GAM

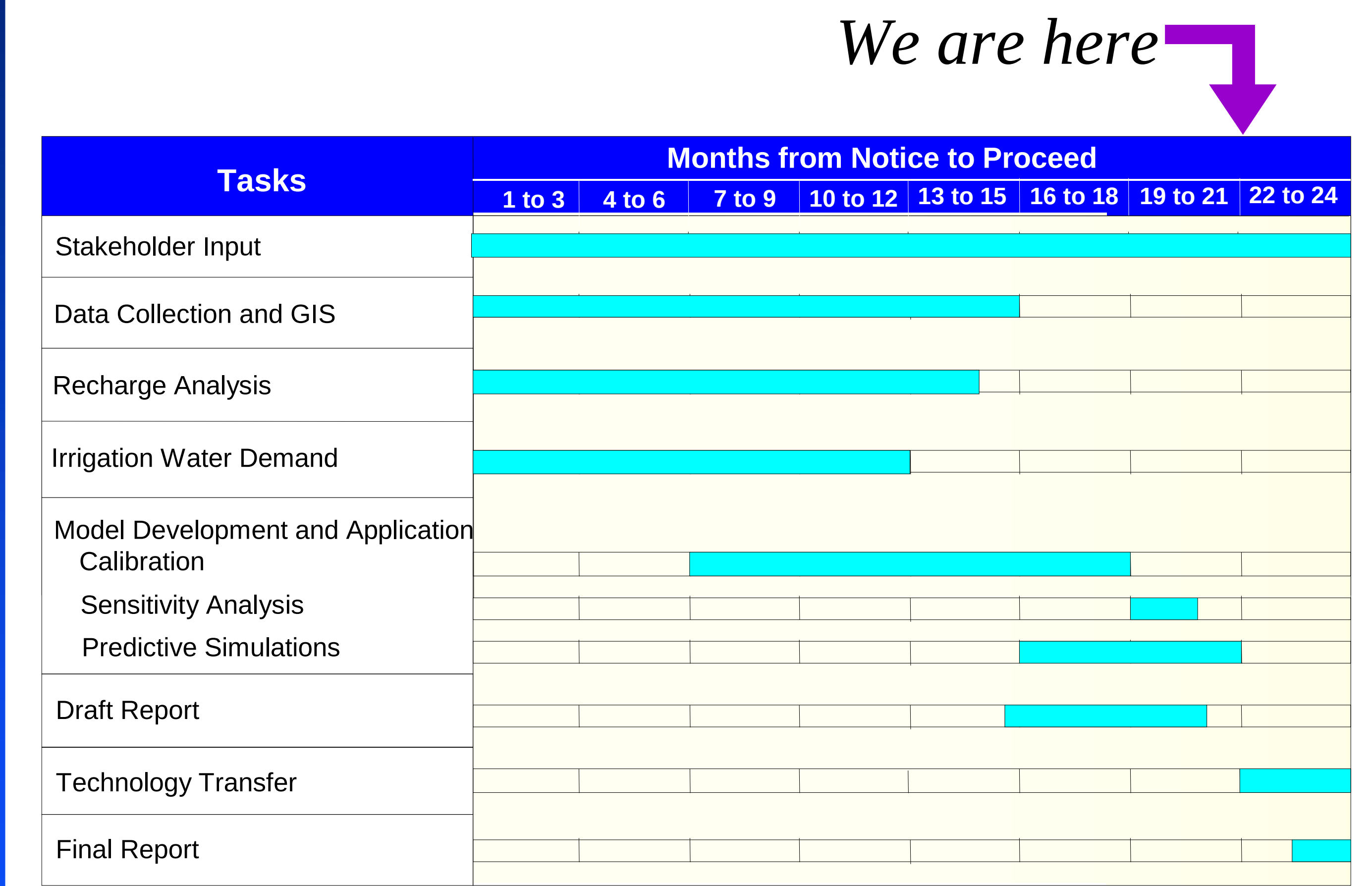
Groundwater Availability Modeling

texas water development board

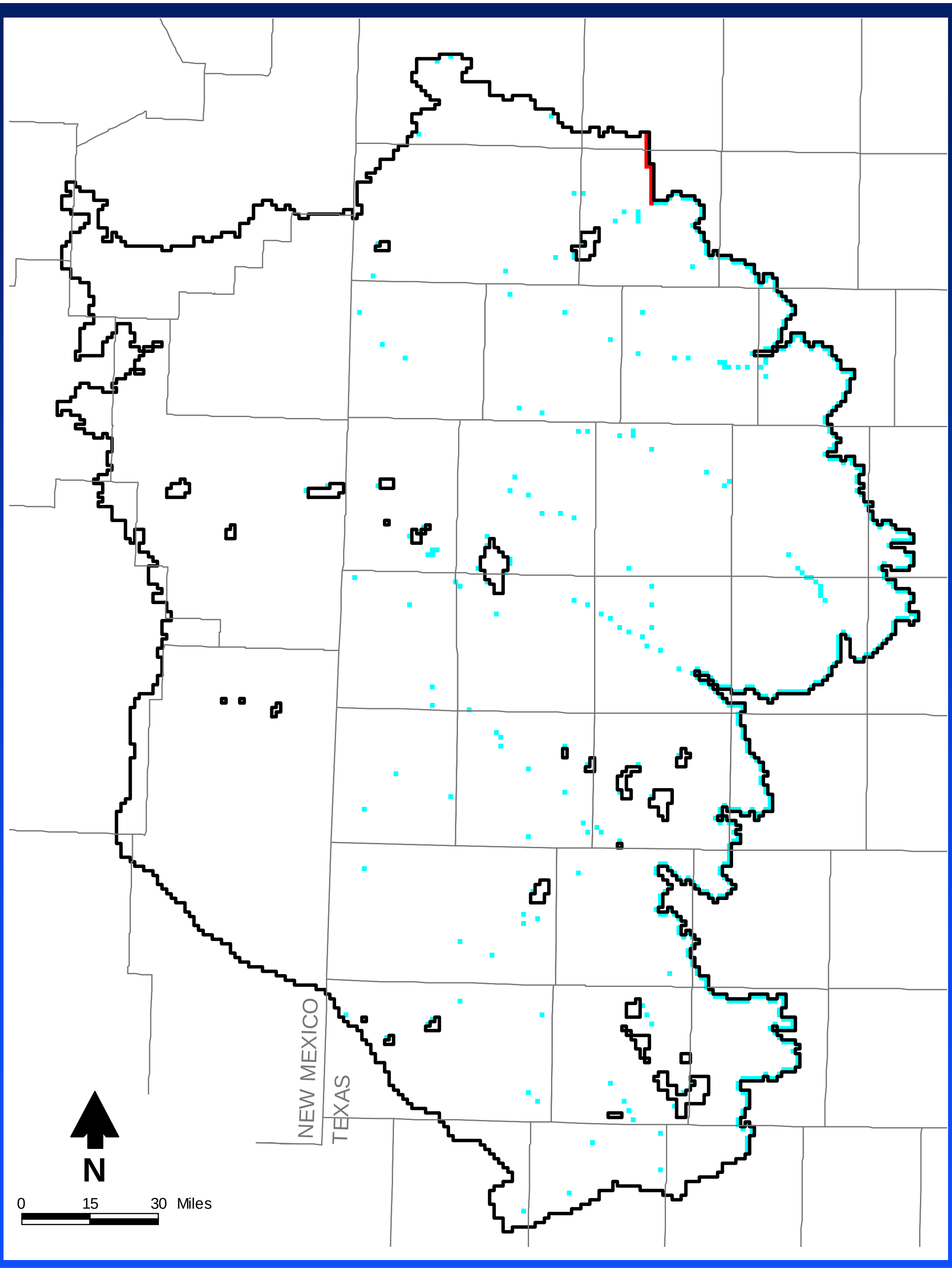
Agenda for Stakeholder Advisory Forum No. 7 - November 4, 2002

