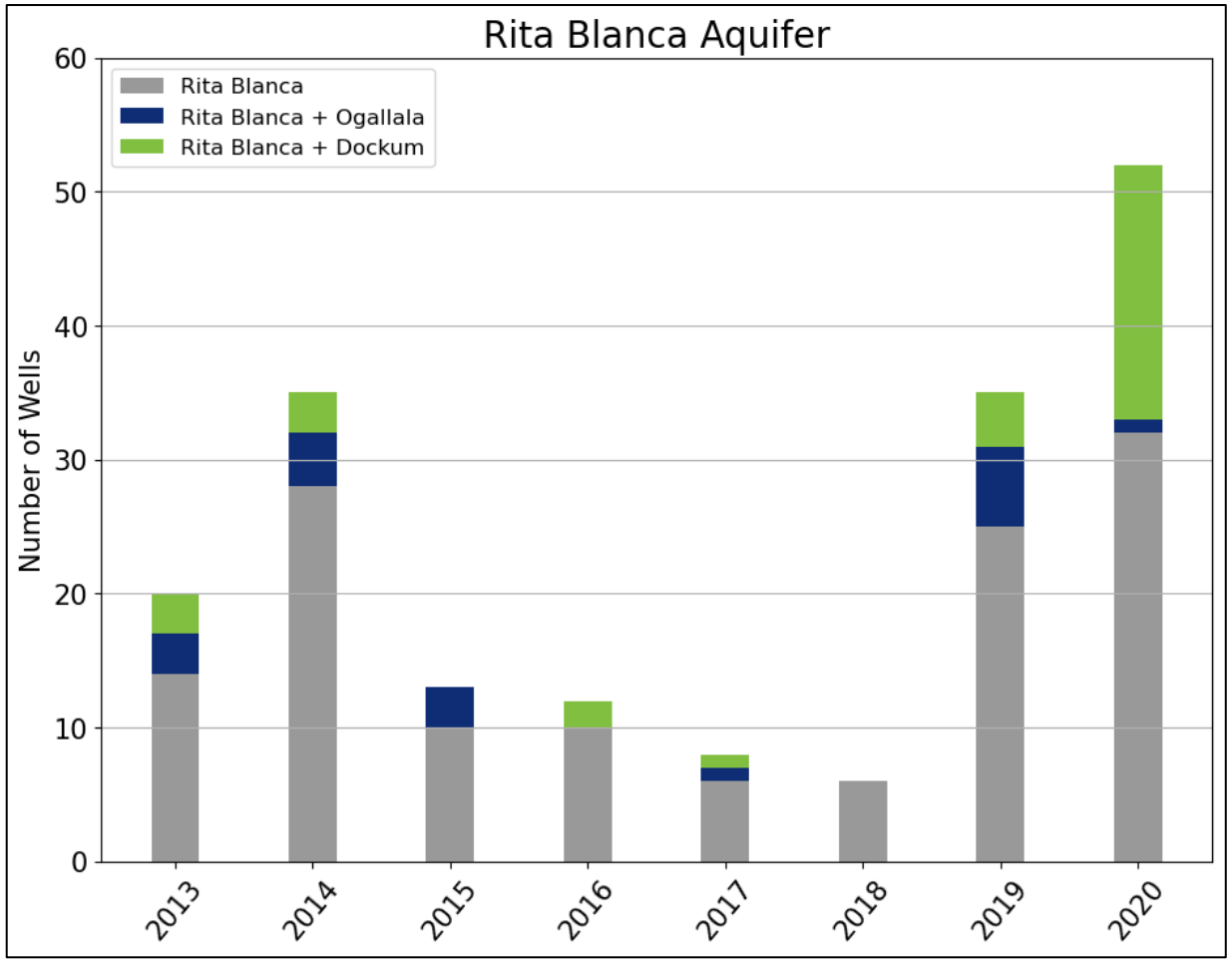
Submitted Drillers Report Database





Submitted Drillers Report Database





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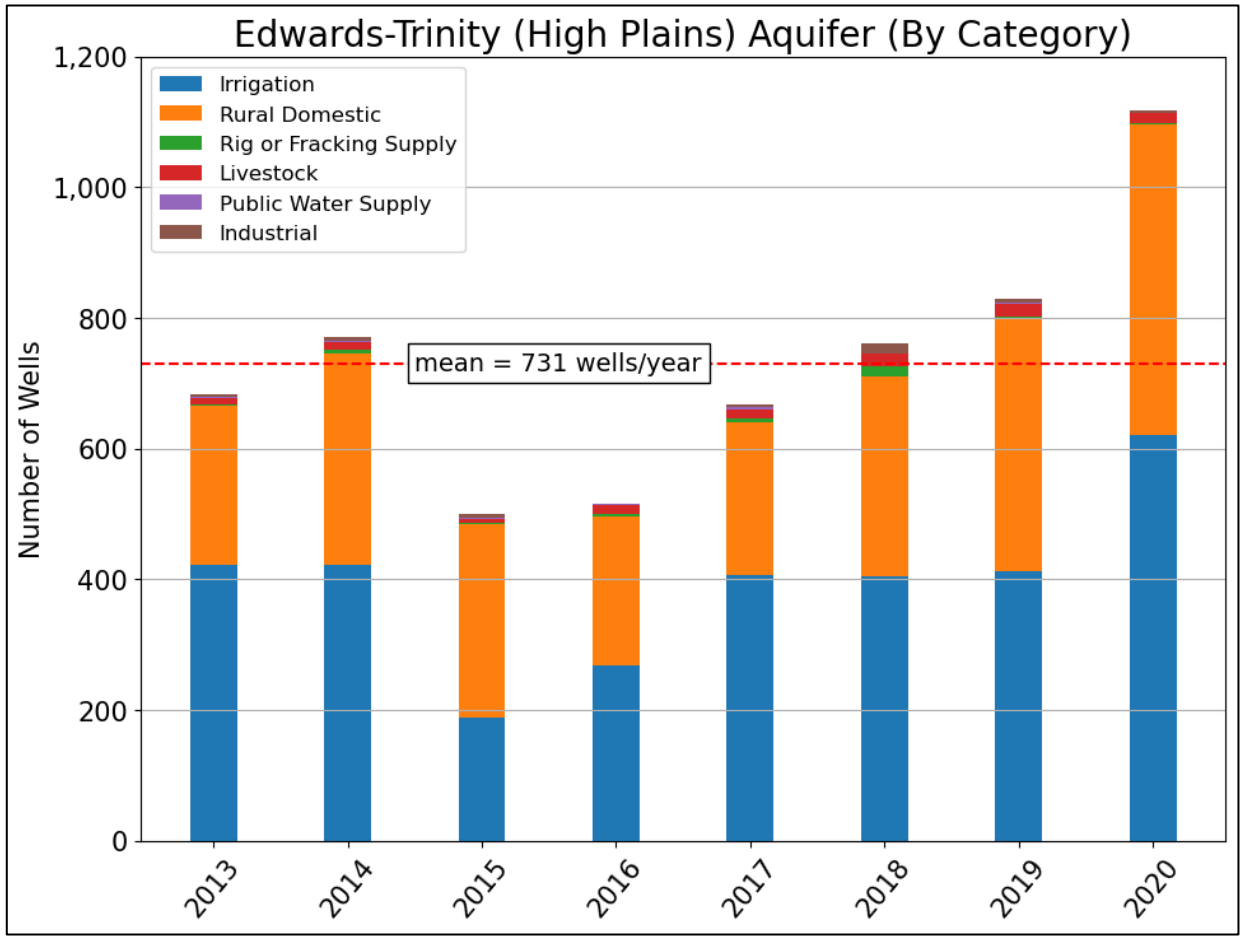
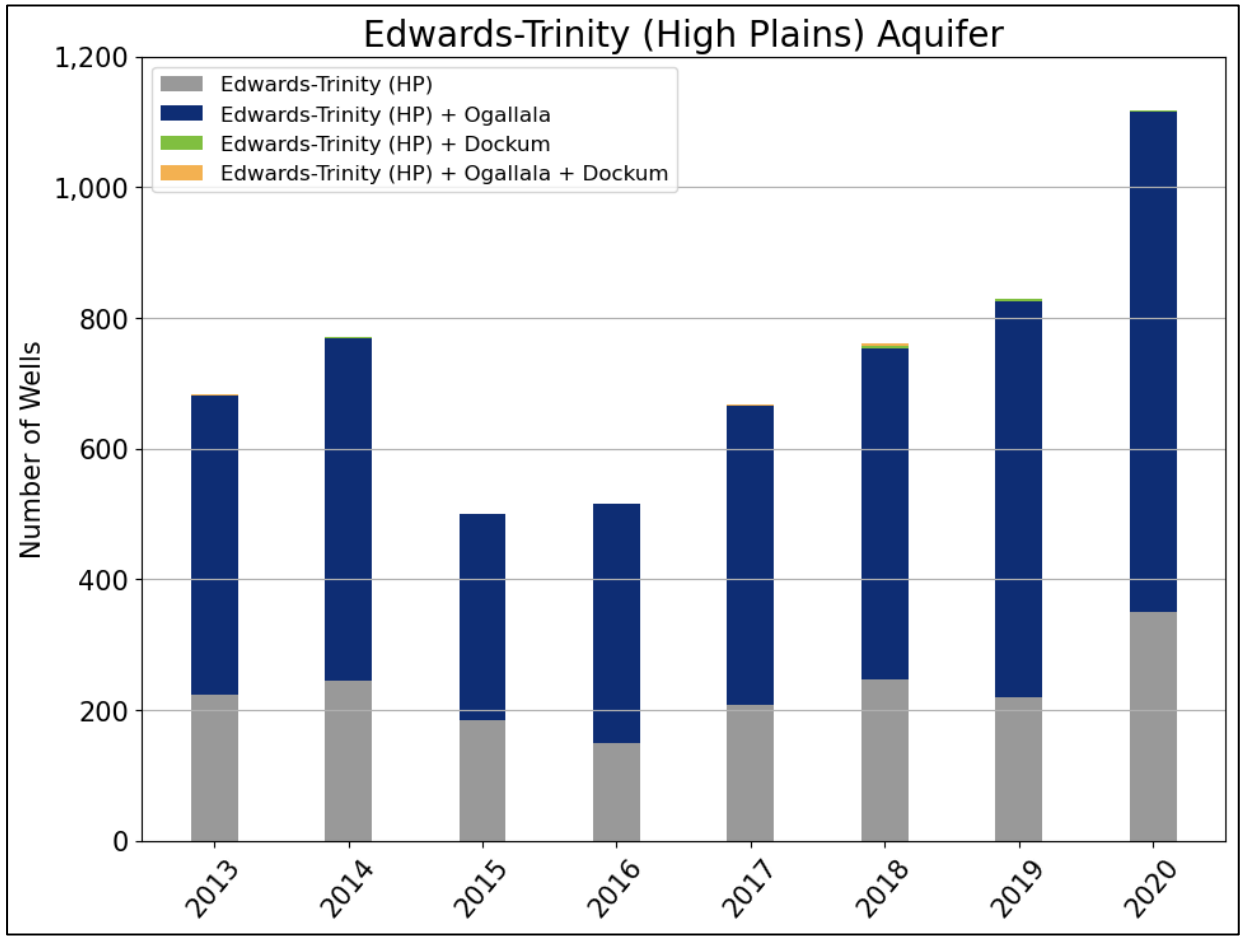
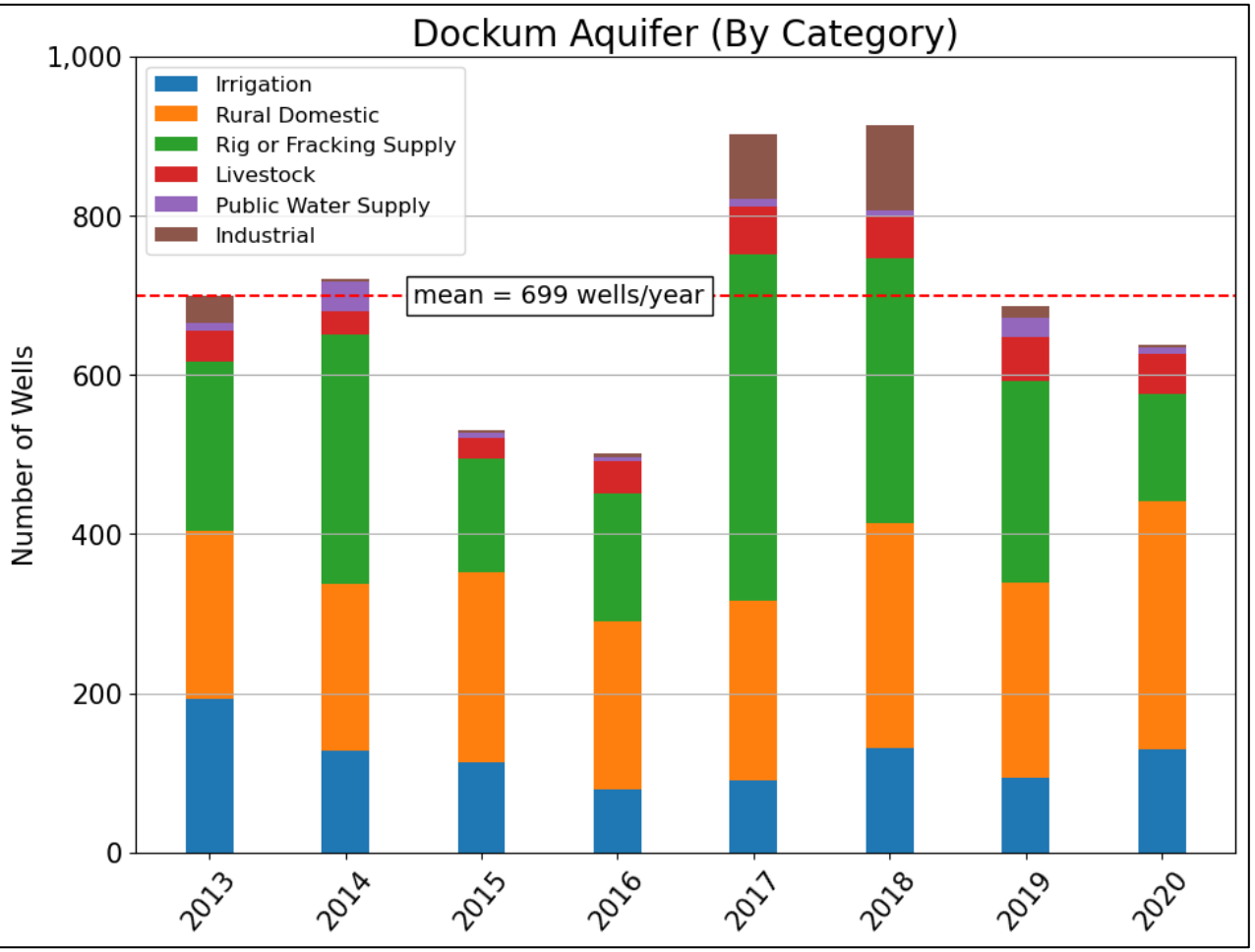
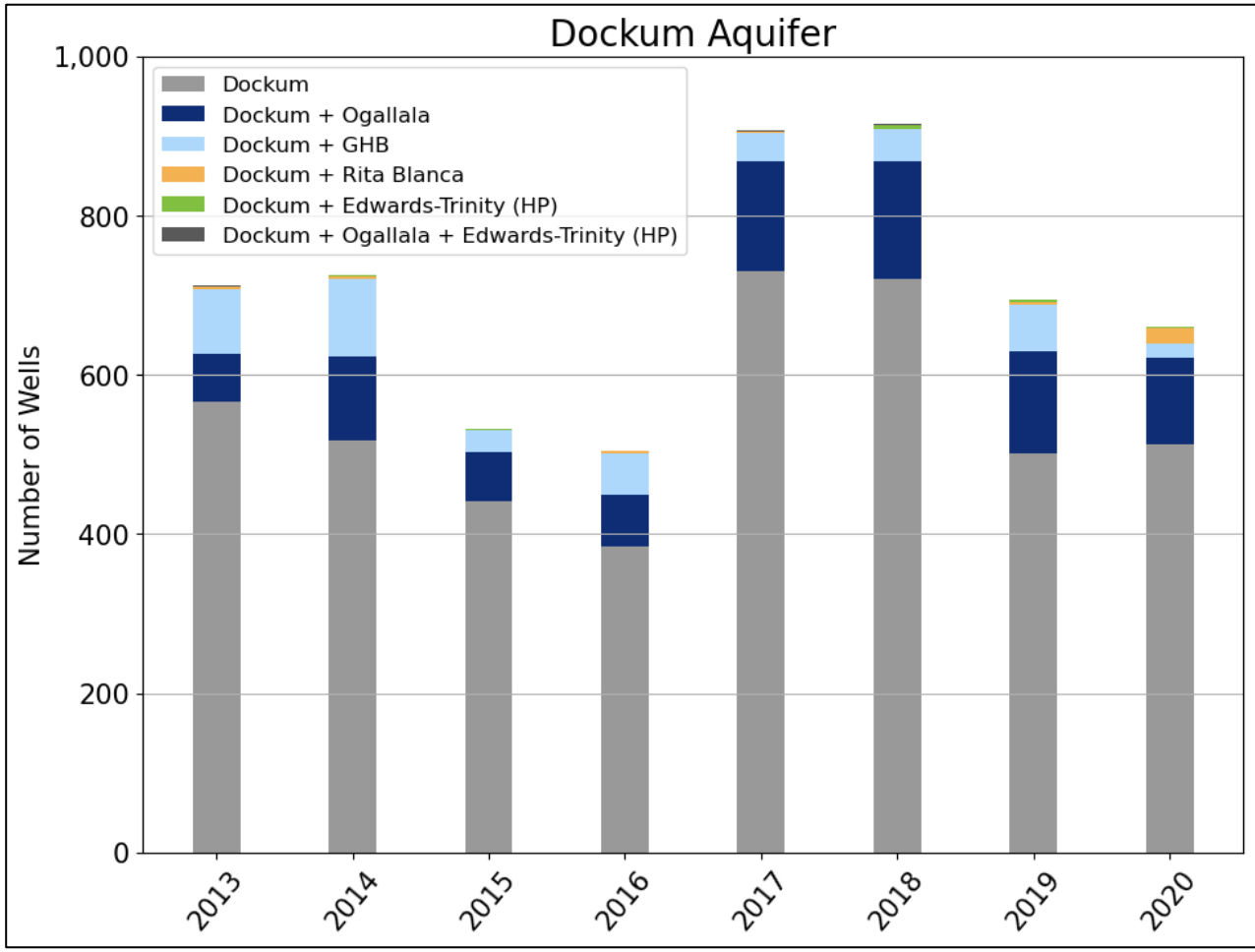




Submitted Drillers Report Database





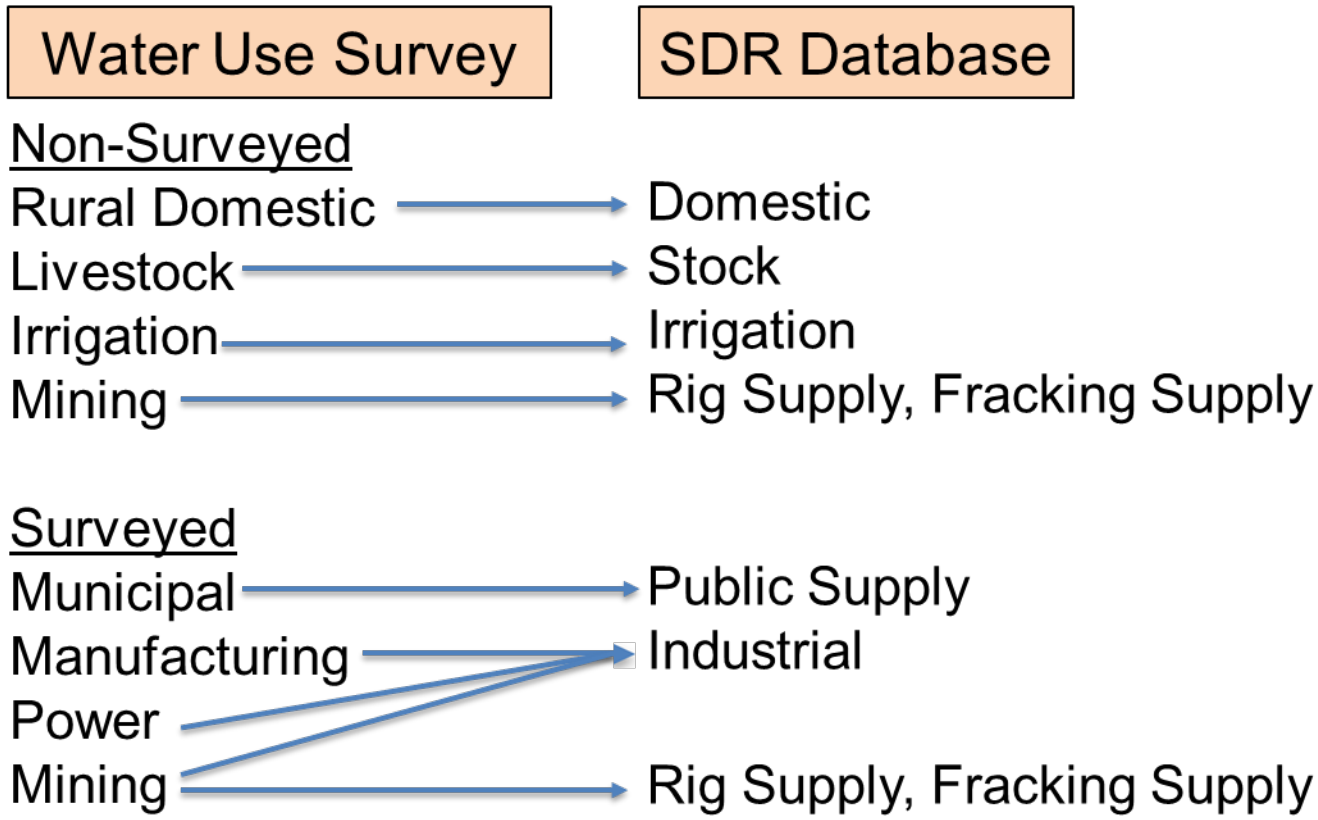
Well Package Extension

1) Pumping Estimates
2) Well Dataset
3) Distribute Pumping to Wells

Pumping Distribution

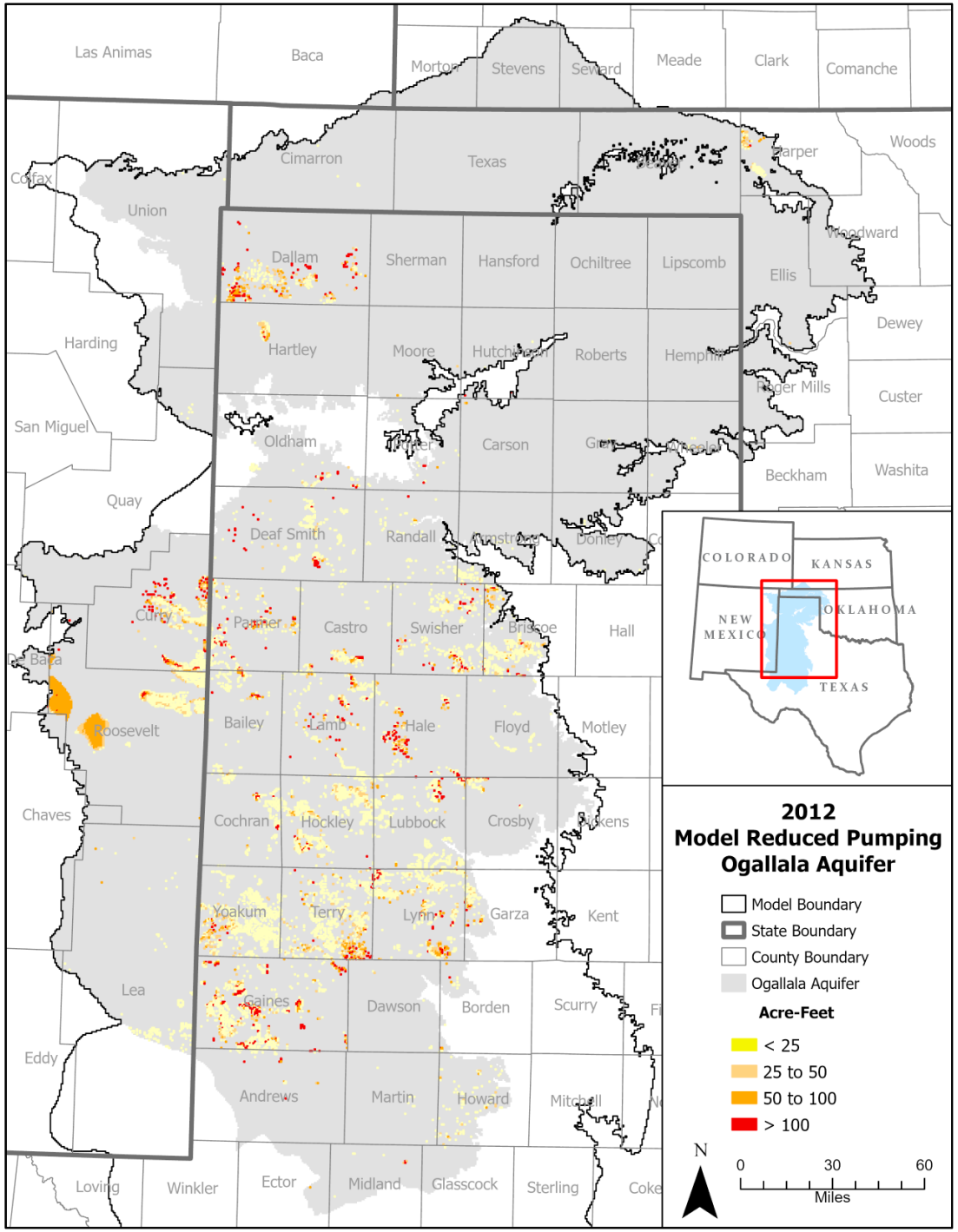
- WUS Surveyed pumping
  - Matched to well owner names using fuzzy matching script.
- WUS County Estimates
  - Distributed evenly to wells by category
- North Plains GCD
  - Metered pumping distributed evenly to wells within each groundwater production unit.
- New Mexico
  - County estimates for 2015 distributed evenly to wells by category.

Matching Water Use to Well Points



Model Reduced Pumping

- Minimum Saturated Thickness
  - A saturated thickness of 30 feet is the minimum thickness before MODFLOW-NWT starts reducing pumping.
- Original Model Approach
  - The original modeling effort redistributed some pumping in low saturated thickness areas to areas with higher saturated thickness through an iterative process.
- Model Extension Approach
  - Try a simpler approach. Evenly distribute county pumping.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Baca
Morton
Stevens
Seward
Meade
Clark
Comanche
Cimarron
Texas
Woods
Harper
Union
Woodward
Dallam
Sherman
Hansford
Ochiltree
Lipscomb
Ellis
Harding
Hartley
Moore
Hutchinson
Roberts
Hemphill
Roger Mills
Dewey
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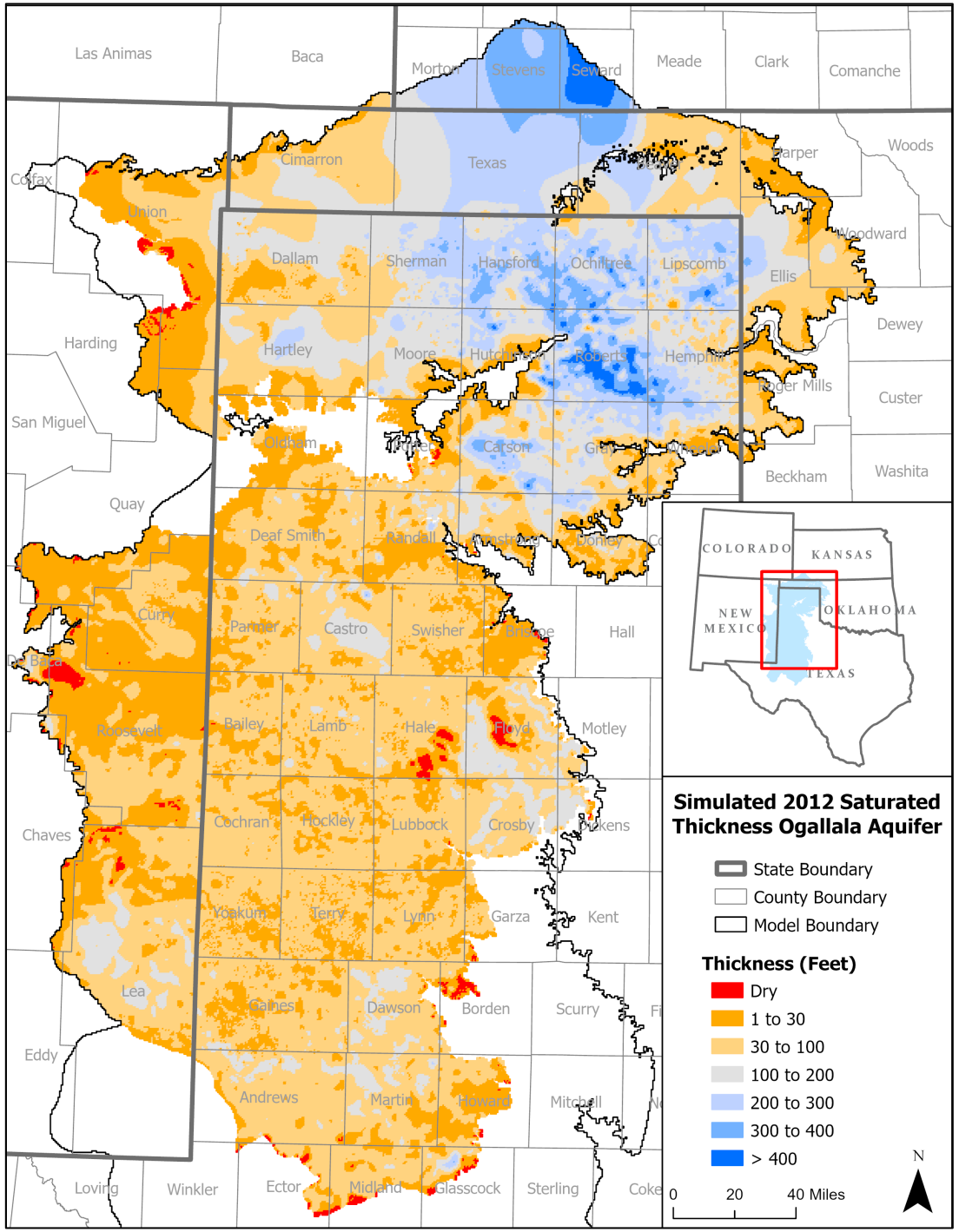
Swisher
Hall
Roosevelt
Bailey
Lamb
Hale
Floyd
Motley
Chaves
Cochran
Hockley
Lubbock
Crosby
Yoakum
Terry
Lynn
Garza
Kent
Lea
Gaines
Dawson
Borden
Scurry
Eddy
Andrews
Martin
Howard
Mitchell
Loving
Winkler
Ector
Midland
Glasscock
Sterling
COLORADO
KANSAS
NEW MEXICO
OKLAHOMA
TEXAS
2012
Model Reduced Pumping
Ogallala Aquifer
Model Boundary
State Boundary
County Boundary
Ogallala Aquifer
Acre-Feet
< 25
25 to 50
50 to 100
> 100
N
0
30
60
Miles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Morton
Stevens
Seward
Meade
Clark
Comanche
Cimarron
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Woods
Harper
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Woodward
Dallam
Sherman
Hansford
Ochiltree
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Lubbock
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Eddy
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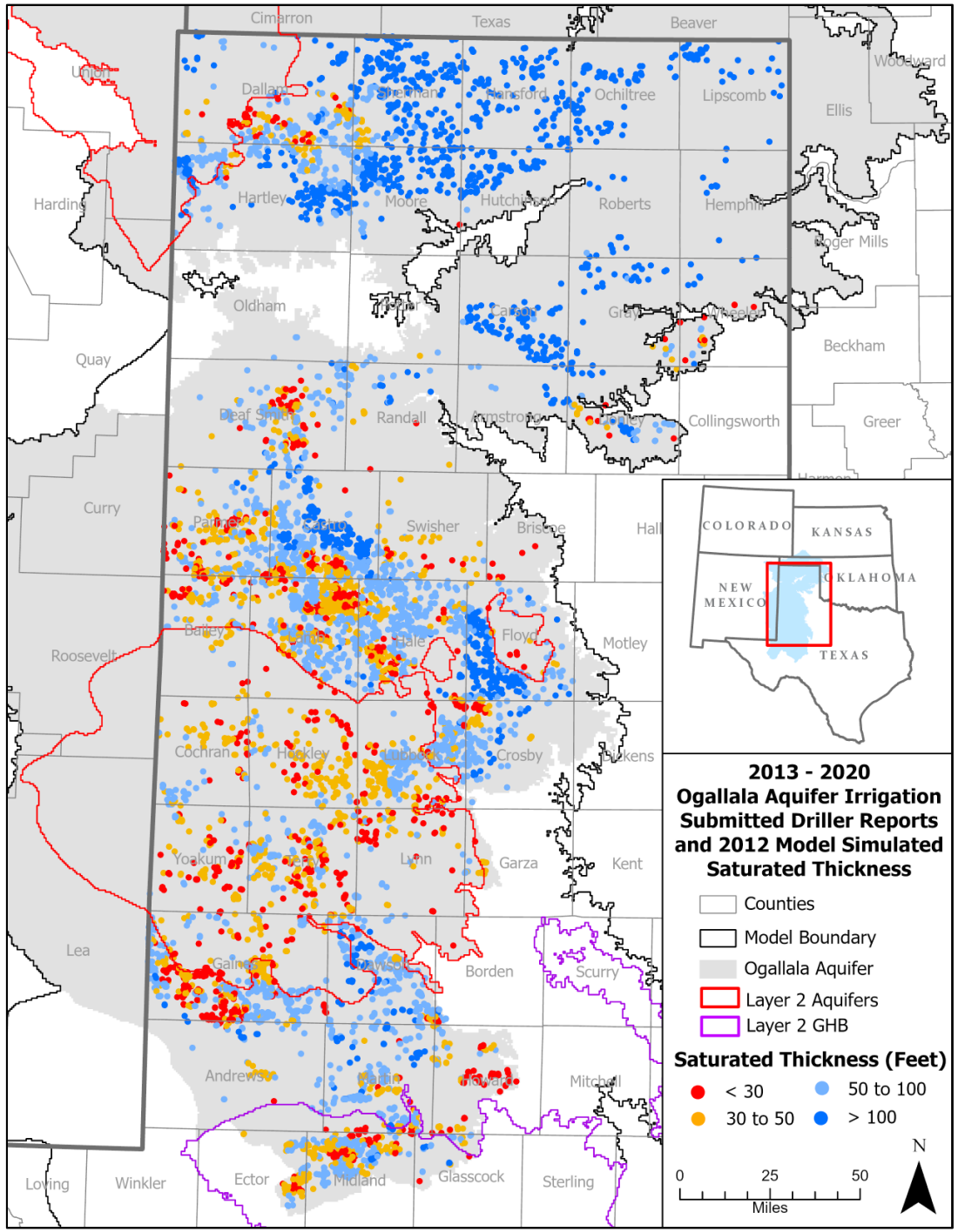
Martin
Howard
Mitchell
Loving
Winkler
Ector
Midland
Glasscock
Sterling
COLORADO
KANSAS
NEW MEXICO
OKLAHOMA
TEXAS
Simulated 2012 Saturated
Thickness Ogallala Aquifer
State Boundary
County Boundary
Model Boundary
Thickness (Feet)
Dry
1 to 30
30 to 100
100 to 200
200 to 300
300 to 400
> 400
N
0
20
40 Miles

2013 – 2020 Submitted Driller's Reports Use Type = Irrigation and 2012 Model Simulated Saturated Thickness

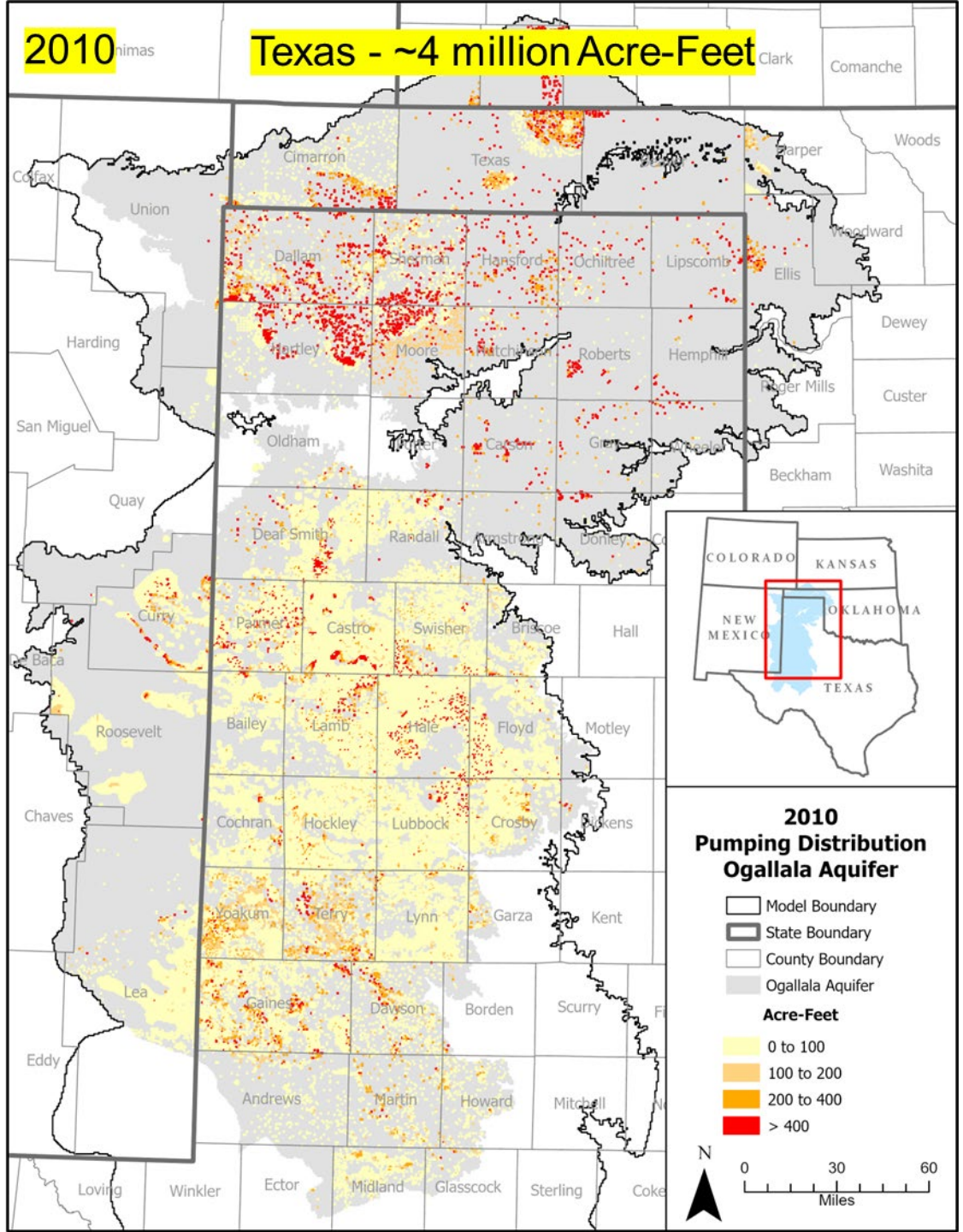
Ogallala Aquifer

2012 Saturated Thickness (Feet)	2013 – 2020 Irrigation Wells	%	Multi-Aquifer Wells
< 30 feet	1,117	14%	95
30 to 50 feet	2,028	25%	76
50 to 100 feet	3,372	41%	69
> 100 feet	1,648	20%	18
Total	**8,165**	**100%**	**258**

86% in areas of > 30 feet



Draft Model Results


2010
Texas - ~4 million Acre-Feet
Clark
Comanche
Woods
Cimarron
Texas
Harper
Union
Woodward
Dallam
Sherman
Hansford
Ochiltree
Lipscomb
Ellis
Harding
Hartley
Moore
Roberts
Hemphill
Dewey
Roger Mills
Custer
San Miguel
Oldham
Carson
Gray
Beckham
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Quay
Deaf Smith
Randall
Armstrong
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Curry
Parmer
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Swisher
Briscoe
Hall
Roosevelt
Bailey
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Hale
Floyd
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Chaves
Cochran
Hockley
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Terry
Lynn
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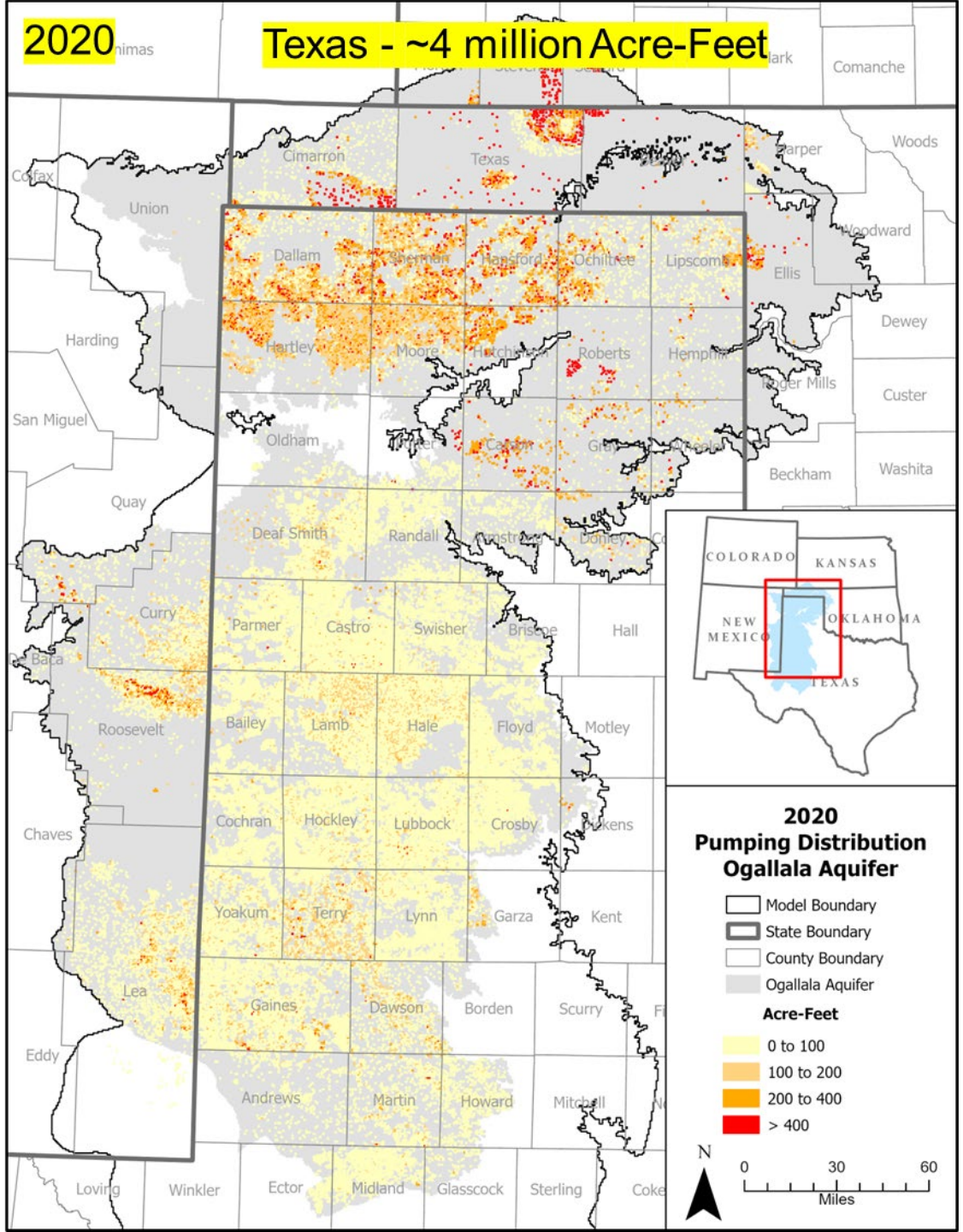
Lea
Gaines
Dawson
Borden
Scurry
Eddy
Andrews
Martin
Howard
Mitchell
Loving
Winkler
Ector
Midland
Glasscock
Sterling
COLORADO
KANSAS
NEW MEXICO
OKLAHOMA
TEXAS
2010
Pumping Distribution
Ogallala Aquifer
Model Boundary
State Boundary
County Boundary
Ogallala Aquifer
Acre-Feet
0 to 100
100 to 200
200 to 400
> 400
N
0
30
60
Miles


2020
Texas - ~4 million Acre-Feet
Clark
Comanche
Woods
Cimarron
Texas
Harper
Union
Woodward
Dallam
Sherman
Hansford
Ochiltree
Lipscomb
Ellis
Harding
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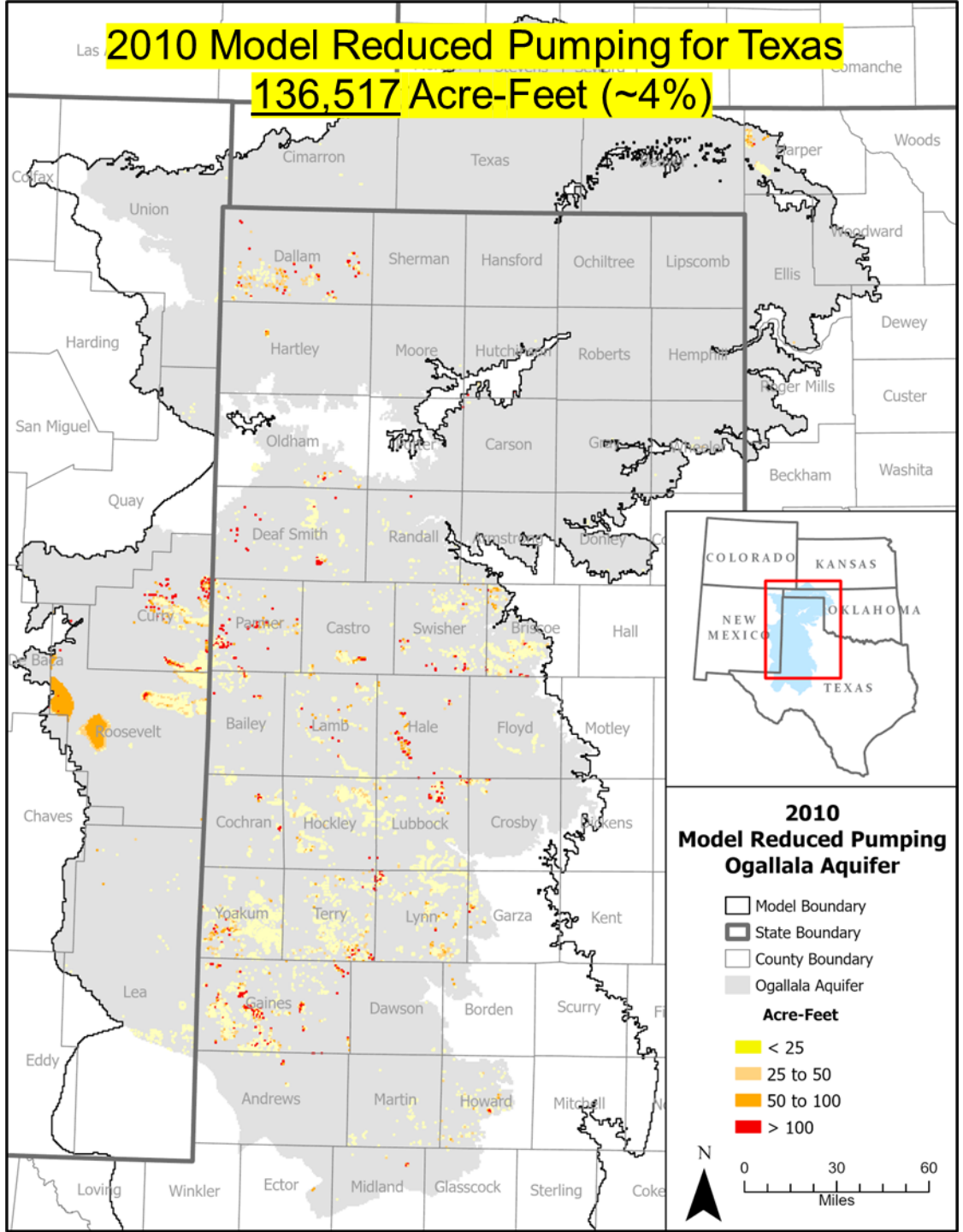
Borden
Scurry
Eddy
Andrews
Martin
Howard
Mitchell
Loving
Winkler
Ector
Midland
Glasscock
Sterling
COLORADO
KANSAS
NEW MEXICO
OKLAHOMA
TEXAS
2020
Pumping Distribution
Ogallala Aquifer
Model Boundary
State Boundary
County Boundary
Ogallala Aquifer
Acre-Feet
0 to 100
100 to 200
200 to 400
> 400
N
0
30
60
Miles