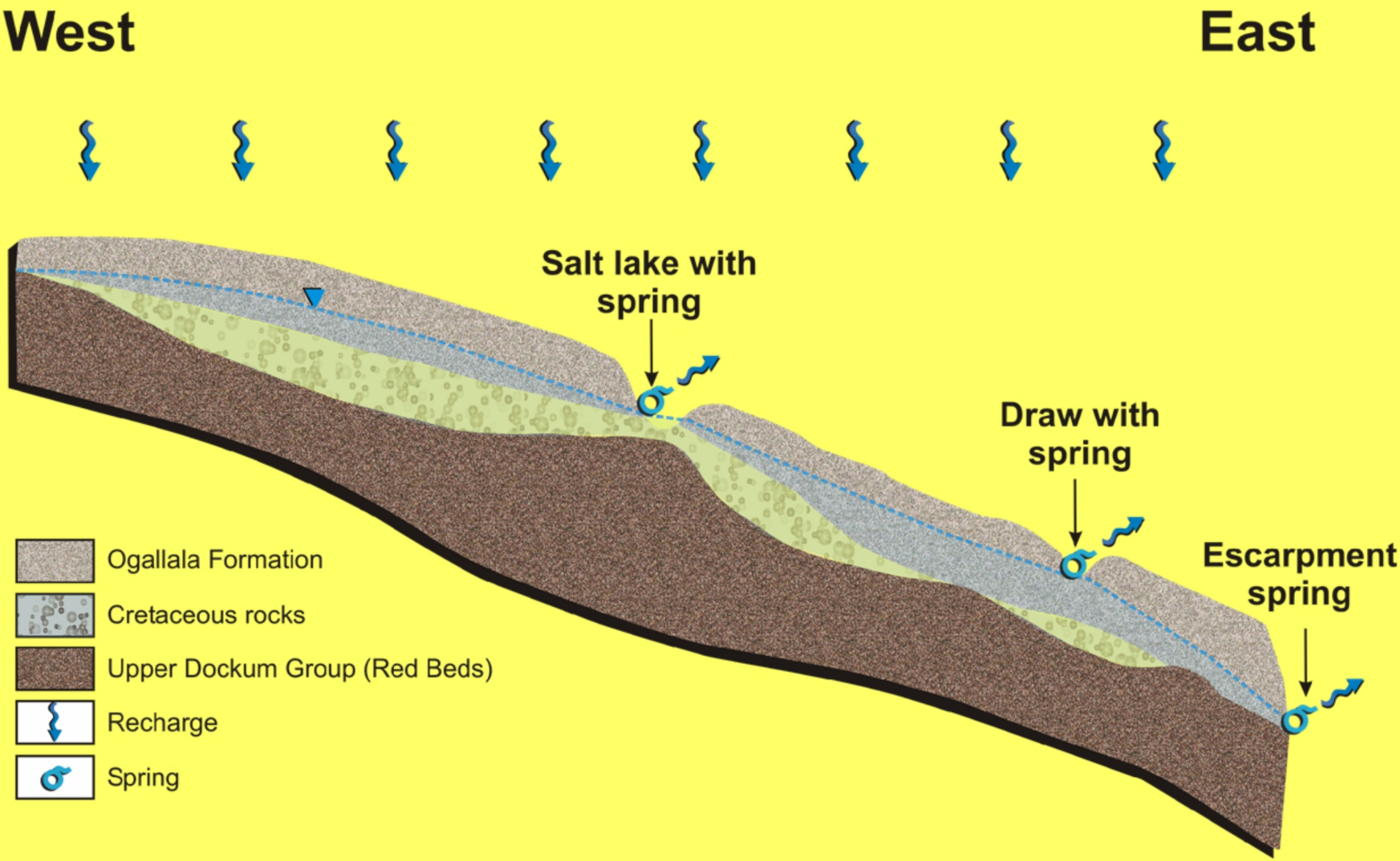
- Updated transient simulation results
- Predictive simulations\draft report
- Overview of conclusions
- Questions, comments, input