2010 Model Reduced Pumping for Texas
136,517 Acre-Feet (~4%)
Las
Comanche
Cimarron
Texas
Woods
Harper
Union
Ellis
Dallam
Sherman
Hansford
Ochiltree
Lipscomb
Harding
Dewey
Hartley
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Roberts
Custer
San Miguel
Oldham
Carson
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Quay
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Hockley
Lubbock
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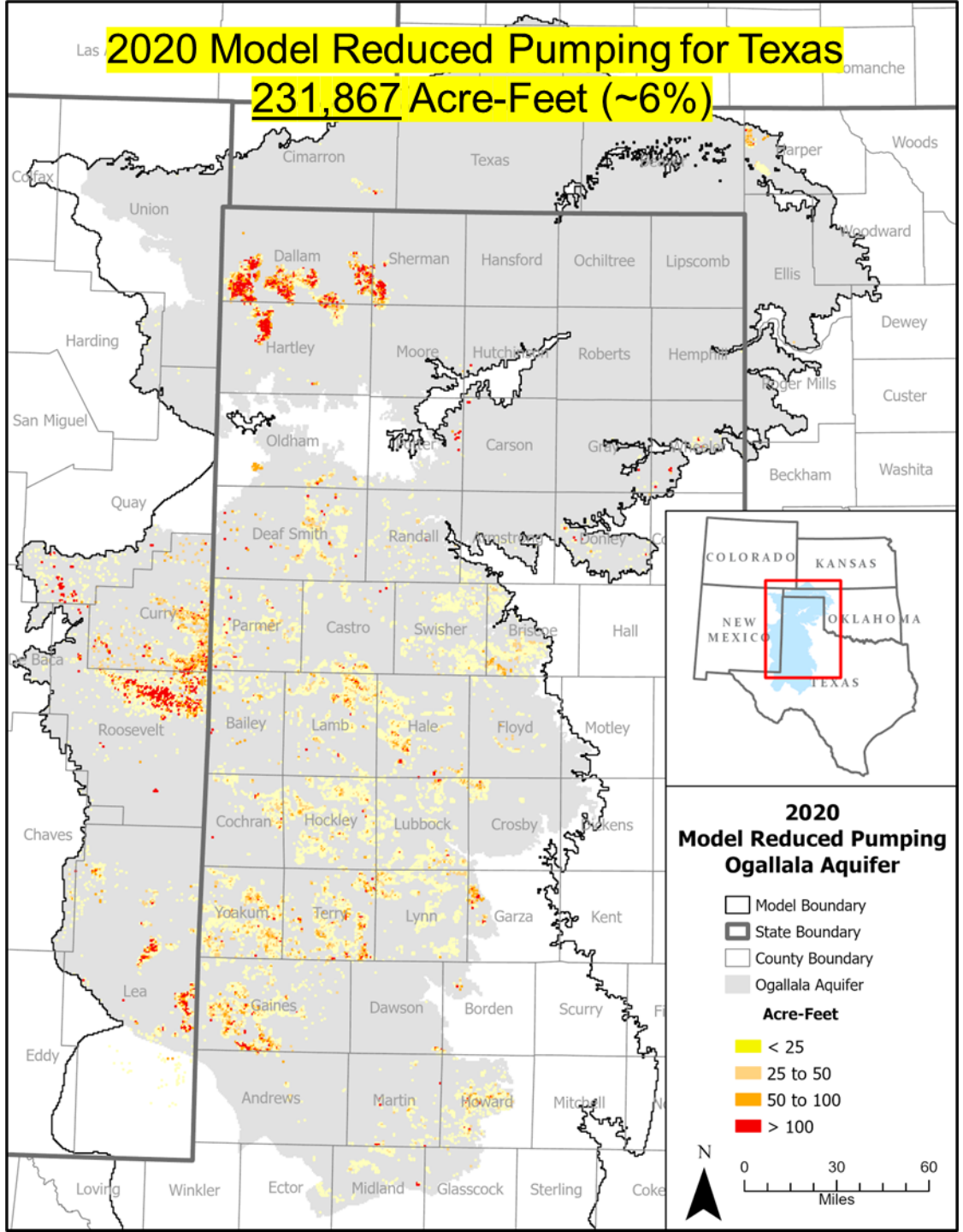
Loving
Winkler
Ector
Midland
Glasscock
Sterling
COLORADO
KANSAS
NEW MEXICO
OKLAHOMA
TEXAS
2010
Model Reduced Pumping
Ogallala Aquifer
Model Boundary
State Boundary
County Boundary
Ogallala Aquifer
Acre-Feet
< 25
25 to 50
50 to 100
> 100
N
0
30
60
Miles


2020 Model Reduced Pumping for Texas
231,867 Acre-Feet (~6%)
Las
Comanche
Cimarron
Texas
Woods
Harper
Union
Ellis
Dallam
Sherman
Hansford
Ochiltree
Lipscomb
Harding
Dewey
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Eddy
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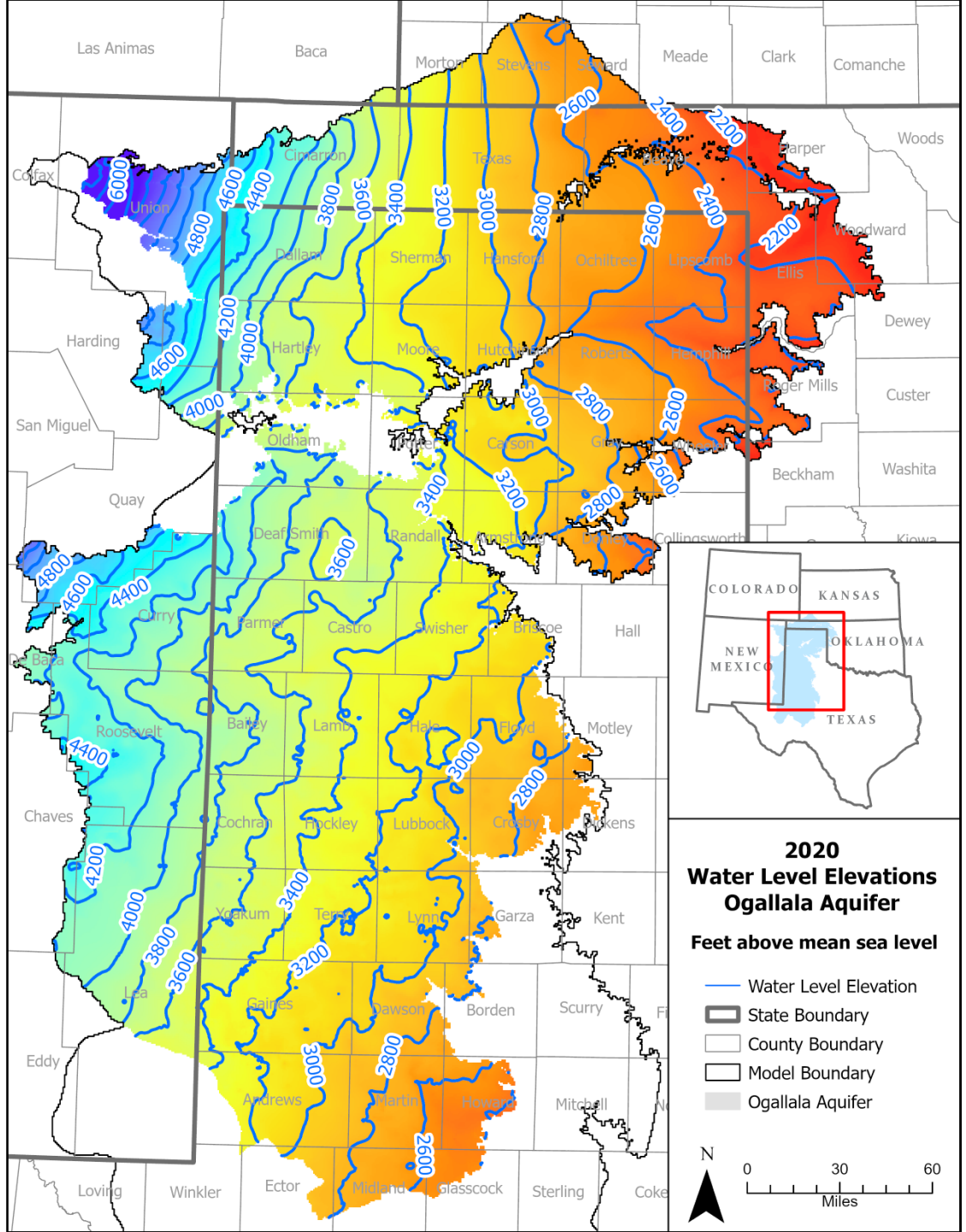
Howard
Mitchell
Loving
Winkler
Ector
Midland
Glasscock
Sterling
COLORADO
KANSAS
NEW MEXICO
OKLAHOMA
TEXAS
2020
Model Reduced Pumping
Ogallala Aquifer
Model Boundary
State Boundary
County Boundary
Ogallala Aquifer
Acre-Feet
< 25
25 to 50
50 to 100
> 100
N
0
30
60
Miles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Coke
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4200
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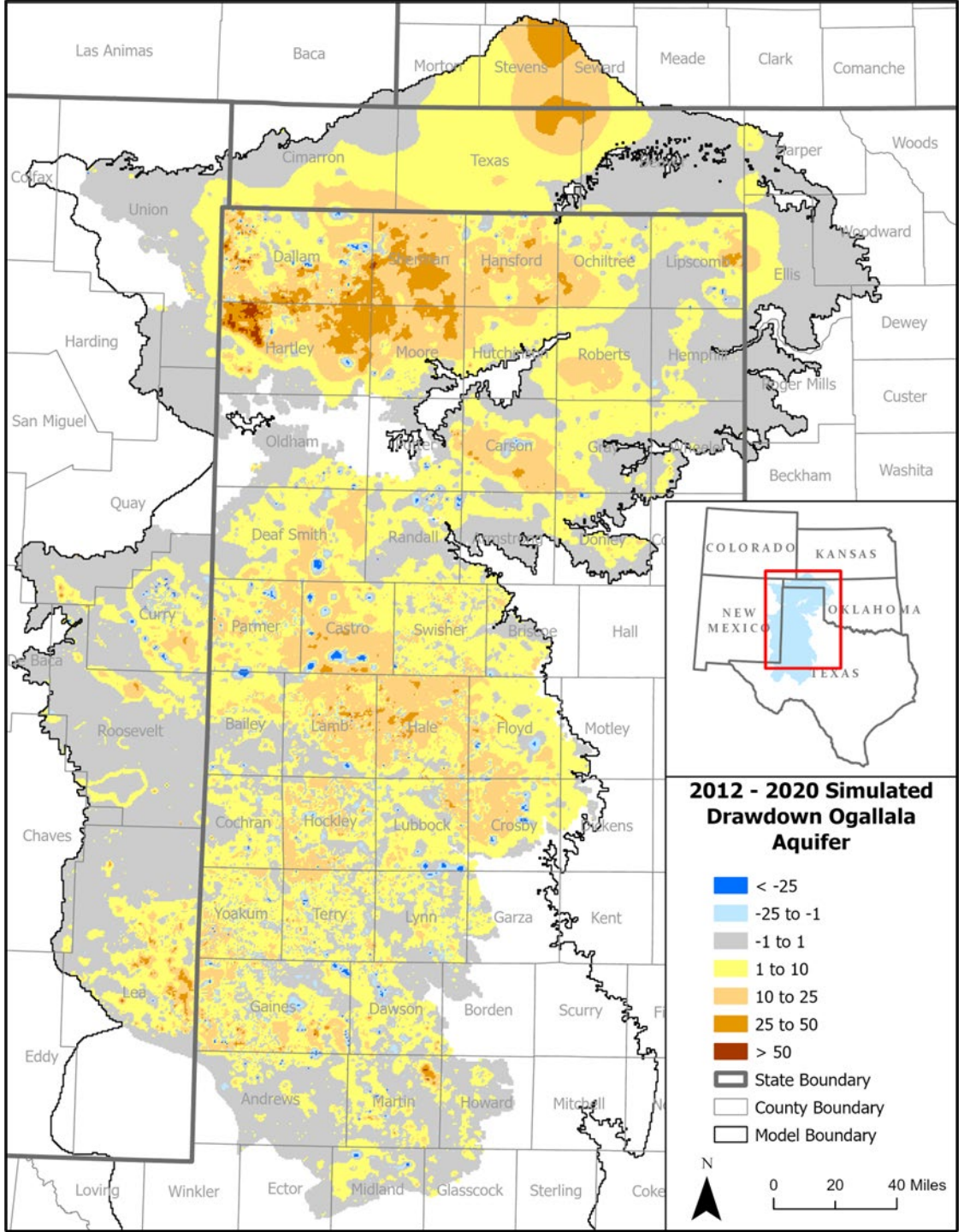
3600
3400
3200
3000
2800
2600
2400
2200
COLORADO
KANSAS
NEW MEXICO
OKLAHOMA
TEXAS
2020
Water Level Elevations
Ogallala Aquifer
Feet above mean sea level
Water Level Elevation
State Boundary
County Boundary
Model Boundary
Ogallala Aquifer
N
0
30
60
Miles


Las Animas
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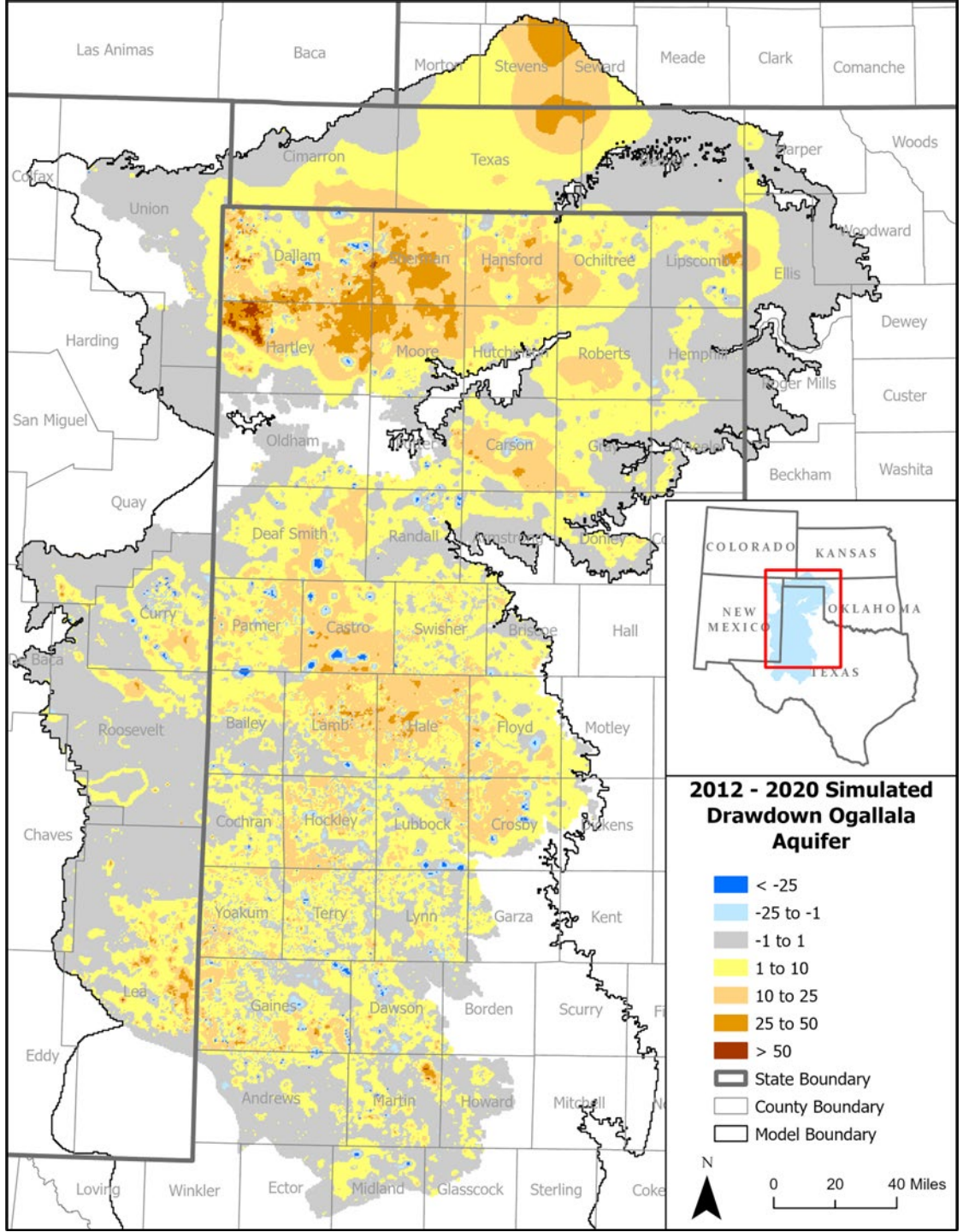
Winkler
Ector
Midland
Glasscock
Sterling
Coke
COLORADO
KANSAS
NEW MEXICO
OKLAHOMA
TEXAS
2012 - 2020 Simulated
Drawdown Ogallala
Aquifer
< -25
-25 to -1
-1 to 1
1 to 10
10 to 25
25 to 50
> 50
State Boundary
County Boundary
Model Boundary
N
0
20
40 Miles


Las Animas
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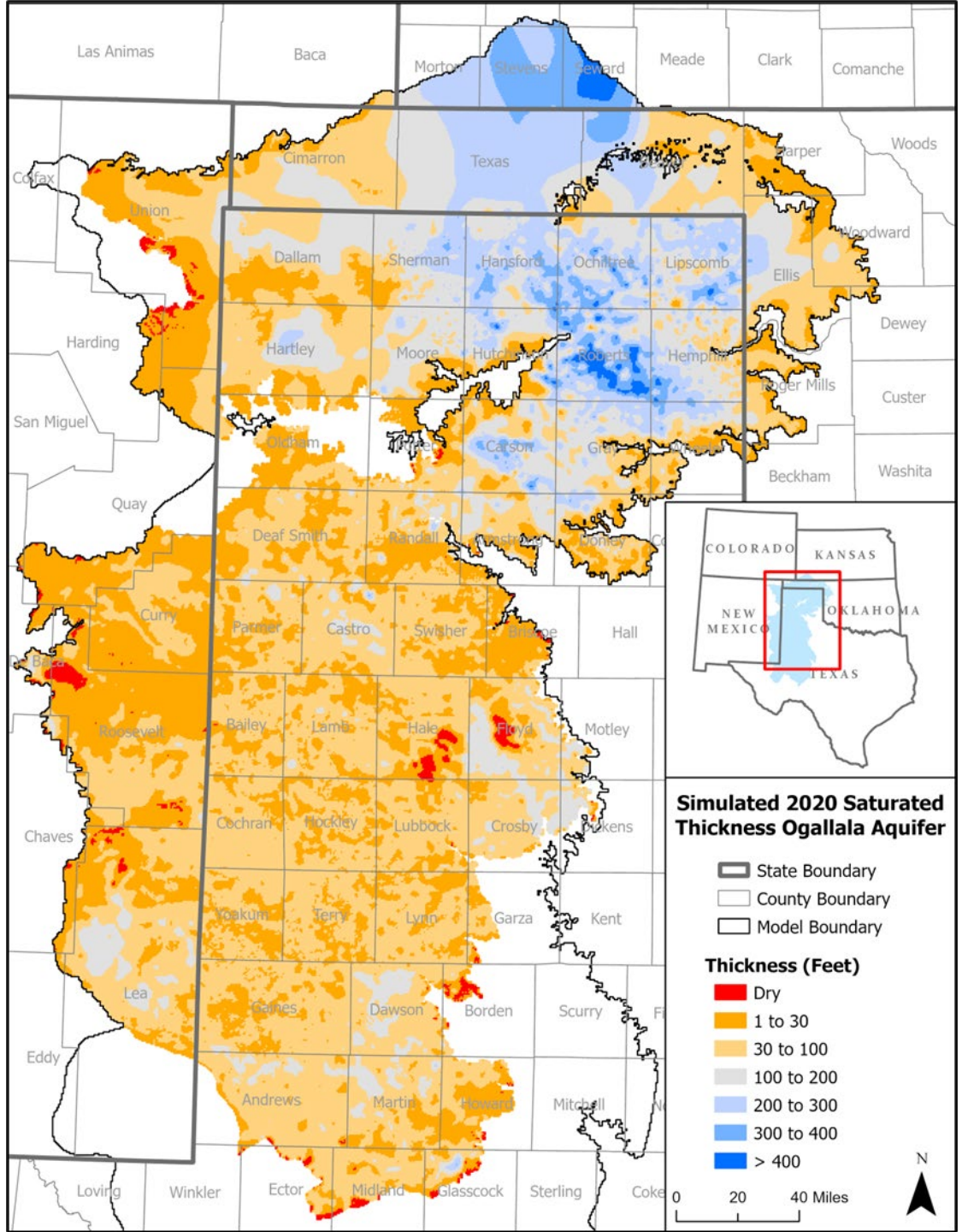
Howard
Mitchell
Loving
Winkler
Ector
Midland
Glasscock
Sterling
COLORADO
KANSAS
NEW MEXICO
OKLAHOMA
TEXAS
2012 - 2020 Simulated Drawdown Ogallala Aquifer
< -25
-25 to -1
-1 to 1
1 to 10
10 to 25
25 to 50
> 50
State Boundary
County Boundary
Model Boundary
N
0
20
40 Miles


Las Animas
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Yoakum
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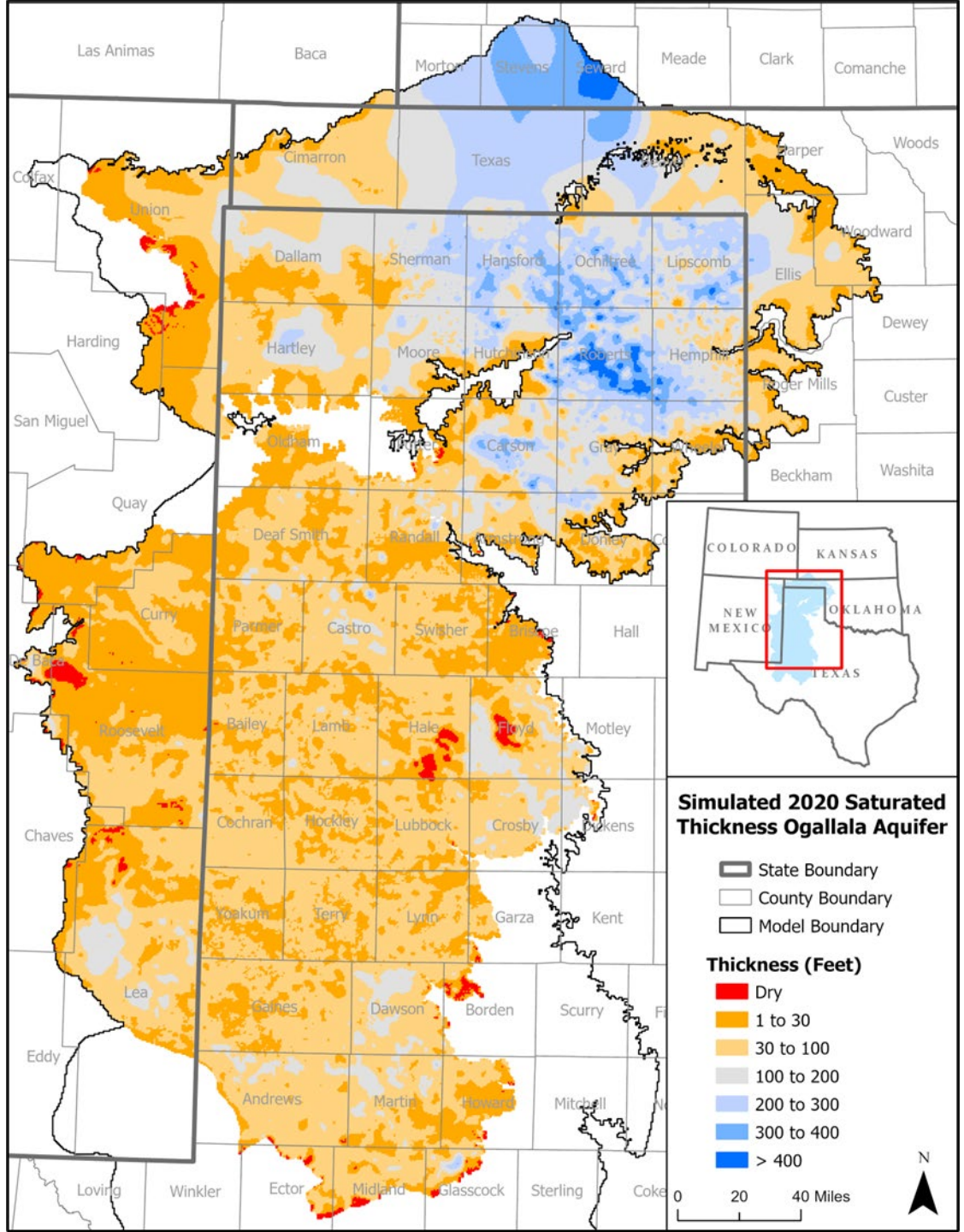
Garza
Kent
Lea
Gaines
Dawson
Borden
Scurry
Eddy
Andrews
Martin
Howard
Mitchell
Loving
Winkler
Ector
Midland
Glasscock
Sterling
COLORADO
KANSAS
NEW MEXICO
OKLAHOMA
TEXAS
Simulated 2020 Saturated Thickness Ogallala Aquifer
State Boundary
County Boundary
Model Boundary
Thickness (Feet)
Dry
1 to 30
30 to 100
100 to 200
200 to 300
300 to 400
> 400
N
0
20
40 Miles


Las Animas
Baca
Morton
Stevens
Seward
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Comanche
Cimarron
Texas
Woods
Harper
Colfax
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Woodward
Dallam
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Ochiltree
Lipscomb
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Floyd
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Chaves
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Hockley
Lubbock
Crosby
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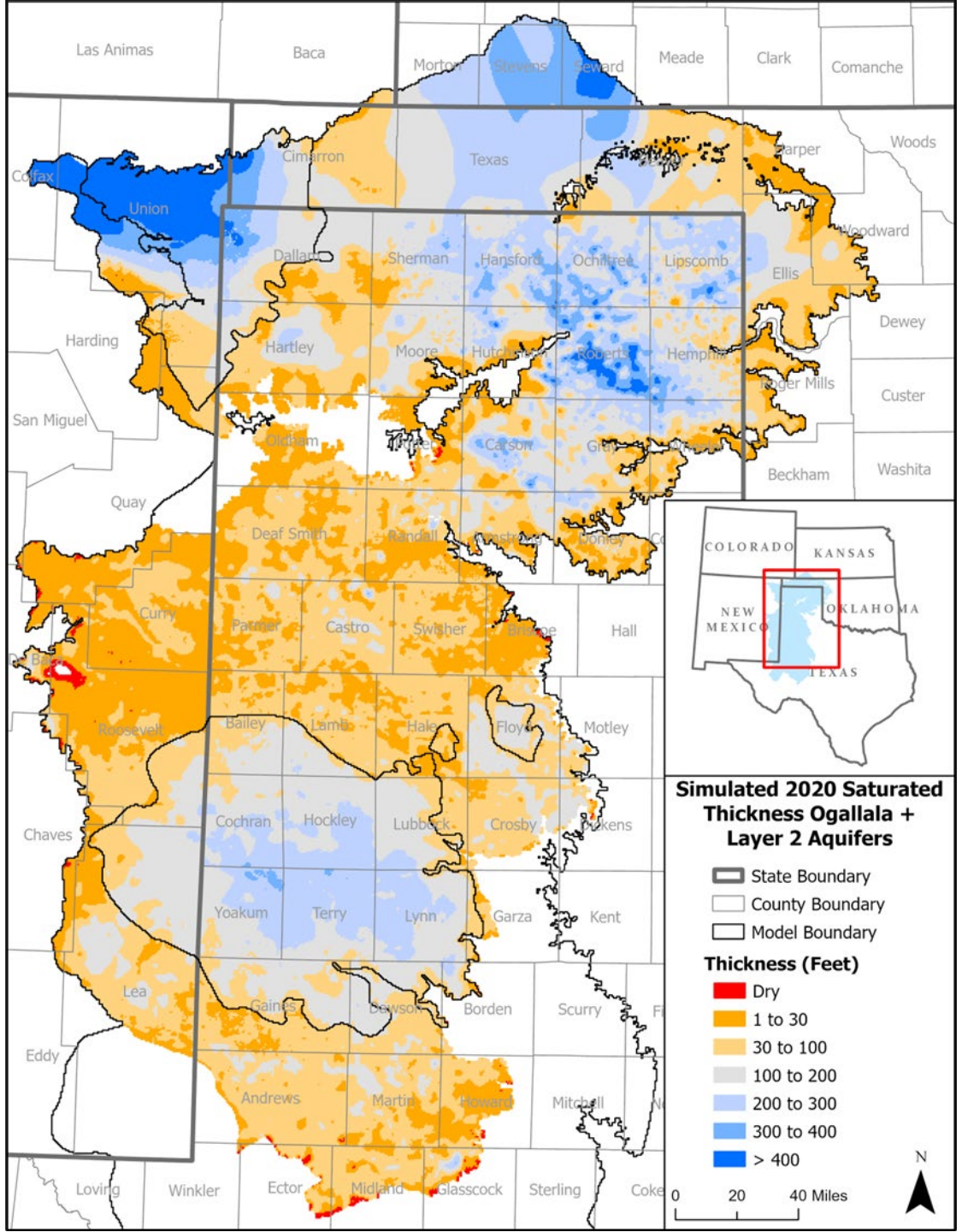
Borden
Scurry
Eddy
Andrews
Martin
Howard
Mitchell
Loving
Winkler
Ector
Midland
Glasscock
Sterling
Coke
COLORADO
KANSAS
NEW MEXICO
OKLAHOMA
TEXAS
Simulated 2020 Saturated Thickness Ogallala Aquifer
State Boundary
County Boundary
Model Boundary
Thickness (Feet)
Dry
1 to 30
30 to 100
100 to 200
200 to 300
300 to 400
> 400
N
0
20
40 Miles


Las Animas
Baca
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Cimarron
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Cochran
Hockley
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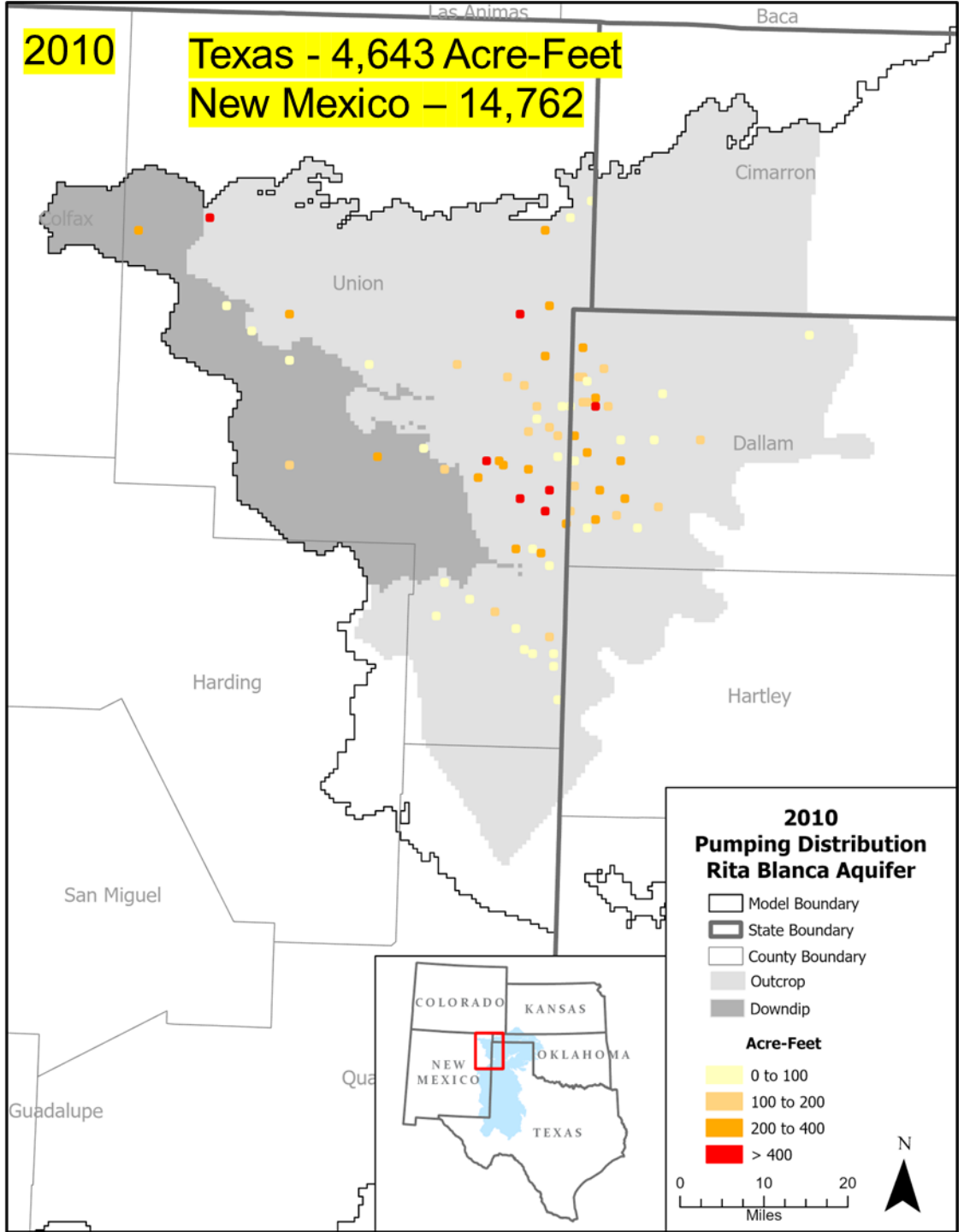
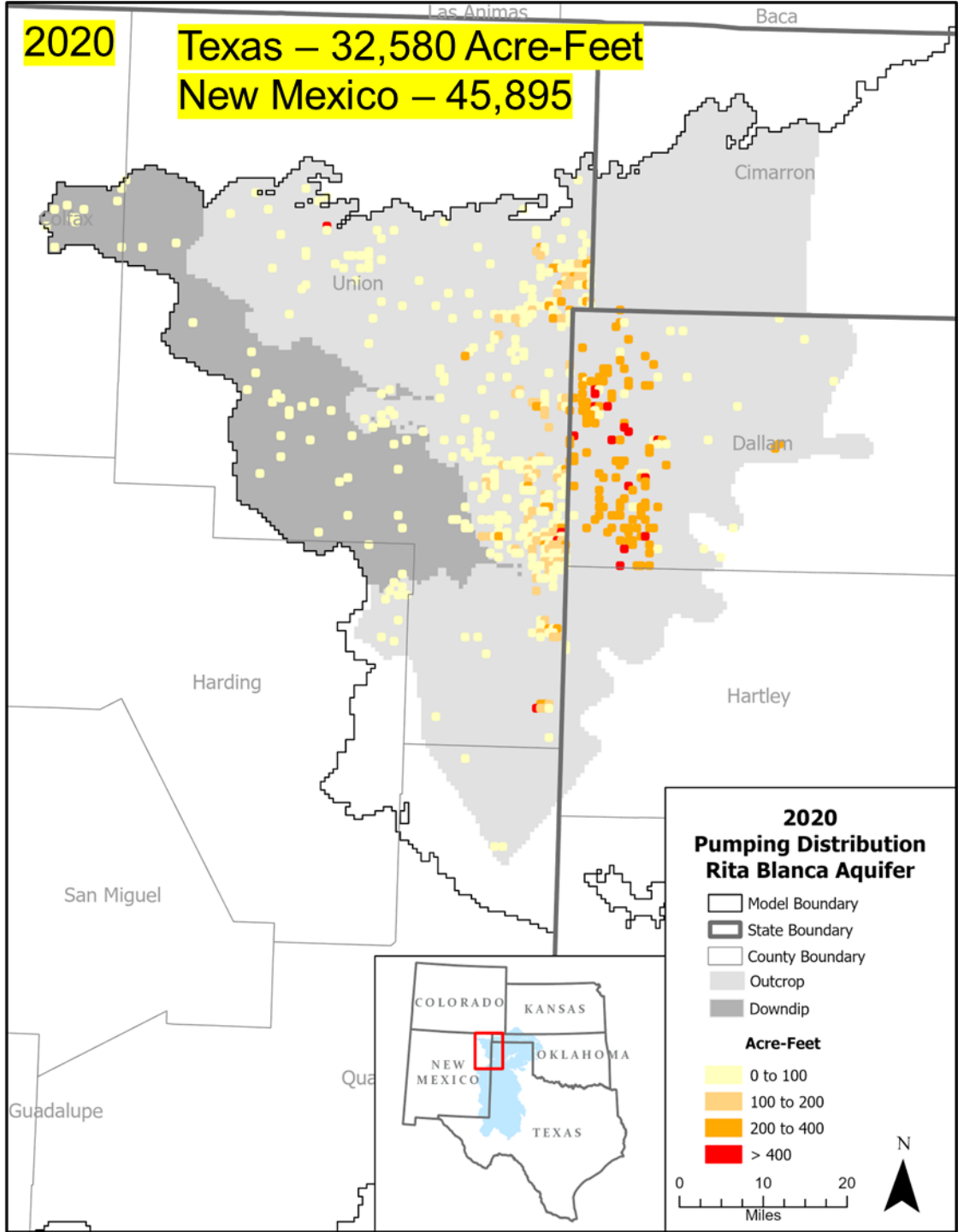
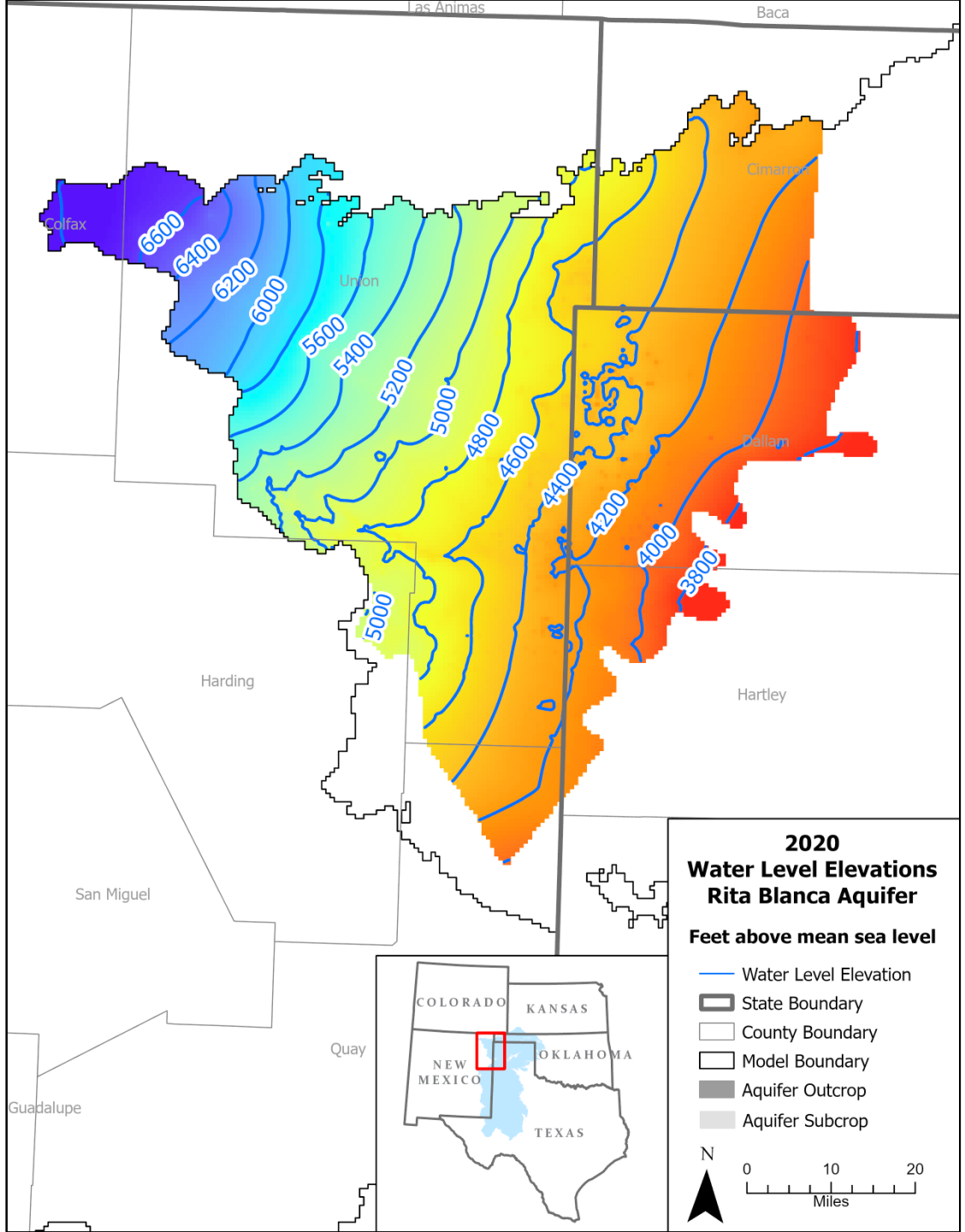
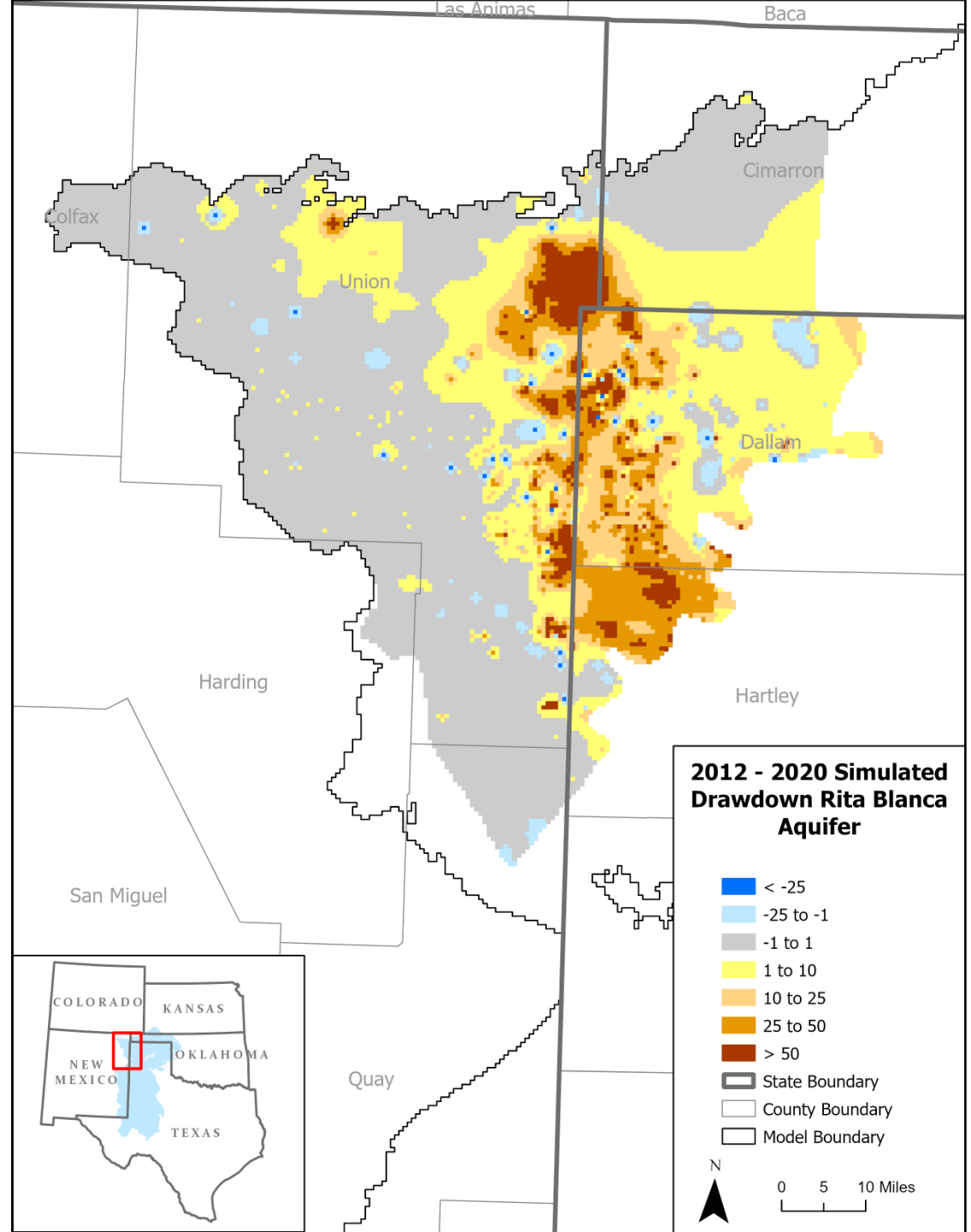
Eddy
Andrews
Martin
Howard
Mitchell
Loving
Winkler
Ector
Midland
Glasscock
Sterling
Coke
COLORADO
KANSAS
NEW MEXICO
OKLAHOMA
TEXAS
Simulated 2020 Saturated Thickness Ogallala + Layer 2 Aquifers
State Boundary
County Boundary
Model Boundary
Thickness (Feet)
Dry
1 to 30
30 to 100
100 to 200
200 to 300
300 to 400
> 400
N
0
20
40 Miles

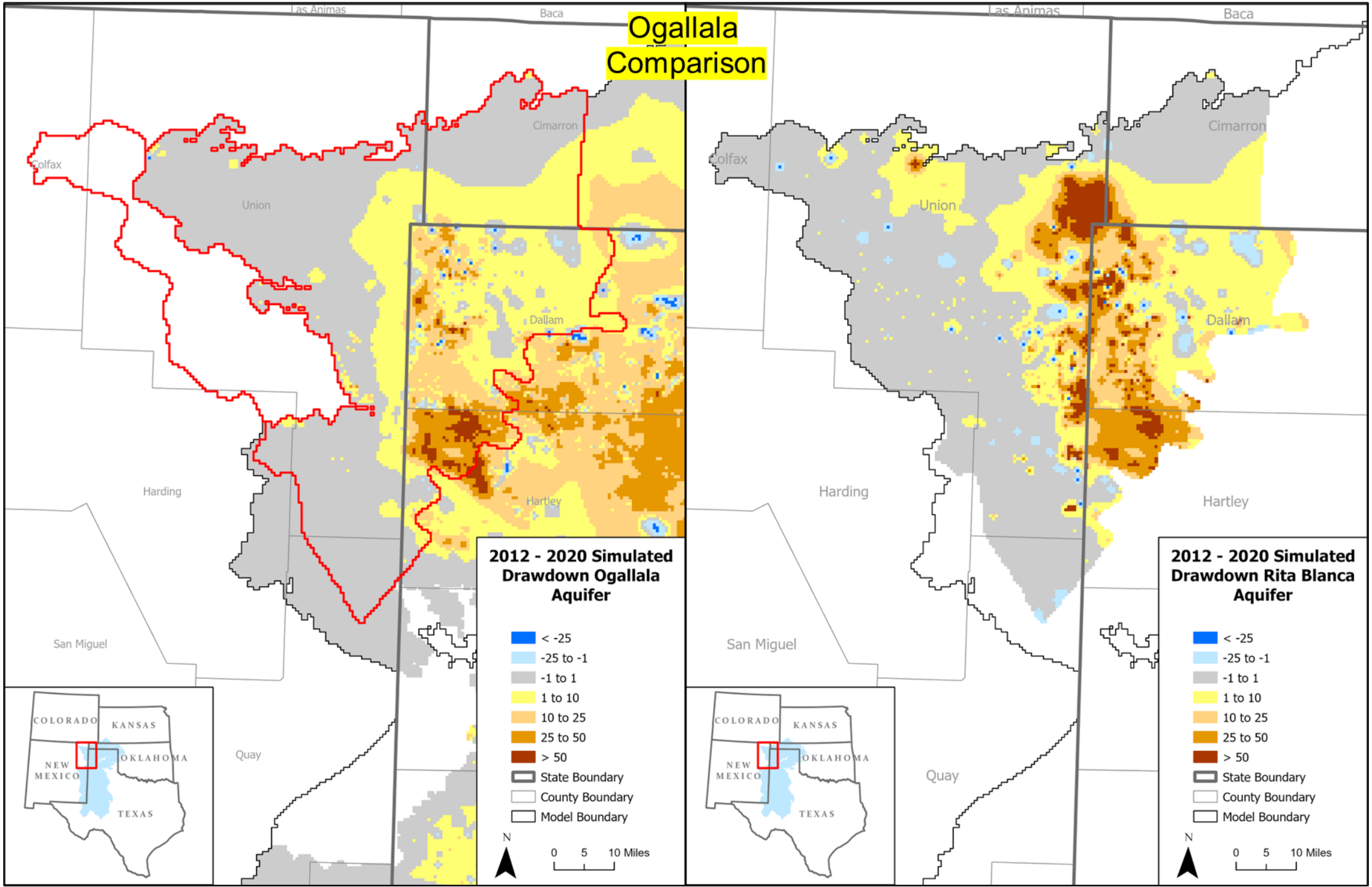

2010
Texas - 4,643 Acre-Feet
New Mexico – 14,762
Las Animas
Baca
Cimarron
Colfax
Union
Dallam
Harding
Hartley
San Miguel
Guadalupe
2010
Pumping Distribution
Rita Blanca Aquifer
Model Boundary
State Boundary
County Boundary
Outcrop
Downdip
Acre-Feet
0 to 100
100 to 200
200 to 400
> 400
0
10
20
Miles
N
COLORADO
KANSAS
NEW MEXICO
OKLAHOMA
TEXAS

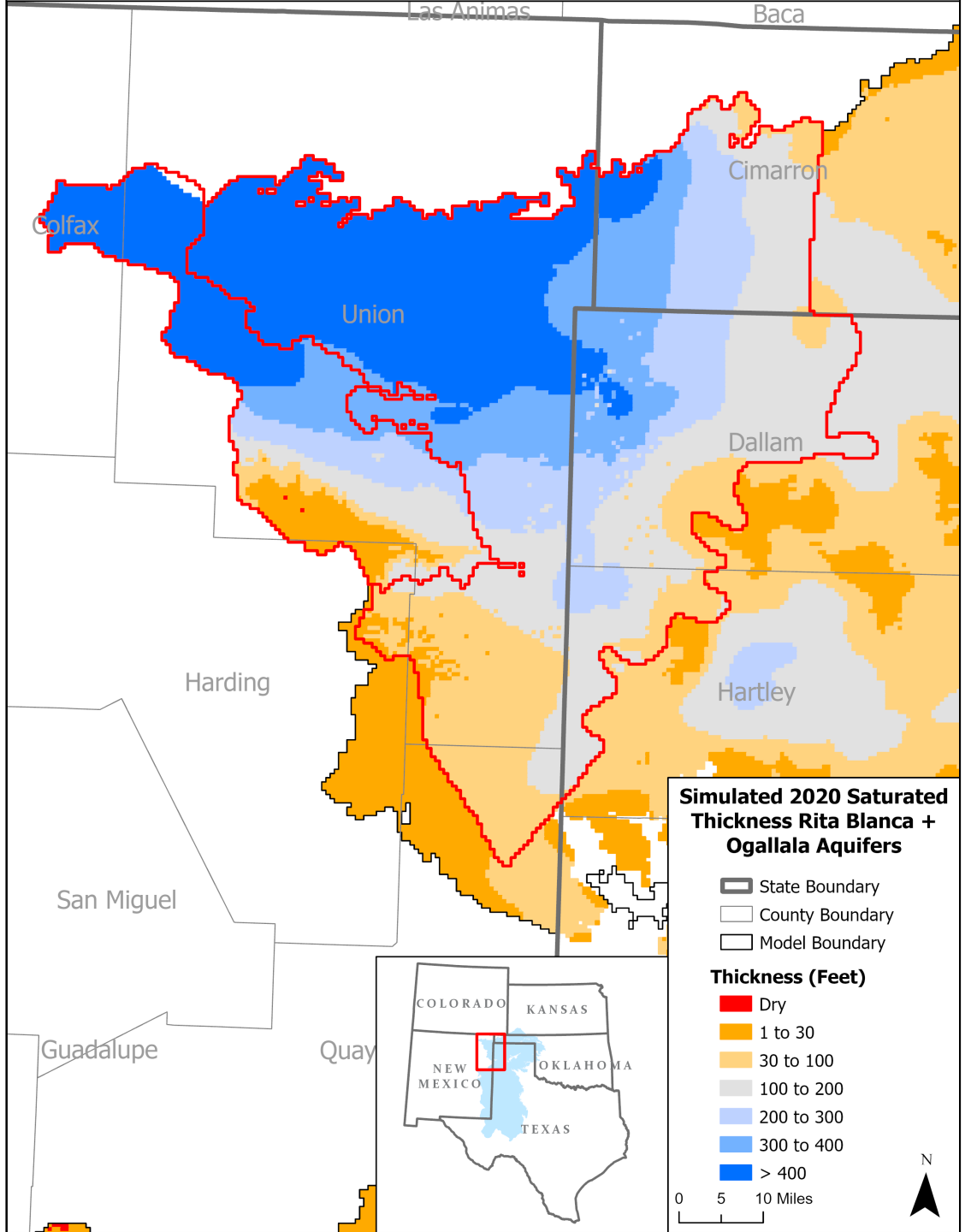

2020
Texas – 32,580 Acre-Feet
New Mexico – 45,895
Las Animas
Baca
Cimarron
Colfax
Union
Dallam
Harding
Hartley
San Miguel
Guadalupe
2020
Pumping Distribution
Rita Blanca Aquifer
Model Boundary
State Boundary
County Boundary
Outcrop
Downdip
Acre-Feet
0 to 100
100 to 200
200 to 400
> 400
0
10
20
Miles
N
COLORADO
KANSAS
NEW MEXICO
OKLAHOMA
TEXAS