Project Schedule



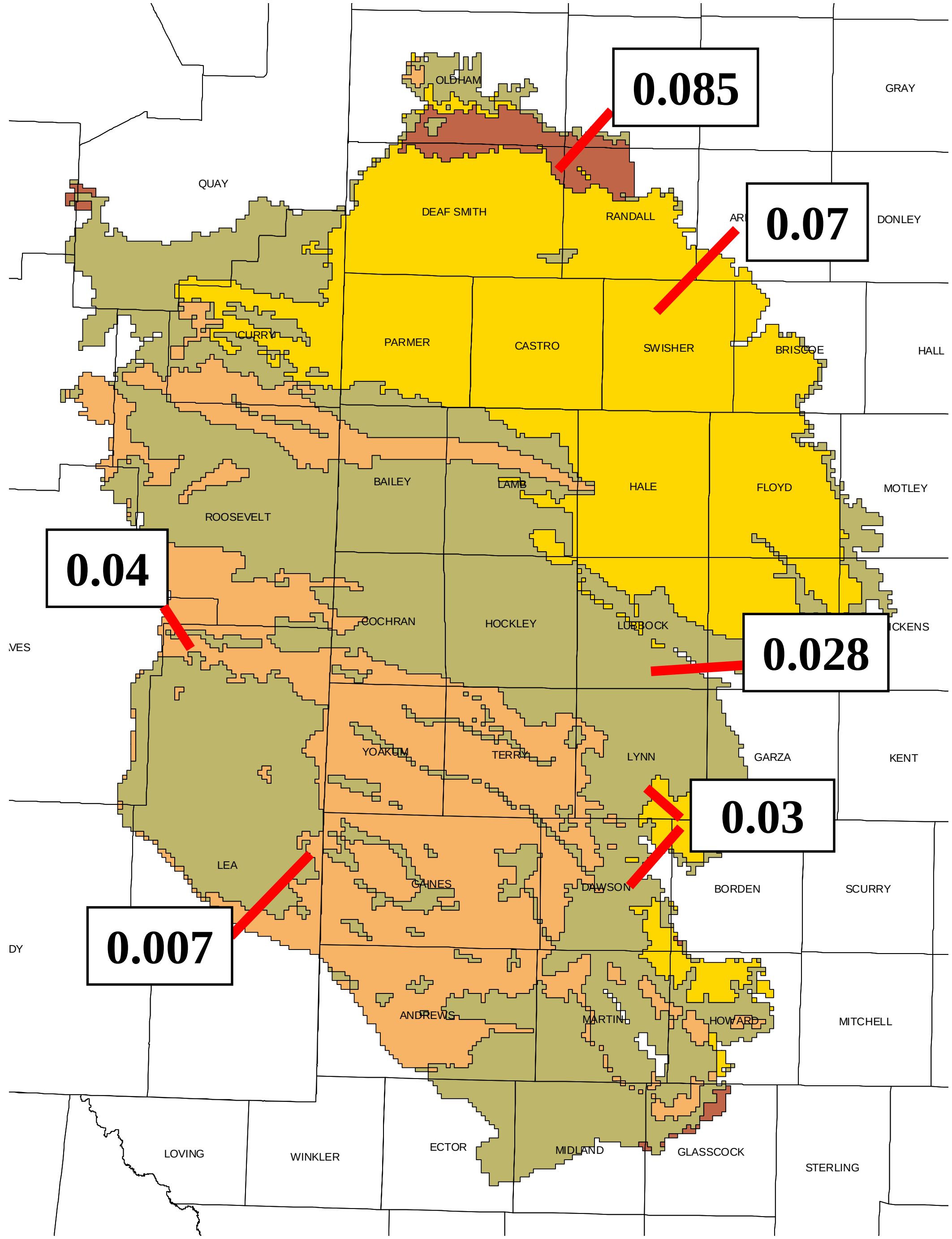
Model Boundaries





West
East
Salt lake with spring
Draw with spring
Escarpment spring
Ogallala Formation
Cretaceous rocks
Upper Dockum Group (Red Beds)
Recharge
Spring

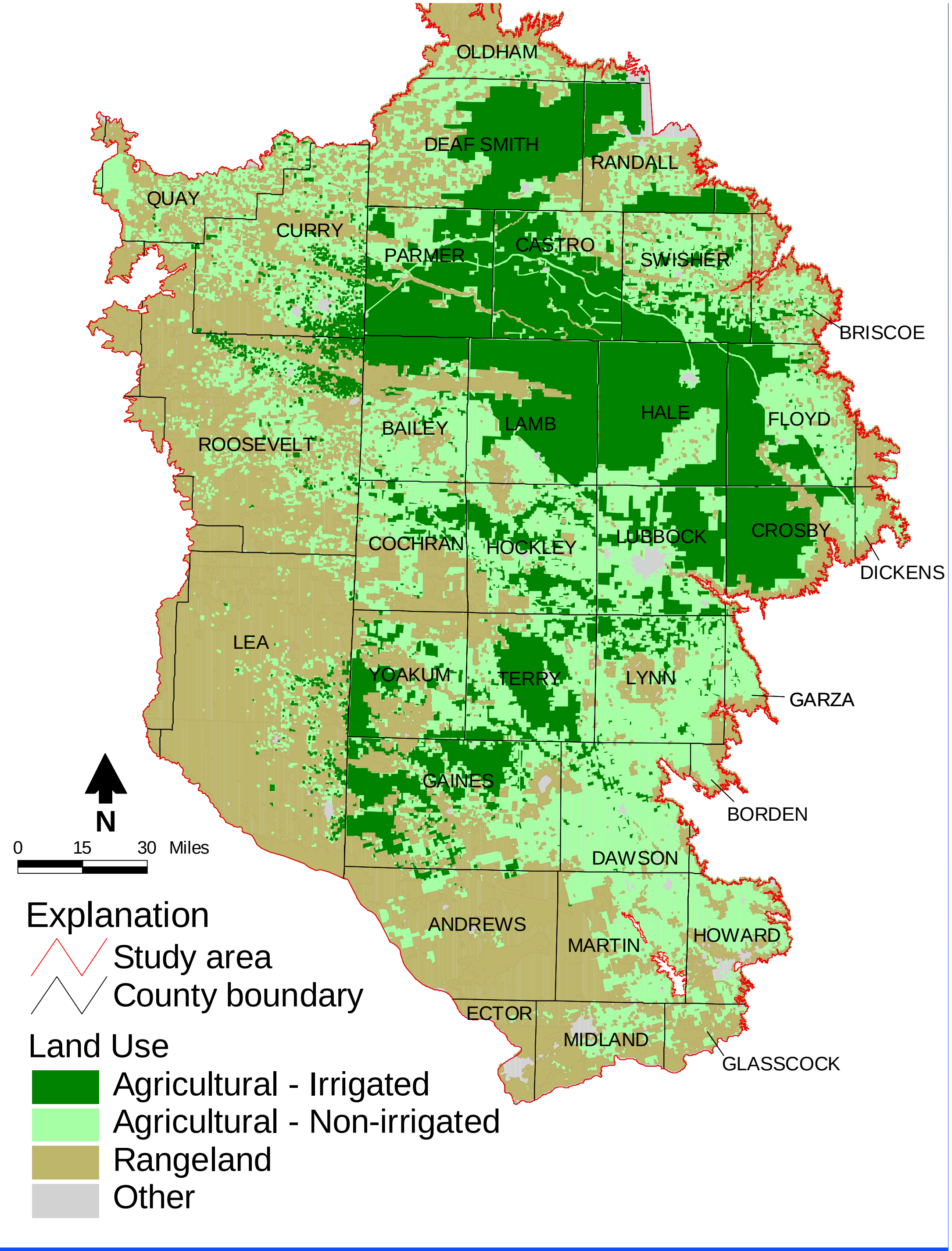
Final Recharge Zones Used in the Model (inches/yr)