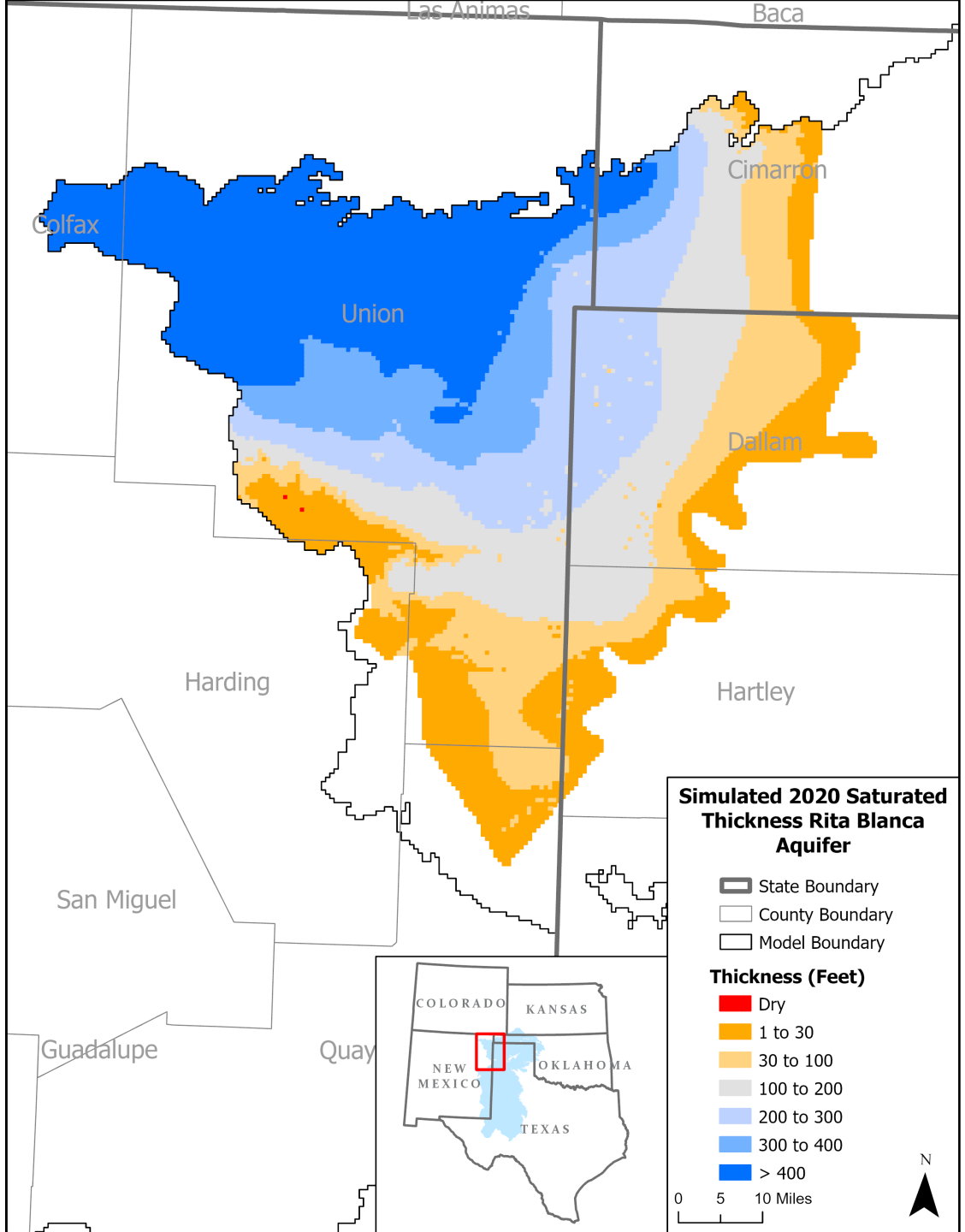

Las Animas
Baca
Colfax
Union
Cimarron
Dallam
Harding
Hartley
San Miguel
Quay
Guadalupe
6600
6400
6200
6000
5600
5400
5200
5000
4800
4600
4400
4200
4000
3800
5000
2020
Water Level Elevations
Rita Blanca Aquifer
Feet above mean sea level
Water Level Elevation
State Boundary
County Boundary
Model Boundary
Aquifer Outcrop
Aquifer Subcrop
N
0
10
20
Miles
COLORADO
KANSAS
NEW MEXICO
OKLAHOMA
TEXAS

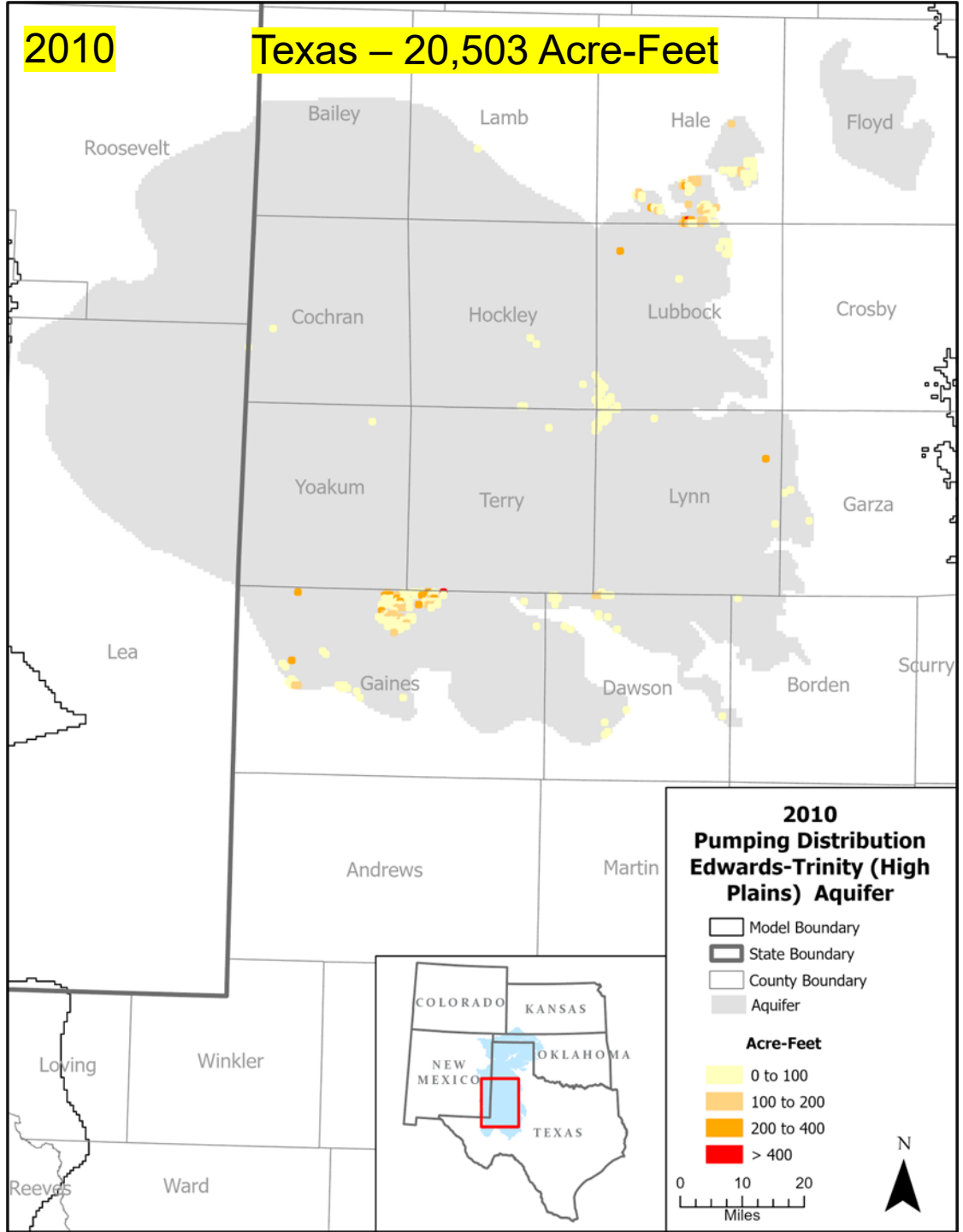

Las Animas
Baca
Colfax
Union
Cimarron
Dallam
Harding
Hartley
San Miguel
Quay
2012 - 2020 Simulated
Drawdown Rita Blanca
Aquifer
< -25
-25 to -1
-1 to 1
1 to 10
10 to 25
25 to 50
> 50
State Boundary
County Boundary
Model Boundary
N
0
5
10 Miles
COLORADO
KANSAS
NEW MEXICO
OKLAHOMA
TEXAS

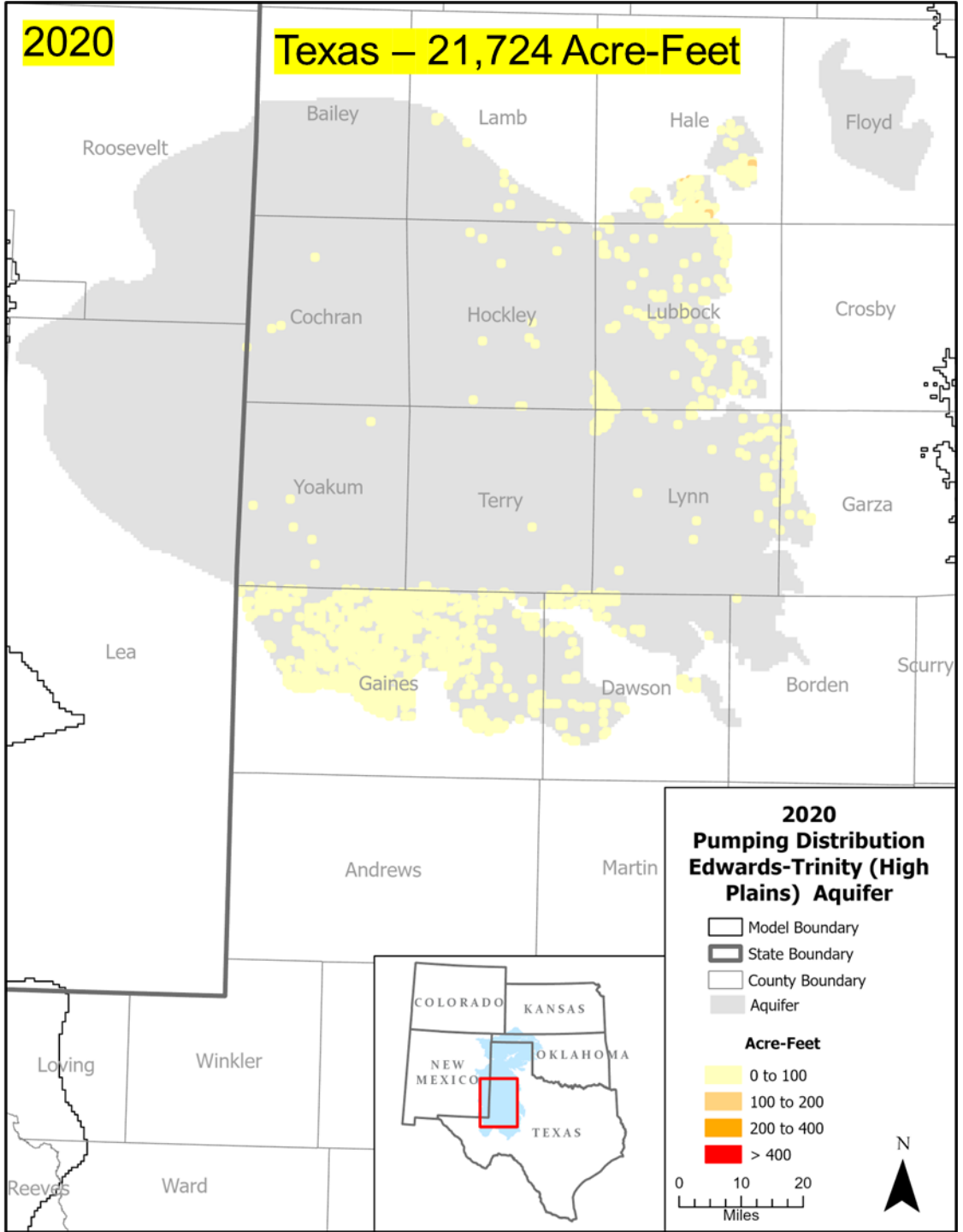
Ogallala Comparison

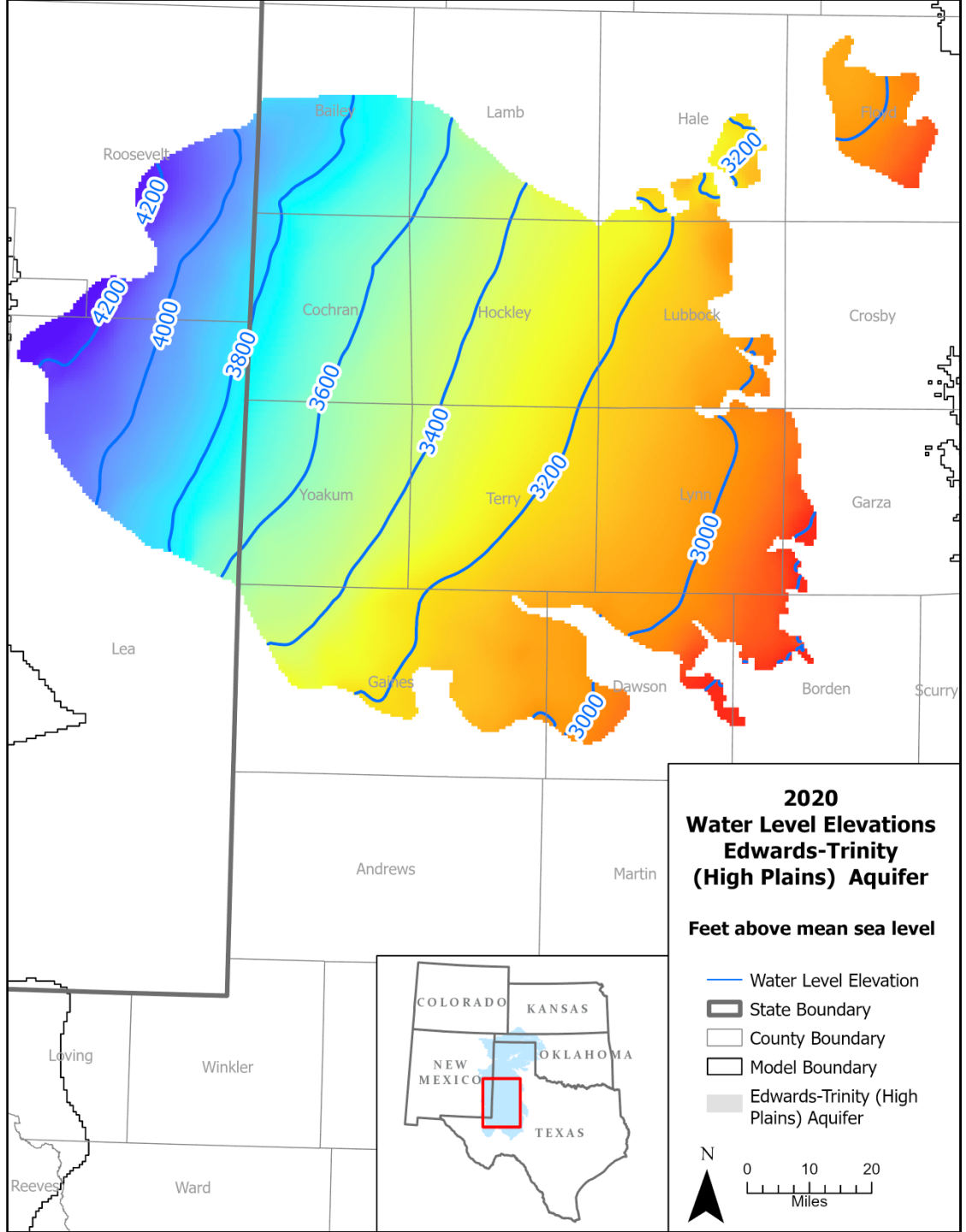


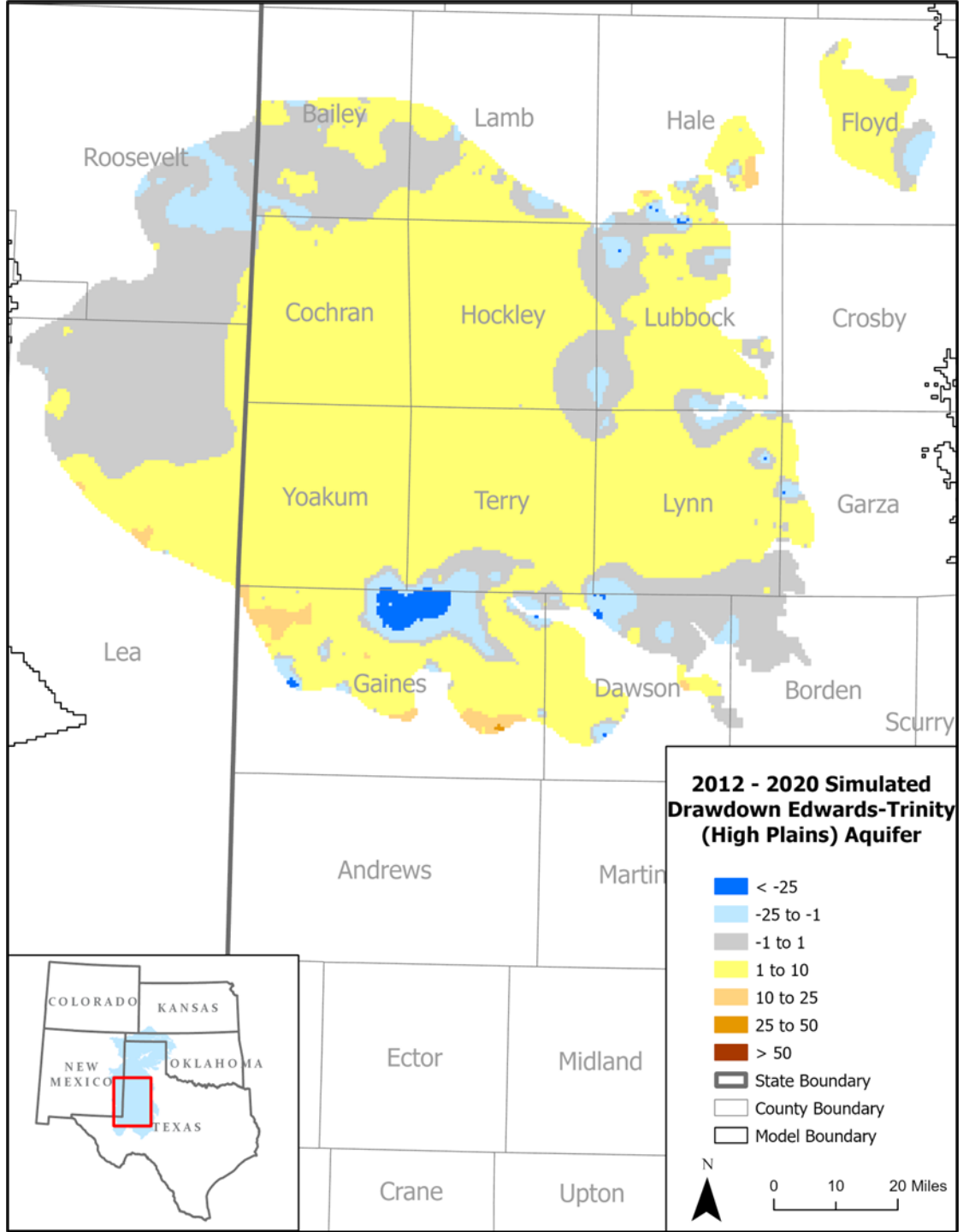

Las Animas
Baca
Cimarron
Colfax
Union
Dallam
Harding
Hartley
San Miguel
Guadalupe
Quay
Simulated 2020 Saturated Thickness Rita Blanca + Ogallala Aquifers
State Boundary
County Boundary
Model Boundary
Thickness (Feet)
Dry
1 to 30
30 to 100
100 to 200
200 to 300
300 to 400
> 400
0 5 10 Miles
N
COLORADO
KANSAS
NEW MEXICO
OKLAHOMA
TEXAS

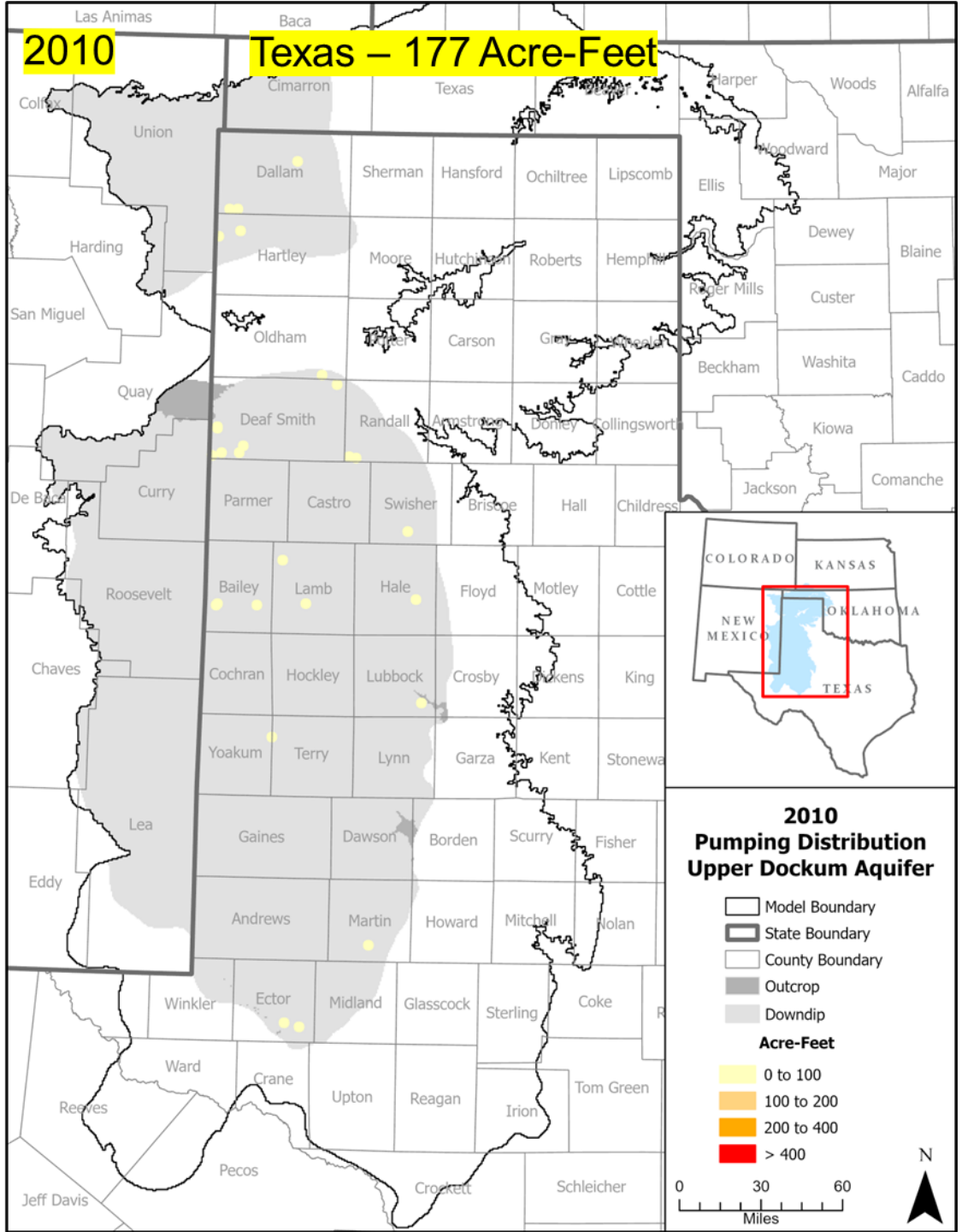

Las Animas
Baca
Cimarron
Colfax
Union
Dallam
Harding
Hartley
San Miguel
Guadalupe
Quay
Simulated 2020 Saturated Thickness Rita Blanca Aquifer
State Boundary
County Boundary
Model Boundary
Thickness (Feet)
Dry
1 to 30
30 to 100
100 to 200
200 to 300
300 to 400
> 400
0 5 10 Miles
N
COLORADO
KANSAS
NEW MEXICO
OKLAHOMA
TEXAS

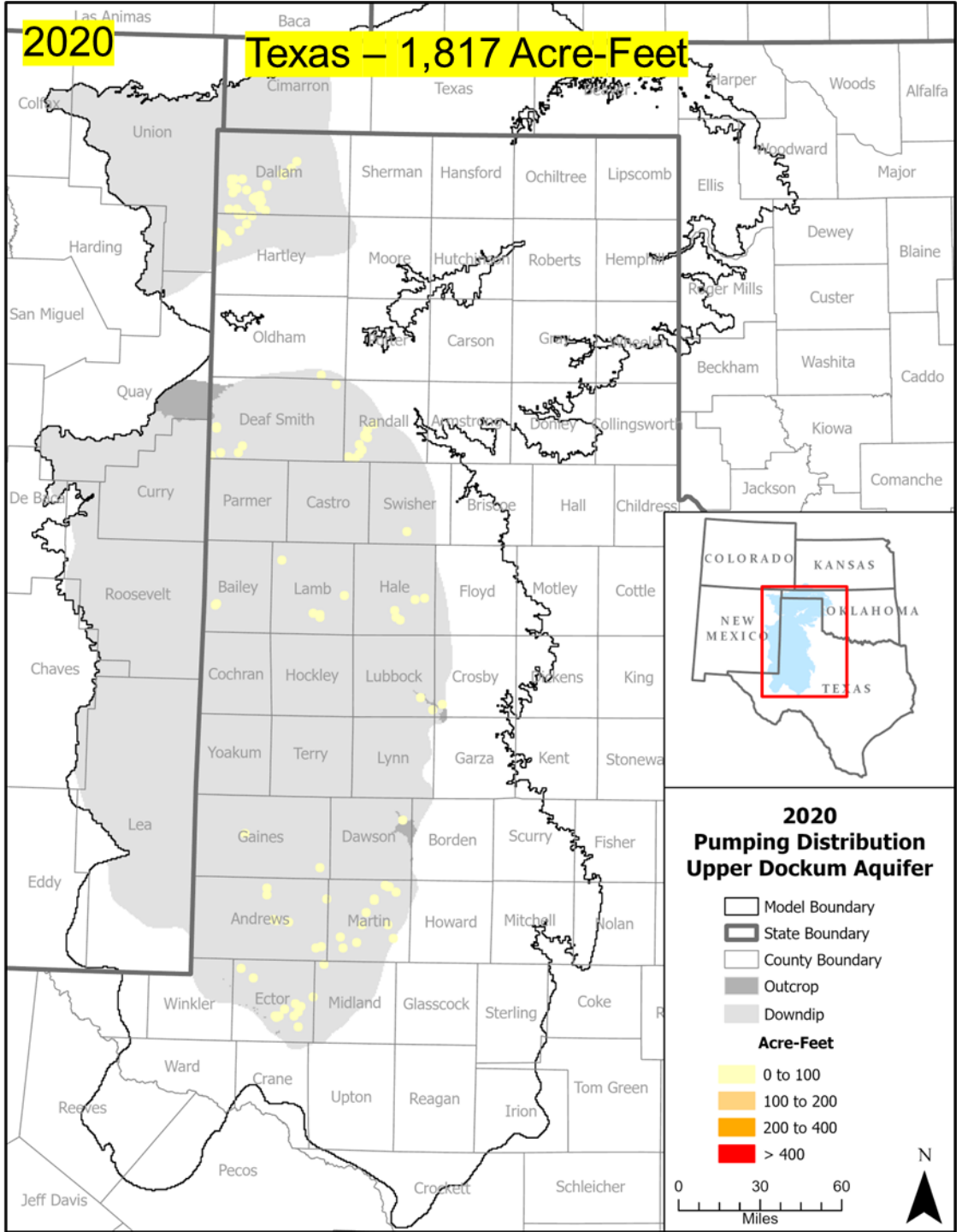

2010
Texas – 20,503 Acre-Feet
Roosevelt
Bailey
Lamb
Hale
Floyd
Cochran
Hockley
Lubbock
Crosby
Yoakum
Terry
Lynn
Garza
Lea
Gaines
Dawson
Borden
Scurry
Andrews
Martin
Loving
Winkler
Reeves
Ward
COLORADO
KANSAS
NEW MEXICO
OKLAHOMA
TEXAS
2010 Pumping Distribution Edwards-Trinity (High Plains) Aquifer
Model Boundary
State Boundary
County Boundary
Aquifer
Acre-Feet
0 to 100
100 to 200
200 to 400
> 400
0 10 20
Miles
N


2020
Texas – 21,724 Acre-Feet
Roosevelt
Bailey
Lamb
Hale
Floyd
Cochran
Hockley
Lubbock
Crosby
Yoakum
Terry
Lynn
Garza
Lea
Gaines
Dawson
Borden
Scurry
Andrews
Martin
Loving
Winkler
Reeves
Ward
COLORADO
KANSAS
NEW MEXICO
OKLAHOMA
TEXAS
2020 Pumping Distribution Edwards-Trinity (High Plains) Aquifer
Model Boundary
State Boundary
County Boundary
Aquifer
Acre-Feet
0 to 100
100 to 200
200 to 400
> 400
0 10 20
Miles
N

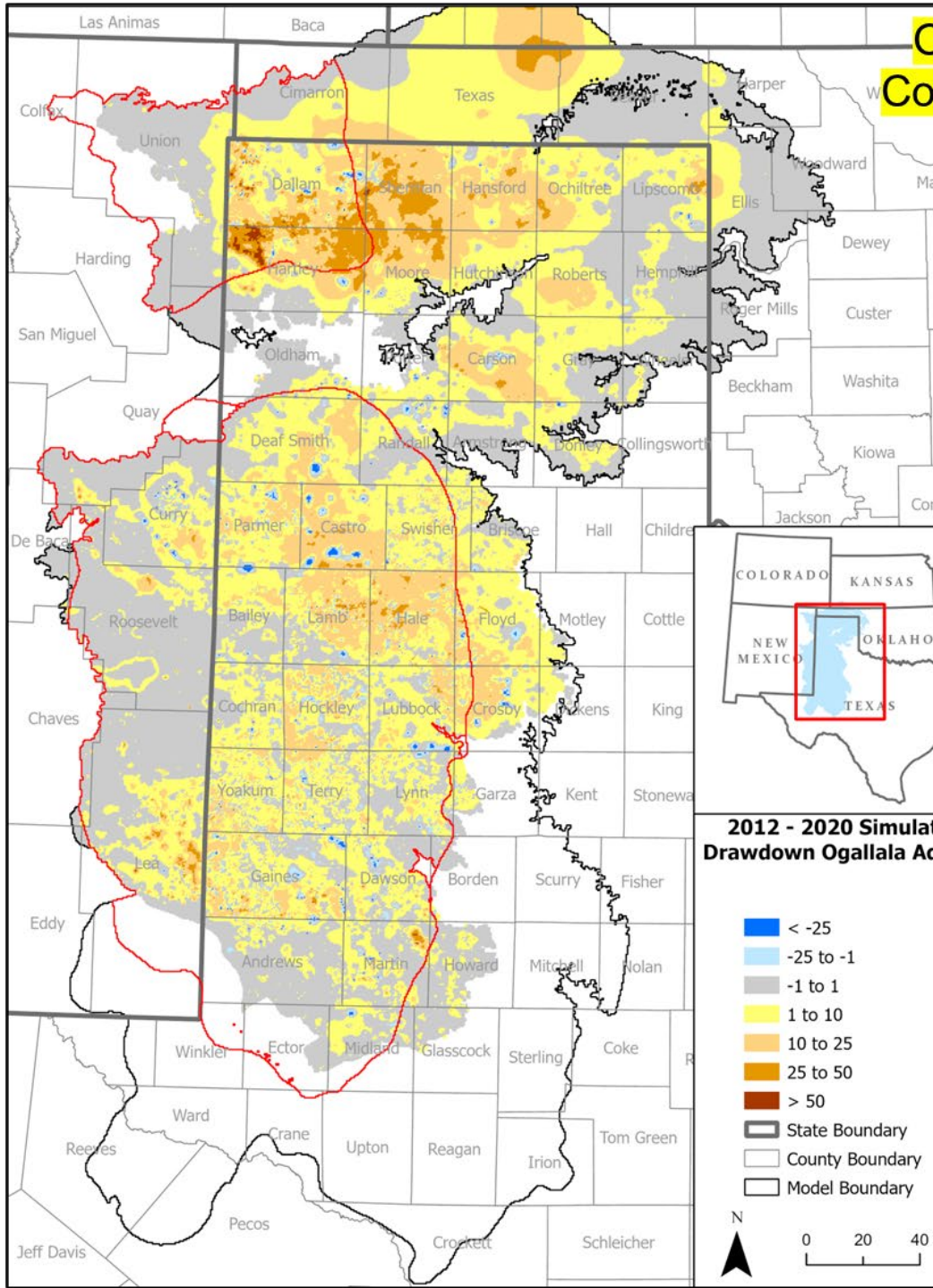

Bailey
Lamb
Hale
Floyd
Roosevelt
Cochran
Hockley
Lubbock
Crosby
Yoakum
Terry
Lynn
Garza
Lea
Gaines
Dawson
Borden
Scurry
Andrews
Martin
Loving
Winkler
Reeves
Ward
4200
4000
3800
3600
3400
3200
3000
2020
Water Level Elevations
Edwards-Trinity
(High Plains) Aquifer
Feet above mean sea level
Water Level Elevation
State Boundary
County Boundary
Model Boundary
Edwards-Trinity (High Plains) Aquifer
N
0 10 20
Miles
COLORADO
KANSAS
NEW MEXICO
OKLAHOMA
TEXAS

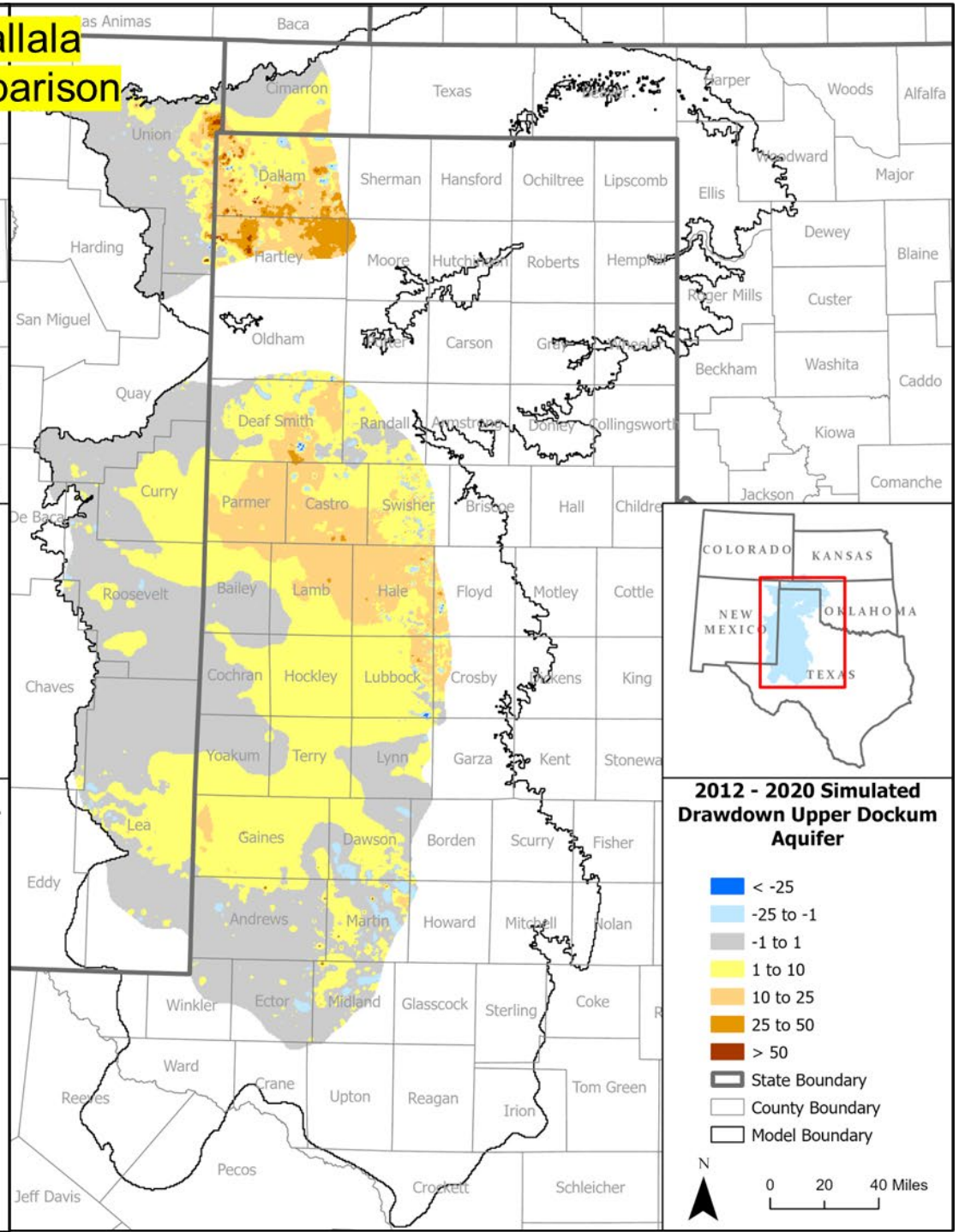

Bailey
Lamb
Hale
Floyd
Roosevelt
Cochran
Hockley
Lubbock
Crosby
Yoakum
Terry
Lynn
Garza
Lea
Gaines
Dawson
Borden
Scurry
Andrews
Martin
Ector
Midland
Crane
Upton
2012 - 2020 Simulated
Drawdown Edwards-Trinity
(High Plains) Aquifer
< -25
-25 to -1
-1 to 1
1 to 10
10 to 25
25 to 50
> 50
State Boundary
County Boundary
Model Boundary
N
0 10 20 Miles
COLORADO
KANSAS
NEW MEXICO
OKLAHOMA
TEXAS

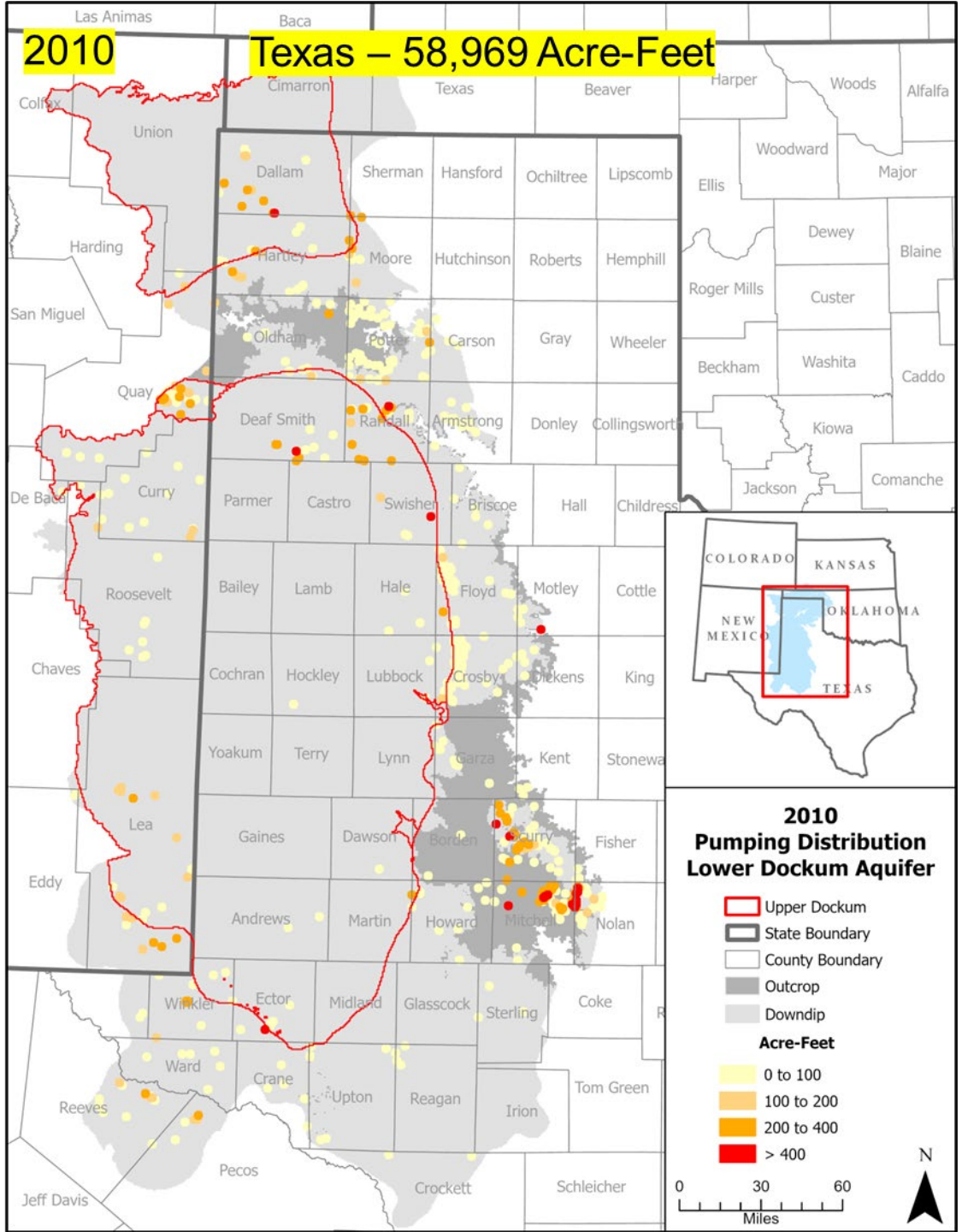

2010
Texas – 177 Acre-Feet
Las Animas
Baca
Cimarron
Texas
Harper
Woods
Alfalfa
Colfax
Union
Woodward
Major
Dallam
Sherman
Hansford
Ochiltree
Lipscomb
Ellis
Harding
Dewey
Blaine
Hartley
Moore
Roberts
Roger Mills
Custer
San Miguel
Oldham
Carson
Beckham
Washita
Caddo
Quay
Deaf Smith
Randall
Kiowa
Curry
Parmer
Castro
Swisher
Hall
Jackson
Comanche
De Baca
Roosevelt
Bailey
Lamb
Hale
Floyd
Motley
Cottle
Chaves
Cochran
Hockley
Lubbock
Crosby
King
Yoakum
Terry
Lynn
Garza
Kent
Lea
Gaines
Dawson
Borden
Scurry
Fisher
Eddy
Andrews
Martin
Howard
Mitchell
Nolan
Winkler
Ector
Midland
Glasscock
Sterling
Coke
Ward
Crane
Upton
Reagan
Irion
Tom Green
Reeves
Pecos
Crockett
Schleicher
Jeff Davis
COLORADO
KANSAS
NEW MEXICO
OKLAHOMA
TEXAS
2010
Pumping Distribution
Upper Dockum Aquifer
Model Boundary
State Boundary
County Boundary
Outcrop
Downdip
Acre-Feet
0 to 100
100 to 200
200 to 400
> 400
N
0
30
60
Miles

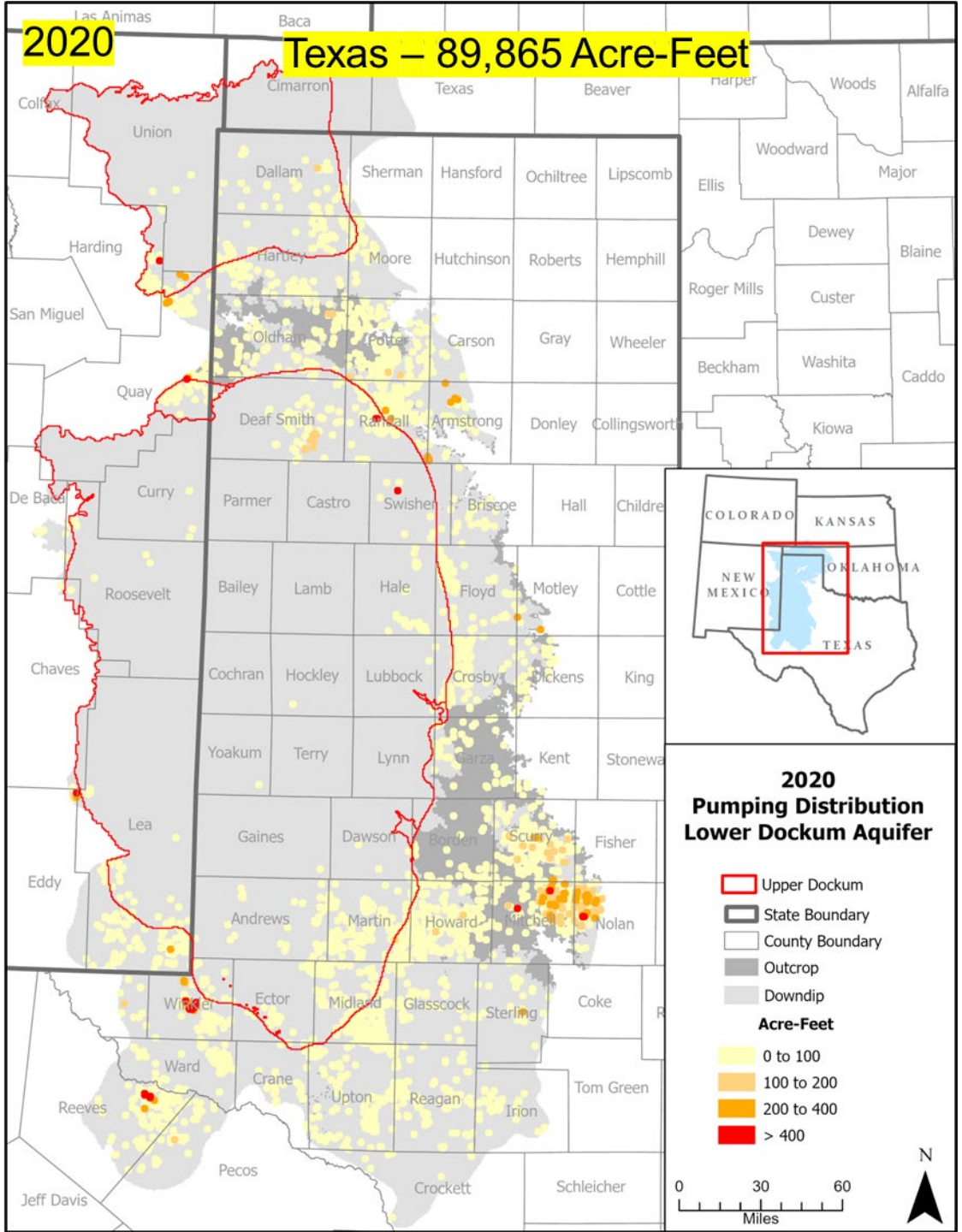

2020
Texas – 1,817 Acre-Feet
Las Animas
Baca
Cimarron
Texas
Harper
Woods
Alfalfa
Colfax
Union
Woodward
Major
Dallam
Sherman
Hansford
Ochiltree
Lipscomb
Ellis
Harding
Dewey
Blaine
Hartley
Moore
Roberts
Roger Mills
Custer
San Miguel
Oldham
Carson
Beckham
Washita
Caddo
Quay
Deaf Smith
Randall
Kiowa
Curry
Parmer
Castro
Swisher
Hall
Jackson
Comanche
De Baca
Roosevelt
Bailey
Lamb
Hale
Floyd
Motley
Cottle
Chaves
Cochran
Hockley
Lubbock
Crosby
King
Yoakum
Terry
Lynn
Garza
Kent
Lea
Gaines
Dawson
Borden
Scurry
Fisher
Eddy
Andrews
Martin
Howard
Mitchell
Nolan
Winkler
Ector
Midland
Glasscock
Sterling
Coke
Ward
Crane
Upton
Reagan
Irion
Tom Green
Reeves
Pecos
Crockett
Schleicher
Jeff Davis
COLORADO
KANSAS
NEW MEXICO
OKLAHOMA
TEXAS
2020
Pumping Distribution
Upper Dockum Aquifer
Model Boundary
State Boundary
County Boundary
Outcrop
Downdip
Acre-Feet
0 to 100
100 to 200
200 to 400
> 400
N
0
30
60
Miles

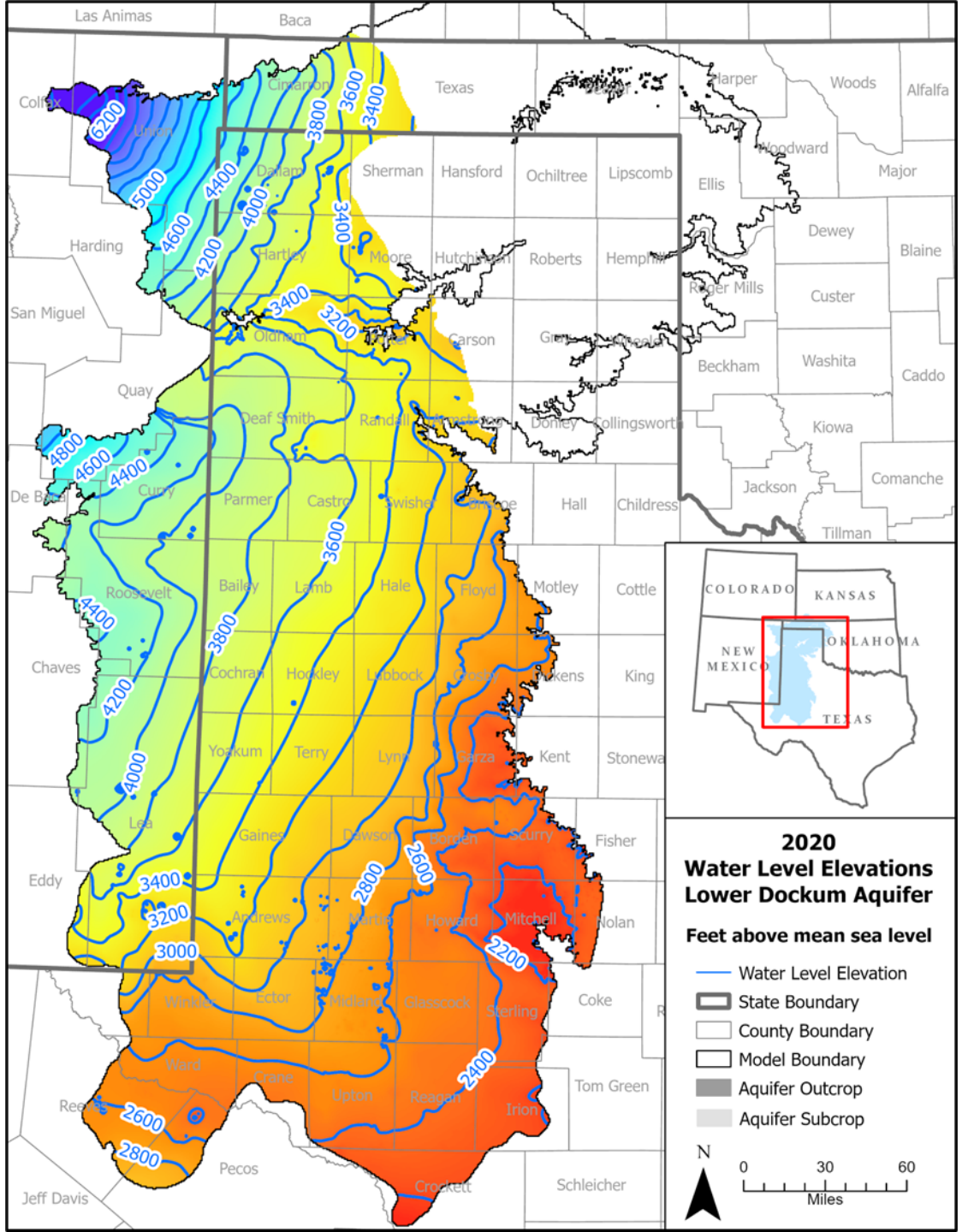
Ogallala Comparison

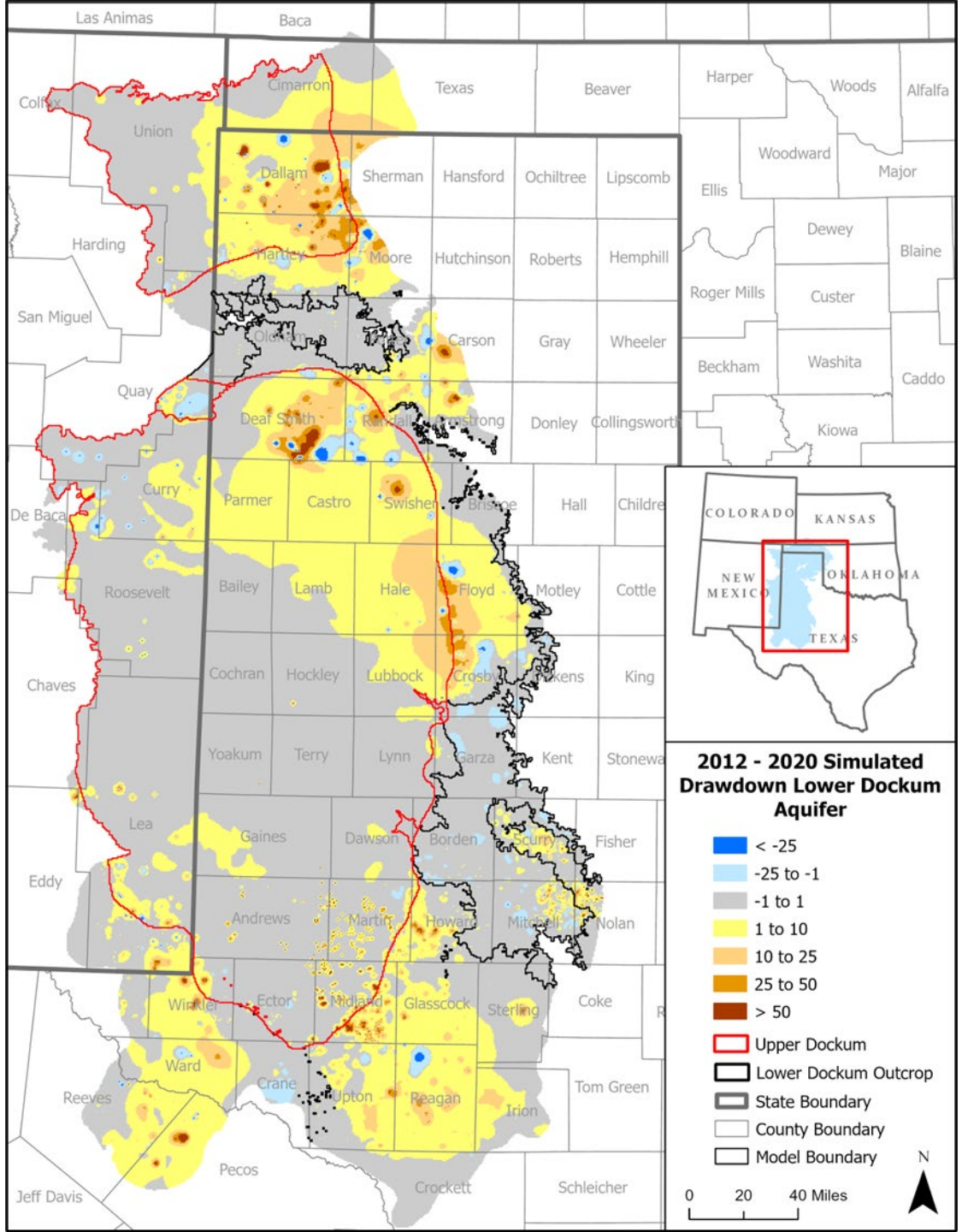





2010
Texas – 58,969 Acre-Feet
Las Animas
Baca
Colfax
Cimarron
Texas
Beaver
Harper
Woods
Alfalfa
Union
Woodward
Major
Ellis
Dallam
Sherman
Hansford
Ochiltree
Lipscomb
Harding
Hartley
Moore
Hutchinson
Roberts
Hemphill
Dewey
Blaine
Roger Mills
Custer
San Miguel
Oldham
Potter
Carson
Gray
Wheeler
Beckham
Washita
Caddo
Quay
Deaf Smith
Randall
Armstrong
Donley
Collingsworth
Kiowa
Jackson
Comanche
De Baca
Curry
Parmer
Castro
Swisher
Briscoe
Hall
Childress
Roosevelt
Bailey
Lamb
Hale
Floyd
Motley
Cottle
Chaves
Cochran
Hockley
Lubbock
Crosby
Dickens
King
Yoakum
Terry
Lynn
Garza
Kent
Stonewall
Lea
Gaines
Dawson
Borden
Scurry
Fisher
Eddy
Andrews
Martin
Howard
Mitchell
Nolan
Winkler
Ector
Midland
Glasscock
Sterling
Coke
Ward
Crane
Upton
Reagan
Irion
Tom Green
Reeves
Pecos
Crockett
Schleicher
Jeff Davis
COLORADO
KANSAS
NEW MEXICO
OKLAHOMA
TEXAS
2010
Pumping Distribution
Lower Dockum Aquifer
Upper Dockum
State Boundary
County Boundary
Outcrop
Downdip
Acre-Feet
0 to 100
100 to 200
200 to 400
> 400
N
0
30
60
Miles


2020
Texas – 89,865 Acre-Feet
Las Animas
Baca
Colfax
Cimarron
Texas
Beaver
Harper
Woods
Alfalfa
Union
Woodward
Major
Ellis
Dallam
Sherman
Hansford
Ochiltree
Lipscomb
Harding
Hartley
Moore
Hutchinson
Roberts
Hemphill
Dewey
Blaine
Roger Mills
Custer
San Miguel
Oldham
Potter
Carson
Gray
Wheeler
Beckham
Washita
Caddo
Quay
Deaf Smith
Randall
Armstrong
Donley
Collingsworth
Kiowa
De Baca
Curry
Parmer
Castro
Swisher
Briscoe
Hall
Childress
Roosevelt
Bailey
Lamb
Hale
Floyd
Motley
Cottle
Chaves
Cochran
Hockley
Lubbock
Crosby
Dickens
King
Yoakum
Terry
Lynn
Garza
Kent
Stonewall
Lea
Gaines
Dawson
Borden
Scurry
Fisher
Eddy
Andrews
Martin
Howard
Mitchell
Nolan
Winkler
Ector
Midland
Glasscock
Sterling
Coke
Ward
Crane
Upton
Reagan
Irion
Tom Green
Reeves
Pecos
Crockett
Schleicher
Jeff Davis
COLORADO
KANSAS
NEW MEXICO
OKLAHOMA
TEXAS
2020
Pumping Distribution
Lower Dockum Aquifer
Upper Dockum
State Boundary
County Boundary
Outcrop
Downdip
Acre-Feet
0 to 100
100 to 200
200 to 400
> 400
N
0
30
60
Miles

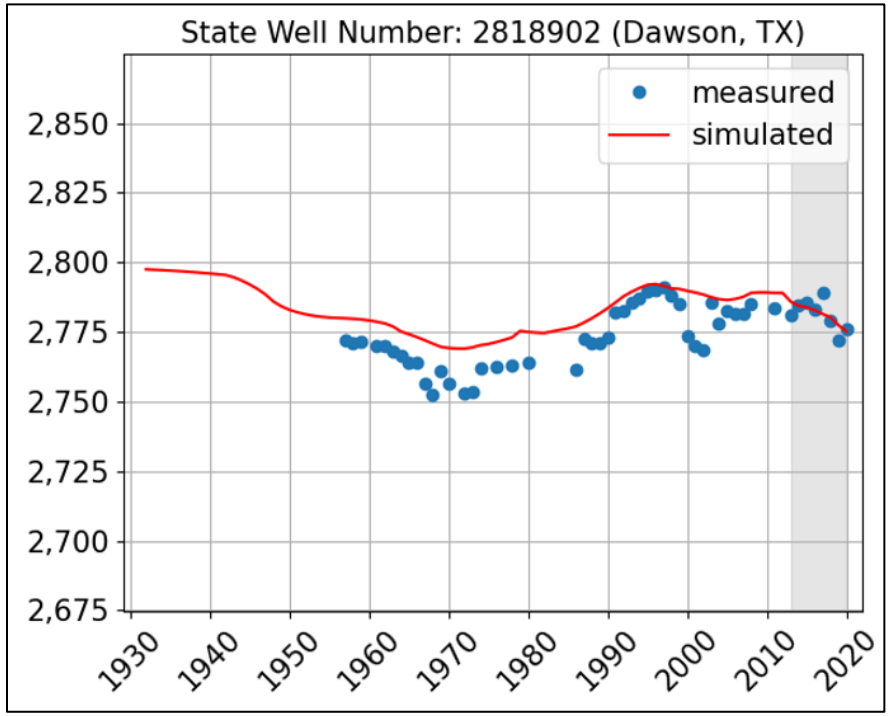

2020
Water Level Elevations
Lower Dockum Aquifer
Feet above mean sea level
Water Level Elevation
State Boundary
County Boundary
Model Boundary
Aquifer Outcrop
Aquifer Subcrop
N
0 30 60
Miles
COLORADO
KANSAS
OKLAHOMA
NEW MEXICO
TEXAS


2012 - 2020 Simulated
Drawdown Lower Dockum
Aquifer
< -25
-25 to -1
-1 to 1
1 to 10
10 to 25
25 to 50
> 50
Upper Dockum
Lower Dockum Outcrop
State Boundary
County Boundary
Model Boundary
N
0 20 40 Miles
COLORADO
KANSAS
OKLAHOMA
NEW MEXICO
TEXAS

Water Level Targets

Water Level Targets and Model Performance

- Compare observed to model simulated heads
  - Model Error Statistics
  - Hydrographs
- Data Sources (2013 – 2020)
  - Same target wells as original model
  - TWDB Groundwater Database
  - USGS Groundwater Data
- Methodology
  - MOD2OBS executable
  - Only measurements between October and April
  - Remove questionable measurement codes
  - Averaged well measurements per year



GAM Standards and Original Model Goals

Page 3-27, "As noted in Section 2, while standard practice is to calibrate to a relative error of less than 10 percent, the large range for all of the aquifers in this model led to setting more absolute goals for the mean absolute error. Given the calibration of the previous groundwater availability models, the goals were approximately 30 feet mean absolute error for the Ogallala Aquifer, and approximately 50 feet for the minor aquifers."

GAM Standard
MAE/Range < 10% (0.1)

Original GAM Goals
Ogallala – MAE < 30 feet
Minor Aquifers – MAE < 50 feet

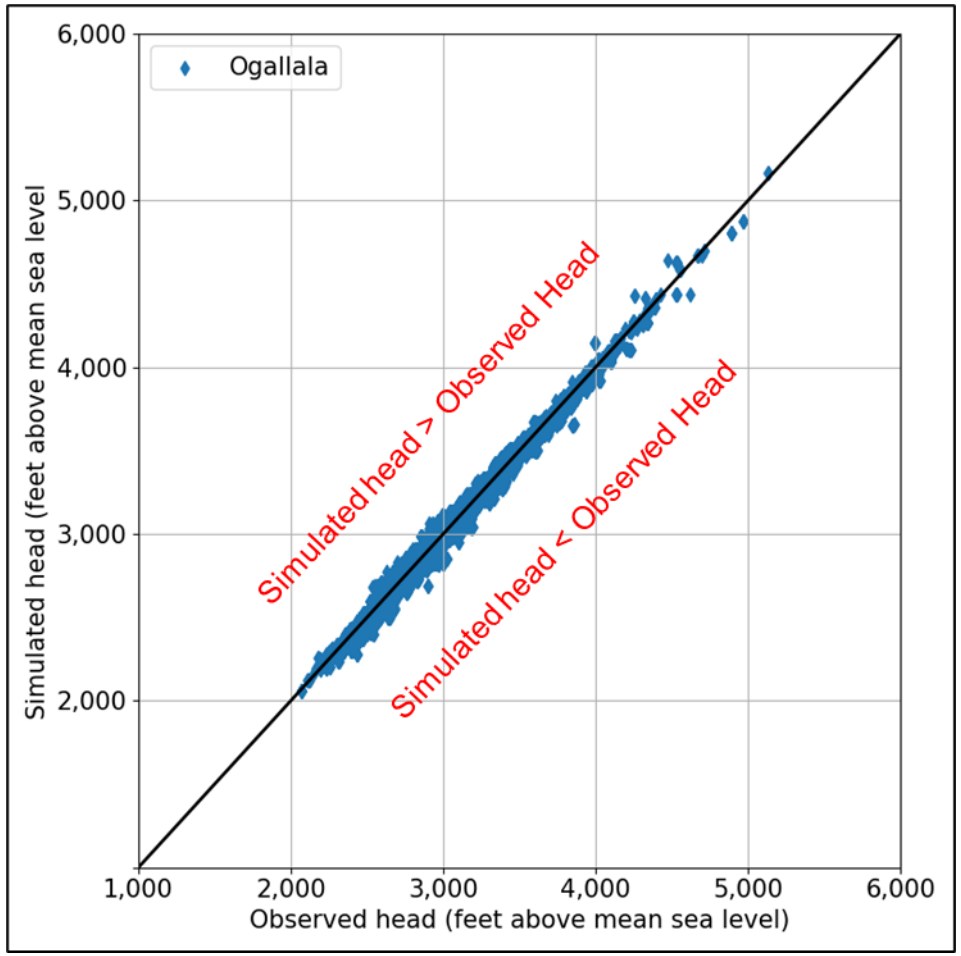
MAE = Mean Absolute Error
ME = Mean Error
Range = Range of Water Level Elevations

Year Range	Aquifer	Mean Error (feet)	Mean Absolute Error (feet)	Range	Mean Absolute Error/Range	Number
Predevelopment	Ogallala	15.3	27.3	2,752	0.010	436
	Rita Blanca	-30.3	61.7	3,014	0.020	87
	Edwards-Trinity (High Plains)	-35.3	42.9	1,415	0.030	257
	Upper Dockum	-39.0	47.4	2,119	0.022	84
	Lower Dockum	10.3	52.0	3,050	0.017	233
1930-1979	Ogallala	-3.8	25.2	3,091	0.008	78,063
	Rita Blanca	-20.3	32.9	746	0.044	301
	Edwards-Trinity (High Plains)	-45.1	49.0	1,430	0.034	1,113
	Upper Dockum	-27.9	30.9	1,912	0.016	326
	Lower Dockum	-14.3	45.1	3,145	0.014	3,220
1980-2012	Ogallala	1.5	28.4	3,529	0.008	91,805
	Rita Blanca	-24.0	42.6	2,841	0.015	1,078
	Edwards-Trinity (High Plains)	-19.4	29.7	1,327	0.022	1,945
	Upper Dockum	-27.4	33.2	2,125	0.016	671
	Lower Dockum	-15.6	53.3	3,465	0.015	4,744
2013 - 2020	Ogallala	5.5	-1.7	26.7	3,065	+0.001 0.009	12,827
	Rita Blanca	-30.3	+16.6	59.2	2,744	+0.007 0.022	130
	Edwards-Trinity (High Plains)	-20.7	-2.5	27.2	1,085	+0.009 0.025	159
	Upper Dockum	-14.1	+1.4	34.4	1,745	+0.004 0.020	159
	Lower Dockum	-16.3	-7.2	45.9	3,056	0.000 0.015	960

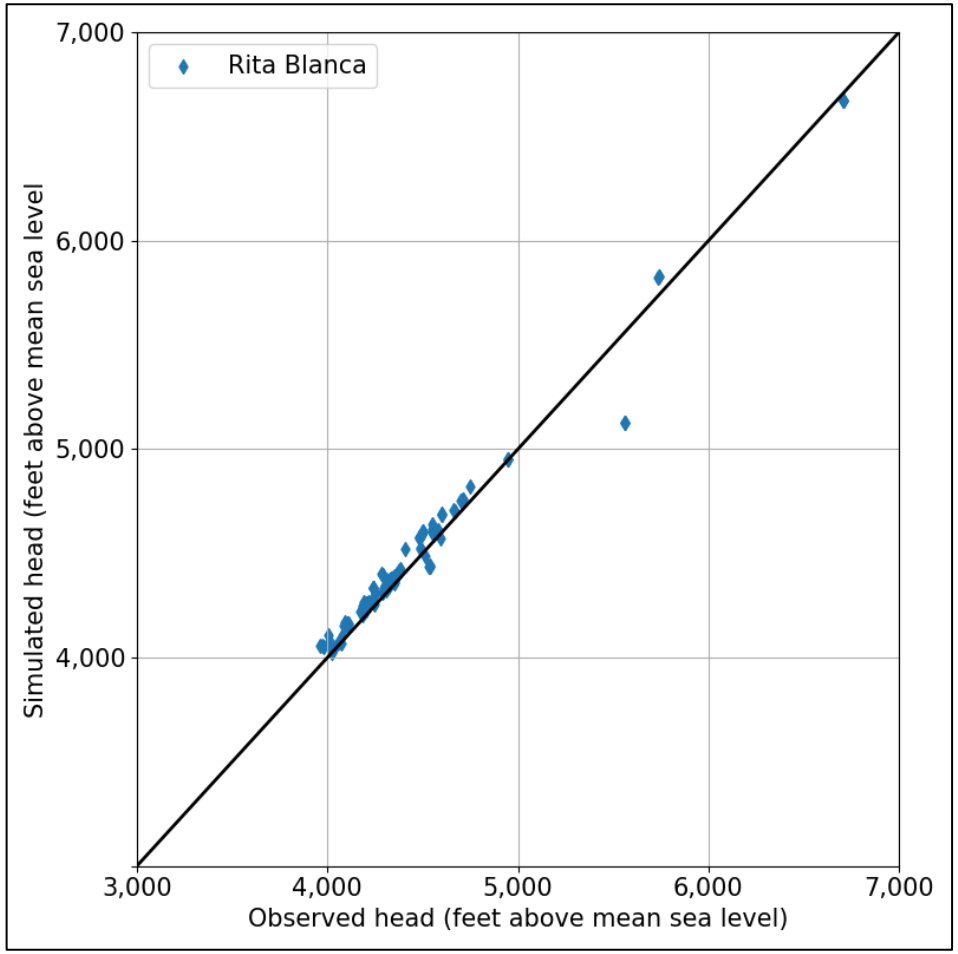
GAM Standard
MAE/Range < 10% (0.1)

Original GAM Goals
Ogallala – MAE < 30 feet
Minor Aquifers – MAE < 50 feet

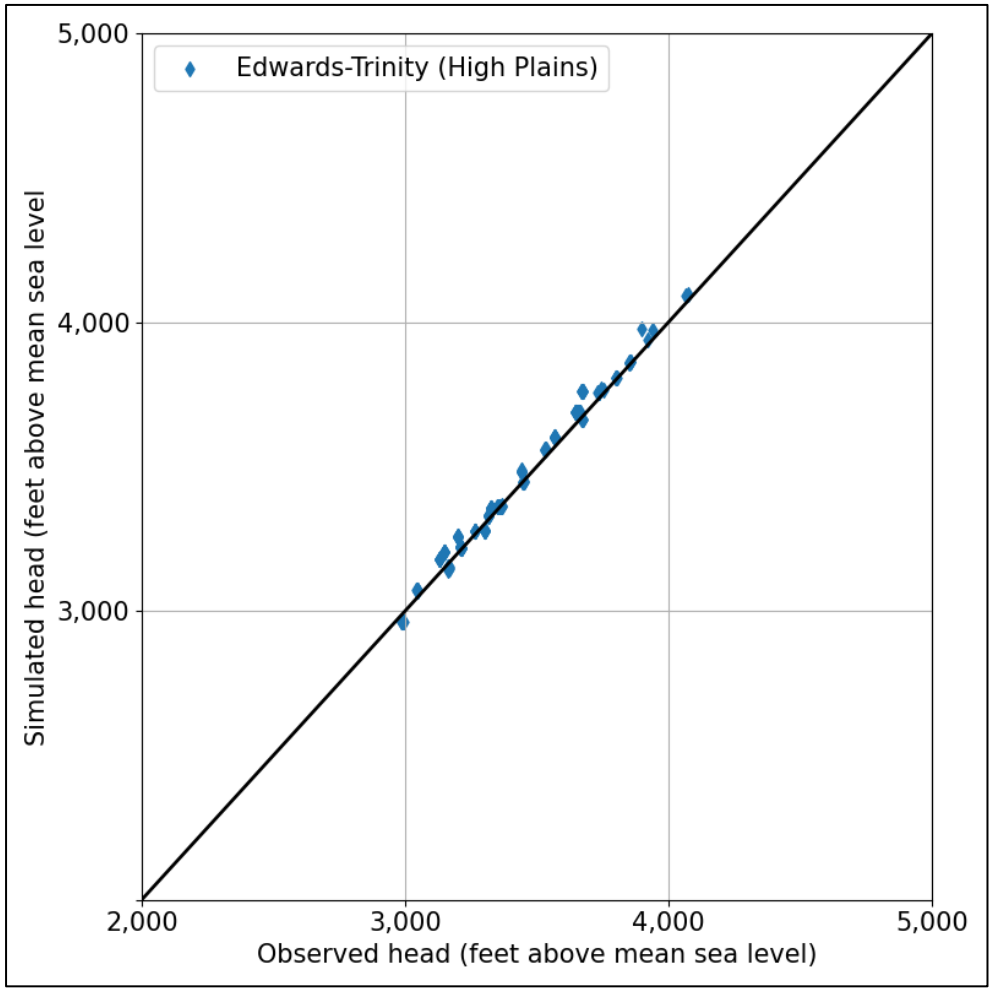
Ogallala (2013 – 2020)



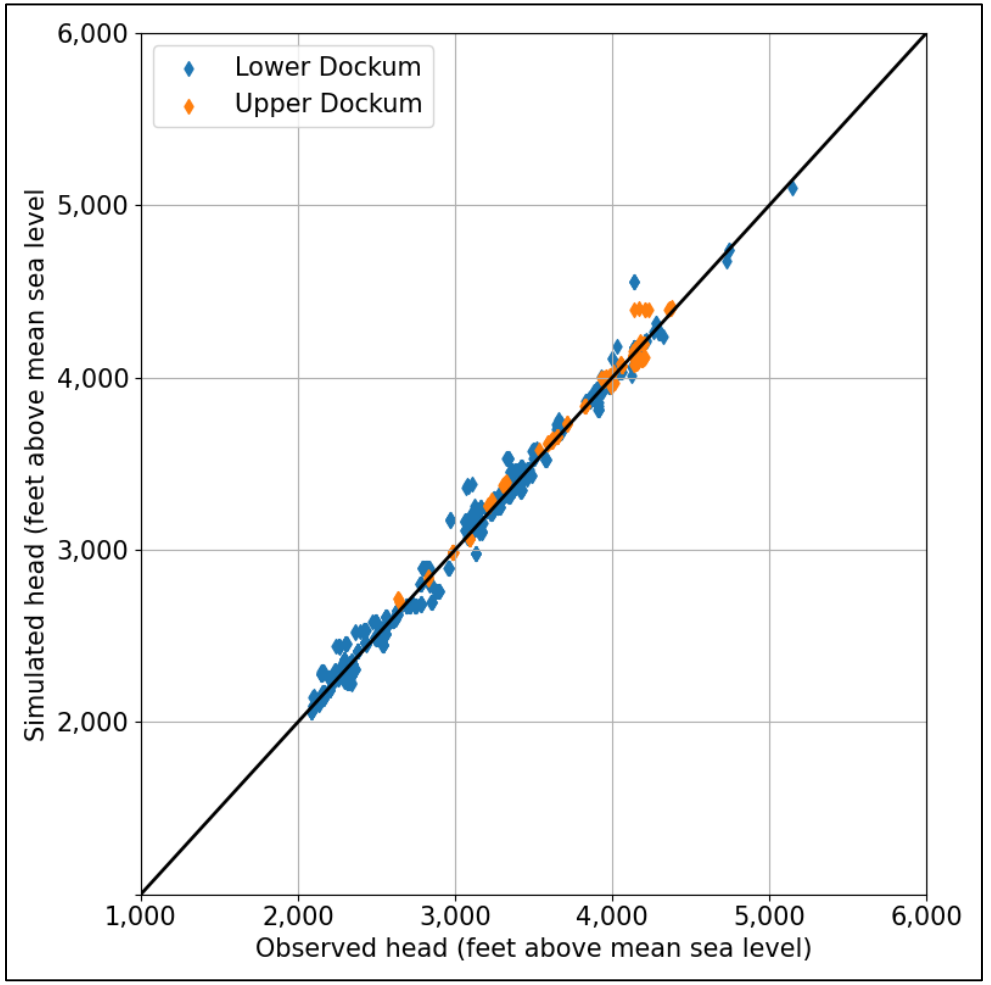
Rita Blanca (2013 – 2020)

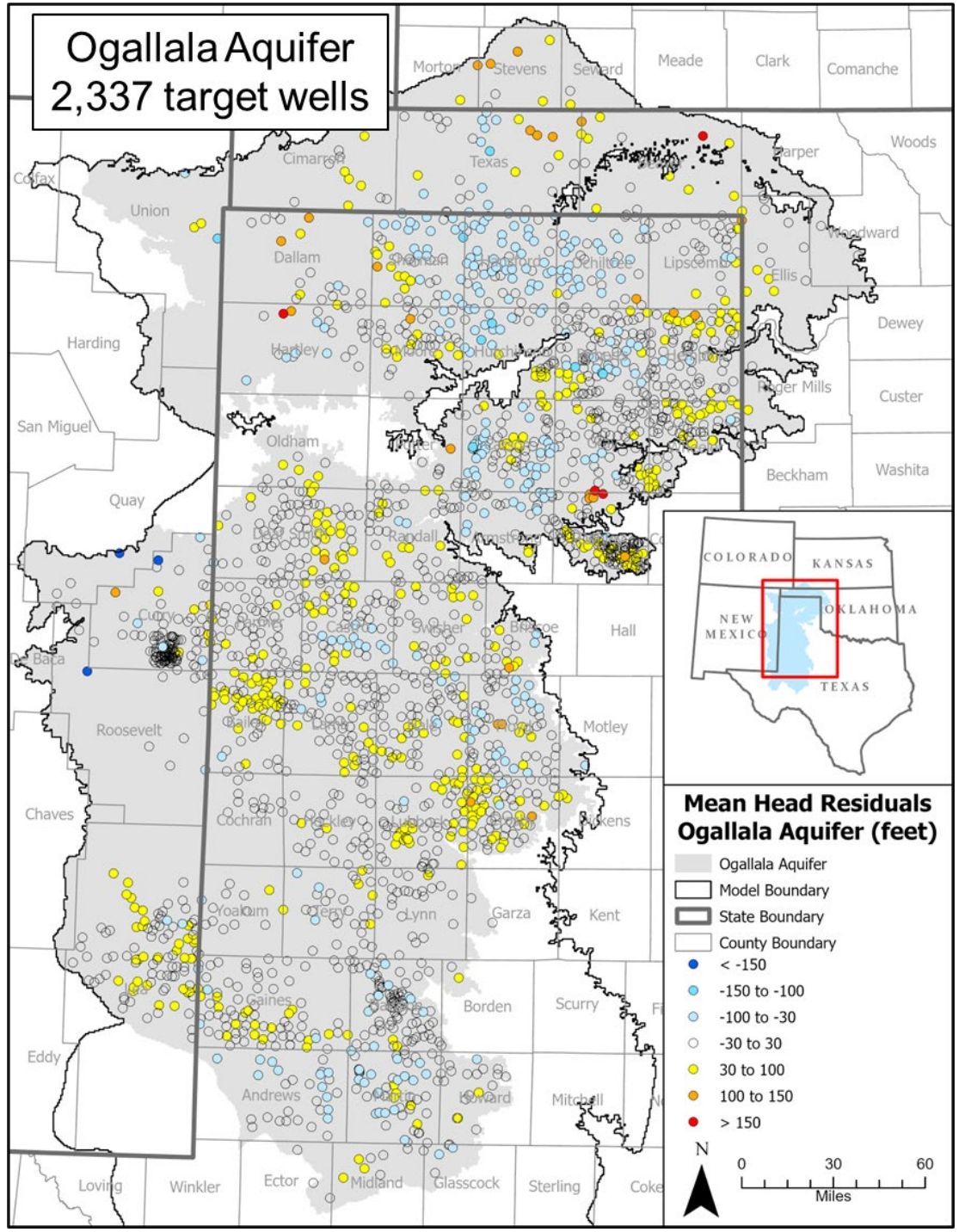


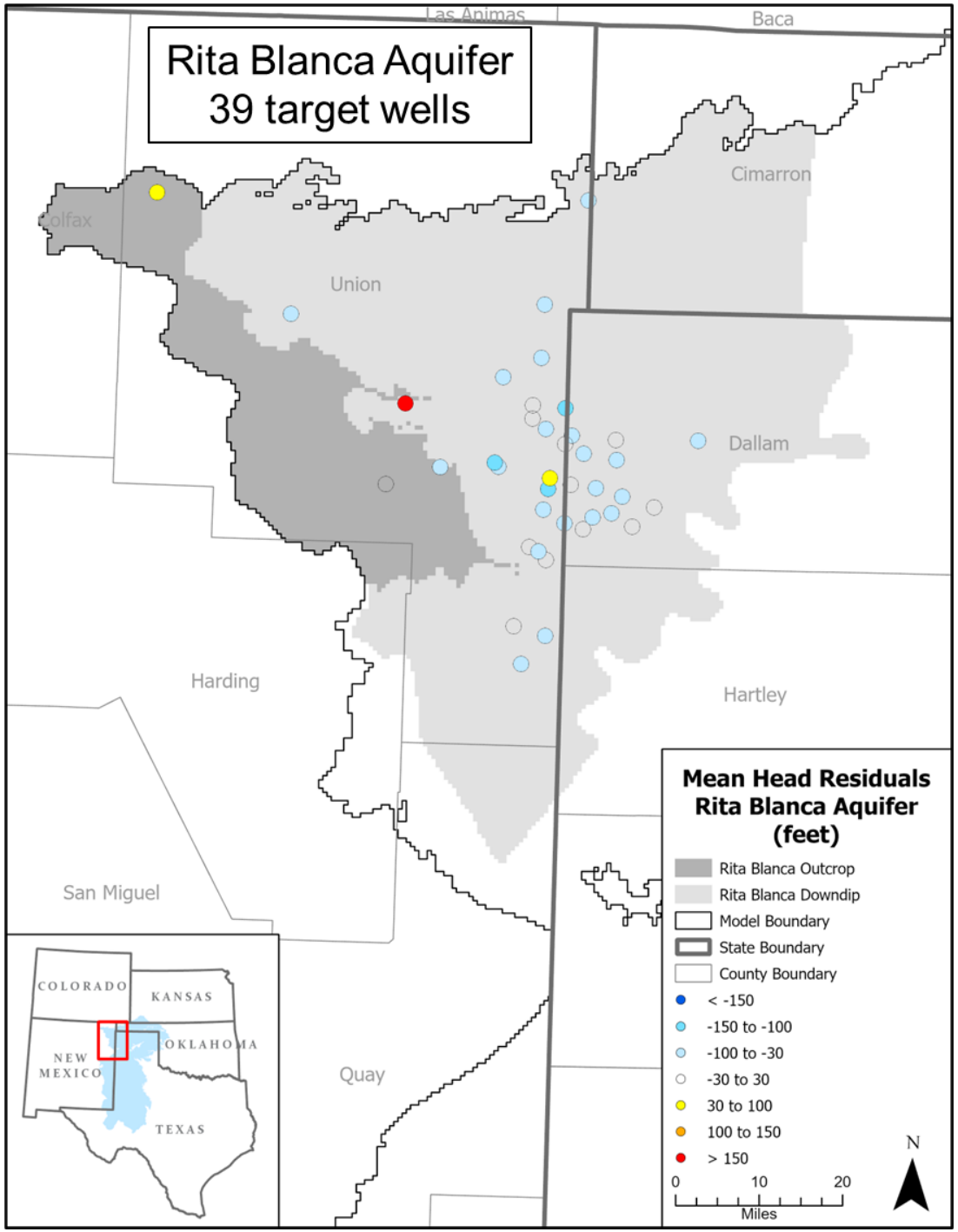
Edwards-Trinity (High Plains) (2013 – 2020)

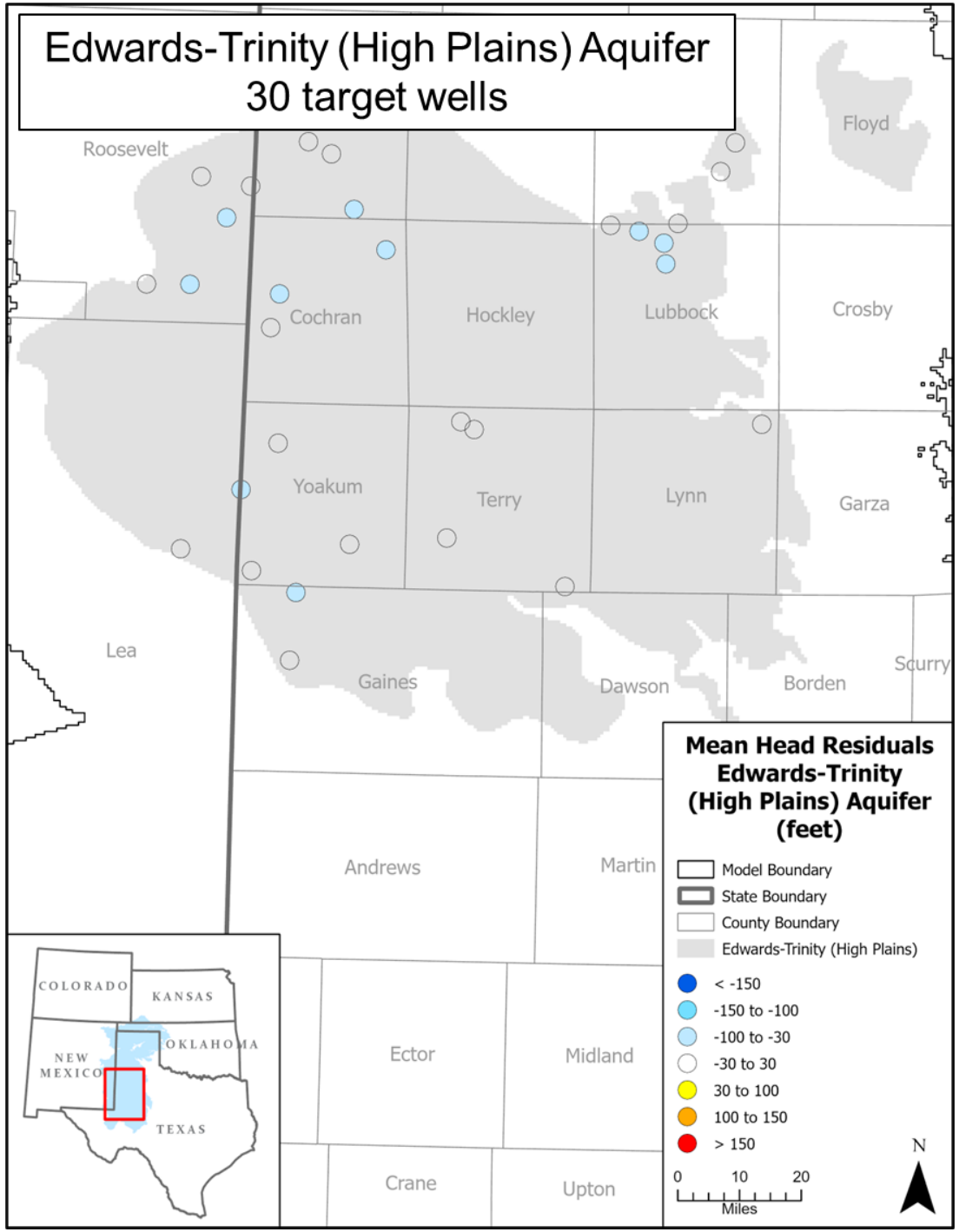


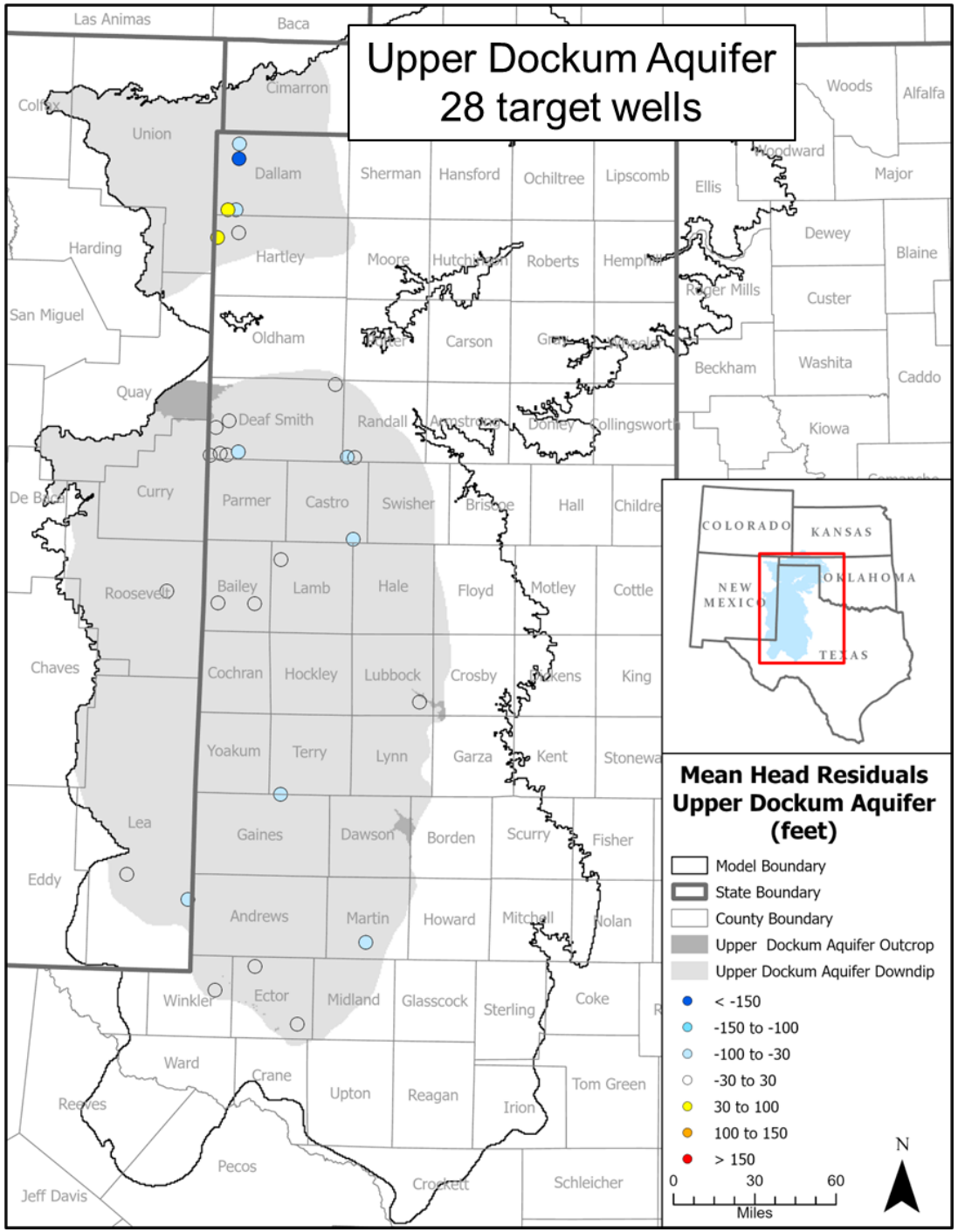
Dockum (2013 – 2020)

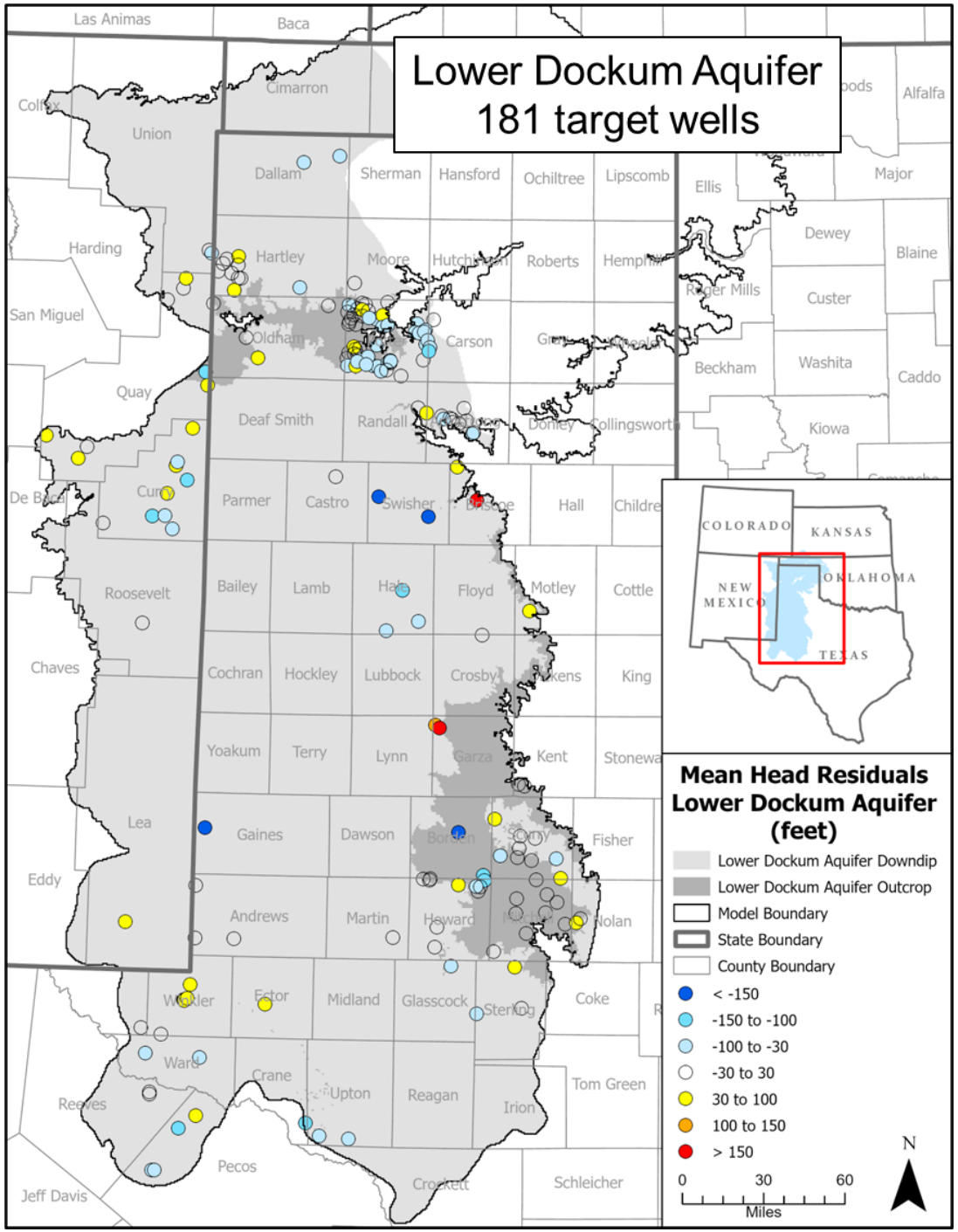


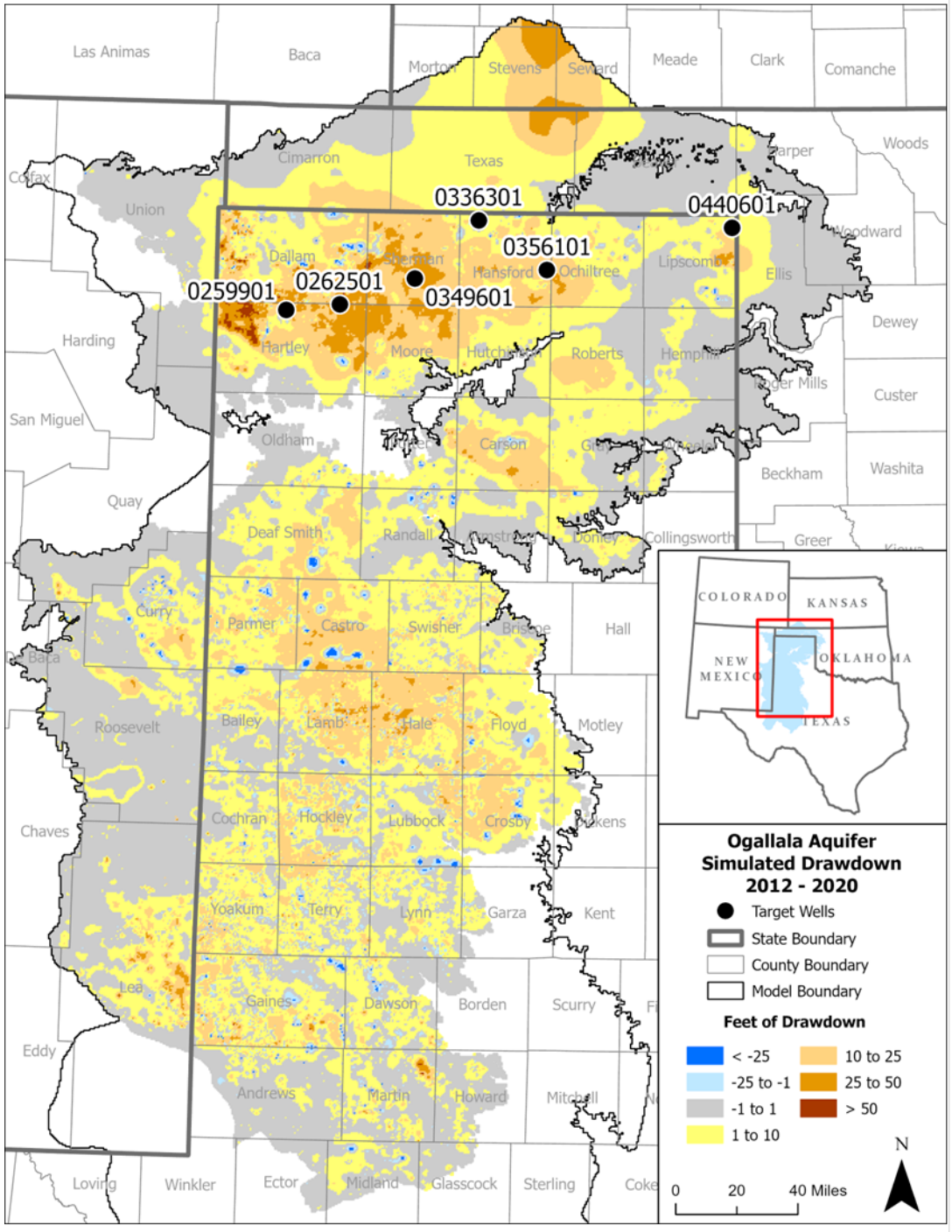

Ogallala Aquifer
2,337 target wells
Mean Head Residuals
Ogallala Aquifer (feet)
Ogallala Aquifer
Model Boundary
State Boundary
County Boundary
< -150
-150 to -100
-100 to -30
-30 to 30
30 to 100
100 to 150
> 150
N
0
30
60
Miles
COLORADO
KANSAS
NEW MEXICO
OKLAHOMA
TEXAS
Morton
Stevens
Seward
Meade
Clark
Comanche
Cimarron
Texas
Harper
Woods
Union
Dallam
Hartley
Oldham
Ellis
Woodward
Dewey
Harding
San Miguel
Quay
Roger Mills
Custer
Beckham
Washita
Hall
Motley
Roosevelt
Chaves
Cochran
Lynn
Garza
Kent
Borden
Scurry
Eddy
Andrews
Mitchell
Loving
Winkler
Ector
Midland
Glasscock
Sterling