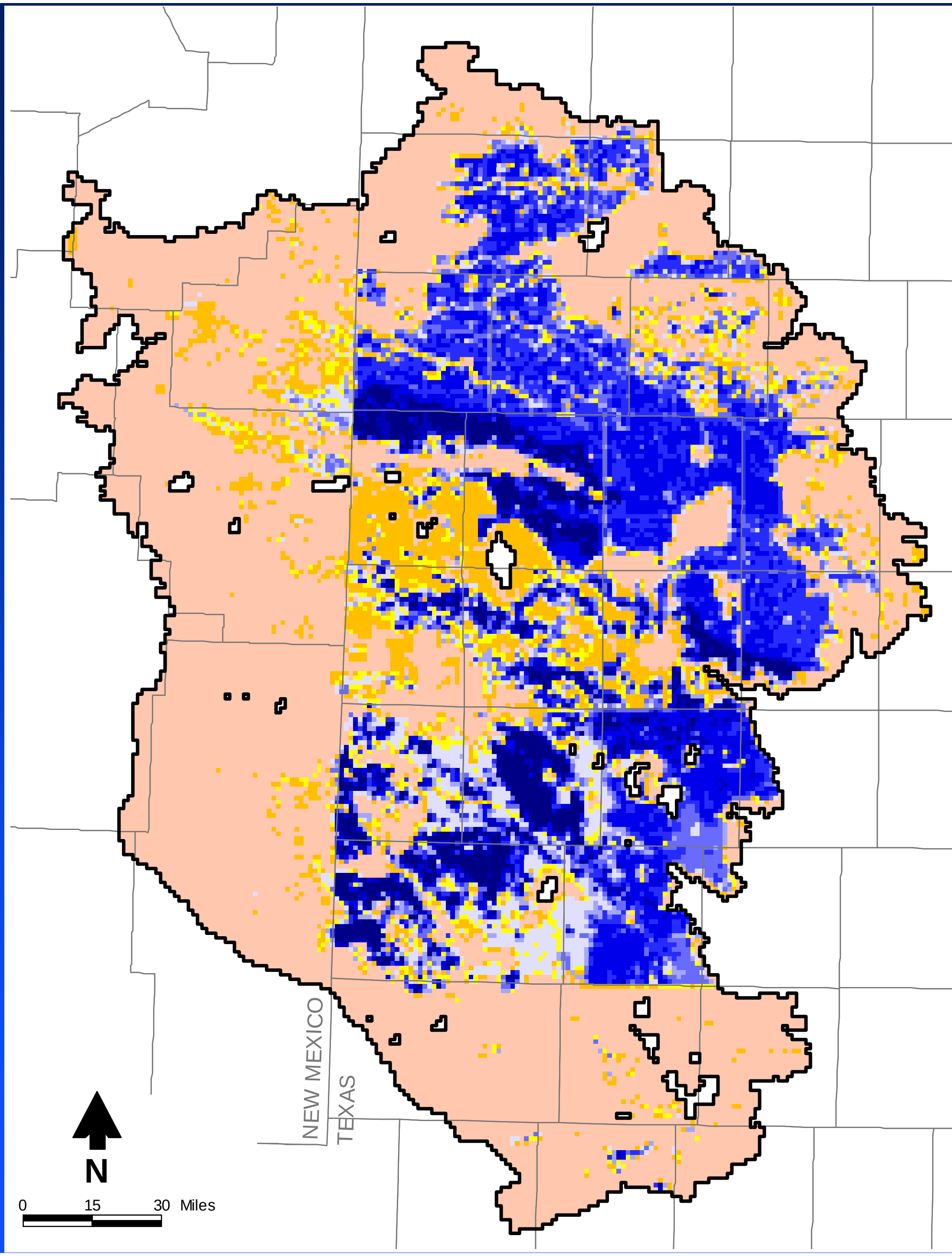
Enhanced Recharge

- Irrigated areas; 1.75 - 2.5 in/yr
- Dry land farming; 0.25 - 2.0 in/yr
- Non-farmed areas; predevelopment rates