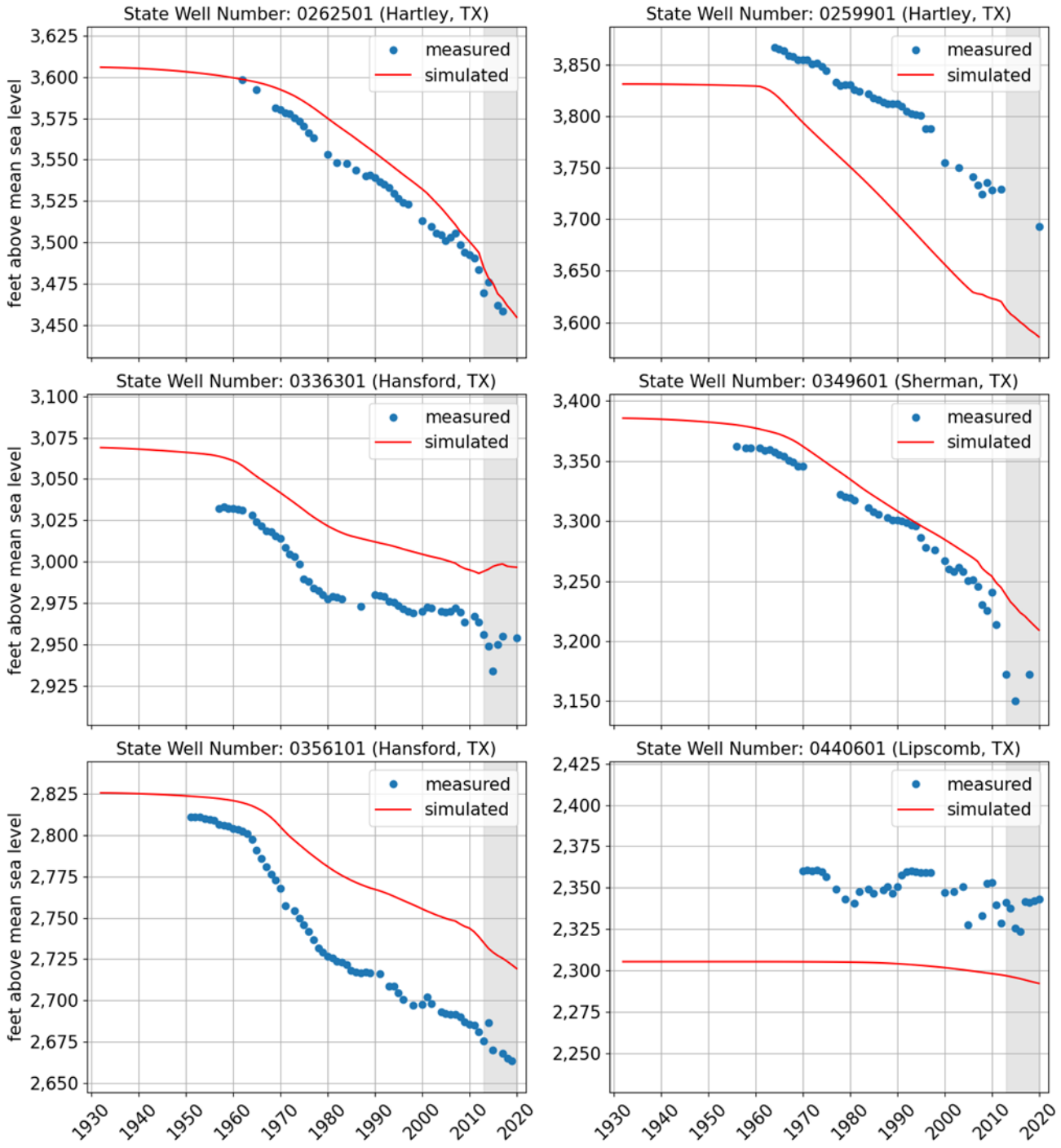

Rita Blanca Aquifer
39 target wells
Las Animas
Baca
Cimarron
Colfax
Union
Dallam
Harding
Hartley
San Miguel
Quay
Mean Head Residuals
Rita Blanca Aquifer
(feet)
Rita Blanca Outcrop
Rita Blanca Downdip
Model Boundary
State Boundary
County Boundary
< -150
-150 to -100
-100 to -30
-30 to 30
30 to 100
100 to 150
> 150
0
10
20
Miles
N
COLORADO
KANSAS
NEW MEXICO
OKLAHOMA
TEXAS

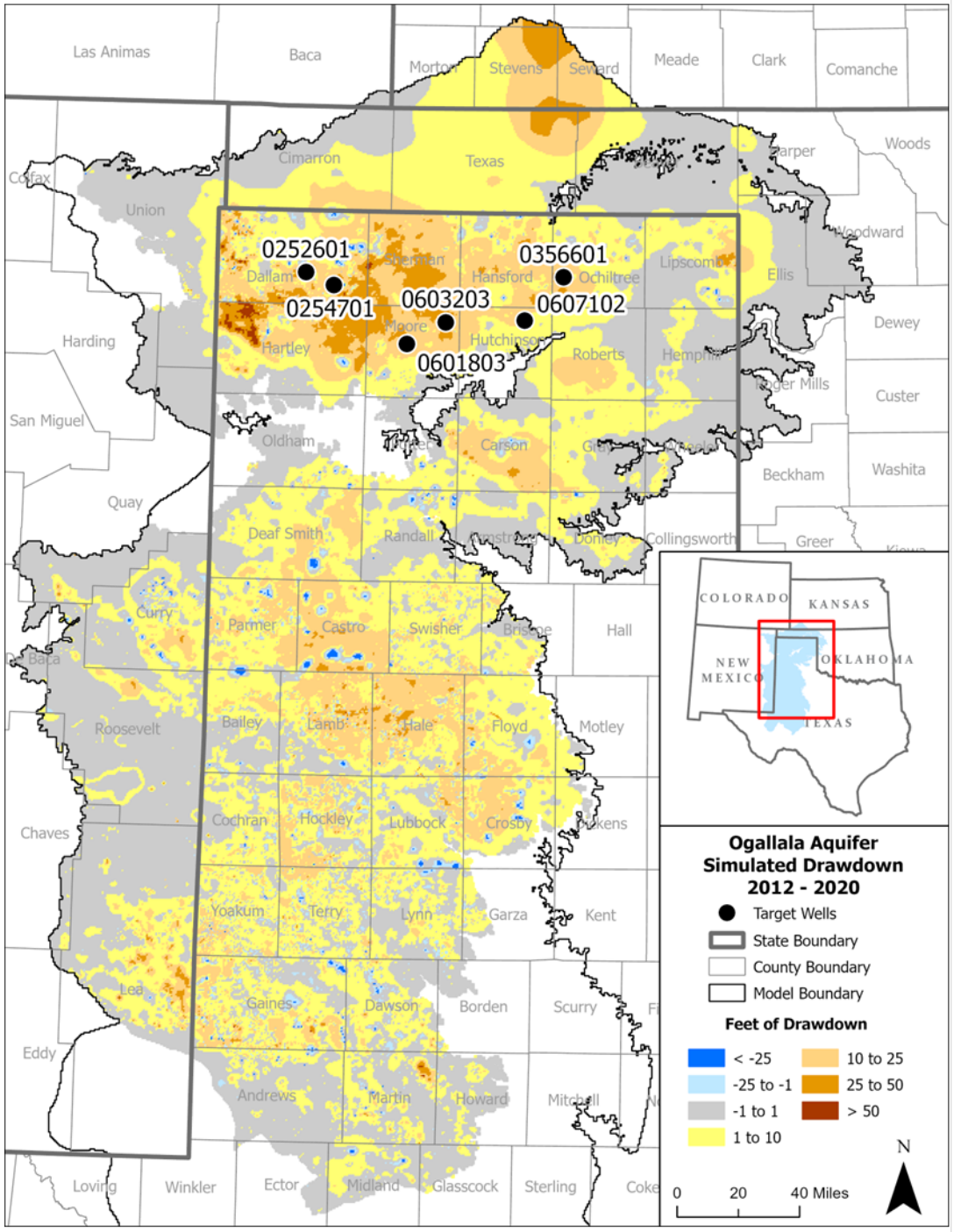

Edwards-Trinity (High Plains) Aquifer
30 target wells
Roosevelt
Floyd
Cochran
Hockley
Lubbock
Crosby
Yoakum
Terry
Lynn
Garza
Lea
Gaines
Dawson
Borden
Scurry
Andrews
Martin
Ector
Midland
Crane
Upton
Mean Head Residuals
Edwards-Trinity
(High Plains) Aquifer
(feet)
Model Boundary
State Boundary
County Boundary
Edwards-Trinity (High Plains)
< -150
-150 to -100
-100 to -30
-30 to 30
30 to 100
100 to 150
> 150
0
10
20
Miles
N
COLORADO
KANSAS
NEW MEXICO
OKLAHOMA
TEXAS

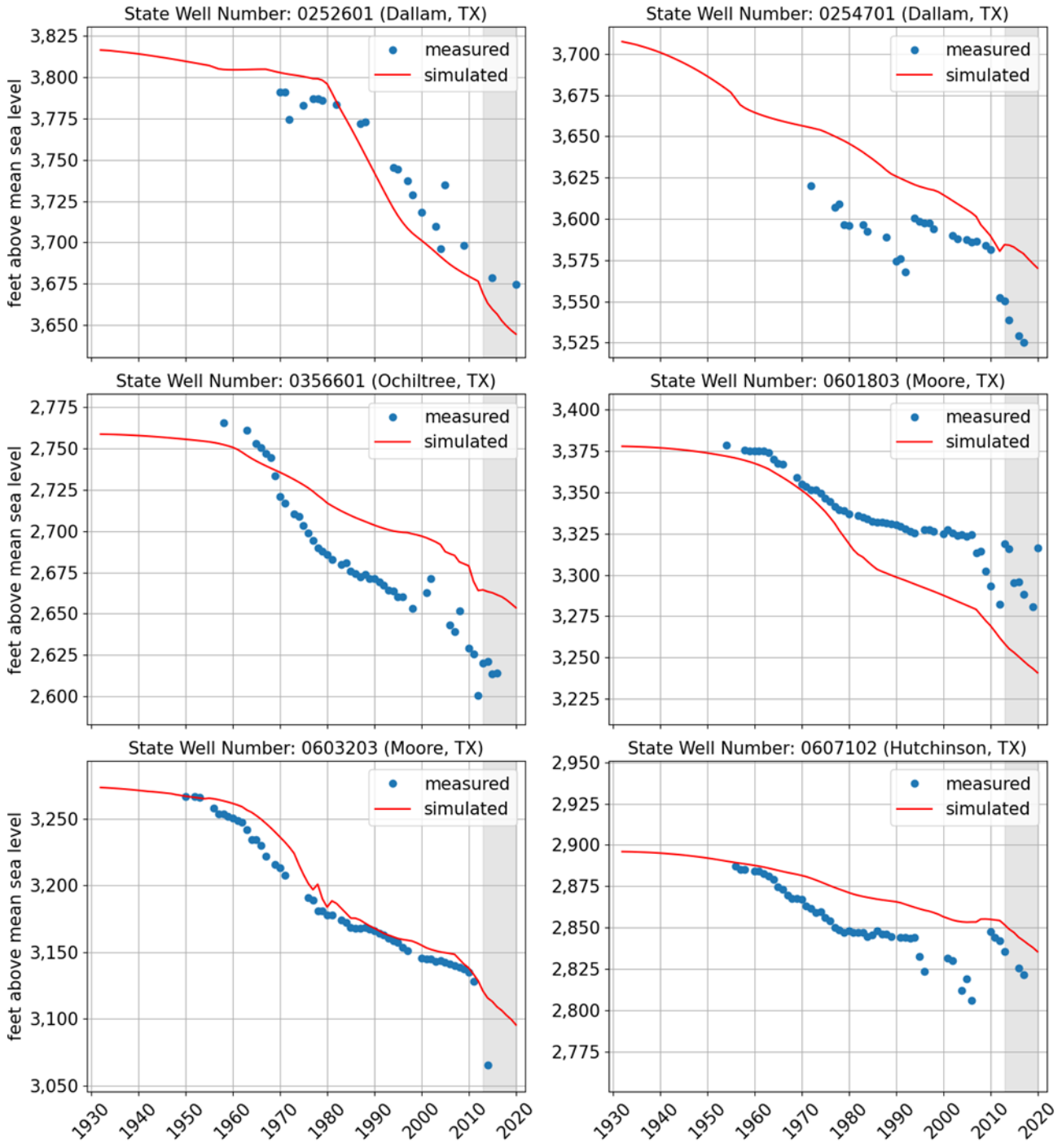

Upper Dockum Aquifer
28 target wells
Las Animas
Baca
Cimarron
Union
Dallam
Sherman
Hansford
Ochiltree
Lipscomb
Woods
Alfalfa
Ellis
Major
Harding
Hartley
Moore
Hutchinson
Roberts
Hemphill
Roger Mills
Dewey
Blaine
Custer
San Miguel
Oldham
Carson
Beckham
Washita
Caddo
Quay
Deaf Smith
Randall
Donley
Collingsworth
Kiowa
Curry
Parmer
Castro
Swisher
Hall
Roosevelt
Bailey
Lamb
Hale
Floyd
Motley
Cottle
Chaves
Cochran
Hockley
Lubbock
Crosby
King
Yoakum
Terry
Lynn
Garza
Kent
Stonewall
Lea
Gaines
Dawson
Borden
Scurry
Fisher
Eddy
Andrews
Martin
Howard
Mitchell
Nolan
Winkler
Ector
Midland
Glasscock
Sterling
Coke
Ward
Crane
Upton
Reagan
Irion
Tom Green
Reeves
Pecos
Crockett
Schleicher
Jeff Davis
COLORADO
KANSAS
OKLAHOMA
NEW MEXICO
TEXAS
Mean Head Residuals
Upper Dockum Aquifer
(feet)
Model Boundary
State Boundary
County Boundary
Upper Dockum Aquifer Outcrop
Upper Dockum Aquifer Downdip
< -150
-150 to -100
-100 to -30
-30 to 30
30 to 100
100 to 150
> 150
N
0
30
60
Miles

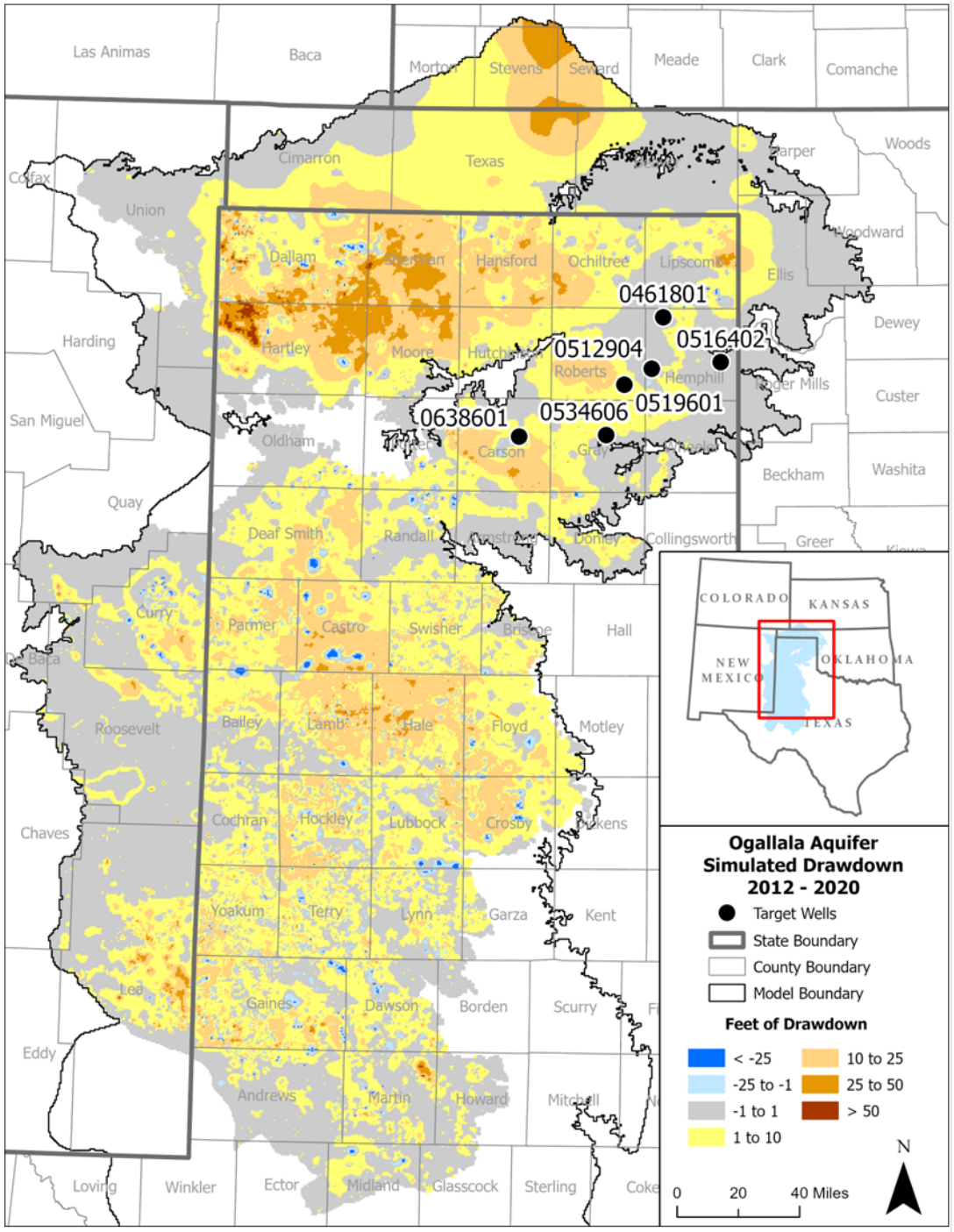

Lower Dockum Aquifer
181 target wells
Las Animas
Baca
Cimarron
Union
Dallam
Sherman
Hansford
Ochiltree
Lipscomb
Alfalfa
Ellis
Major
Harding
Hartley
Moore
Roberts
Dewey
Blaine
Custer
San Miguel
Oldham
Carson
Beckham
Washita
Caddo
Quay
Deaf Smith
Randall
Donley
Kiowa
Curry
Parmer
Castro
Swisher
Hall
Roosevelt
Bailey
Lamb
Floyd
Motley
Cottle
Chaves
Cochran
Hockley
Lubbock
Crosby
King
Yoakum
Terry
Lynn
Garza
Kent
Lea
Gaines
Dawson
Fisher
Eddy
Andrews
Martin
Howard
Nolan
Ector
Midland
Glasscock
Coke
Ward
Crane
Upton
Reagan
Irion
Tom Green
Reeves
Pecos
Crockett
Schleicher
Jeff Davis
COLORADO
KANSAS
OKLAHOMA
NEW MEXICO
TEXAS
Mean Head Residuals
Lower Dockum Aquifer
(feet)
Lower Dockum Aquifer Downdip
Lower Dockum Aquifer Outcrop
Model Boundary
State Boundary
County Boundary
< -150
-150 to -100
-100 to -30
-30 to 30
30 to 100
100 to 150
> 150
N
0
30
60
Miles

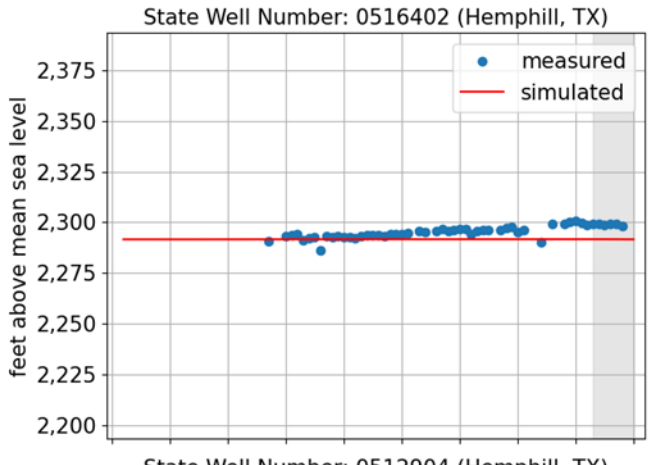

0336301
0440601
0356101
0259901
0262501
0349601
Texas
Las Animas
Baca
Morton
Stevens
Seward
Meade
Clark
Comanche
Cimarron
Harper
Woods
Union
Dallam
Sherman
Hansford
Ochiltree
Lipscomb
Woodward
Ellis
Harding
Hartley
Moore
Hutchinson
Roberts
Hemphill
Roger Mills
Dewey
Custer
San Miguel
Oldham
Carson
Beckham
Washita
Quay
Deaf Smith
Randall
Donley
Collingsworth
Greer
Curry
Parmer
Castro
Swisher
Hall
Roosevelt
Bailey
Lamb
Hale
Floyd
Motley
Chaves
Cochran
Hockley
Lubbock
Crosby
Yoakum
Terry
Lynn
Garza
Kent
Lea
Gaines
Dawson
Borden
Scurry
Eddy
Andrews
Martin
Howard
Mitchell
Loving
Winkler
Ector
Midland
Glasscock
Sterling
COLORADO
KANSAS
NEW MEXICO
OKLAHOMA
TEXAS
Ogallala Aquifer
Simulated Drawdown
2012 - 2020
Target Wells
State Boundary
County Boundary
Model Boundary
Feet of Drawdown
< -25
-25 to -1
-1 to 1
1 to 10
10 to 25
25 to 50
> 50
N
0
20
40 Miles

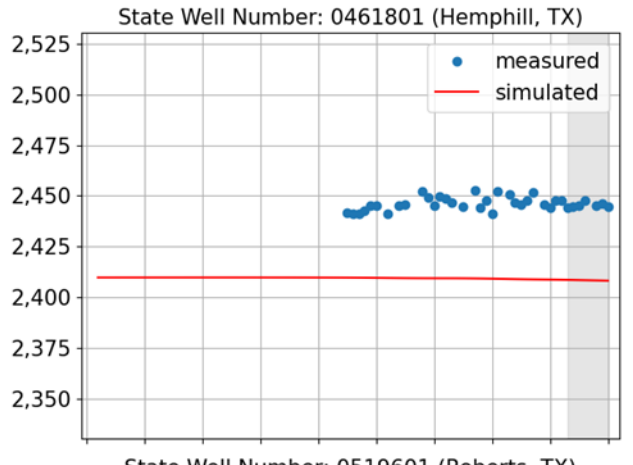

State Well Number: 0262501 (Hartley, TX)
State Well Number: 0259901 (Hartley, TX)
State Well Number: 0336301 (Hansford, TX)
State Well Number: 0349601 (Sherman, TX)
State Well Number: 0356101 (Hansford, TX)
State Well Number: 0440601 (Lipscomb, TX)
measured
simulated
feet above mean sea level
3,625
3,600
3,575
3,550
3,525
3,500
3,475
3,450
3,850
3,800
3,750
3,700
3,650
3,600
3,100
3,075
3,050
3,025
3,000
2,975
2,950
2,925
3,400
3,350
3,300
3,250
3,200
3,150
2,825
2,800
2,775
2,750
2,725
2,700
2,675
2,650
2,425
2,400
2,375
2,350
2,325
2,300
2,275
2,250
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020

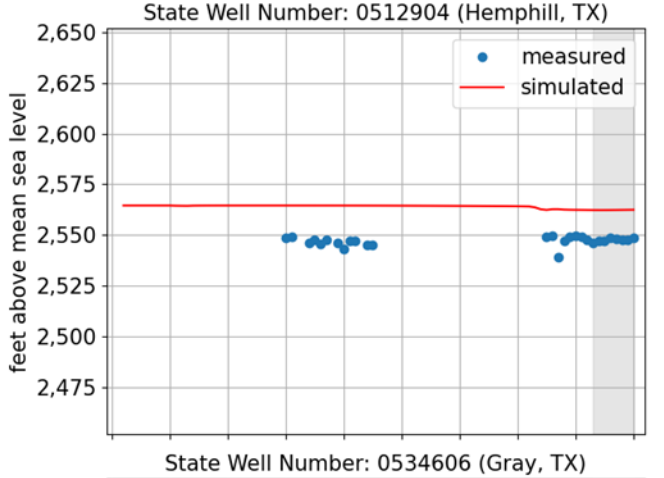

0252601
0254701
0356601
0603203
0607102
0601803
Las Animas
Baca
Morton
Stevens
Seward
Meade
Clark
Comanche
Cimarron
Texas
Woods
Union
Woodward
Dallam
Sherman
Hansford
Ochiltree
Lipscomb
Ellis
Harding
Moore
Hutchinson
Roberts
Hemphill
Dewey
Custer
Hartley
Oldham
Carson
Roger Mills
Washita
San Miguel
Beckham
Quay
Deaf Smith
Randall
Donley
Collingsworth
Greer
Curry
Parmer
Castro
Swisher
Hall
Roosevelt
Bailey
Lamb
Hale
Floyd
Motley
Chaves
Cochran
Hockley
Lubbock
Crosby
Kent
Yoakum
Terry
Lynn
Garza
Lea
Gaines
Dawson
Borden
Scurry
Eddy
Andrews
Martin
Howard
Mitchell
Loving
Winkler
Ector
Midland
Glasscock
Sterling
Coke
COLORADO
KANSAS
NEW MEXICO
OKLAHOMA
TEXAS
Ogallala Aquifer
Simulated Drawdown
2012 - 2020
Target Wells
State Boundary
County Boundary
Model Boundary
Feet of Drawdown
< -25
-25 to -1
-1 to 1
1 to 10
10 to 25
25 to 50
> 50
N
0
20
40 Miles

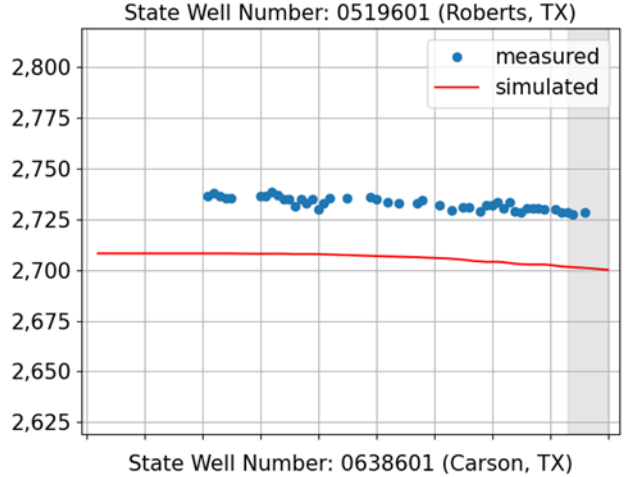

State Well Number: 0252601 (Dallam, TX)
State Well Number: 0254701 (Dallam, TX)
State Well Number: 0356601 (Ochiltree, TX)
State Well Number: 0601803 (Moore, TX)
State Well Number: 0603203 (Moore, TX)
State Well Number: 0607102 (Hutchinson, TX)
measured
simulated
feet above mean sea level
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020

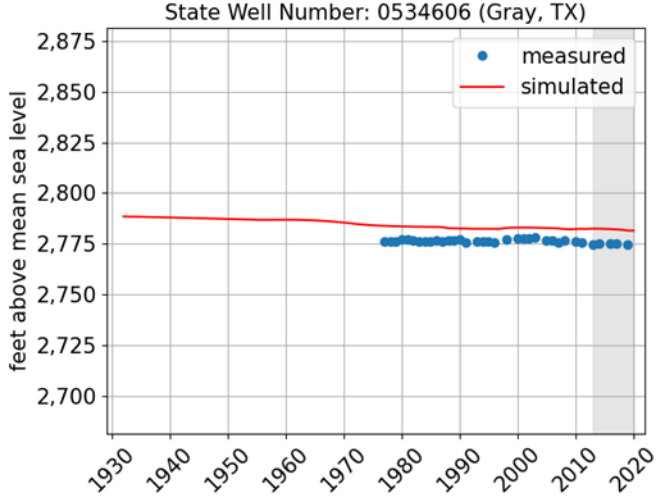

Las Animas
Baca
Morton
Stevens
Seward
Meade
Clark
Comanche
Cimarron
Texas
Harper
Woods
Union
Dallam
Sherman
Hansford
Ochiltree
Lipscomb
Ellis
Woodward
0461801
0516402
0512904
0519601
0534606
0638601
Harding
Hartley
Moore
Roberts
Hemphill
Roger Mills
Dewey
Custer
San Miguel
Oldham
Carson
Gray
Beckham
Washita
Quay
Deaf Smith
Randall
Donley
Collingsworth
Greer
Curry
Parmer
Castro
Swisher
Hall
Roosevelt
Bailey
Lamb
Hale
Floyd
Motley
Chaves
Cochran
Hockley
Lubbock
Crosby
Yoakum
Terry
Lynn
Garza
Kent
Lea
Gaines
Dawson
Borden
Scurry
Eddy
Andrews
Martin
Howard
Mitchell
Loving
Winkler
Ector
Midland
Glasscock
Sterling
Coke
COLORADO
KANSAS
NEW MEXICO
OKLAHOMA
TEXAS
Ogallala Aquifer
Simulated Drawdown
2012 - 2020
Target Wells
State Boundary
County Boundary
Model Boundary
Feet of Drawdown
< -25
-25 to -1
-1 to 1
1 to 10
10 to 25
25 to 50
> 50
N
0
20
40 Miles

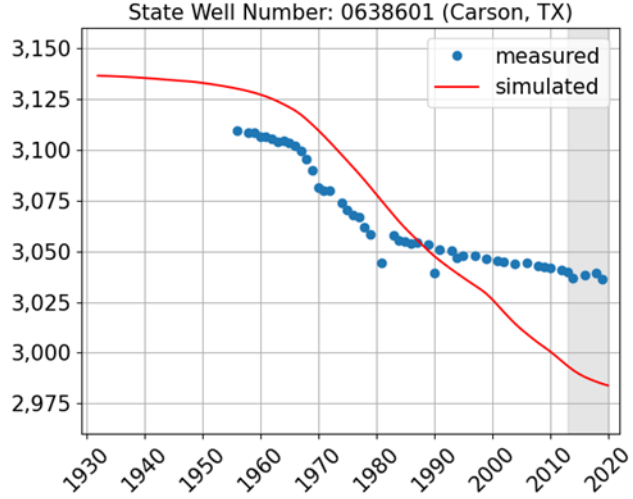

State Well Number: 0516402 (Hemphill, TX)
feet above mean sea level
measured
simulated

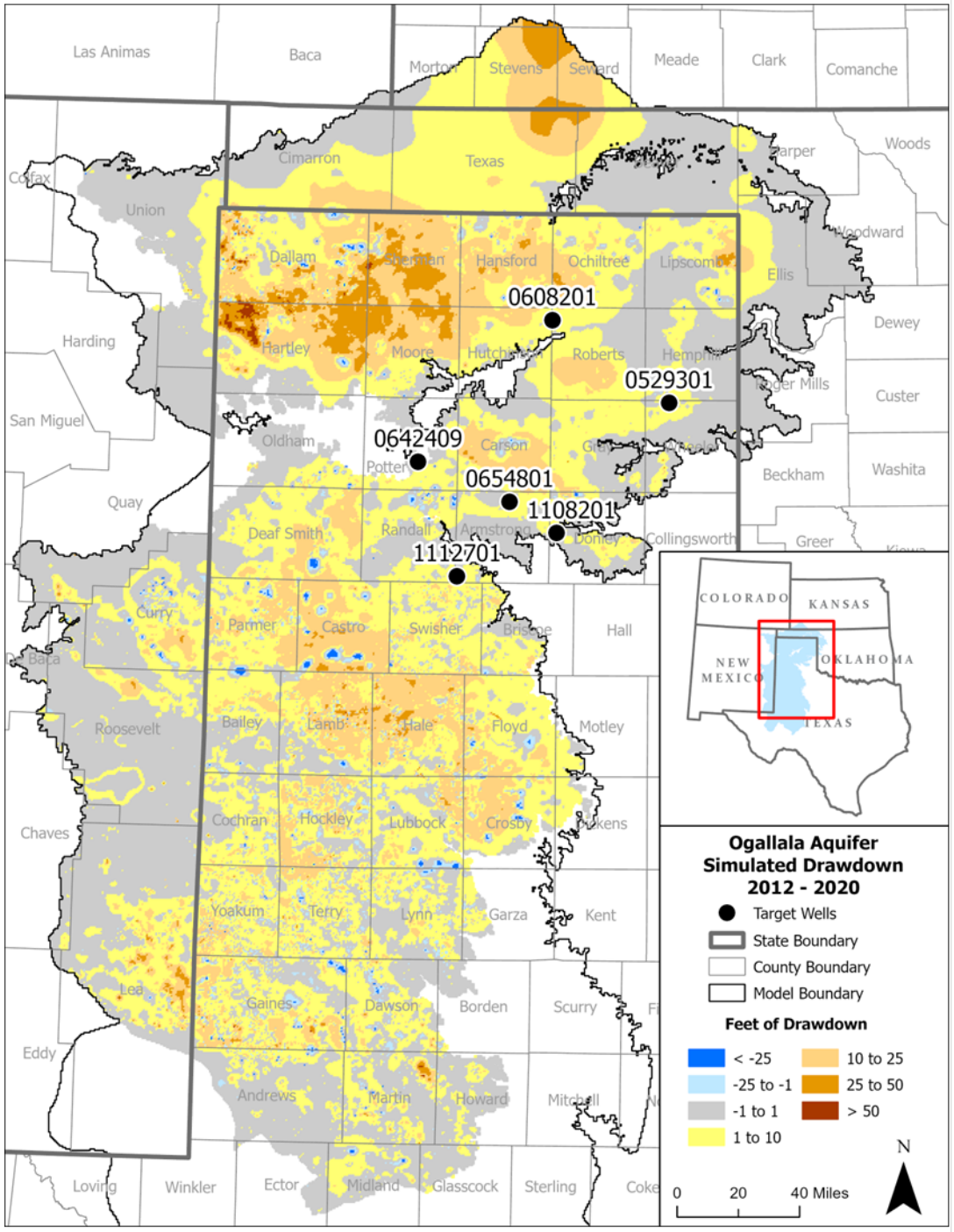

State Well Number: 0461801 (Hemphill, TX)
measured
simulated

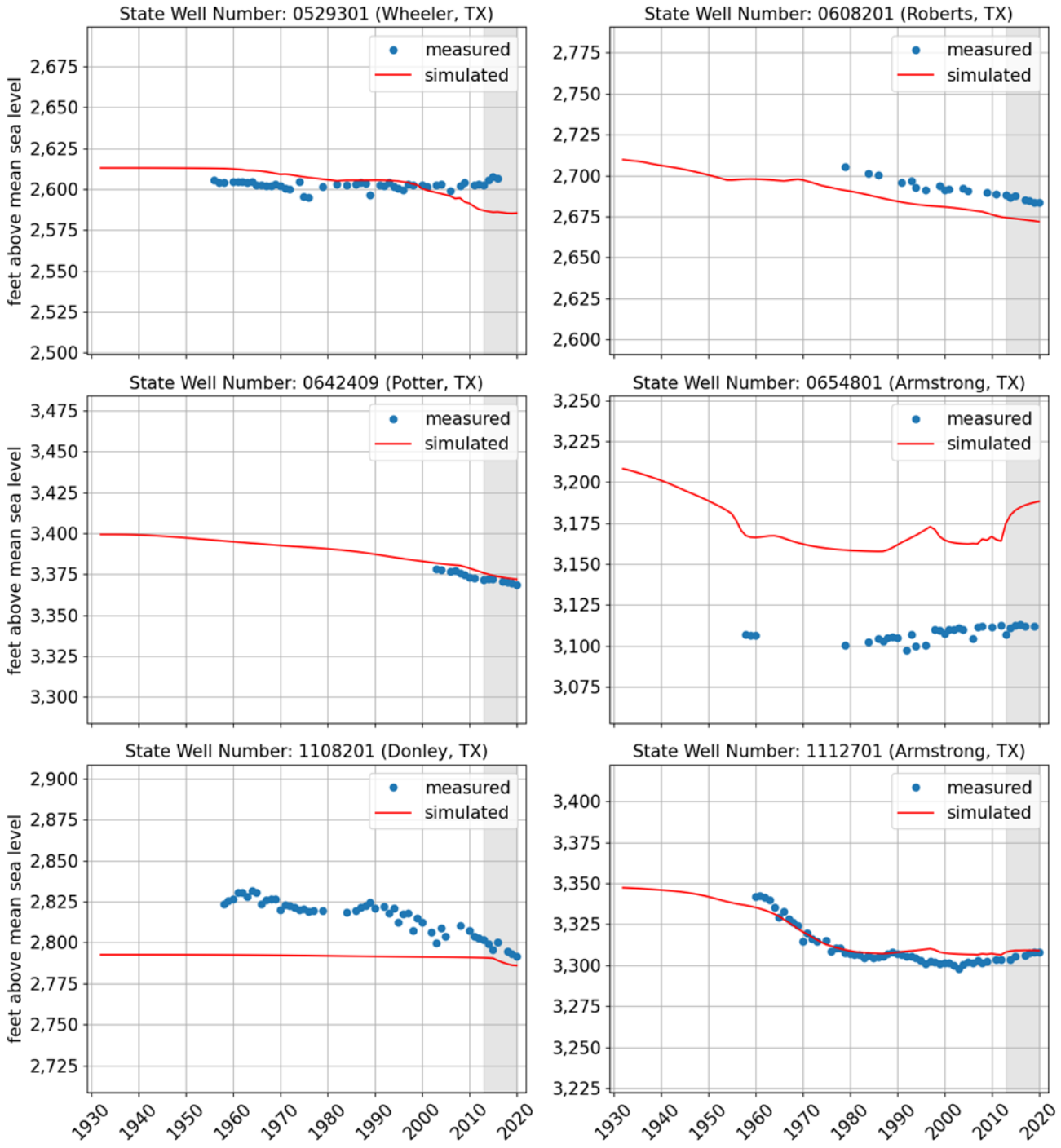

State Well Number: 0512904 (Hemphill, TX)
feet above mean sea level
measured
simulated

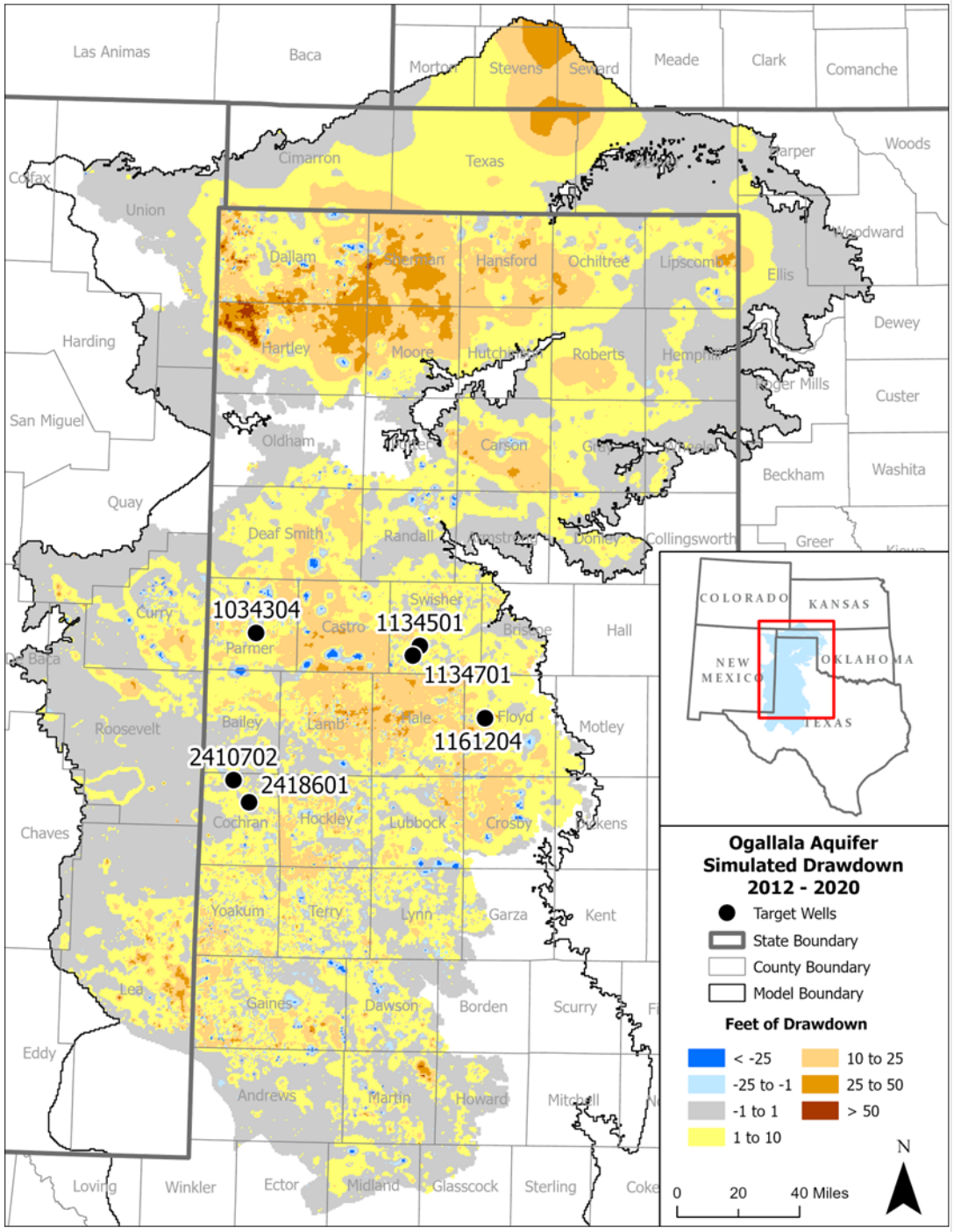

State Well Number: 0519601 (Roberts, TX)
measured
simulated

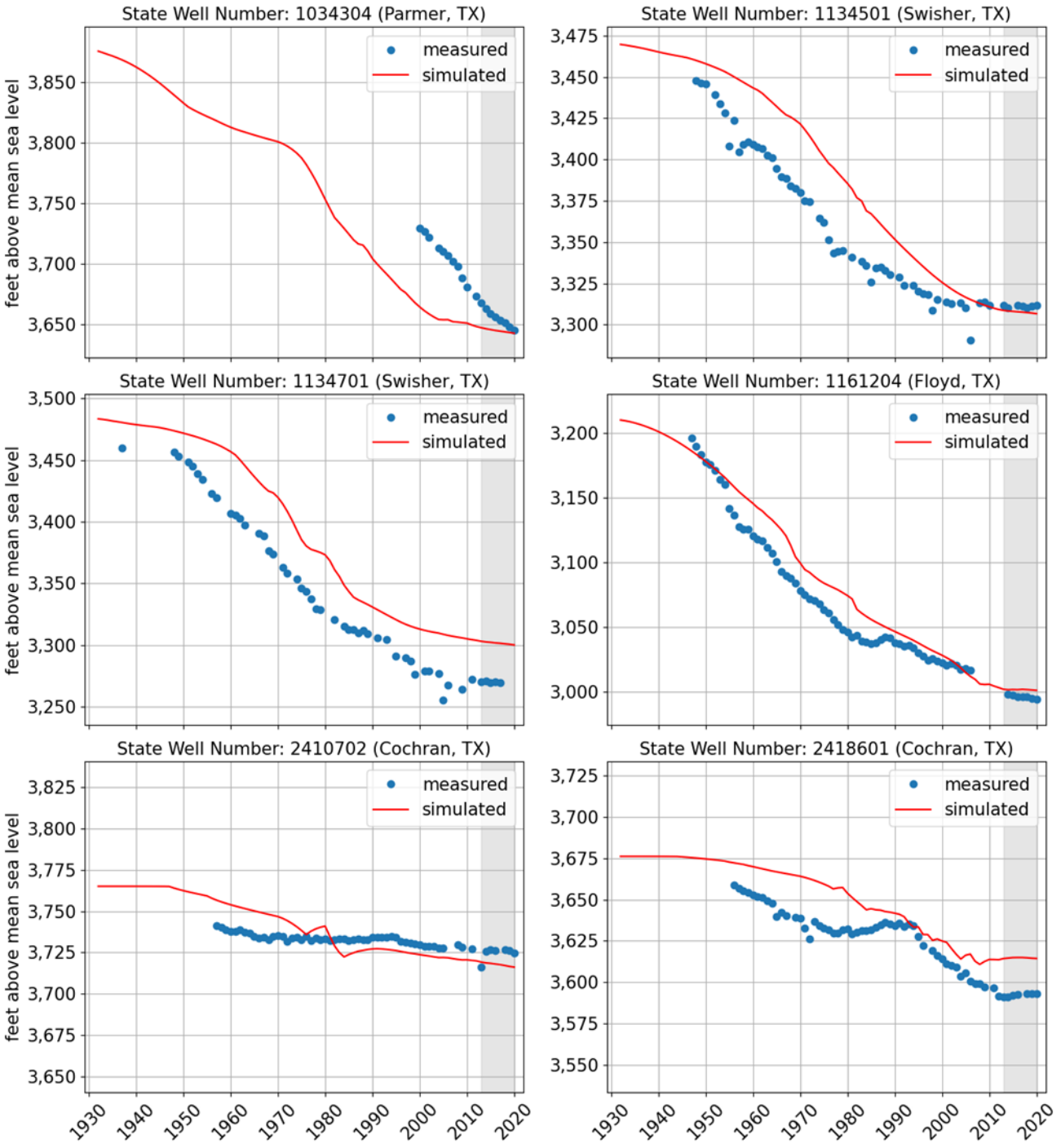

State Well Number: 0534606 (Gray, TX)
feet above mean sea level
measured
simulated
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020

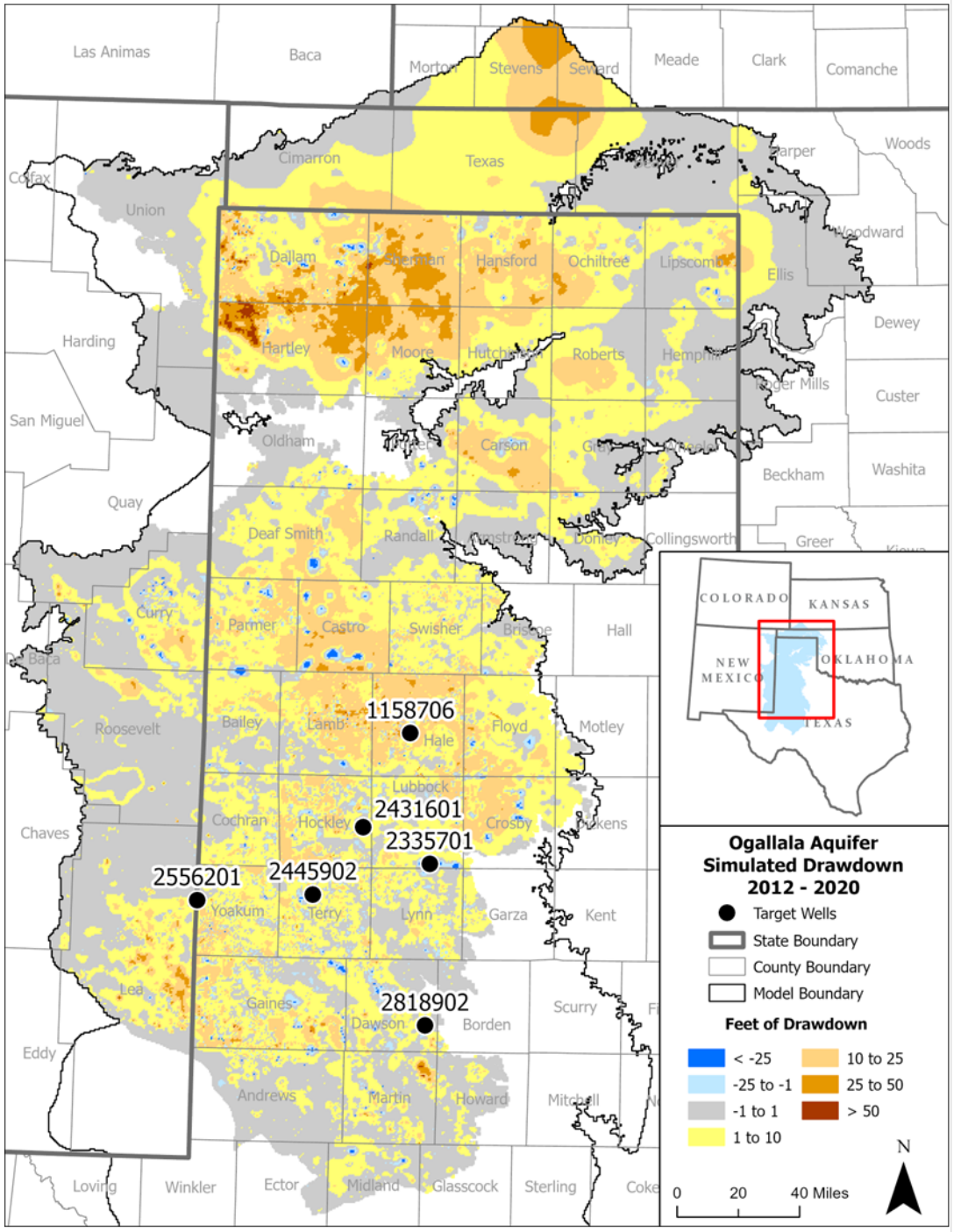

State Well Number: 0638601 (Carson, TX)
measured
simulated
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020