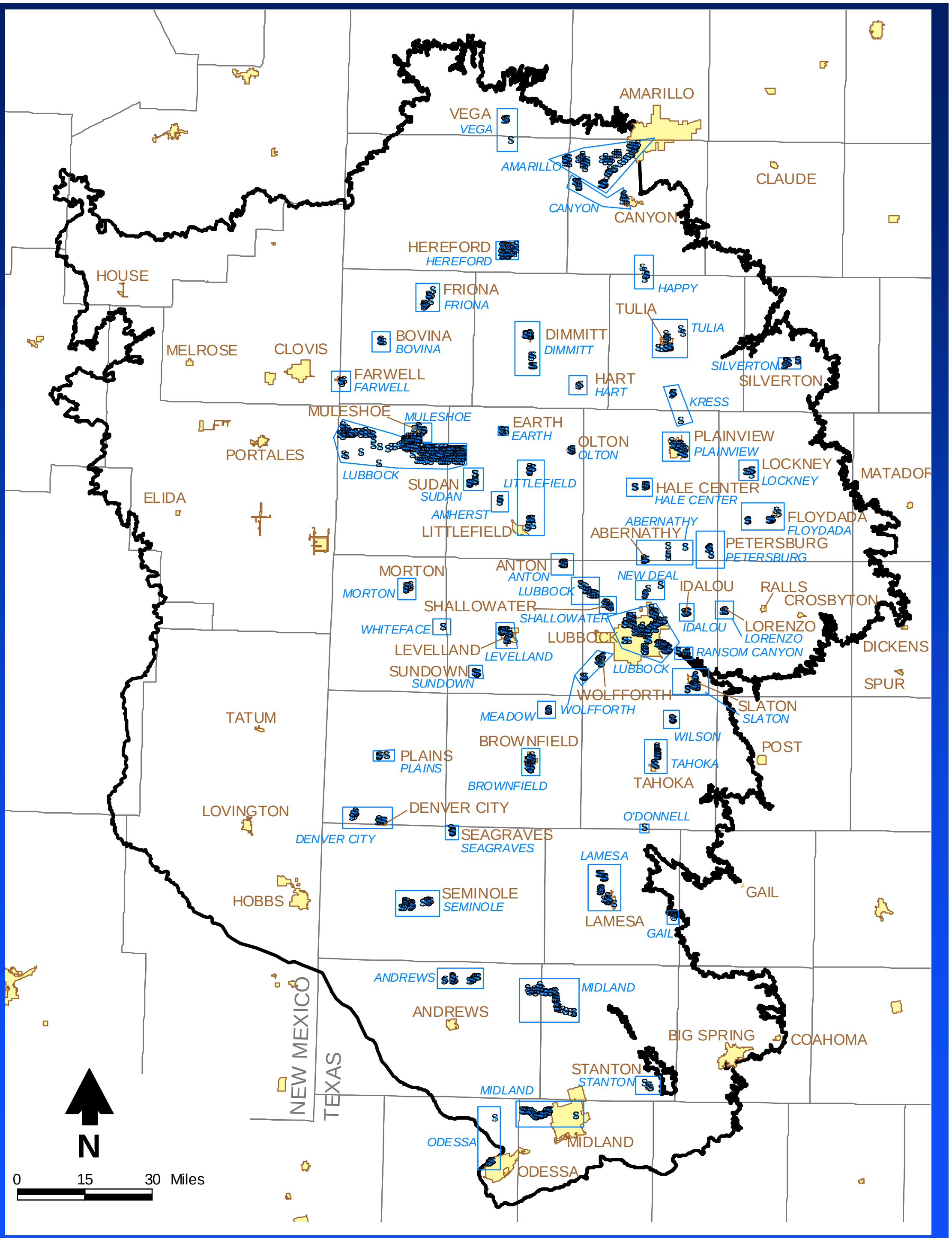
Land Use


OLDHAM
DEAF SMITH
RANDALL
QUAY
CURRY
PARMER
CASTRO
SWISHER
BRISCOE
BAILEY
LAMB
HALE
FLOYD
ROOSEVELT
COCHRAN
HOCKLEY
LUBBOCK
CROSBY
DICKENS
LEA
YOAKUM
TERRY
LYNN
GARZA
GAINES
BORDEN
DAWSON
ANDREWS
MARTIN
HOWARD
ECTOR
MIDLAND
GLASSCOCK
N
0 15 30 Miles
Explanation
Study area
County boundary
Land Use
Agricultural - Irrigated
Agricultural - Non-irrigated
Rangeland
Other

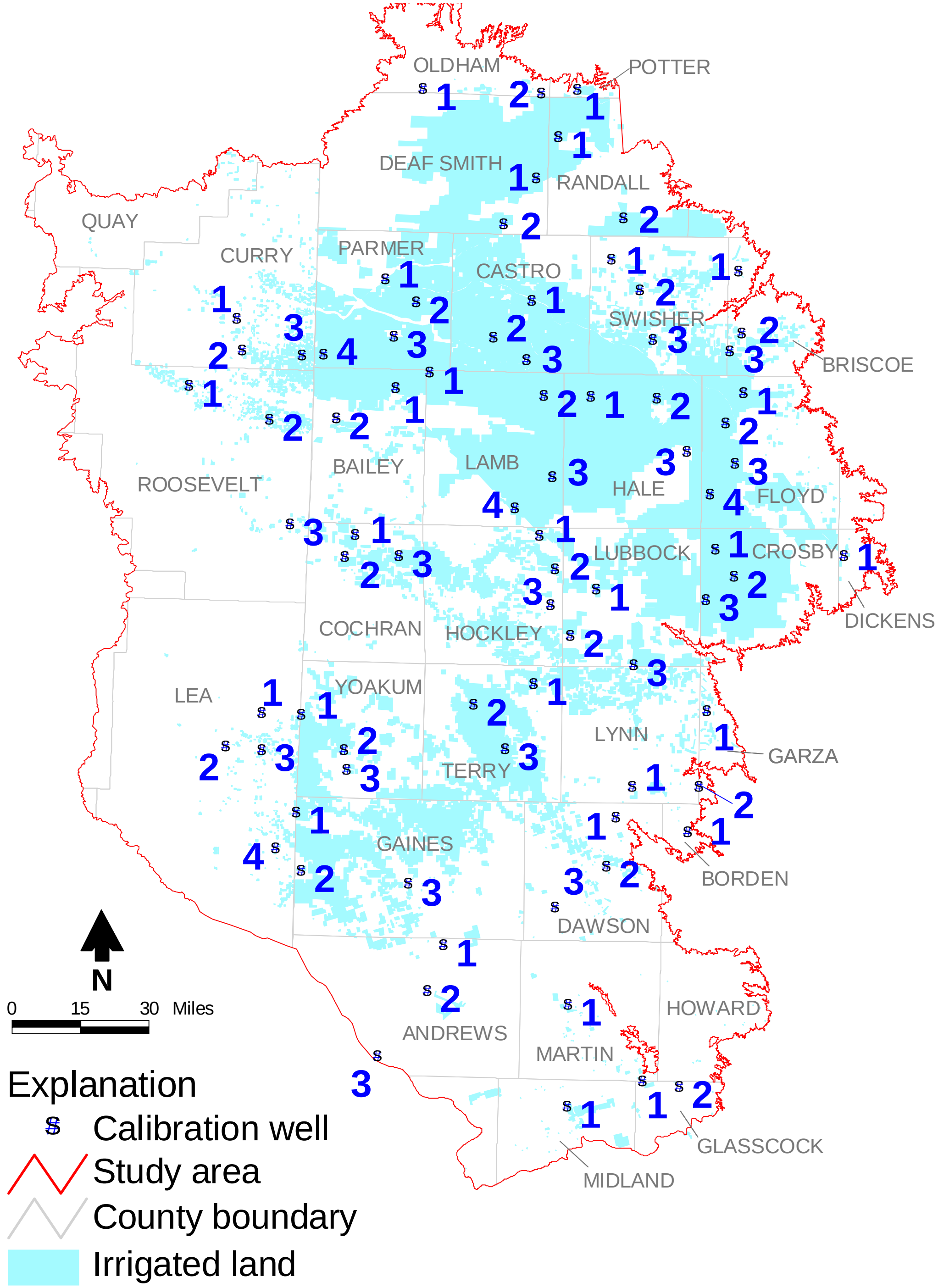
Post-Development Recharge Rates

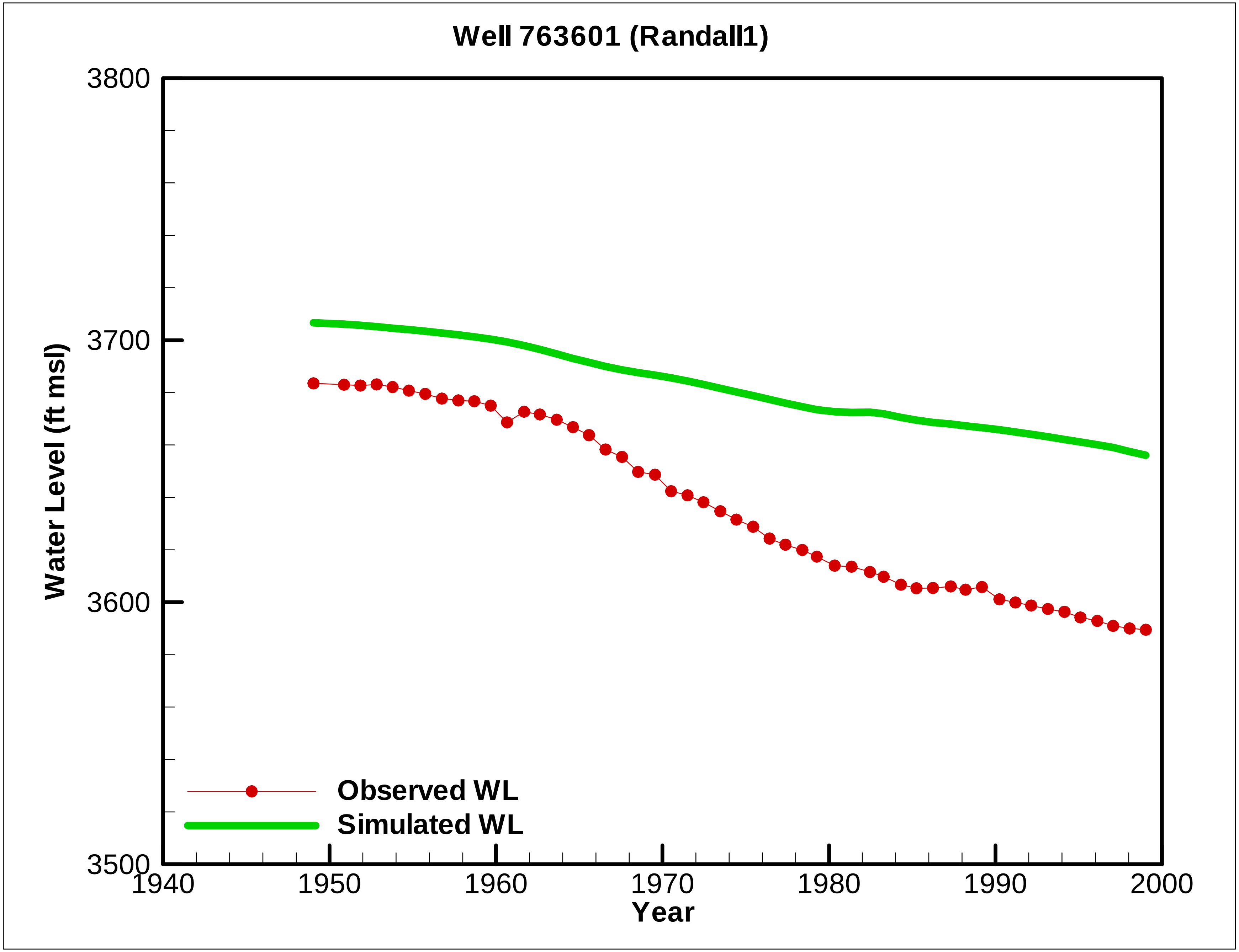


Non-Agricultural Pumping

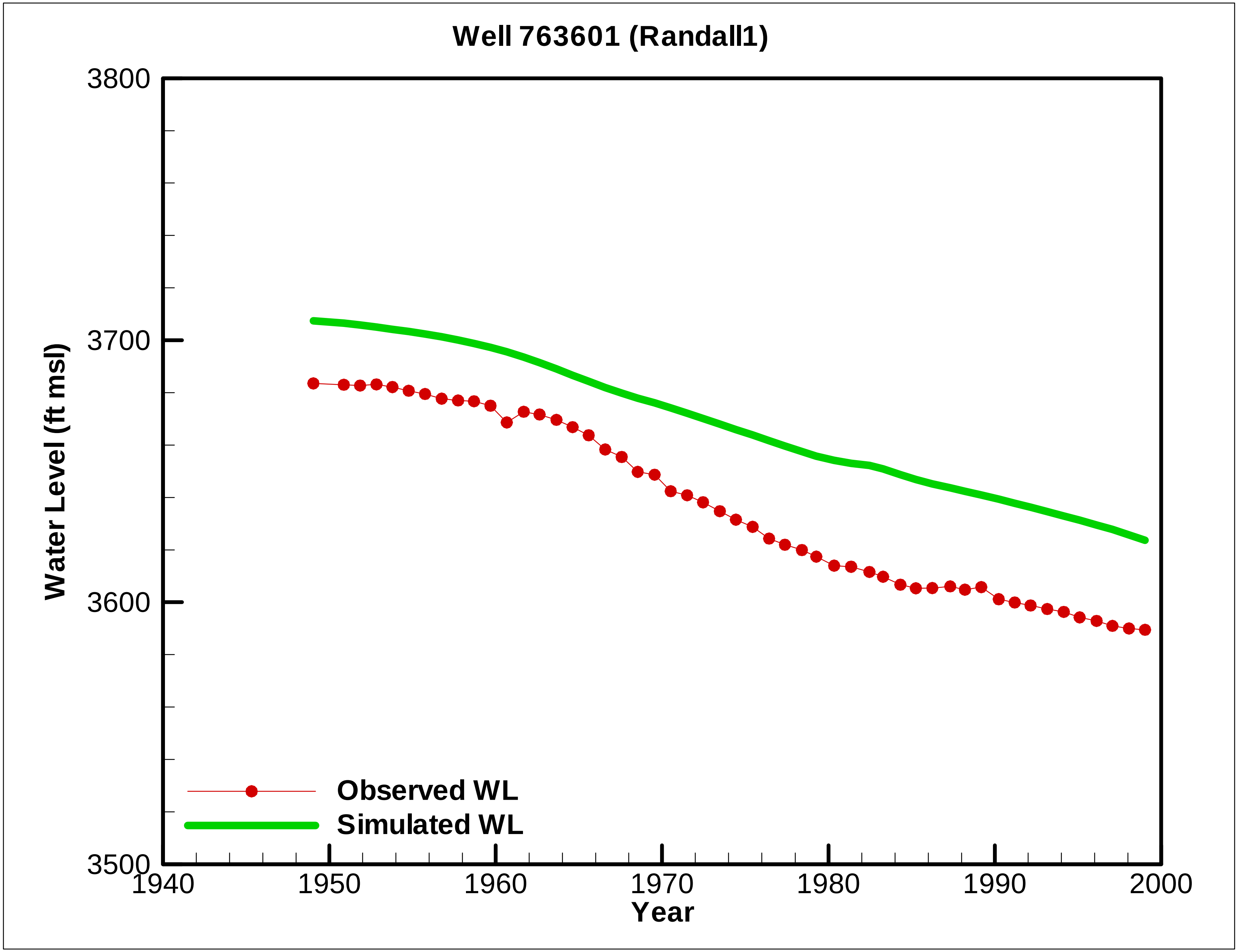


Transient Calibration Points





Well 763601 (Randall1)
Water Level (ft msl)
3800
3700
3600
3500
1940
1950
1960
1970
1980
1990
2000
Year
Observed WL
Simulated WL