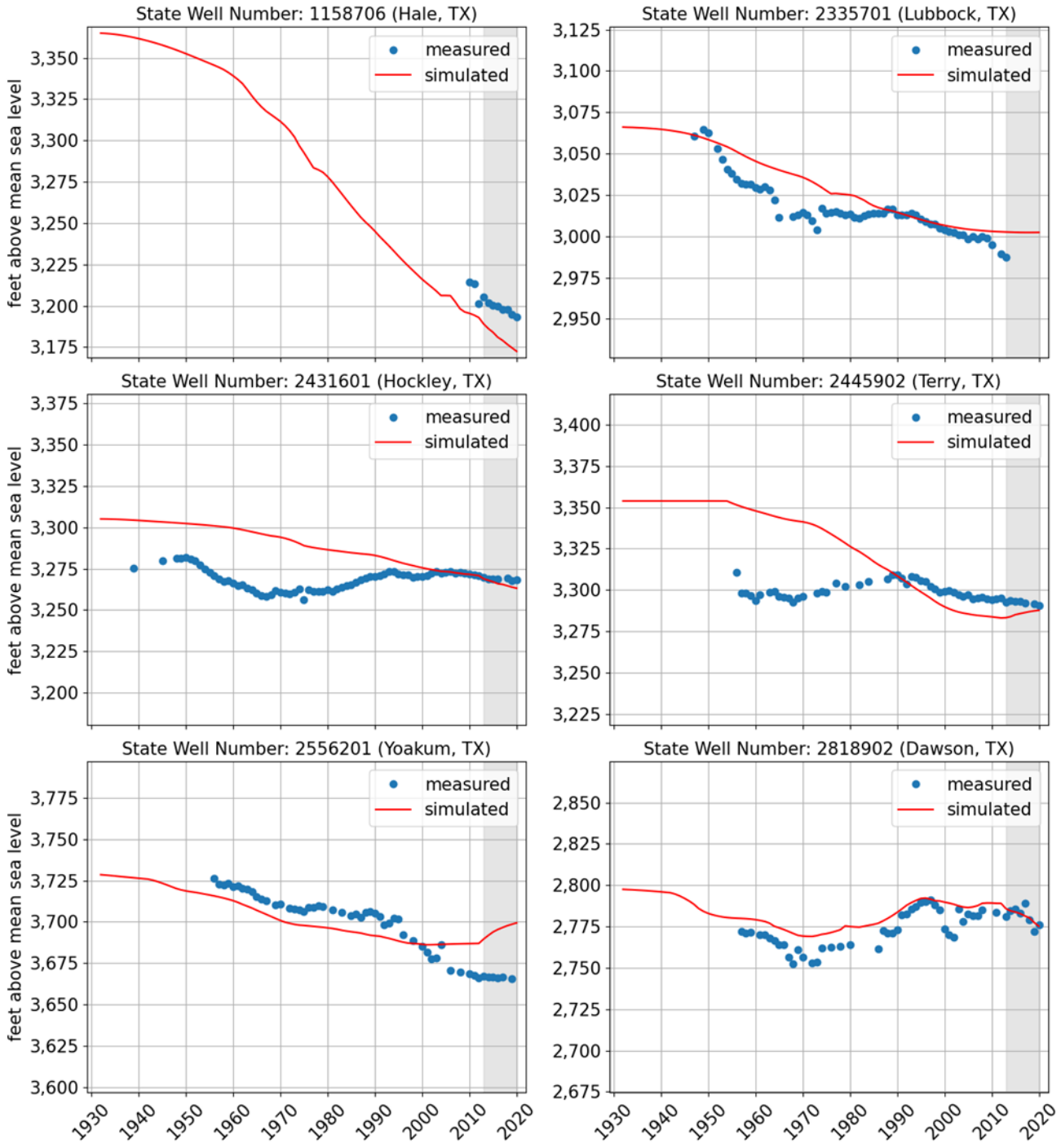

Las Animas
Baca
Morton
Stevens
Seward
Meade
Clark
Comanche
Cimarron
Texas
Woods
Union
Dallam
Sherman
Hansford
Ochiltree
Lipscomb
Ellis
Woodward
0608201
Harding
Hartley
Moore
Hutchinson
Roberts
Hemphill
Roger Mills
Dewey
Custer
0529301
San Miguel
Oldham
Carson
Potter
0642409
0654801
Beckham
Washita
Quay
Deaf Smith
Randall
Armstrong
Donley
Collingsworth
Greer
1108201
1112701
Curry
Parmer
Castro
Swisher
Briscoe
Hall
Roosevelt
Bailey
Lamb
Hale
Floyd
Motley
Chaves
Cochran
Hockley
Lubbock
Crosby
Dickens
Yoakum
Terry
Lynn
Garza
Kent
Lea
Gaines
Dawson
Borden
Scurry
Eddy
Andrews
Martin
Howard
Mitchell
Loving
Winkler
Ector
Midland
Glasscock
Sterling
Coke
COLORADO
KANSAS
NEW MEXICO
OKLAHOMA
TEXAS
Ogallala Aquifer
Simulated Drawdown
2012 - 2020
Target Wells
State Boundary
County Boundary
Model Boundary
Feet of Drawdown
< -25
-25 to -1
-1 to 1
1 to 10
10 to 25
25 to 50
> 50
N
0
20
40 Miles

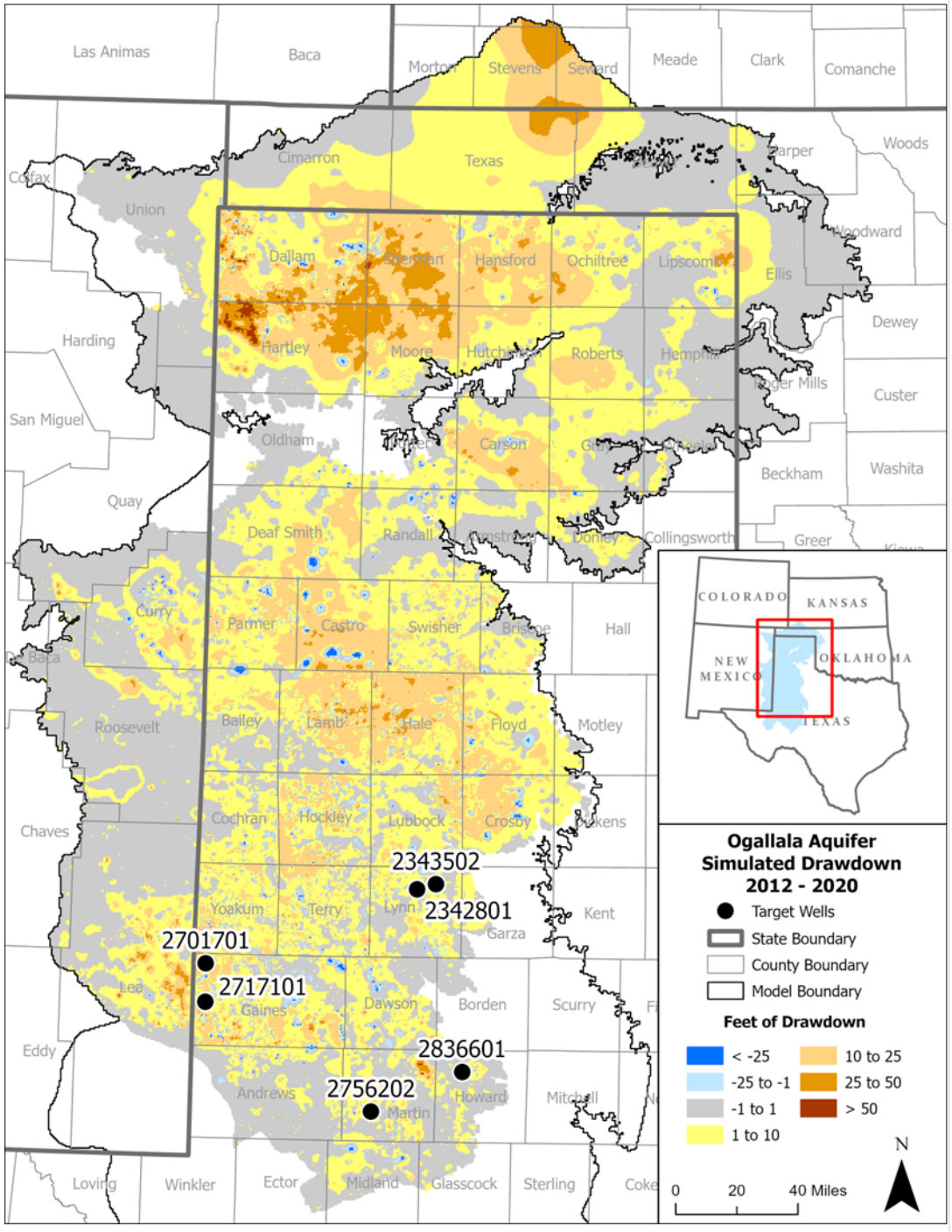

State Well Number: 0529301 (Wheeler, TX)
State Well Number: 0608201 (Roberts, TX)
State Well Number: 0642409 (Potter, TX)
State Well Number: 0654801 (Armstrong, TX)
State Well Number: 1108201 (Donley, TX)
State Well Number: 1112701 (Armstrong, TX)
measured
simulated
feet above mean sea level
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020

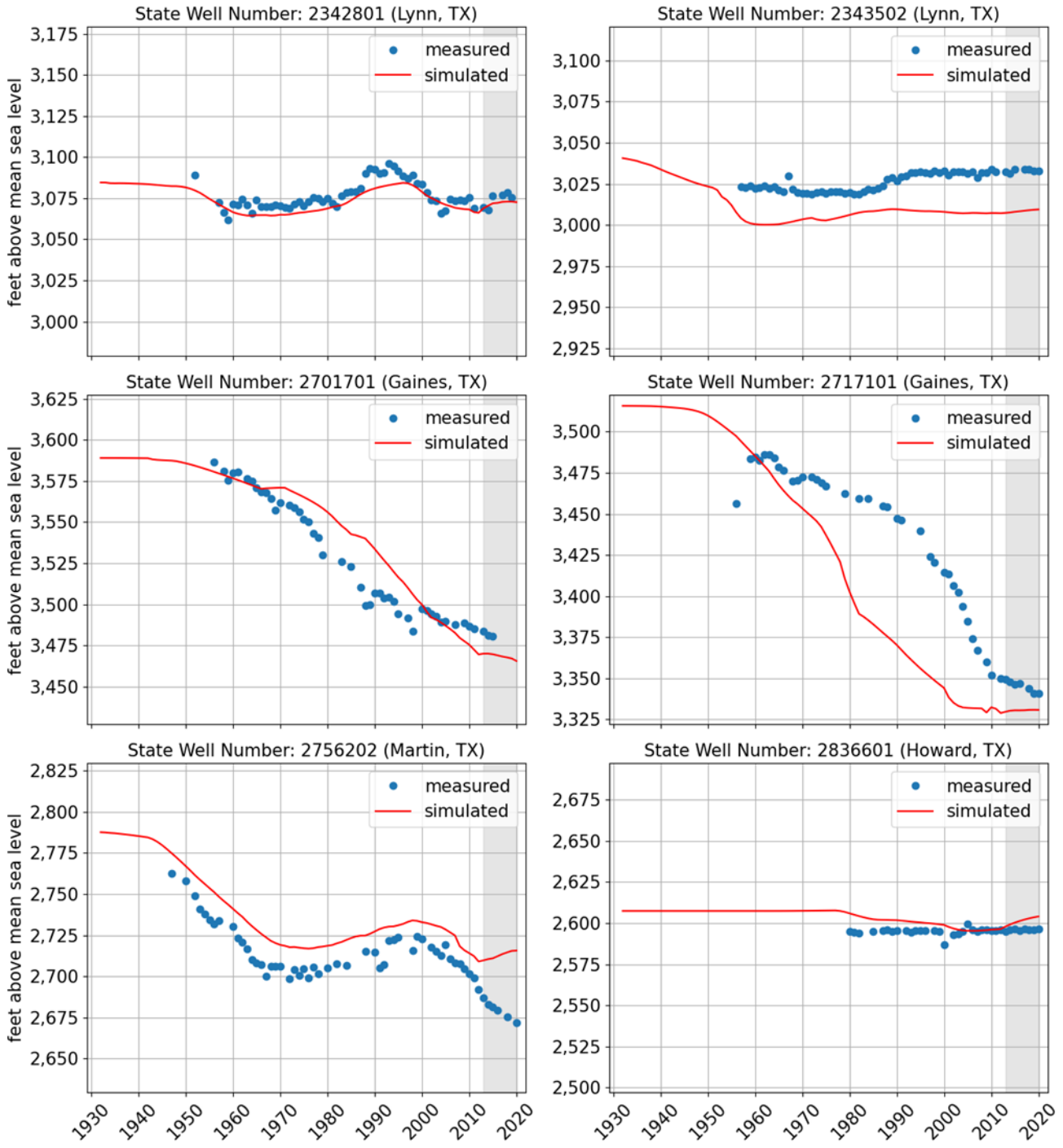

Las Animas
Baca
Morton
Stevens
Seward
Meade
Clark
Comanche
Cimarron
Texas
Woods
Cofax
Union
Dallam
Sherman
Hansford
Ochiltree
Lipscomb
Ellis
Woodward
Harding
Hartley
Moore
Hutchinson
Roberts
Hemphill
Roger Mills
Dewey
Custer
San Miguel
Oldham
Carson
Beckham
Washita
Quay
Deaf Smith
Randall
Donley
Collingsworth
Greer
Curry
Swisher
Castro
Briscoe
Hall
Parmer
1034304
1134501
1134701
Roosevelt
Bailey
Lamb
Hale
Floyd
1161204
Motley
2410702
2418601
Chaves
Cochran
Hockley
Lubbock
Crosby
Yoakum
Terry
Lynn
Garza
Kent
Lea
Gaines
Dawson
Borden
Scurry
Eddy
Andrews
Martin
Howard
Mitchell
Loving
Winkler
Ector
Midland
Glasscock
Sterling
Coke
COLORADO
KANSAS
NEW MEXICO
OKLAHOMA
TEXAS
Ogallala Aquifer
Simulated Drawdown
2012 - 2020
Target Wells
State Boundary
County Boundary
Model Boundary
Feet of Drawdown
< -25
-25 to -1
-1 to 1
1 to 10
10 to 25
25 to 50
> 50
N
0
20
40 Miles

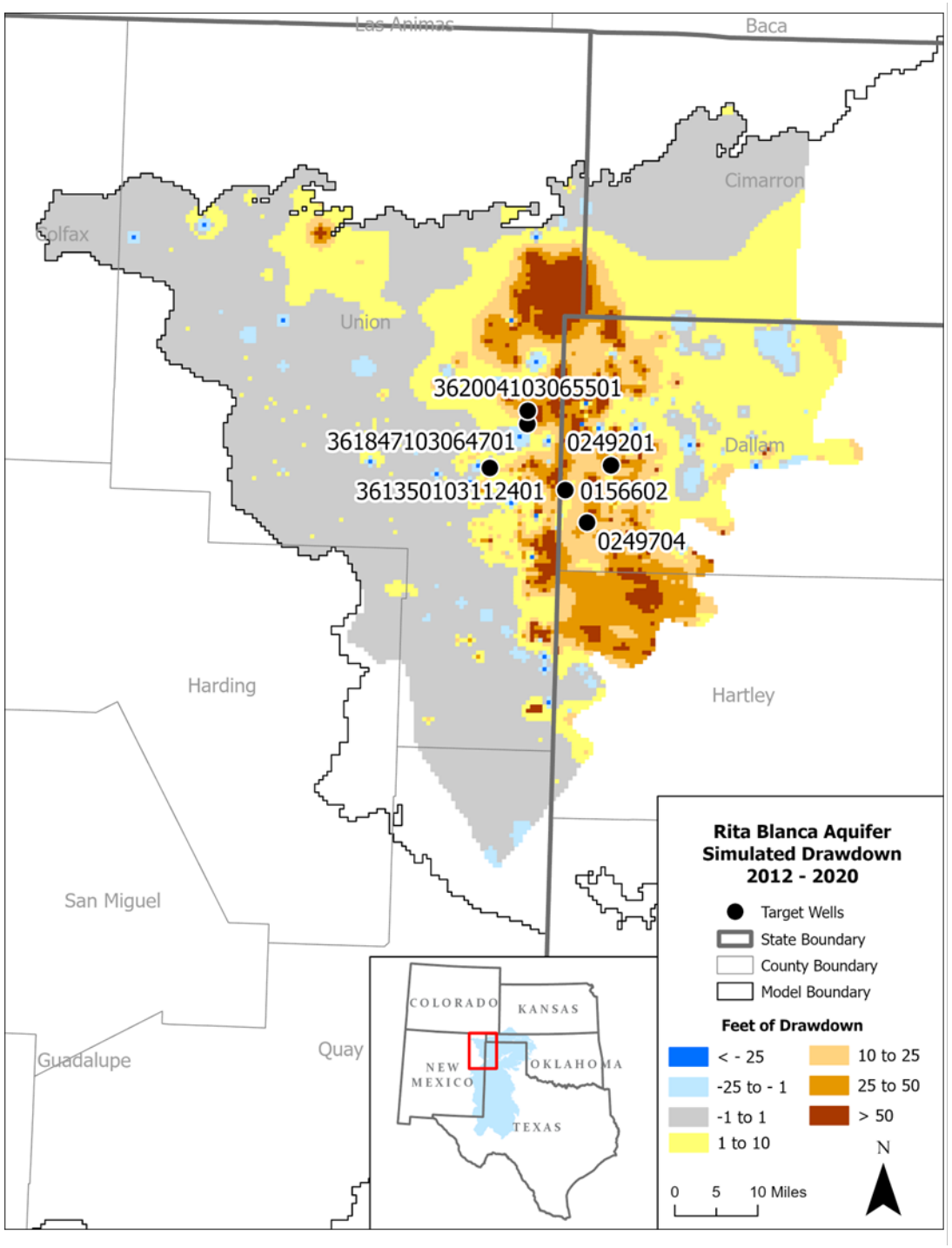

State Well Number: 1034304 (Parmer, TX)
State Well Number: 1134501 (Swisher, TX)
State Well Number: 1134701 (Swisher, TX)
State Well Number: 1161204 (Floyd, TX)
State Well Number: 2410702 (Cochran, TX)
State Well Number: 2418601 (Cochran, TX)
measured
simulated
feet above mean sea level
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020

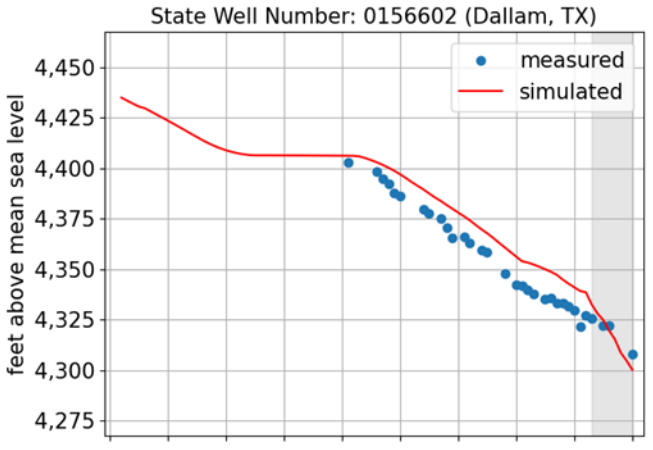

Las Animas
Baca
Morton
Stevens
Seward
Meade
Clark
Comanche
Cimarron
Texas
Woods
Harper
Union
Dallam
Sherman
Hansford
Ochiltree
Lipscomb
Ellis
Woodward
Harding
Hartley
Moore
Hutchinson
Roberts
Hemphill
Roger Mills
Dewey
Custer
San Miguel
Oldham
Carson
Gray
Beckham
Washita
Quay
Deaf Smith
Randall
Armstrong
Donley
Collingsworth
Greer
Curry
Parmer
Castro
Swisher
Briscoe
Hall
Roosevelt
Bailey
Lamb
Floyd
Motley
1158706
Hale
Lubbock
Cochran
Hockley
2431601
Crosby
Dickens
Chaves
2335701
2556201
2445902
Yoakum
Terry
Lynn
Garza
Kent
Lea
Gaines
2818902
Dawson
Borden
Scurry
Eddy
Andrews
Martin
Howard
Mitchell
Loving
Winkler
Ector
Midland
Glasscock
Sterling
Coke
COLORADO
KANSAS
NEW MEXICO
OKLAHOMA
TEXAS
Ogallala Aquifer
Simulated Drawdown
2012 - 2020
Target Wells
State Boundary
County Boundary
Model Boundary
Feet of Drawdown
< -25
-25 to -1
-1 to 1
1 to 10
10 to 25
25 to 50
> 50
N
0
20
40 Miles

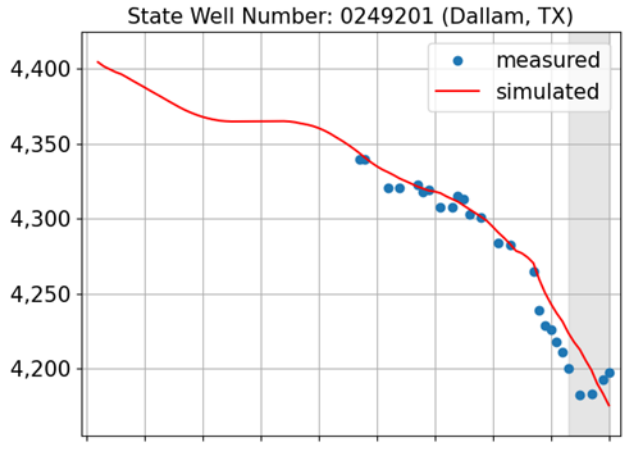

State Well Number: 1158706 (Hale, TX)
State Well Number: 2335701 (Lubbock, TX)
State Well Number: 2431601 (Hockley, TX)
State Well Number: 2445902 (Terry, TX)
State Well Number: 2556201 (Yoakum, TX)
State Well Number: 2818902 (Dawson, TX)
measured
simulated
feet above mean sea level
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020

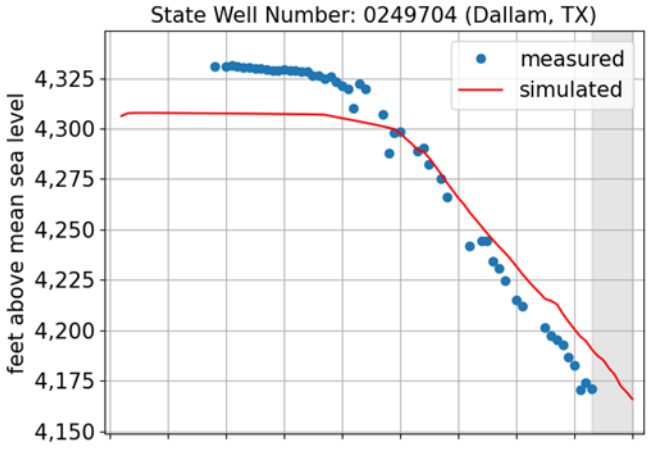

Las Animas
Baca
Morton
Stevens
Seward
Meade
Clark
Comanche
Cimarron
Texas
Woods
Harper
Union
Dallam
Sherman
Hansford
Ochiltree
Lipscomb
Ellis
Woodward
Harding
Hartley
Moore
Hutchinson
Roberts
Hemphill
Roger Mills
Dewey
Custer
San Miguel
Oldham
Carson
Beckham
Washita
Quay
Deaf Smith
Randall
Donley
Collingsworth
Greer
Curry
Parmer
Castro
Swisher
Hall
Roosevelt
Bailey
Lamb
Hale
Floyd
Motley
Chaves
Cochran
Hockley
Lubbock
Crosby
Kent
Yoakum
Terry
Lynn
Garza
Lea
Gaines
Dawson
Borden
Scurry
Eddy
Andrews
Martin
Howard
Mitchell
Loving
Winkler
Ector
Midland
Glasscock
Sterling
Coke
2343502
2342801
2701701
2717101
2836601
2756202
COLORADO
KANSAS
NEW MEXICO
OKLAHOMA
TEXAS
Ogallala Aquifer
Simulated Drawdown
2012 - 2020
Target Wells
State Boundary
County Boundary
Model Boundary
Feet of Drawdown
< -25
-25 to -1
-1 to 1
1 to 10
10 to 25
25 to 50
> 50
N
0
20
40 Miles

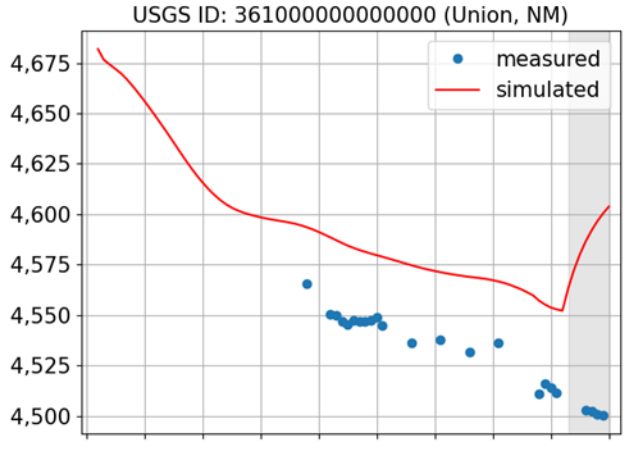

State Well Number: 2342801 (Lynn, TX)
State Well Number: 2343502 (Lynn, TX)
State Well Number: 2701701 (Gaines, TX)
State Well Number: 2717101 (Gaines, TX)
State Well Number: 2756202 (Martin, TX)
State Well Number: 2836601 (Howard, TX)
measured
simulated
feet above mean sea level
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020

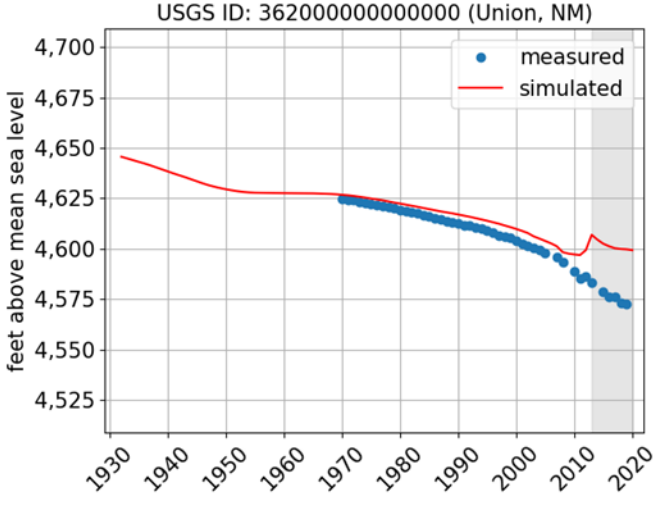

Las Animas
Baca
Cimarron
Colfax
Union
Dallam
Harding
Hartley
San Miguel
Guadalupe
Quay
362004103065501
361847103064701
0249201
361350103112401
0156602
0249704
Rita Blanca Aquifer
Simulated Drawdown
2012 - 2020
Target Wells
State Boundary
County Boundary
Model Boundary
Feet of Drawdown
< - 25
-25 to - 1
-1 to 1
1 to 10
10 to 25
25 to 50
> 50
N
0 5 10 Miles
COLORADO
KANSAS
NEW MEXICO
OKLAHOMA
TEXAS

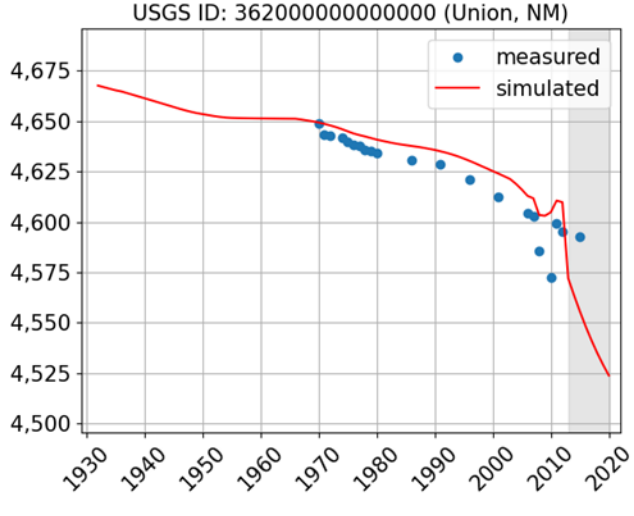

State Well Number: 0156602 (Dallam, TX)
measured
simulated
feet above mean sea level
4,450
4,425
4,400
4,375
4,350
4,325
4,300
4,275

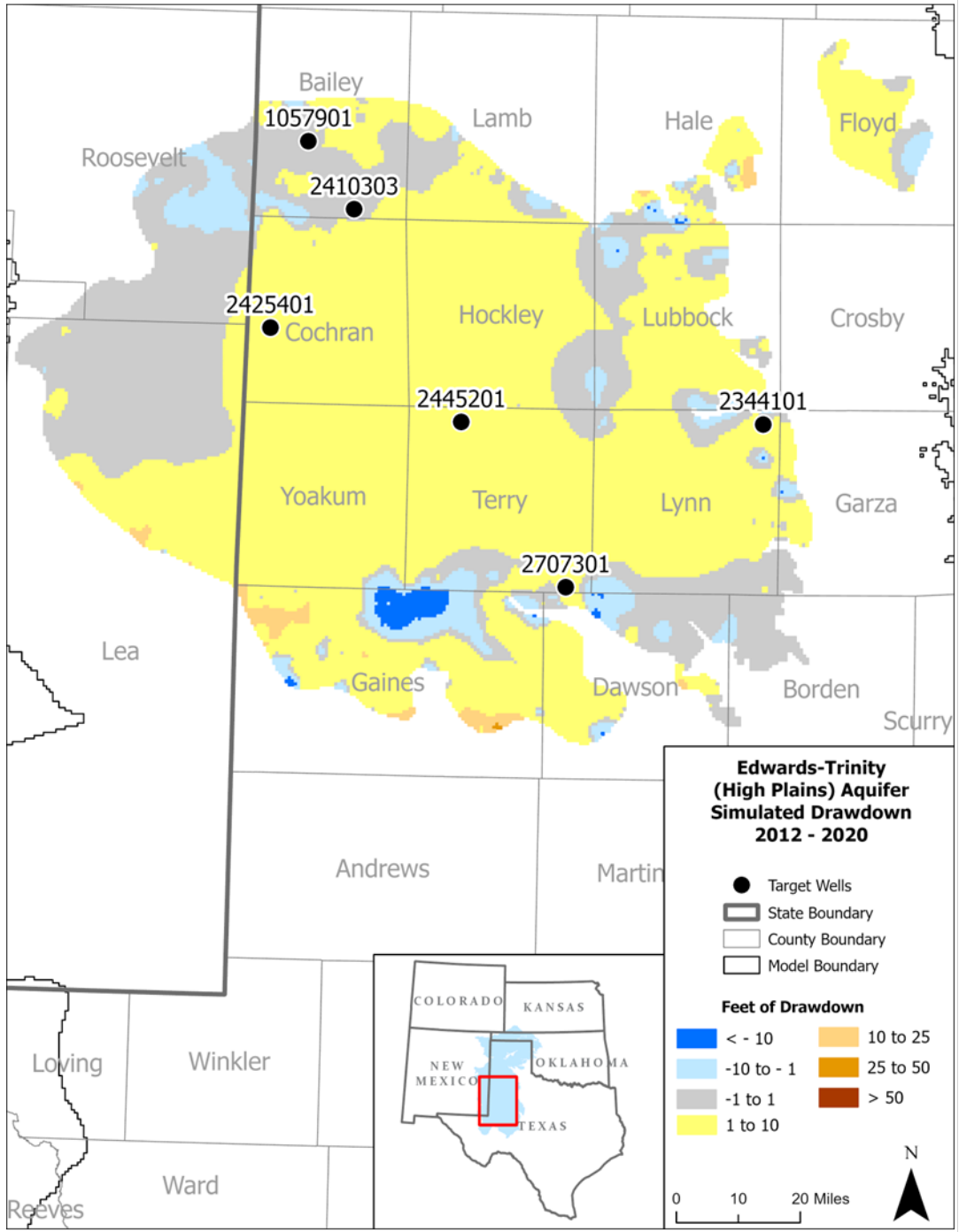

State Well Number: 0249201 (Dallam, TX)
measured
simulated
4,400
4,350
4,300
4,250
4,200

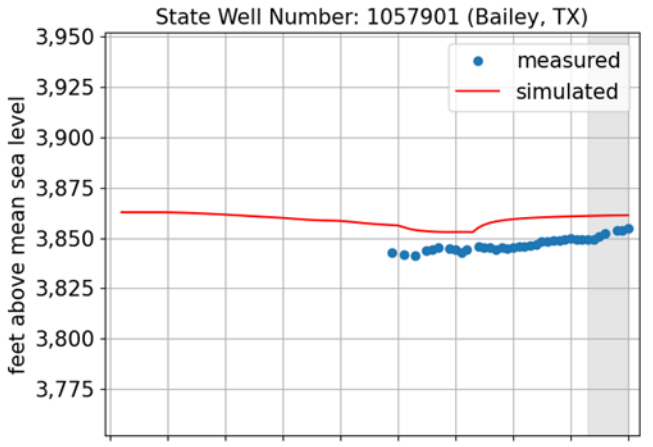

State Well Number: 0249704 (Dallam, TX)
measured
simulated
feet above mean sea level
4,325
4,300
4,275
4,250
4,225
4,200
4,175
4,150

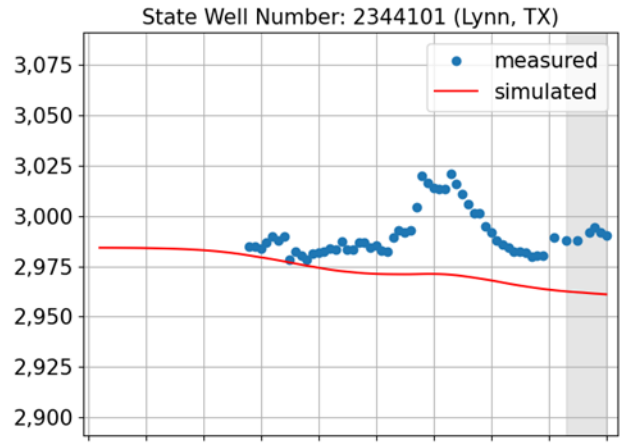

USGS ID: 361000000000000 (Union, NM)
measured
simulated
4,675
4,650
4,625
4,600
4,575
4,550
4,525
4,500

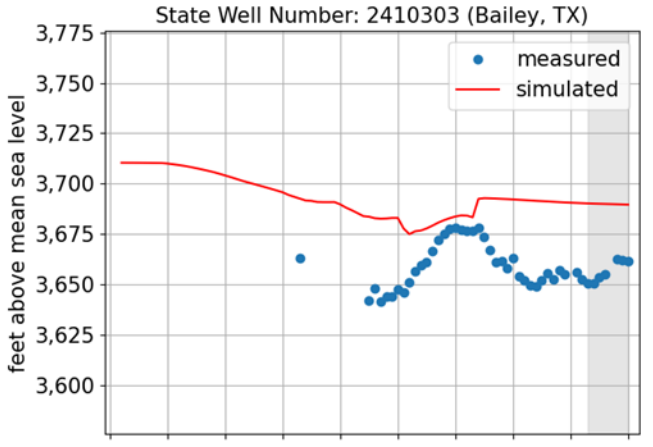

USGS ID: 362000000000000 (Union, NM)
measured
simulated
feet above mean sea level
4,700
4,675
4,650
4,625
4,600
4,575
4,550
4,525
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020

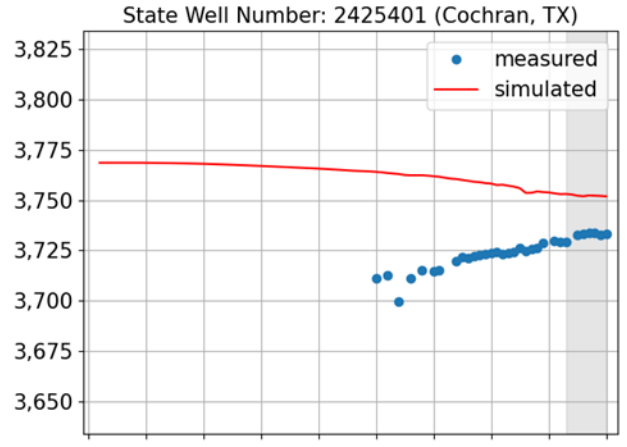

USGS ID: 362000000000000 (Union, NM)
measured
simulated
4,675
4,650
4,625
4,600
4,575
4,550
4,525
4,500
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020

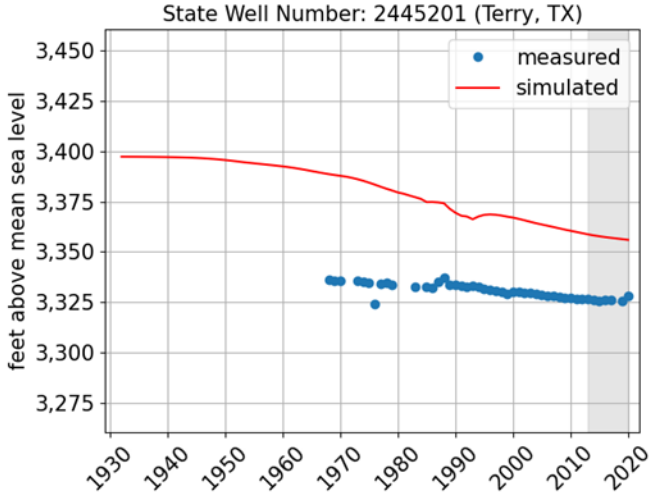

Bailey
1057901
Lamb
Hale
Floyd
Roosevelt
2410303
2425401
Cochran
Hockley
Lubbock
Crosby
2445201
2344101
Yoakum
Terry
Lynn
Garza
2707301
Lea
Gaines
Dawson
Borden
Scurry
Andrews
Martin
Loving
Winkler
Ward
Reeves
COLORADO
KANSAS
NEW MEXICO
OKLAHOMA
TEXAS
Edwards-Trinity (High Plains) Aquifer Simulated Drawdown 2012 - 2020
Target Wells
State Boundary
County Boundary
Model Boundary
Feet of Drawdown
< - 10
-10 to - 1
-1 to 1
1 to 10
10 to 25
25 to 50
> 50
N
0
10
20 Miles

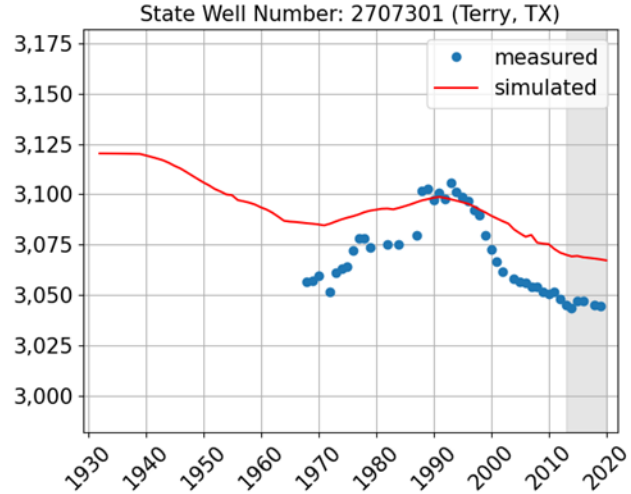

State Well Number: 1057901 (Bailey, TX)
feet above mean sea level
measured
simulated

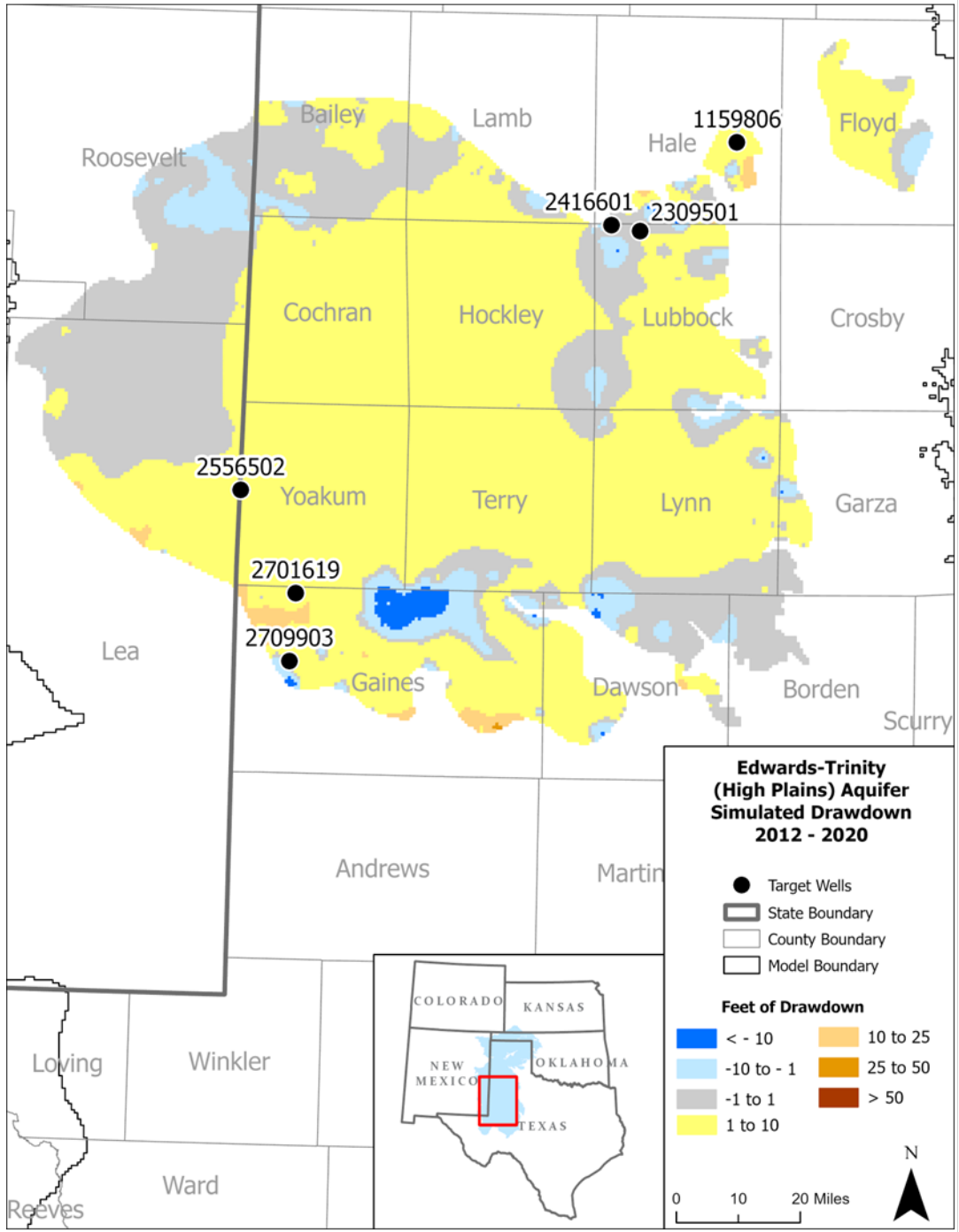

State Well Number: 2344101 (Lynn, TX)
measured
simulated

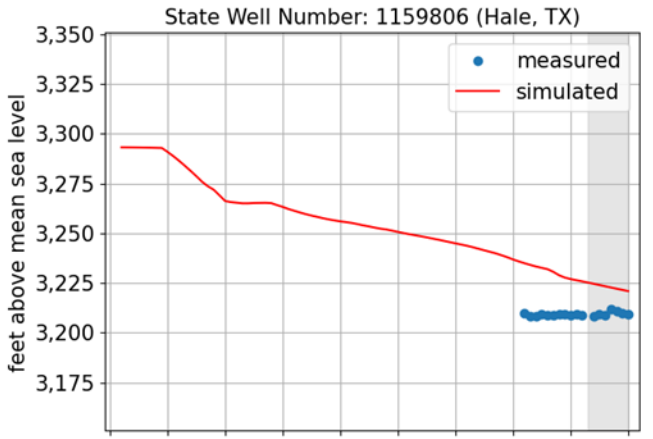

State Well Number: 2410303 (Bailey, TX)
feet above mean sea level
measured
simulated

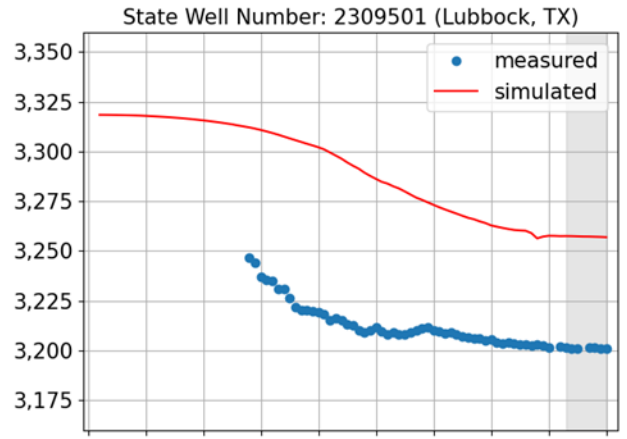

State Well Number: 2425401 (Cochran, TX)
measured
simulated

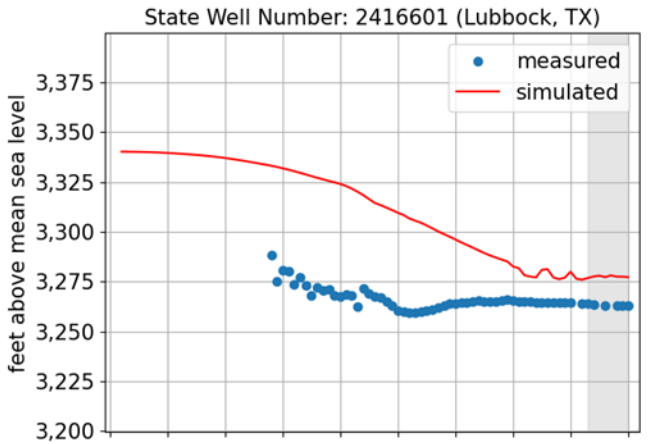

State Well Number: 2445201 (Terry, TX)
feet above mean sea level
measured
simulated
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020

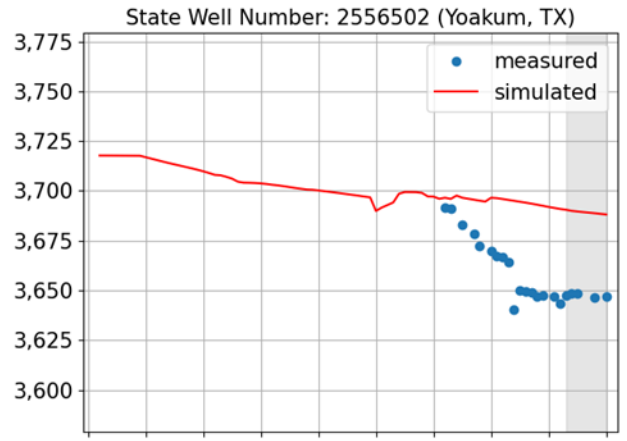

State Well Number: 2707301 (Terry, TX)
measured
simulated

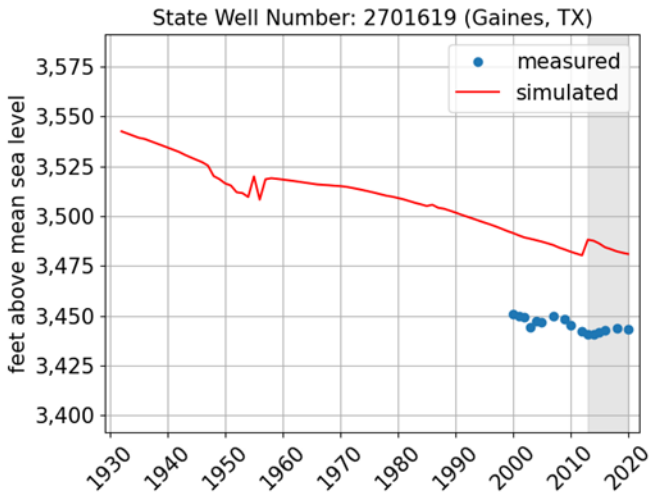

Bailey
Lamb
Floyd
Roosevelt
Hale
1159806
2416601
2309501
Cochran
Hockley
Lubbock
Crosby
2556502
Yoakum
Terry
Lynn
Garza
2701619
2709903
Lea
Gaines
Dawson
Borden
Scurry
Andrews
Martin
Loving
Winkler
Ward
Reeves
COLORADO
KANSAS
NEW MEXICO
OKLAHOMA
TEXAS
Edwards-Trinity (High Plains) Aquifer Simulated Drawdown 2012 - 2020
Target Wells
State Boundary
County Boundary
Model Boundary
Feet of Drawdown
< - 10
-10 to - 1
-1 to 1
1 to 10
10 to 25
25 to 50
> 50
N
0
10
20 Miles

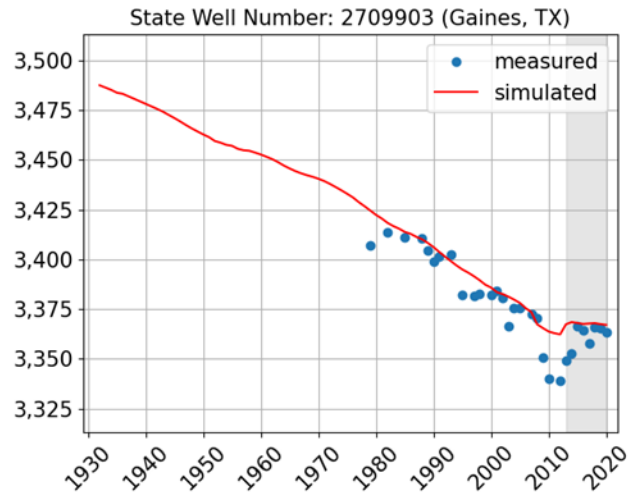

State Well Number: 1159806 (Hale, TX)
feet above mean sea level
measured
simulated

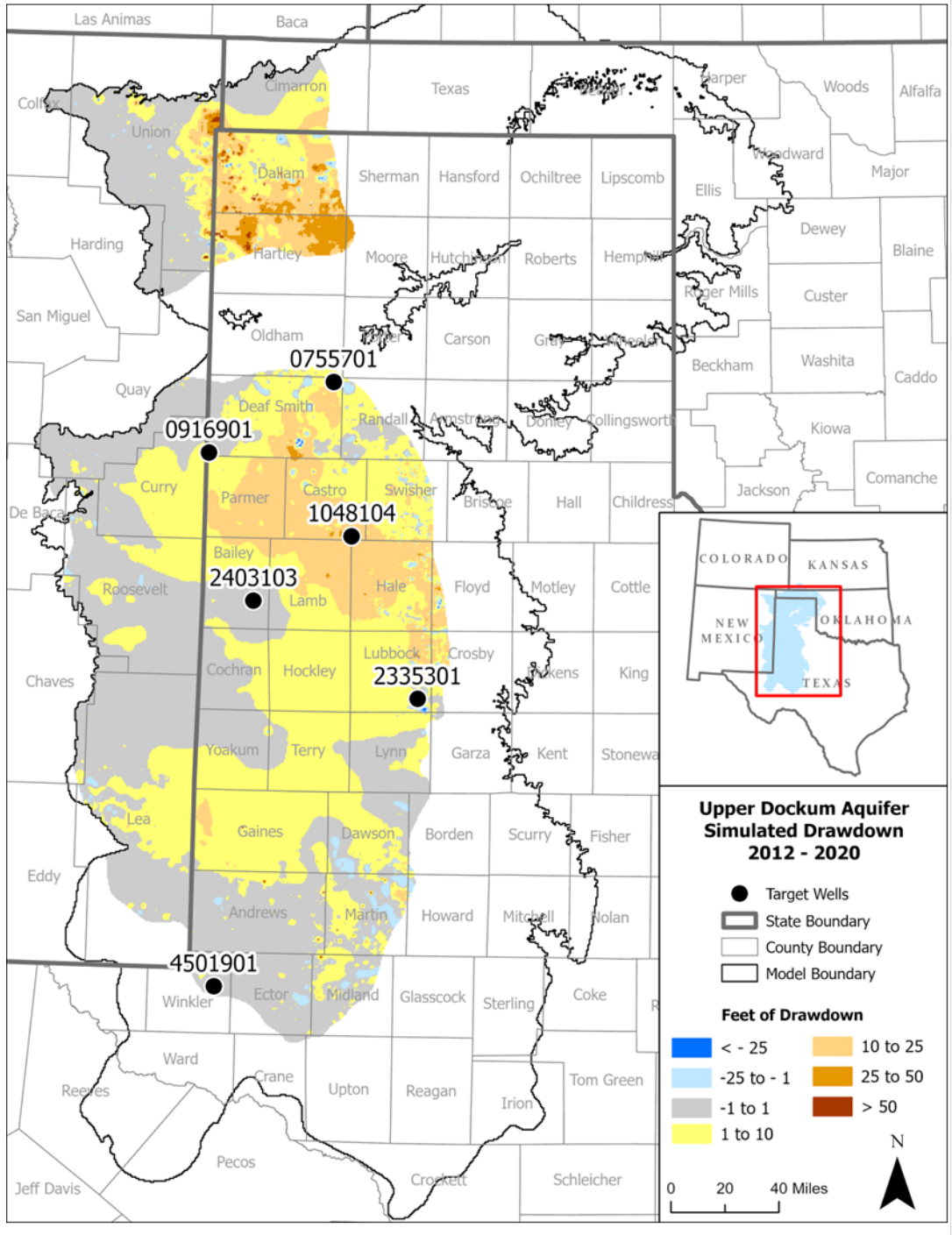

State Well Number: 2309501 (Lubbock, TX)
measured
simulated

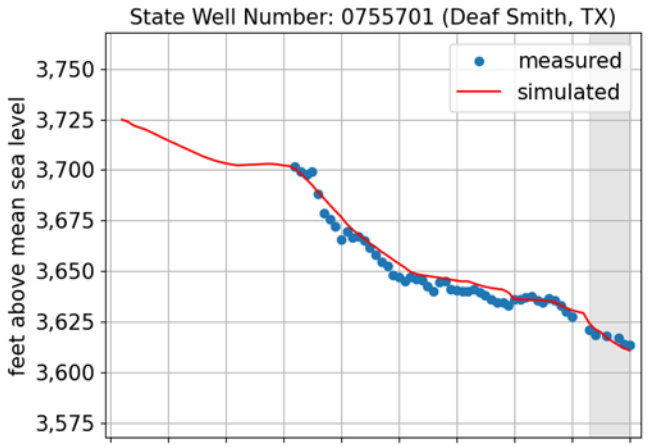

State Well Number: 2416601 (Lubbock, TX)
feet above mean sea level
measured
simulated

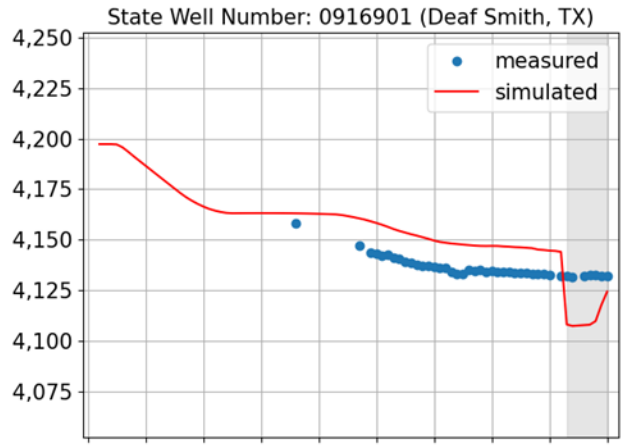

State Well Number: 2556502 (Yoakum, TX)
measured
simulated

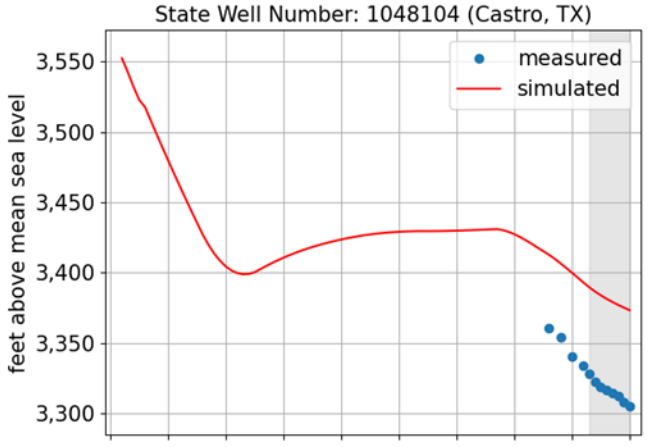

State Well Number: 2701619 (Gaines, TX)
feet above mean sea level
measured
simulated
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020

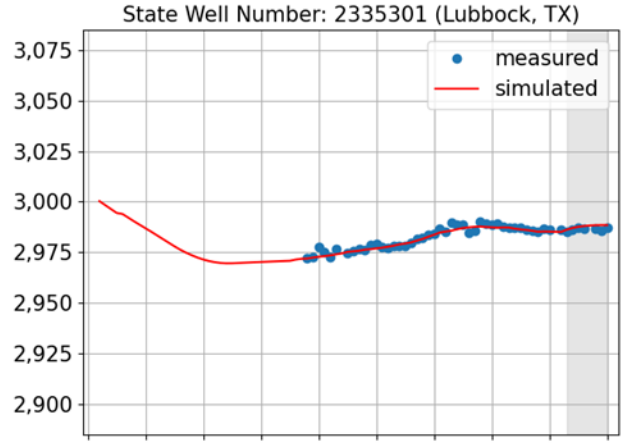

State Well Number: 2709903 (Gaines, TX)
measured
simulated

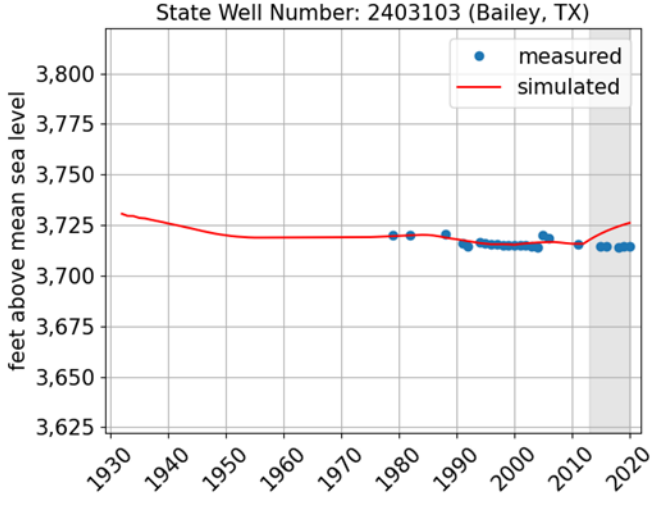

0755701
0916901
1048104
2403103
2335301
4501901
Upper Dockum Aquifer
Simulated Drawdown
2012 - 2020
Target Wells
State Boundary
County Boundary
Model Boundary
Feet of Drawdown
< - 25
-25 to - 1
-1 to 1
1 to 10
10 to 25
25 to 50
> 50
0 20 40 Miles
N
COLORADO
KANSAS
NEW MEXICO
OKLAHOMA
TEXAS

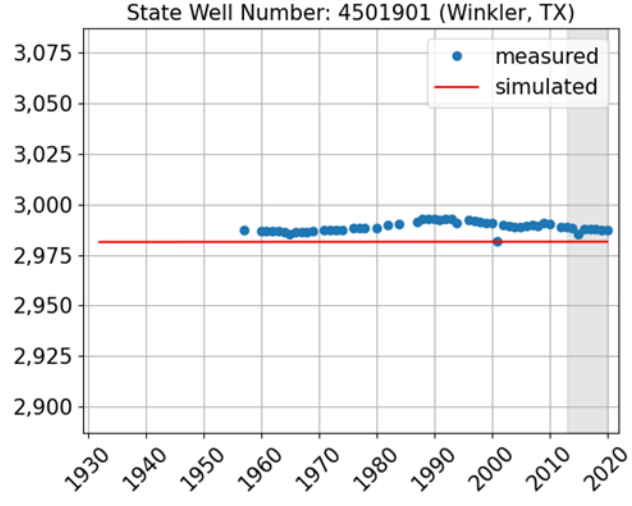

State Well Number: 0755701 (Deaf Smith, TX)
feet above mean sea level
measured
simulated

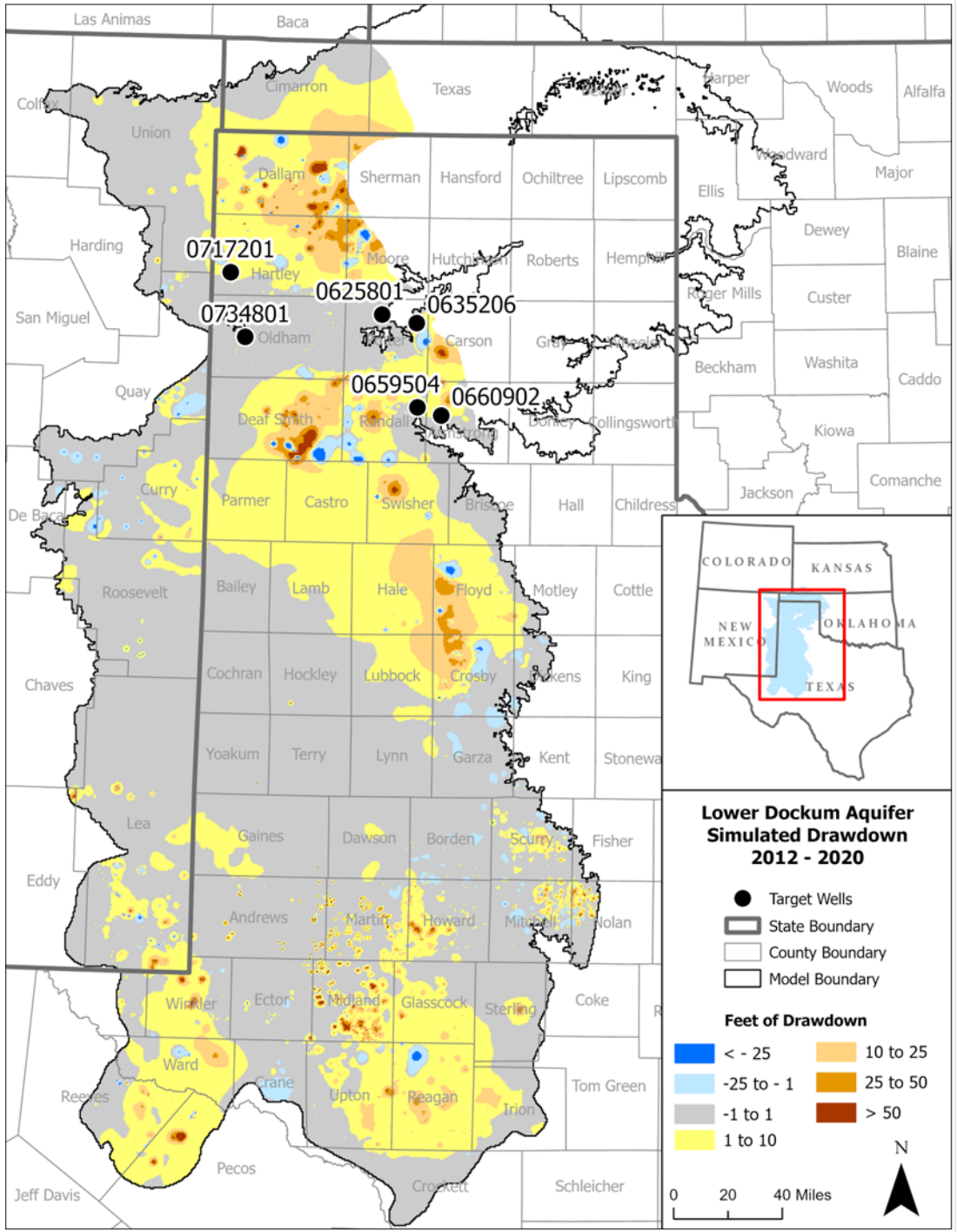

State Well Number: 0916901 (Deaf Smith, TX)
measured
simulated

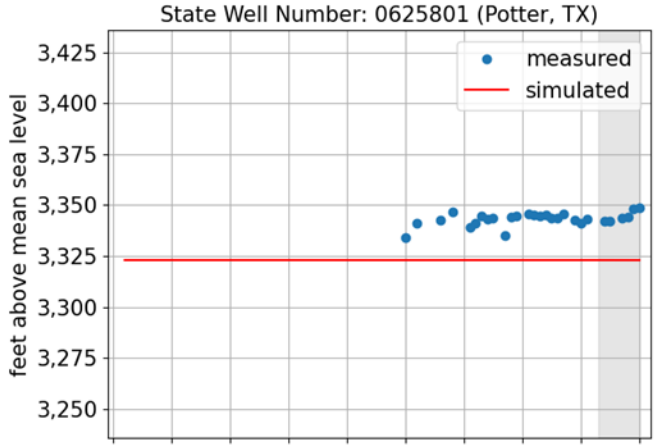

State Well Number: 1048104 (Castro, TX)
feet above mean sea level
measured
simulated

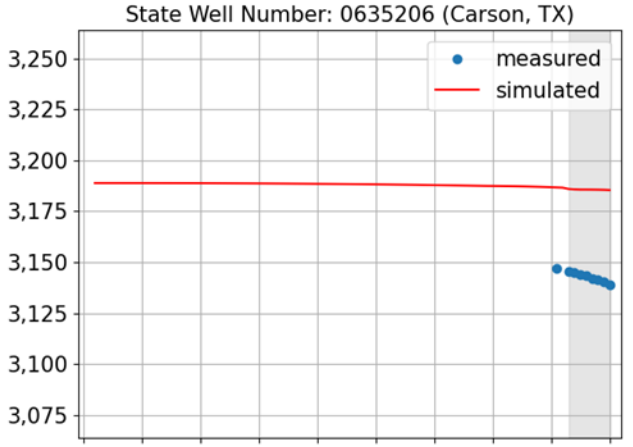

State Well Number: 2335301 (Lubbock, TX)
measured
simulated

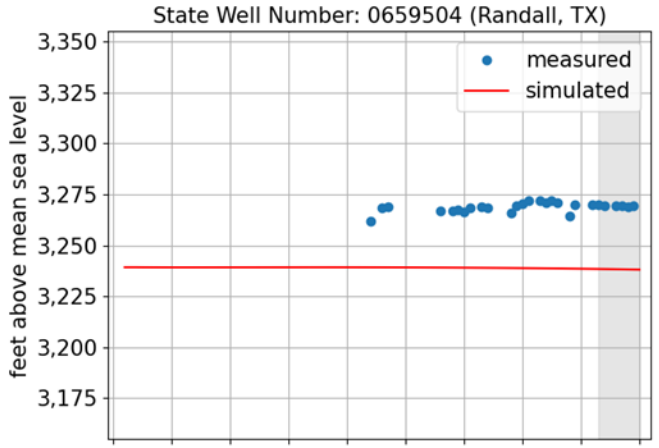

State Well Number: 2403103 (Bailey, TX)
feet above mean sea level
measured
simulated

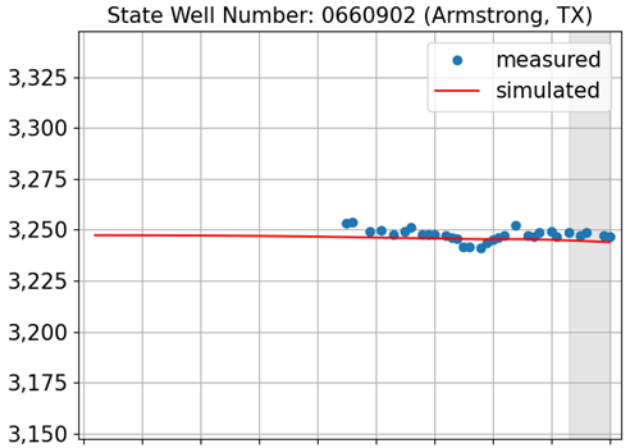

State Well Number: 4501901 (Winkler, TX)
measured
simulated

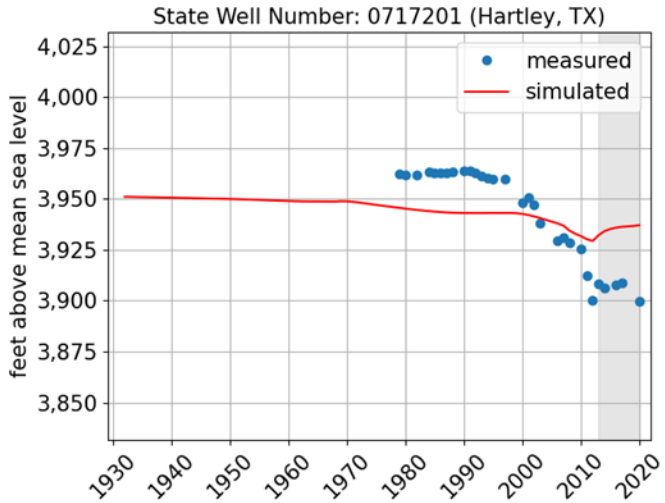

0717201
0625801
0635206
0734801
0659504
0660902
COLORADO
KANSAS
NEW MEXICO
OKLAHOMA
TEXAS
Lower Dockum Aquifer
Simulated Drawdown
2012 - 2020
Target Wells
State Boundary
County Boundary
Model Boundary
Feet of Drawdown
< - 25
-25 to - 1
-1 to 1
1 to 10
10 to 25
25 to 50
> 50
N
0 20 40 Miles

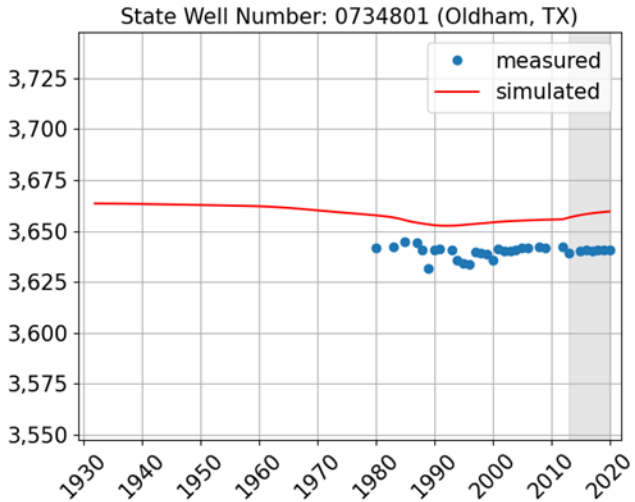

State Well Number: 0625801 (Potter, TX)
feet above mean sea level
measured
simulated

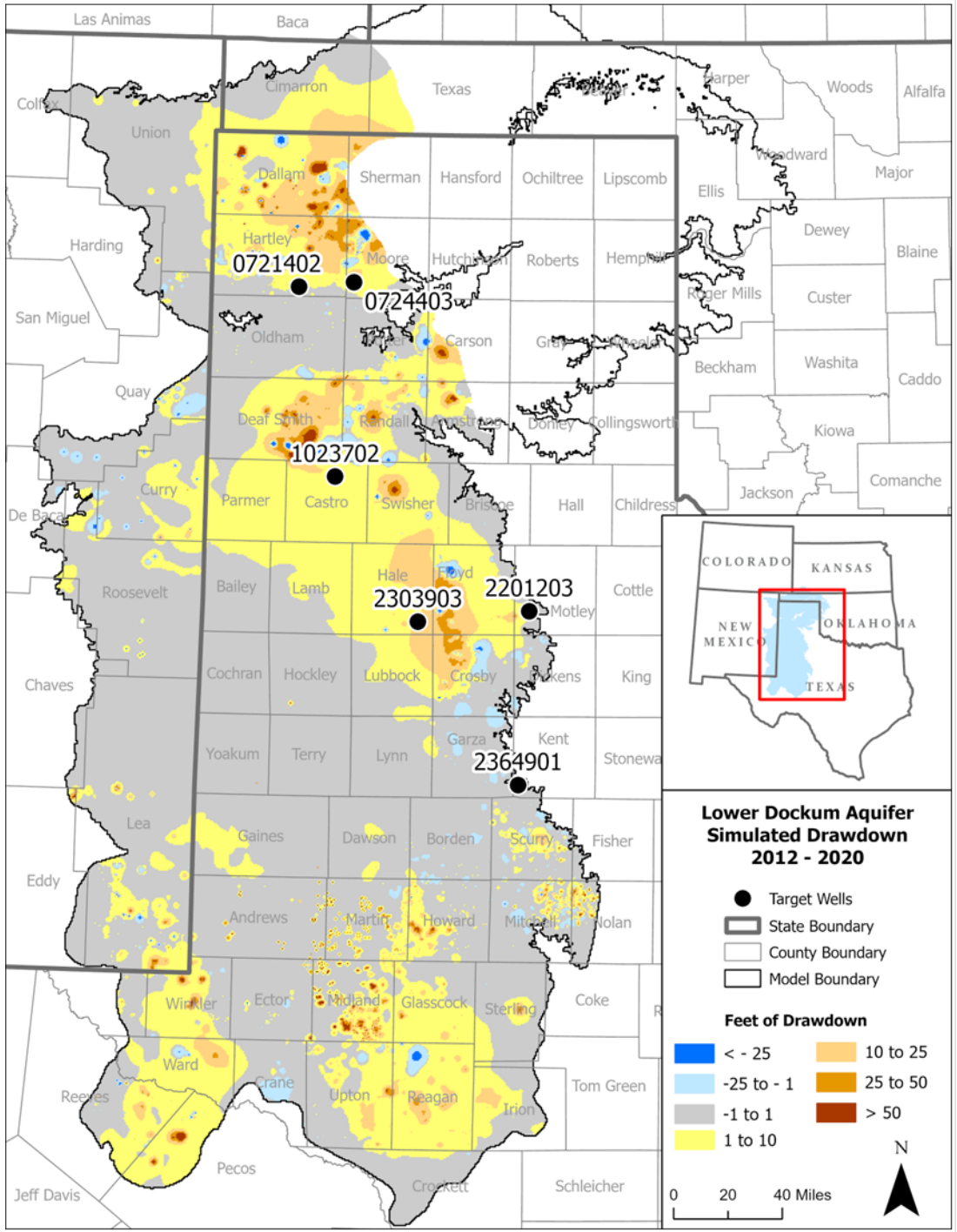

State Well Number: 0635206 (Carson, TX)
measured
simulated

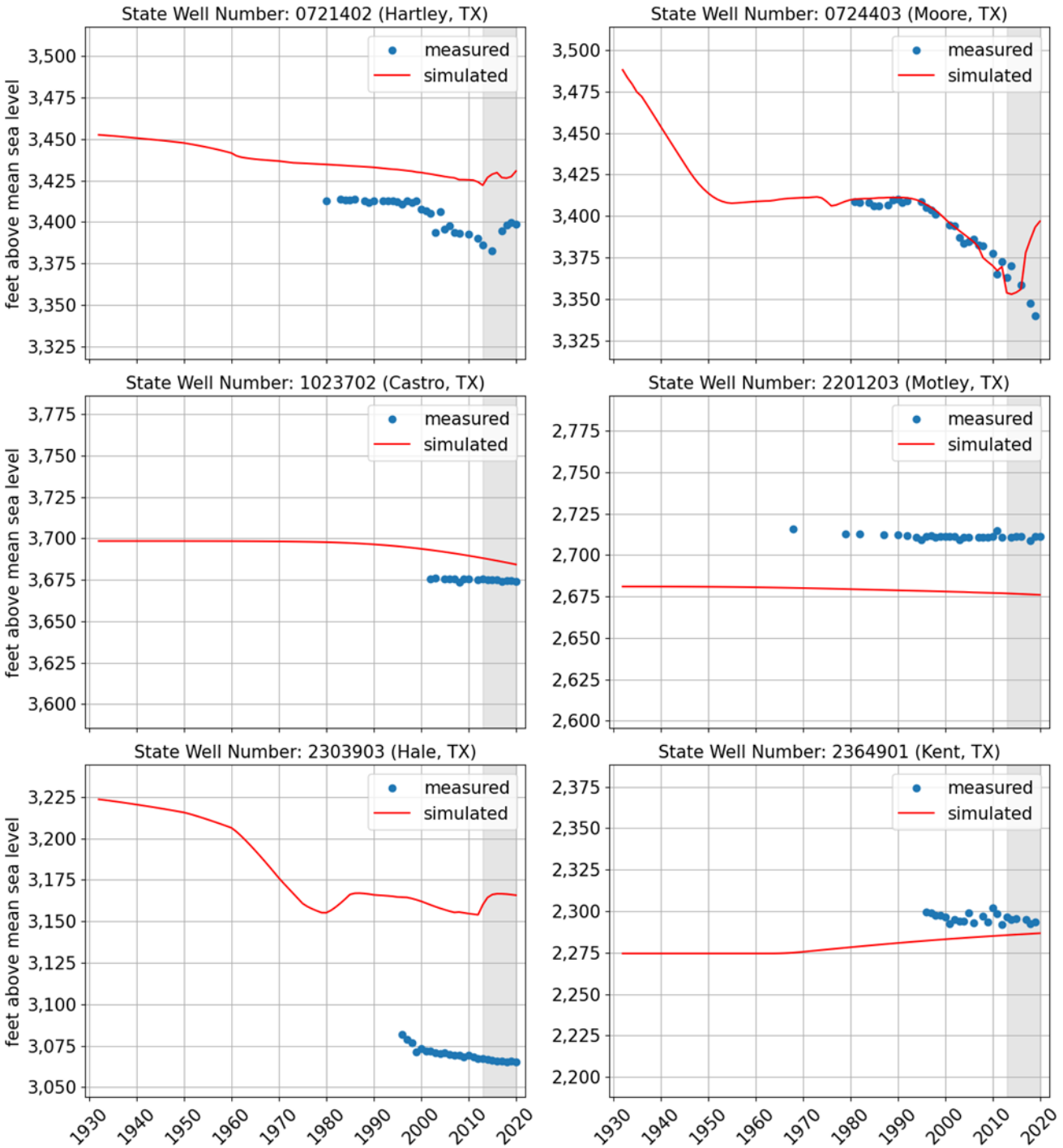

State Well Number: 0659504 (Randall, TX)
feet above mean sea level
measured
simulated

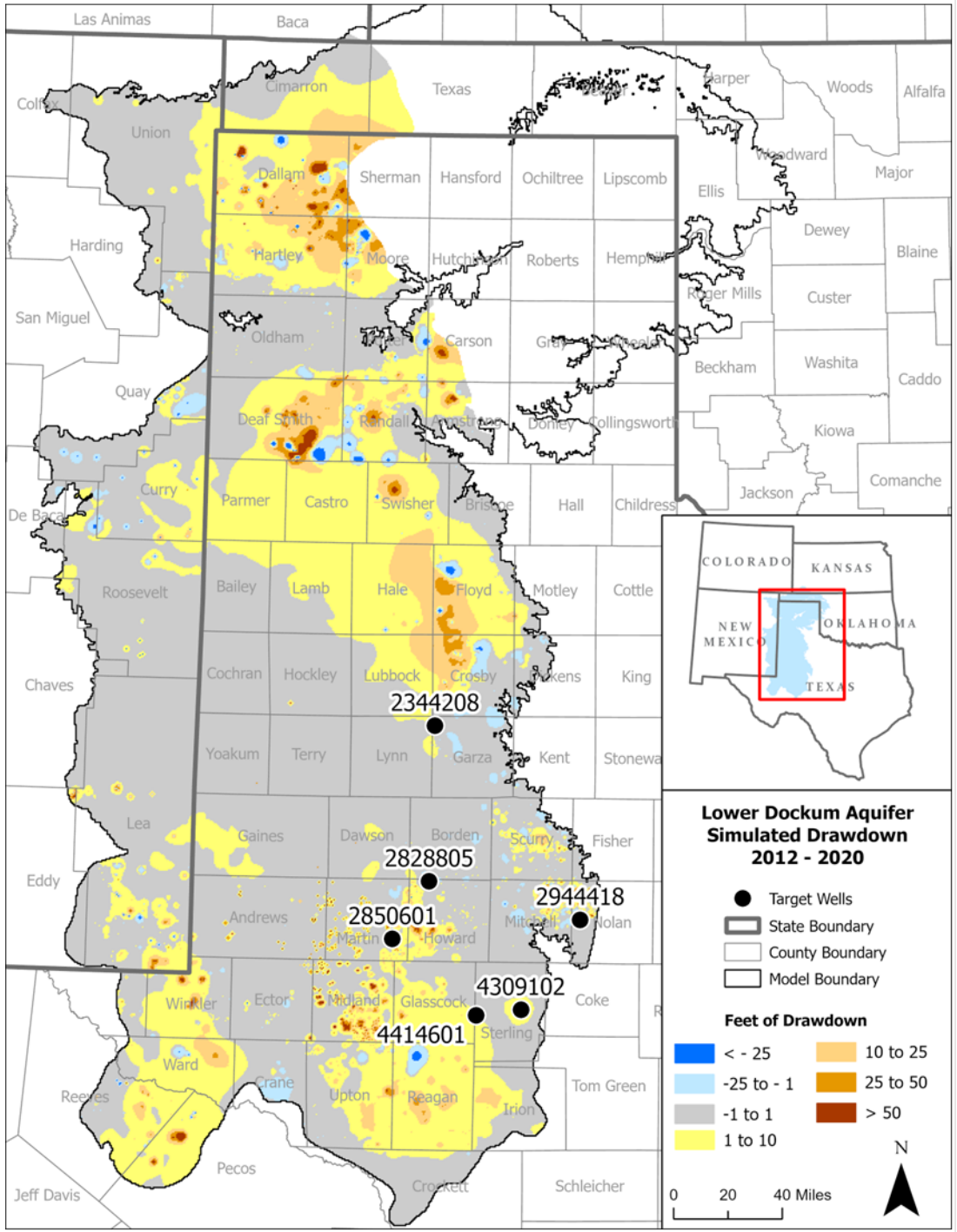

State Well Number: 0660902 (Armstrong, TX)
measured
simulated

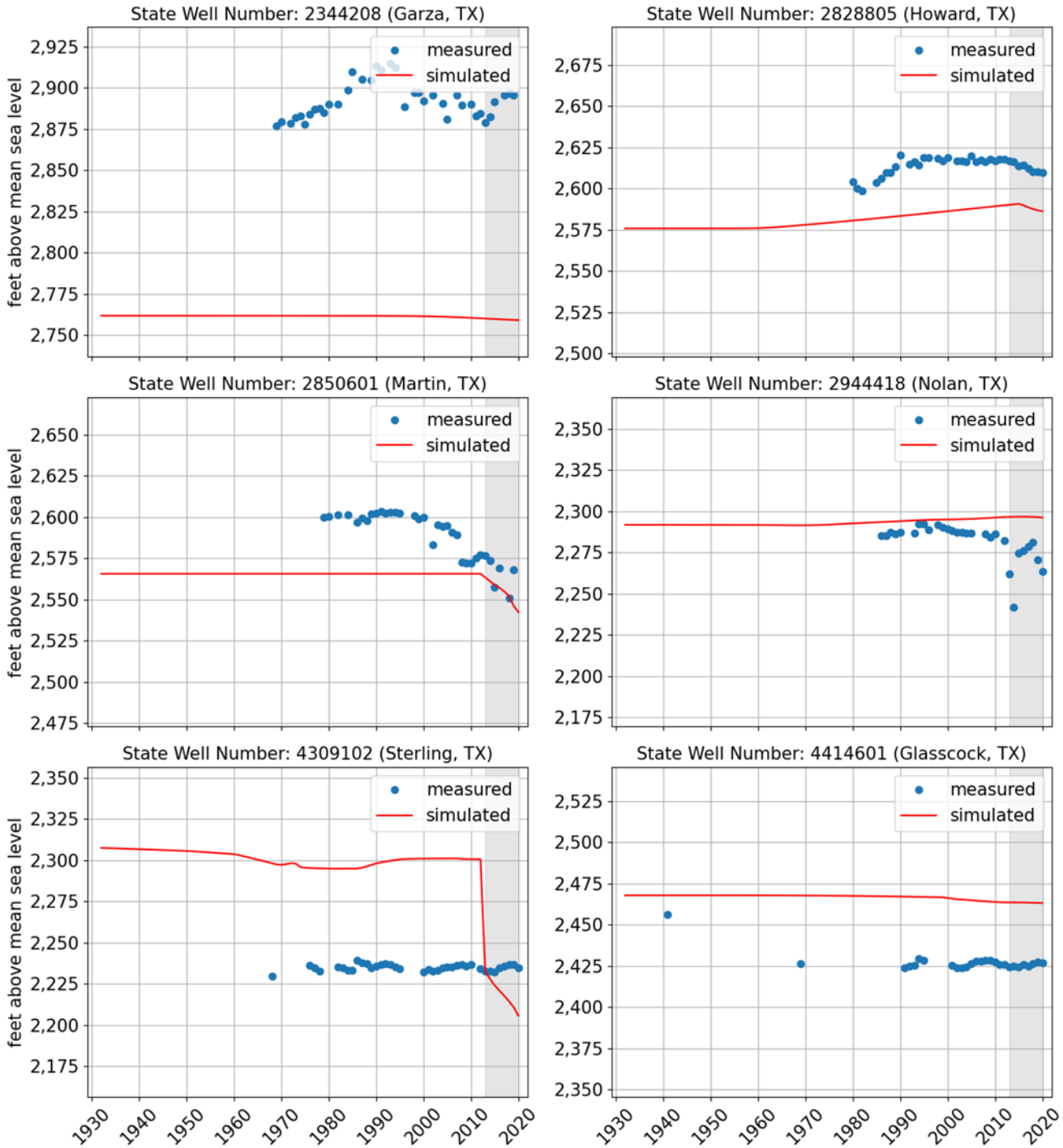

State Well Number: 0717201 (Hartley, TX)
feet above mean sea level
measured
simulated
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020

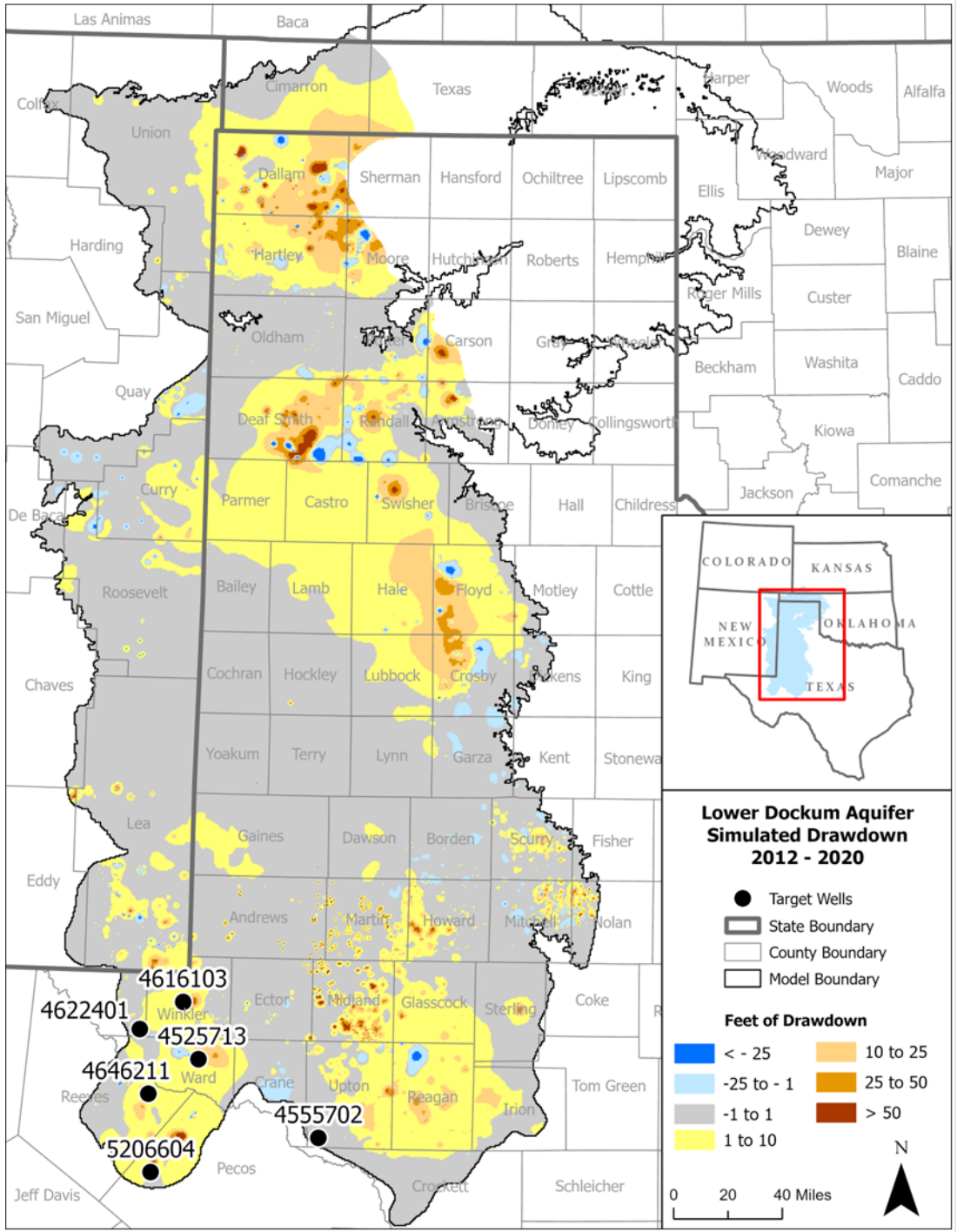

State Well Number: 0734801 (Oldham, TX)
measured
simulated

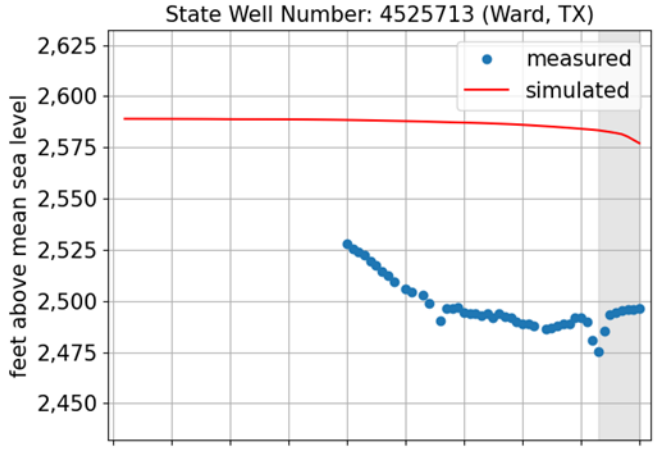

Las Animas
Baca
Cimarron
Texas
Harper
Woods
Alfalfa
Union
Dallam
Sherman
Hansford
Ochiltree
Lipscomb
Ellis
Woodward
Major
Harding
Hartley
0721402
Moore
Hutchinson
Roberts
Hemphill
Roger Mills
Dewey
Blaine
Custer
San Miguel
Oldham
Carson
Gray
Beckham
Washita
Caddo
Quay
Deaf Smith
Randall
Armstrong
Donley
Collingsworth
0724403
1023702
Kiowa
Curry
Parmer
Castro
Swisher
Briscoe
Hall
Childress
Jackson
Comanche
De Baca
Roosevelt
Bailey
Lamb
Hale
Floyd
2303903
2201203
Motley
Cottle
Chaves
Cochran
Hockley
Lubbock
Crosby
Dickens
King
Yoakum
Terry
Lynn
Garza
Kent
2364901
Stonewall
Lea
Gaines
Dawson
Borden
Scurry
Fisher
Eddy
Andrews
Martin
Howard
Mitchell
Nolan
Winkler
Ector
Midland
Glasscock
Sterling
Coke
Ward
Crane
Upton
Reagan
Irion
Tom Green
Reeves
Pecos
Crockett
Schleicher
Jeff Davis
COLORADO
KANSAS
NEW MEXICO
OKLAHOMA
TEXAS
Lower Dockum Aquifer
Simulated Drawdown
2012 - 2020
Target Wells
State Boundary
County Boundary
Model Boundary
Feet of Drawdown
< - 25
-25 to - 1
-1 to 1
1 to 10
10 to 25
25 to 50
> 50
N
0
20
40 Miles

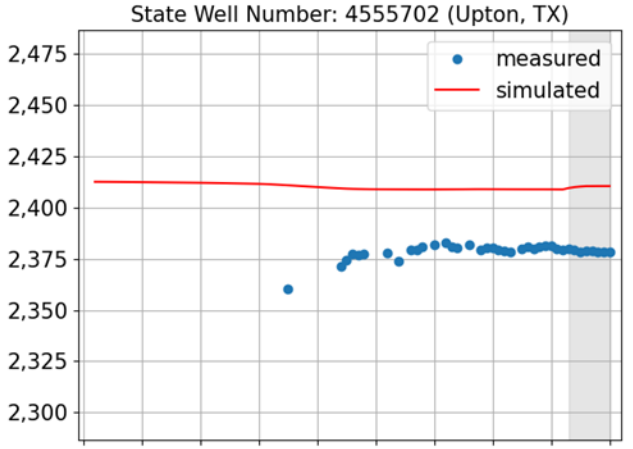

State Well Number: 0721402 (Hartley, TX)
State Well Number: 0724403 (Moore, TX)
State Well Number: 1023702 (Castro, TX)
State Well Number: 2201203 (Motley, TX)
State Well Number: 2303903 (Hale, TX)
State Well Number: 2364901 (Kent, TX)
measured
simulated
feet above mean sea level
3,500
3,475
3,450
3,425
3,400
3,375
3,350
3,325
3,775
3,750
3,725
3,700
3,675
3,650
3,625
3,600
2,775
2,750
2,725
2,700
2,675
2,650
2,625
2,600
3,225
3,200
3,175
3,150
3,125
3,100
3,075
3,050
2,375
2,350
2,325
2,300
2,275
2,250
2,225
2,200
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020

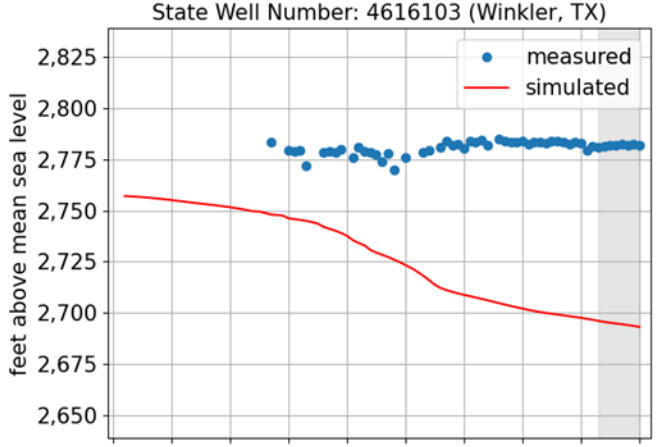

Las Animas
Baca
Cimarron
Texas
Harper
Woods
Alfalfa
Union
Dallam
Sherman
Hansford
Ochiltree
Lipscomb
Ellis
Woodward
Major
Harding
Hartley
Moore
Hutchinson
Roberts
Hemphill
Roger Mills
Dewey
Blaine
Custer
San Miguel
Oldham
Carson
Gray
Beckham
Washita
Caddo
Quay
Deaf Smith
Randall
Donley
Collingsworth
Kiowa
Curry
Parmer
Castro
Swisher
Briscoe
Hall
Childress
Jackson
Comanche
De Baca
Roosevelt
Bailey
Lamb
Hale
Floyd
Motley
Cottle
Chaves
Cochran
Hockley
Lubbock
Crosby
Dickens
King
2344208
Yoakum
Terry
Lynn
Garza
Kent
Stonewall
Lea
Gaines
Dawson
Borden
Scurry
Fisher
Eddy
2828805
2944418
Andrews
2850601
Martin
Howard
Mitchell
Nolan
4309102
Winkler
Ector
Midland
Glasscock
Coke
4414601
Sterling
Ward
Crane
Upton
Reagan
Irion
Tom Green
Reeves
Pecos
Crockett
Schleicher
Jeff Davis
COLORADO
KANSAS
NEW MEXICO
OKLAHOMA
TEXAS
Lower Dockum Aquifer
Simulated Drawdown
2012 - 2020
Target Wells
State Boundary
County Boundary
Model Boundary
Feet of Drawdown
< - 25
-25 to - 1
-1 to 1
1 to 10
10 to 25
25 to 50
> 50
N
0
20
40 Miles

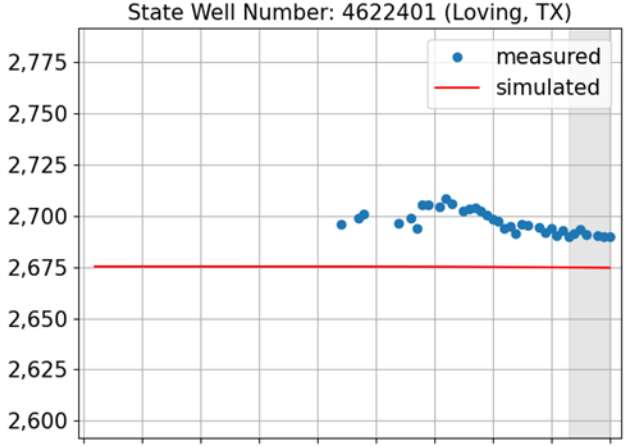

State Well Number: 2344208 (Garza, TX)
State Well Number: 2828805 (Howard, TX)
State Well Number: 2850601 (Martin, TX)
State Well Number: 2944418 (Nolan, TX)
State Well Number: 4309102 (Sterling, TX)
State Well Number: 4414601 (Glasscock, TX)
measured
simulated
feet above mean sea level
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020

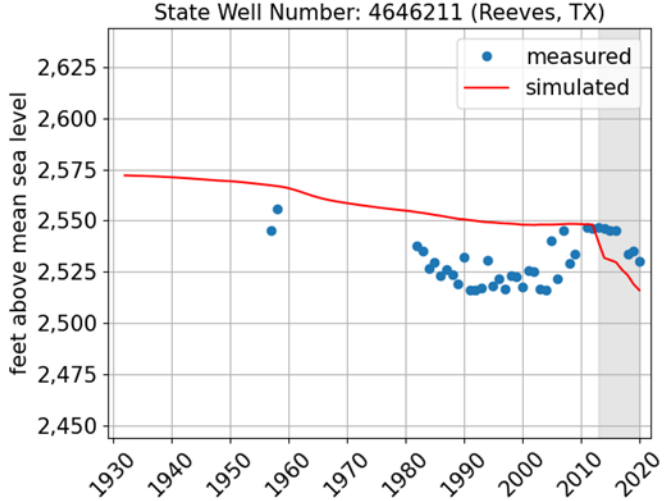

Las Animas
Baca
Cimarron
Texas
Harper
Woods
Alfalfa
Union
Dallam
Sherman
Hansford
Ochiltree
Lipscomb
Ellis
Woodward
Major
Harding
Hartley
Moore
Roberts
Hemphill
Dewey
Blaine
Roger Mills
Custer
San Miguel
Oldham
Carson
Beckham
Washita
Caddo
Quay
Deaf Smith
Randall
Donley
Collingsworth
Kiowa
Curry
Parmer
Castro
Swisher
Hall
Childress
Jackson
Comanche
De Baca
Roosevelt
Bailey
Lamb
Hale
Floyd
Motley
Cottle
Chaves
Cochran
Hockley
Lubbock
Crosby
King
Yoakum
Terry
Lynn
Garza
Kent
Stonewall
Lea
Gaines
Dawson
Borden
Scurry
Fisher
Eddy
Andrews
Martin
Howard
Mitchell
Nolan
Coke
Ector
Midland
Glasscock
Sterling
Winkler
Ward
Crane
Upton
Reagan
Irion
Tom Green
Reeves
Pecos
Crockett
Schleicher
Jeff Davis
4616103
4622401
4525713
4646211
4555702
5206604
COLORADO
KANSAS
NEW MEXICO
OKLAHOMA
TEXAS
Lower Dockum Aquifer
Simulated Drawdown
2012 - 2020
Target Wells
State Boundary
County Boundary
Model Boundary
Feet of Drawdown
< - 25
-25 to - 1
-1 to 1
1 to 10
10 to 25
25 to 50
> 50
N
0
20
40 Miles

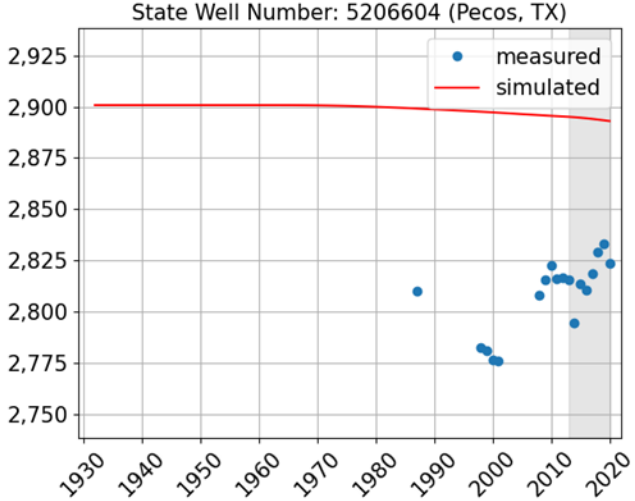

State Well Number: 4525713 (Ward, TX)
feet above mean sea level
measured
simulated


State Well Number: 4555702 (Upton, TX)
measured
simulated


State Well Number: 4616103 (Winkler, TX)
feet above mean sea level
measured
simulated


State Well Number: 4622401 (Loving, TX)
measured
simulated

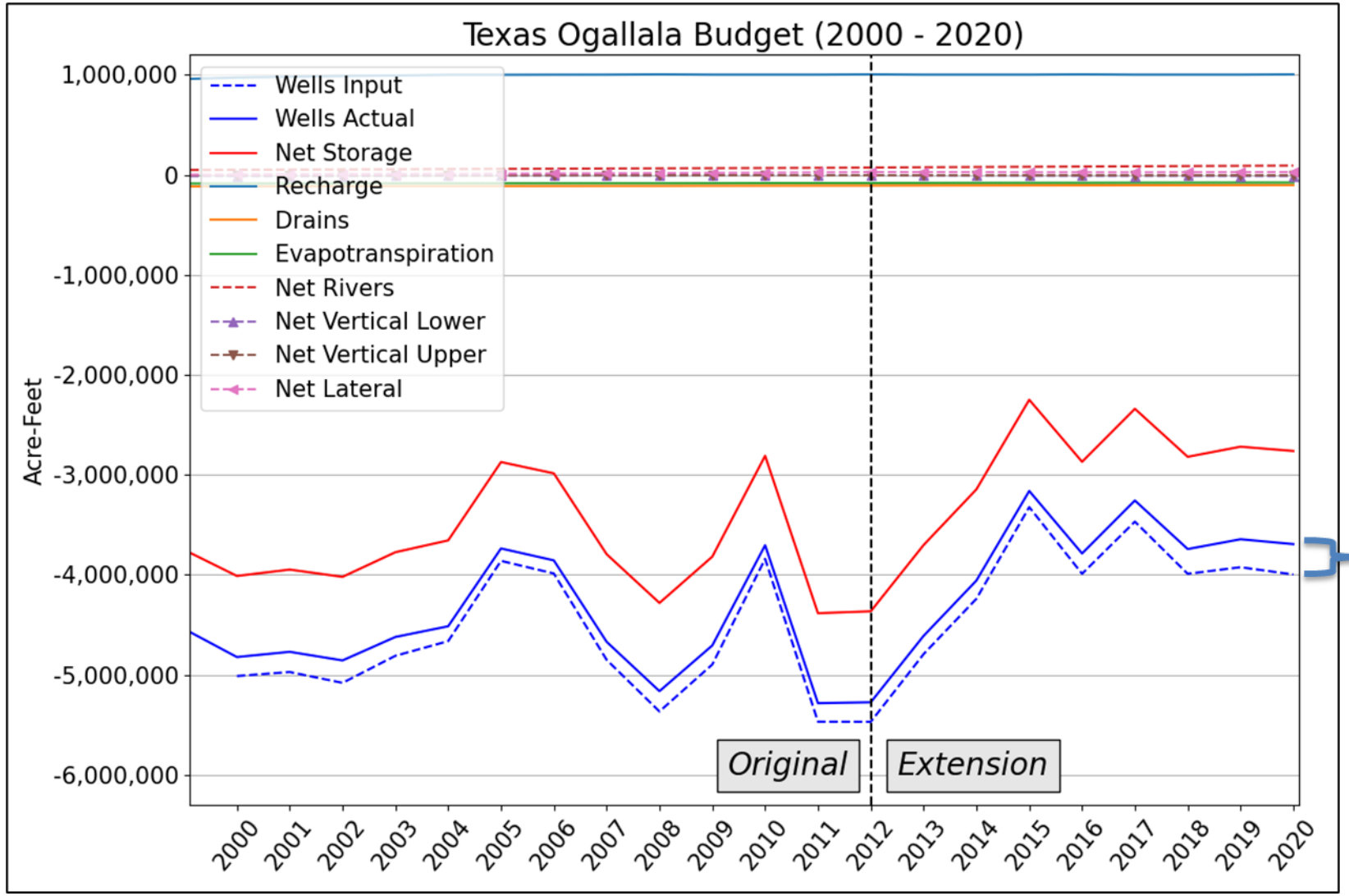

State Well Number: 4646211 (Reeves, TX)
feet above mean sea level
measured
simulated
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020


State Well Number: 5206604 (Pecos, TX)
measured
simulated
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020

Water Budgets

TEXAS WATER DEVELOPMENT BOARD

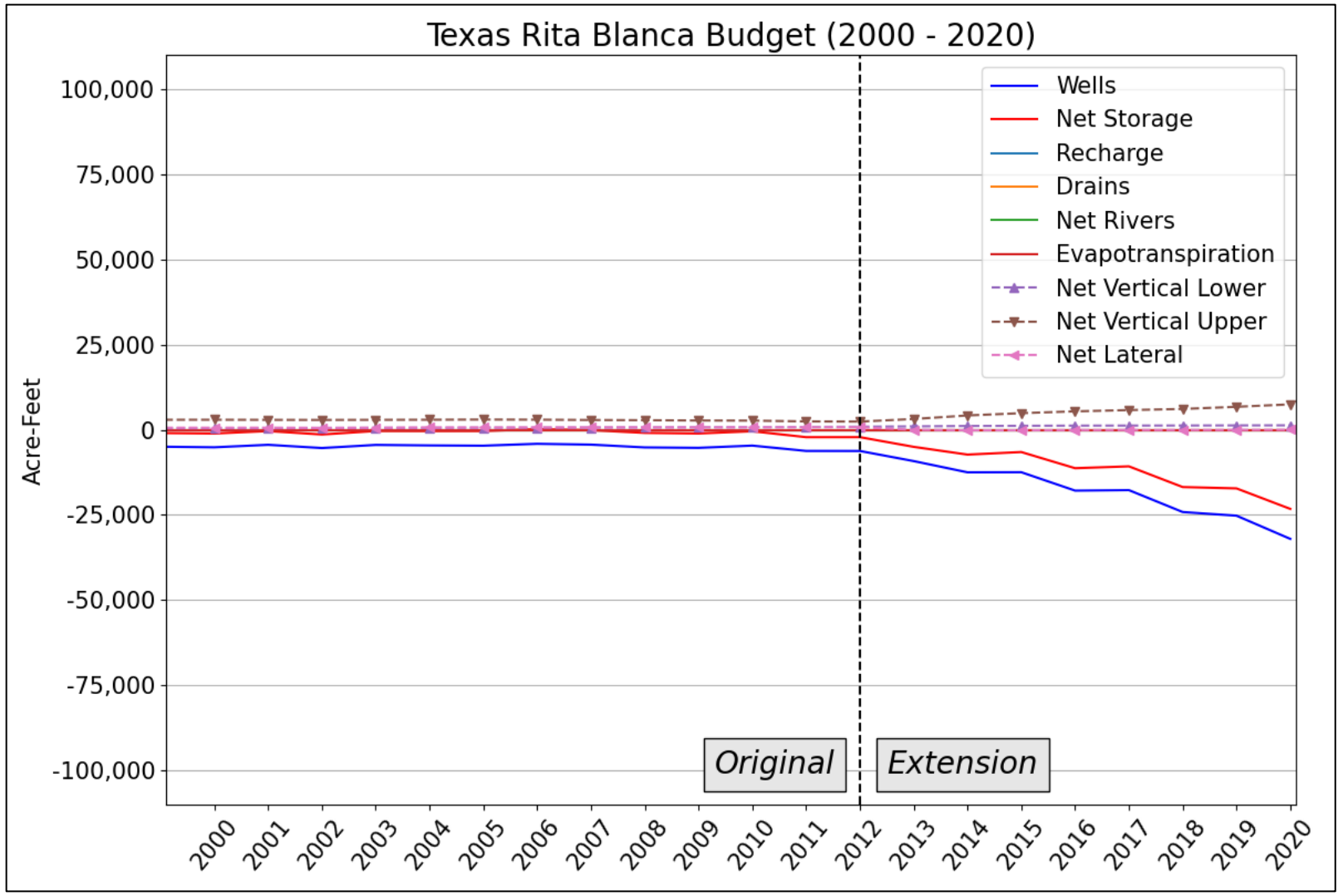
Texas Ogallala Budget



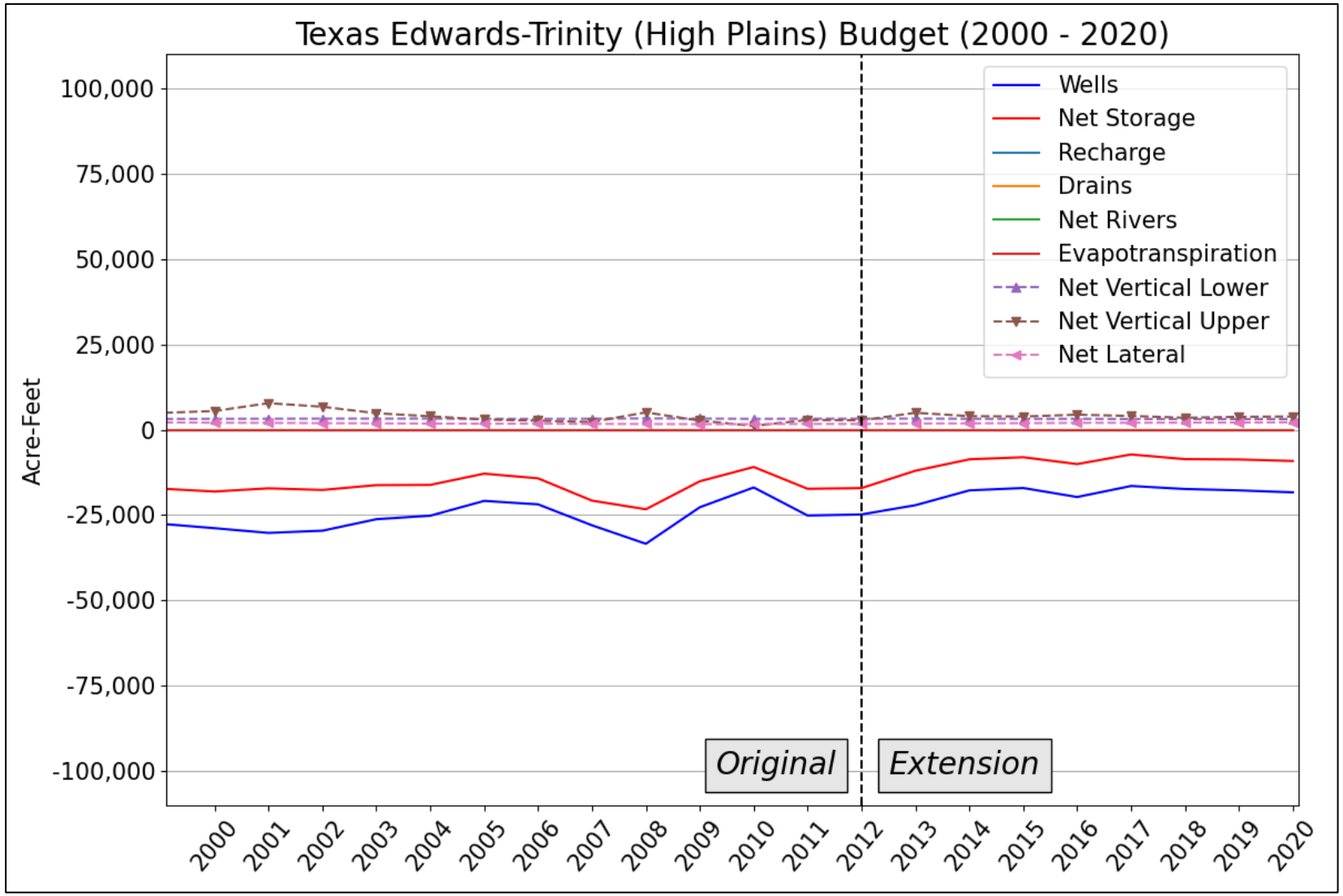
Model Reduced Pumping

2000 – 2012 Average 176,853 AF
2013 – 2020 Average 221,497 AF

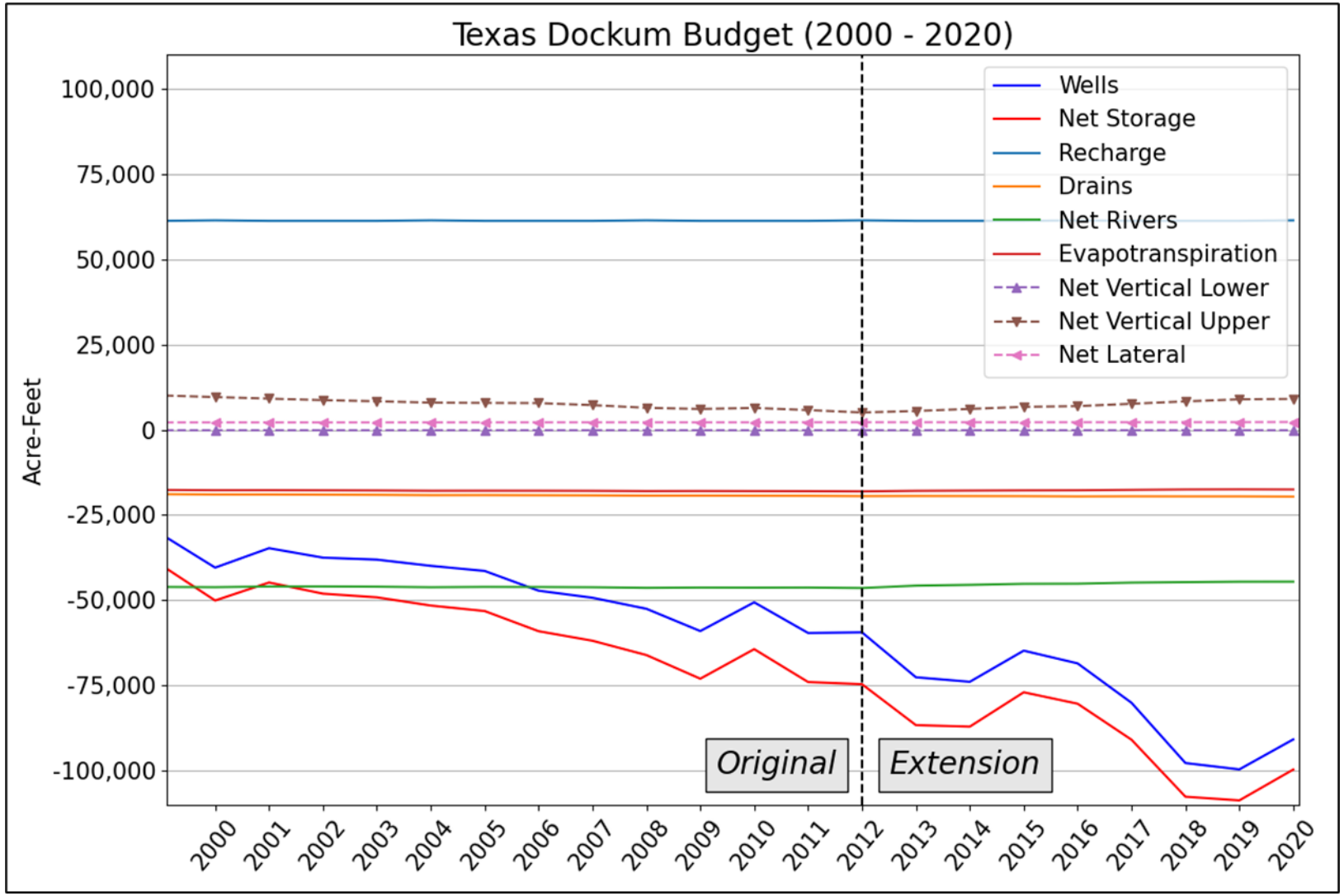
Texas Rita Blanca Budget



Texas Edwards-Trinity (High Plains) Budget



Texas Dockum Budget



Project Task	2023				2024												2025												2026												2027												2028
	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	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J
1.0 Project Management																																																				
2.0 *Update well package*																																																					
2.1 Identify new and plugged wells and assign aquifers																																																				
2.2 Add new Pumping for 2013 through 2020																																																				
2.3 Update New Mexico pumping																																																				
2.4 Distribute pumping to new well dataset																																																				
3.0 Run model and calculate statistics																																																				
3.1 Gather new water level data																																																				
3.2 Run model and calculate statistics																																																			
4.0 Stakeholder Communication																																																				
4.1 Groundwater Management Area Meetings					X		X																																											
4.2 Stakeholder Advisory Forum													X																																						
4.3 Provide draft model files and geodatabase																																																			
5.0 Documentation																																																				
5.1 Develop figures, maps, and tables																																																			
5.1 Draft Modeling Report														X																																					
5.2 Final Modeling Report																	X																																		
GMA Proposed DFCs – May 2026																	May 2026 – GMA Proposed DFCs												X																						
GMA Explanatory Report – January 2027																																									January 2027 – GMA Explanatory Report												X

- Provide draft model files to stakeholders
- Develop model report
- Attend upcoming GMA meetings and answer any questions

Contact Information

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Tim.Cawthon@twdb.texas.gov

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Shirley.Wade@twdb.texas.gov

Daryn Hardwick, Ph.D.
Manager
512-475-0470
Daryn.Hardwick@twdb.texas.gov

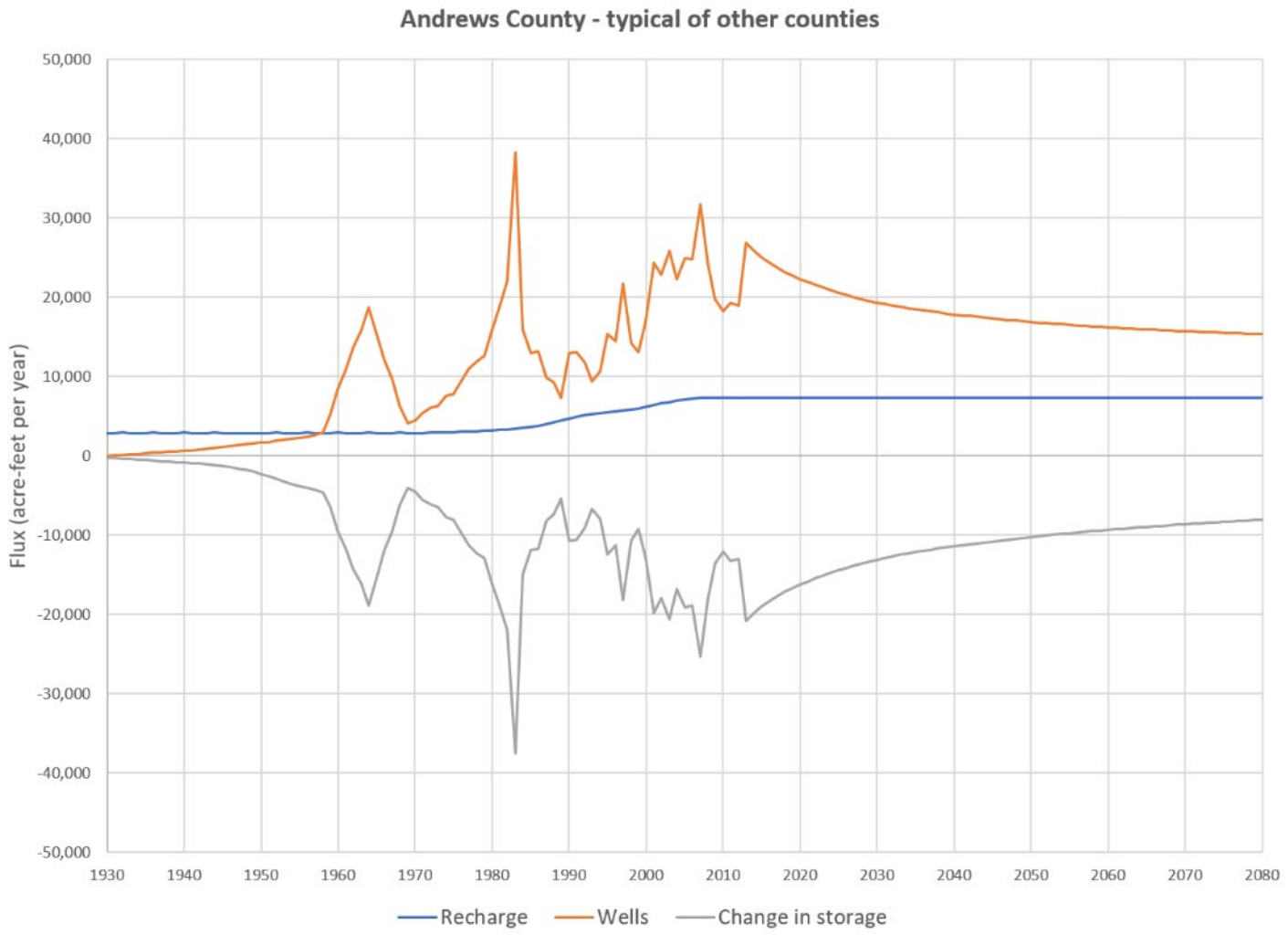
Web information:
https://www.twdb.texas.gov/groundwater/models/gam/hpas/hpas.asp

Howard County Recharge

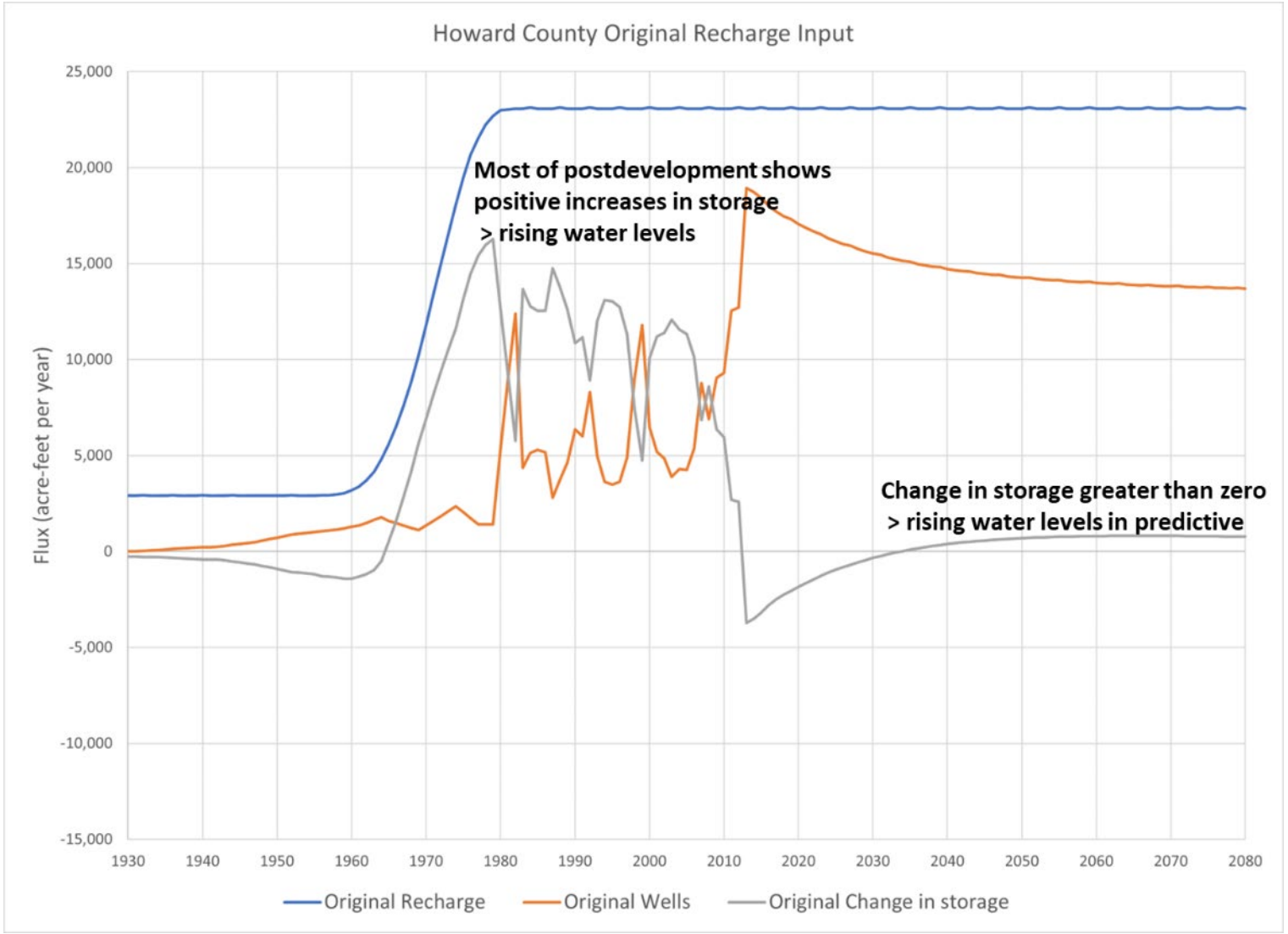
Howard County Recharge Adjustment

- The water budgets for Howard County show unusual behavior during the historical period compared with other county budgets.
- The unusual budget is a result of the relatively large increase in recharge during the postdevelopment period.
- In addition, the storage component of the water budget in Howard County shows a reversal to increasing storage during predictive period.
- We revised the postdevelopment recharge in Howard County by capping the recharge at 1965 levels.
- The water budget is now more consistent with the budgets for other counties and does not show rising water levels during predictive period.

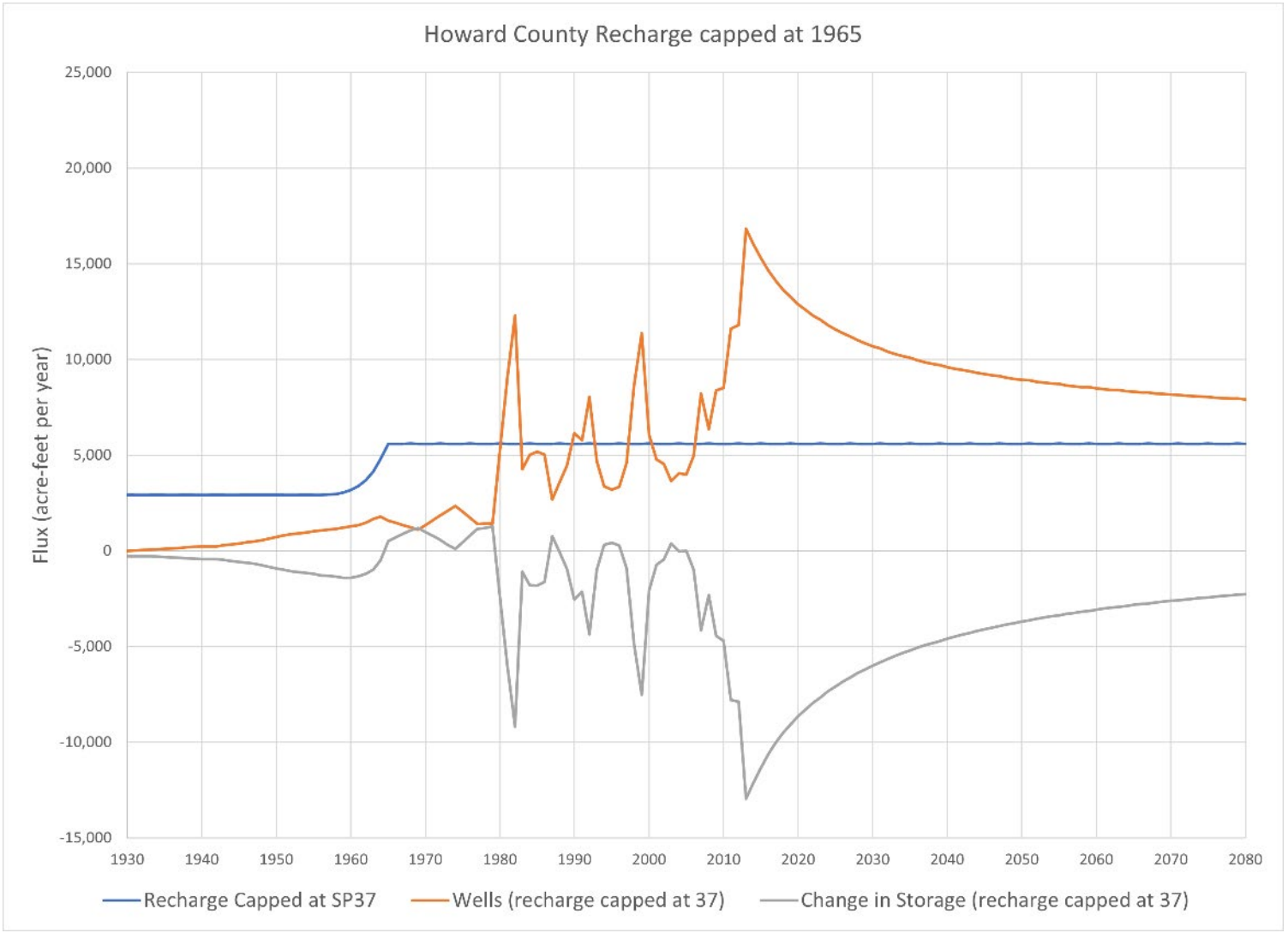
Howard County Recharge Adjustment



Howard County Recharge Adjustment



Howard County Recharge Adjustment



Capped Howard County recharge at stress period 37 (1965)

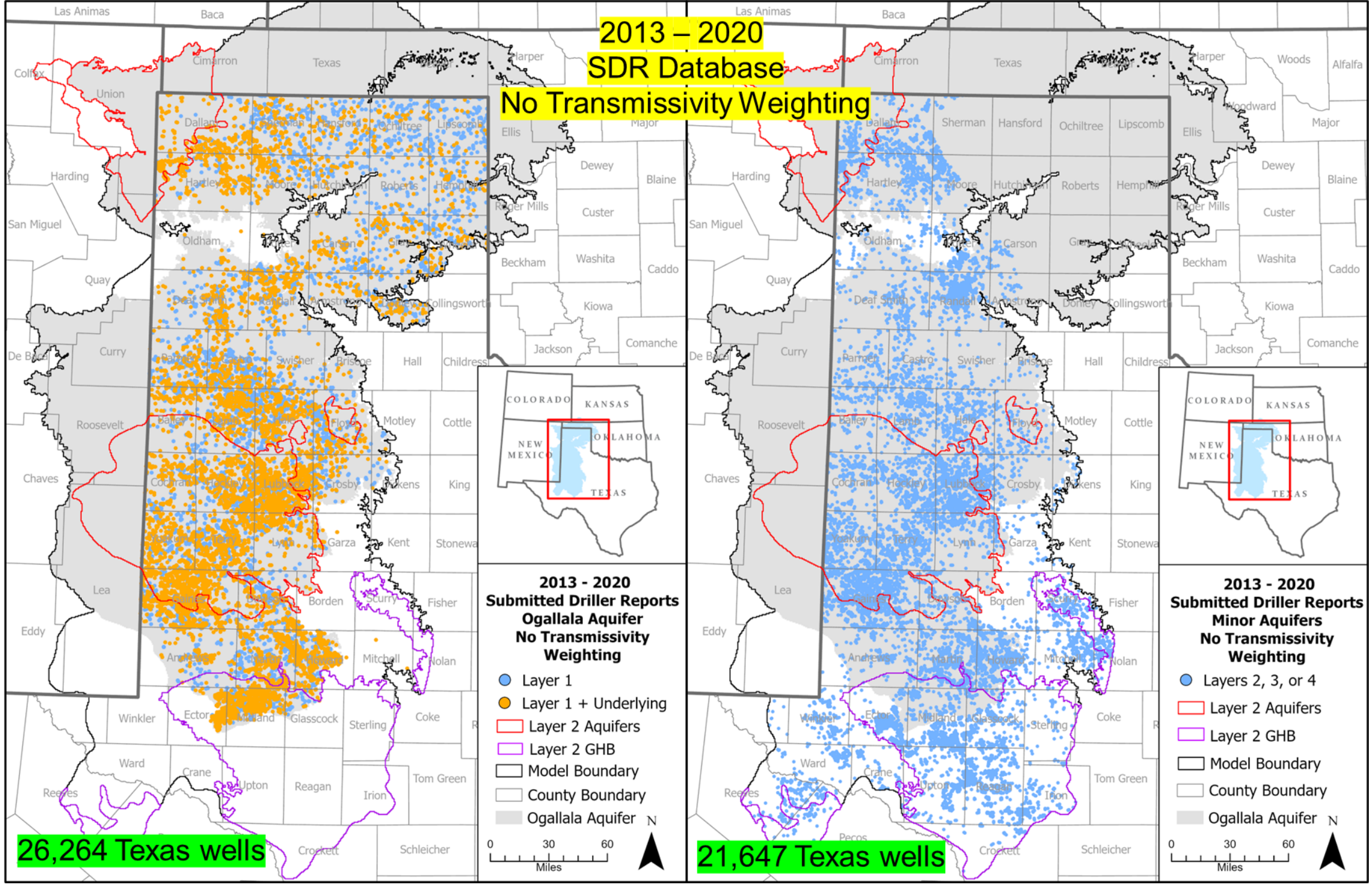
- Maintains conceptual model of rising recharge in postdevelopment, but,
- Storage component of budget rises above zero (rising water levels) only slightly and
- Storage component of budget does not exceed pumping (cross-over in plot).

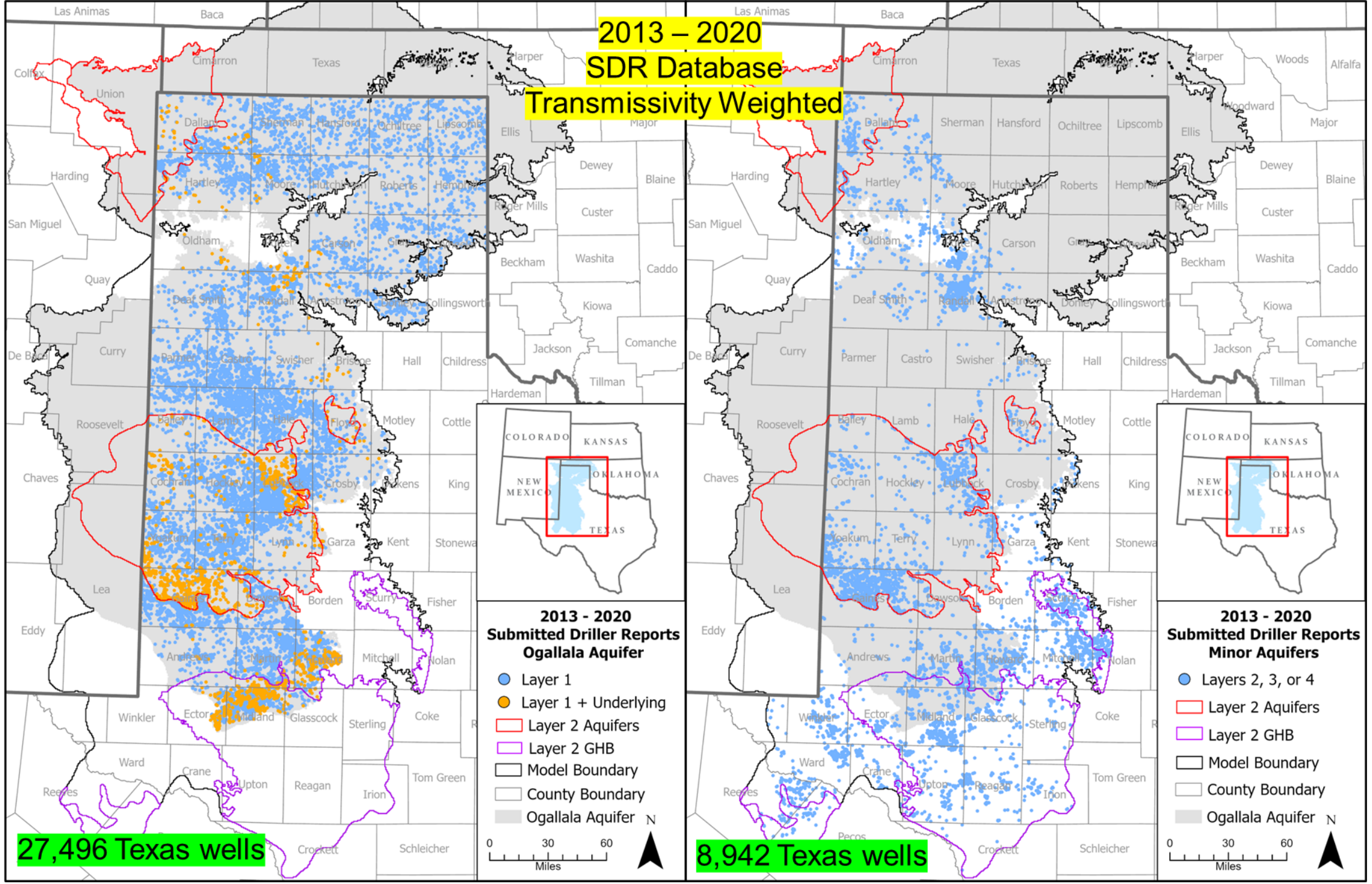
Howard County Recharge Adjustment

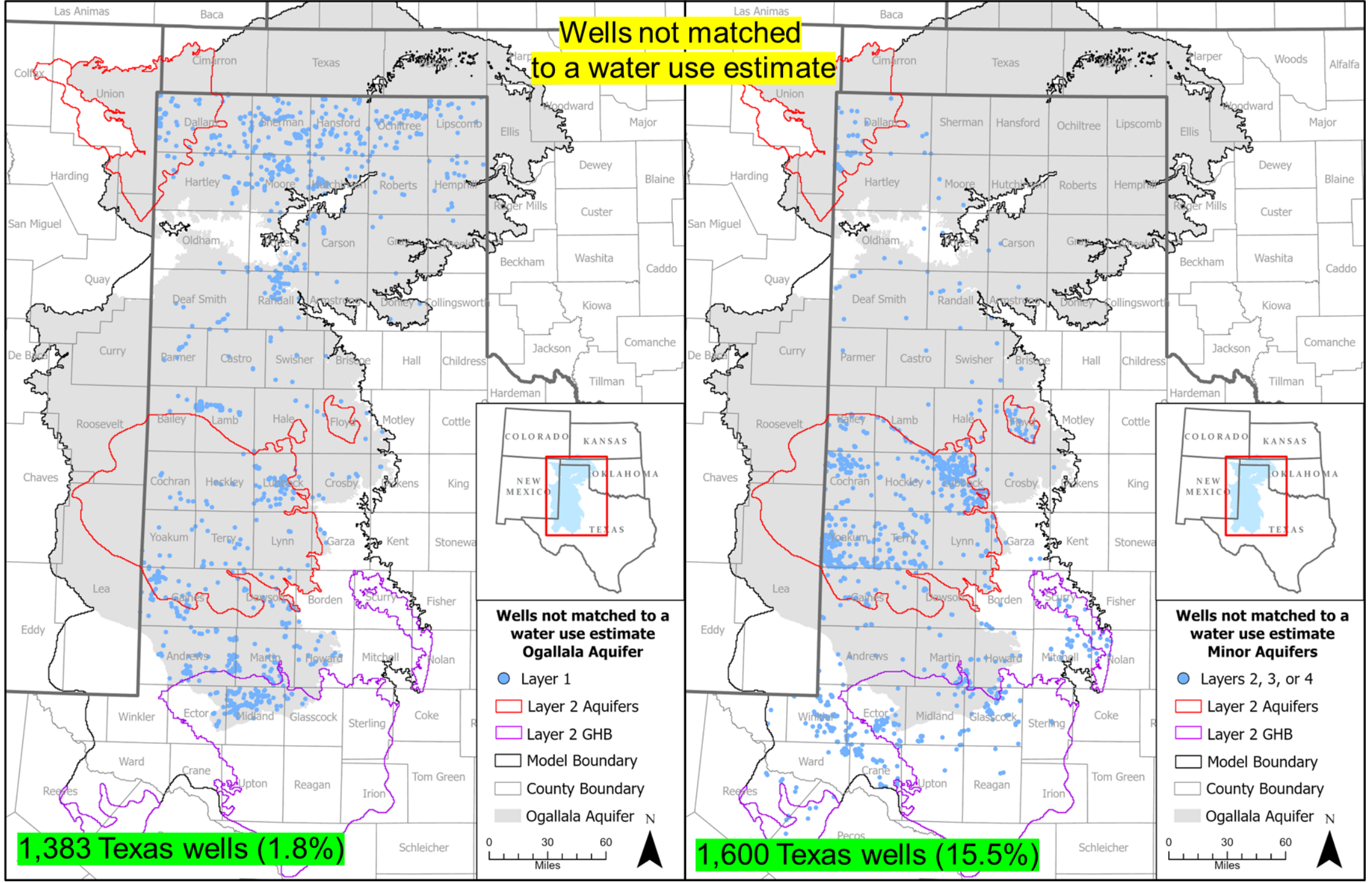
Model-wide slight improvement in target statistics

Statistic/Aquifer	Original HPAS GAM				HPAS with recharge capped at SP 37 in Howard Cnty			
	Ogallala	Layer 2	U. Dockum	L. Dockum	Ogallala	Layer 2	U. Dockum	L. Dockum
Residual mean	-0.95	-27.06	-27.54	-15.07	-0.92	-27.06	-27.54	-15.00
Absolute Residual Mean	26.95	37.91	32.45	49.98	26.95	37.91	32.45	49.95
Residual Standard Deviation	36.59	41.39	36.39	76.95	36.59	41.39	36.39	76.93
RMS Error	36.60	49.45	45.64	78.41	36.60	49.45	45.64	78.38
Number of observations	169,868	4,437	997	7,964	169,868	4,437	997	7,964
Range of observations	3,687.56	3,839.51	2,124.64	3,465.36	3,687.56	3,839.51	2,124.64	3,465.36
Scaled residual standard deviation	0.01	0.01	0.02	0.02	0.01	0.01	0.02	0.02
Scaled absolute residual mean	0.01	0.01	0.02	0.01	0.01	0.01	0.02	0.01
Scaled RMS Error	0.01	0.01	0.02	0.02	0.01	0.01	0.02	0.02
Scaled Residual Mean	0.00	-0.01	-0.01	0.00	0.00	-0.01	-0.01	0.00

Extra Slides


2013 – 2020
SDR Database
No Transmissivity Weighting
26,264 Texas wells
21,647 Texas wells
COLORADO
KANSAS
NEW MEXICO
OKLAHOMA
TEXAS
2013 - 2020
Submitted Driller Reports
Ogallala Aquifer
No Transmissivity
Weighting
Layer 1
Layer 1 + Underlying
Layer 2 Aquifers
Layer 2 GHB
Model Boundary
County Boundary
Ogallala Aquifer
N
0 30 60
Miles
2013 - 2020
Submitted Driller Reports
Minor Aquifers
No Transmissivity
Weighting
Layers 2, 3, or 4
Layer 2 Aquifers
Layer 2 GHB
Model Boundary
County Boundary
Ogallala Aquifer
N
0 30 60
Miles


2013 – 2020
SDR Database
Transmissivity Weighted
27,496 Texas wells
8,942 Texas wells
2013 - 2020
Submitted Driller Reports
Ogallala Aquifer
Layer 1
Layer 1 + Underlying
Layer 2 Aquifers
Layer 2 GHB
Model Boundary
County Boundary
Ogallala Aquifer
2013 - 2020
Submitted Driller Reports
Minor Aquifers
Layers 2, 3, or 4
Layer 2 Aquifers
Layer 2 GHB
Model Boundary
County Boundary
Ogallala Aquifer
N
0 30 60
Miles
COLORADO
KANSAS
OKLAHOMA
TEXAS
NEW MEXICO


Wells not matched
to a water use estimate
Las Animas
Baca
Cimarron
Texas
Harper
Woods
Alfalfa
Collfax
Union
Woodward
Major
Dallam
Sherman
Hansford
Ochiltree
Lipscomb
Ellis
Harding
Dewey
Blaine
Hartley
Moore
Hutchinson
Roberts
Hemphill
Roger Mills
Custer
San Miguel
Oldham
Carson
Beckham
Washita
Caddo
Quay
Deaf Smith
Randall
Armstrong
Donley
Collingsworth
Kiowa
De Baca
Curry
Parmer
Castro
Swisher
Briscoe
Hall
Childress
Jackson
Comanche
Tillman
Hardeman
Roosevelt
Bailey
Lamb
Hale
Floyd
Motley
Cottle
Chaves
Cochran
Hockley
Lubbock
Crosby
Dickens
King
Yoakum
Terry
Lynn
Garza
Kent
Stonewall
Lea
Gaines
Dawson
Borden
Scurry
Fisher
Eddy
Andrews
Martin
Howard
Mitchell
Nolan
Winkler
Ector
Midland
Glasscock
Sterling
Coke
Ward
Crane
Upton
Reagan
Irion
Tom Green
Reeves
Pecos
Schleicher
COLORADO
KANSAS
NEW MEXICO
OKLAHOMA
TEXAS
Wells not matched to a water use estimate Ogallala Aquifer
Layer 1
Layer 2 Aquifers
Layer 2 GHB
Model Boundary
County Boundary
Ogallala Aquifer
N
0
30
60
Miles
1,383 Texas wells (1.8%)
Wells not matched to a water use estimate Minor Aquifers
Layers 2, 3, or 4
Layer 2 Aquifers
Layer 2 GHB
Model Boundary
County Boundary
Ogallala Aquifer
N
0
30
60
Miles
1,600 Texas wells (15.5%)

High Plains Aquifer System Groundwater Availability Model

Stakeholder Advisory Forum

September 20, 2024

1. Questions and Answers

Question 1: Did the Districts besides North Plains review and approve estimates or provide additional information? For example High Plains? (Cindy Ridgeway)

Answer: The TWDB Agriculture Water Conservation Team works with the Districts in developing annual irrigation use estimates for the TWDB Water Use Survey. These estimates are sent to the Districts for review. We sent out a request for production data to all the Districts on November 20, 2023 and received some data. If the pumping data was comprehensive for an entire county we incorporated it into the model. Districts are welcome to review the pumping data for the model extension and provide feedback. We may still have time for adjustments to the input pumping.

Question 2: Discuss General Head Boundary wells and how much that factors in flow into and out of the model. (Cindy Ridgeway)

Answer: In the Original Model, heads from the Edwards-Trinity (Plateau) and Pecos Valley alternative groundwater availability model were used to estimate heads for the layer 1 and 2 general head boundaries implemented in the river package. In the Original Model, the heads were kept constant from 2004 through 2012. For the Model Extension, we kept the head values the same from 2013 through 2020.

Question 3: Do you have a map of actual dry holes in the Ogallala? (Cindy Ridgeway)

Answer: We will consider developing a map of dry holes and including the Final Report.

Question 4: It should be noted in the report of the model artifact in Gaines and model results should be used with caution in this select area. (Cindy Ridgeway)

Answer: We will be sure and use the results with caution in that area.

Question 5: Could you confirm that the Howard County recharge was addressed in this update? (Bill Hutchison)

Answer: Yes, the Howard County recharge issue was addressed in this update.

Question 6: I noticed there were some pretty significant changes and assumptions between how different water uses were implemented in each county and how it was distributed among the wells between what was done in the historical GAM and what was done in this extension period. This is the kind of thing that happens when you do an extension and I don't have any issues with that. It would be good to see an evaluation of the degree to which the model has adjusted to the new pumping distribution so that water level changes picked up at the end of the extension reflect the actual water use that happens after the end of the extension when we're using this in a predictive sense for drought planning versus the model slowly continuing to adjust to a new pumping distribution like you wouldn't want. You know recoveries occurring in an area due to the model adjusting to the extension instead of something happening in the predictive period. When you

change the assumptions the model has to adjust to that change and so having some sort of discussion about the degree to which it has adjusted to the change would be useful. (Wade Oliver)

Answer: We will do a predictive model run to evaluate the degree to which the model has adjusted to the new pumping distribution. We will include the results of this analysis in the Final Report.

Question 7: Need to be clear about what district data was and was not used in the report. (Wade Oliver)

Answer: We will document in the final report what district data was and was not used in the report.

Question 8: Can you tell us why you decided to change those assumptions and spread that pumping back out? (Amy Bush)

Answer: We were unsuccessful in replicating the original model pumping distribution. One of the reasons for this was because the original modeling effort went through an iterative process of running the model and then redistributing pumping within a county from areas of low saturated thickness to areas of higher saturated thickness to reduce the amount of model curtailed pumping. Section 3.1.6 of the Original Numerical Model Report describes this iterative process. We decided to try a different approach of evenly distributing total county pumping estimates for irrigation, rural domestic, livestock, and mining. This approach takes less time, is more transparent, and is able to be replicated for future extensions. The average model curtailed pumping from 2000 through 2012 is 176,853 Acre-Feet compared to an average of 221,497 Acre-Feet from 2013 through 2020 using the new approach. It is also important to note that 7,048 of 8,165 new Submitted Driller Reports from 2013 through 2020 with a proposed use of Irrigation were in areas of 2012 model simulated saturated thickness greater than 30 feet.

2. Attendance List

Name	Organization
Christa Perry	Hemphill County Underground Water Conservation District
Jason Coleman	High Plains Underground Conservation District
Odell Ward	North Plains Groundwater Conservation District
Janet Guthrie	North Plains Groundwater Conservation District
Ashley Ausbrooks	Panhandle Groundwater Conservation District
Britney Britten	Panhandle Groundwater Conservation District
Amber Blount	Sandy Land Underground Water Conservation District
Adam Foster	Texas Alliance of Groundwater Districts
Michael Chambers	City of Lorenzo
Fabian Heaney	Red River Authority of Texas
Cole Walker	Colorado River Municipal Water District
Paula Jo Lemonds	HDR, Inc.
Wade Oliver	INTERA
John Ellis	INTERA
Alyssa Balzen	KT Groundwater
Philip Webster	KT Groundwater
Bill Hutchison	Consultant
Darrell Peckham	BNP Land LLC
Amy Bush	RMBJ Geo Inc.
Ray Brady	RMBJ Geo Inc.
Larry French	Texas Public Policy Foundation
Cindy Ridgeway	
Zedric Capus	Texas Water Development Board
Sara Sutton	Texas Water Development Board
Heather Rose	Texas Water Development Board
Connie Beniquez	Texas Water Development Board
Jennifer Badhwar	Texas Water Development Board
Ian Jones	Texas Water Development Board
Shirley Wade	Texas Water Development Board
Saheli Majumdar	Texas Water Development Board
Tim Cawthon	Texas Water Development Board
Daryn Hardwick	Texas Water Development Board