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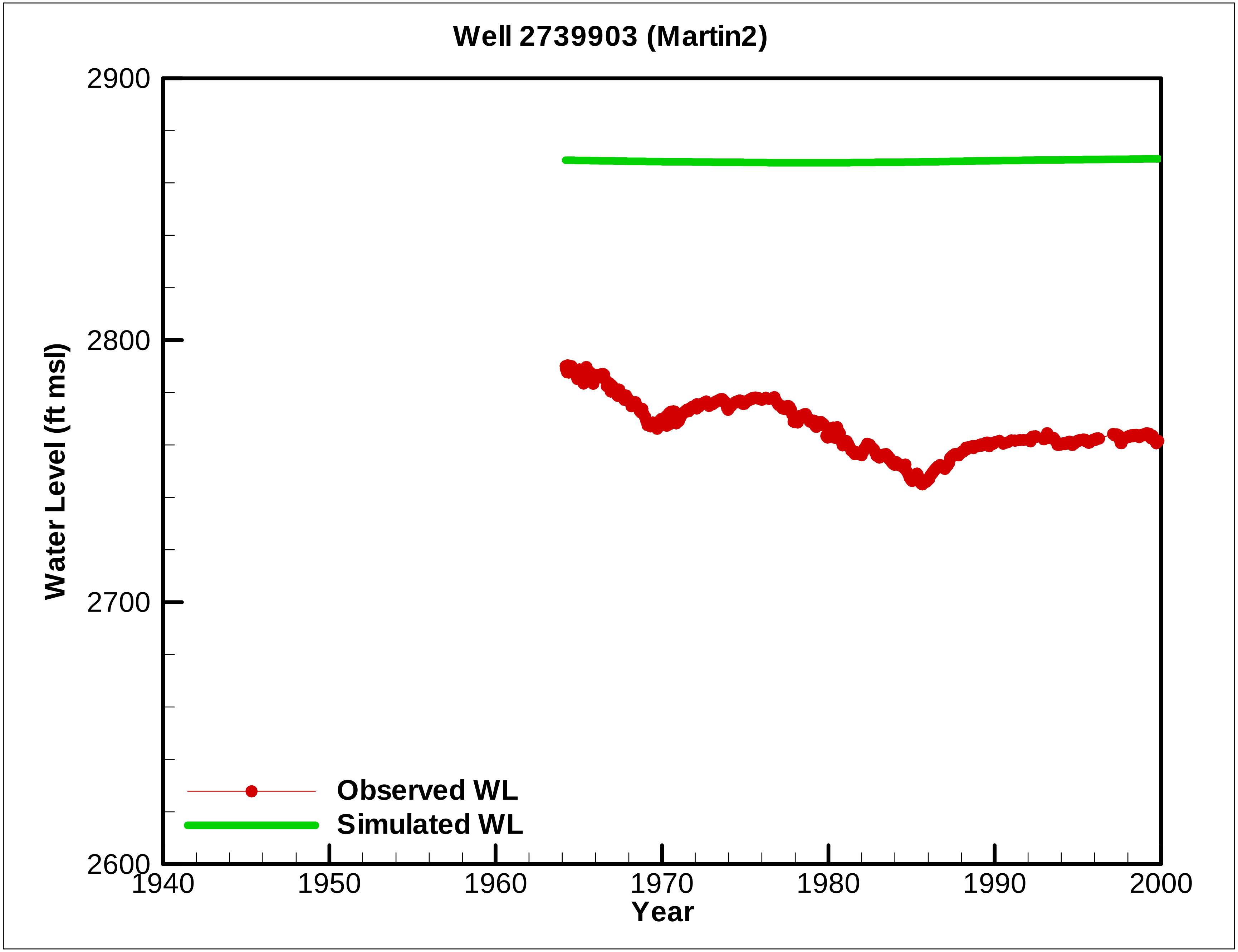
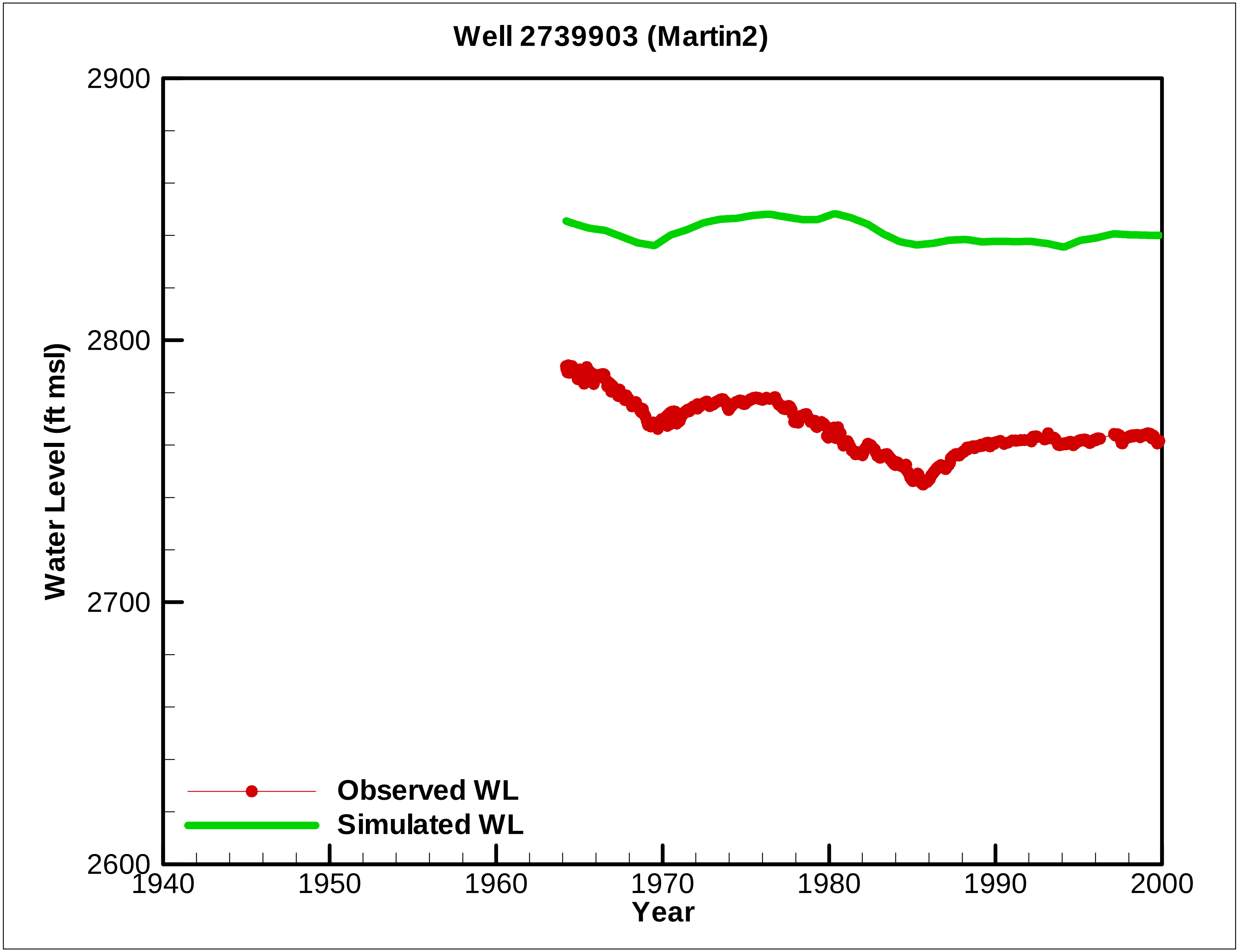


Well 2739903 (Martin2)
2900
2800
2700
2600
Water Level (ft msl)
1940
1950
1960
1970
1980
1990
2000
Year
Observed WL
Simulated WL


Well 2739903 (Martin2)
2900
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2700
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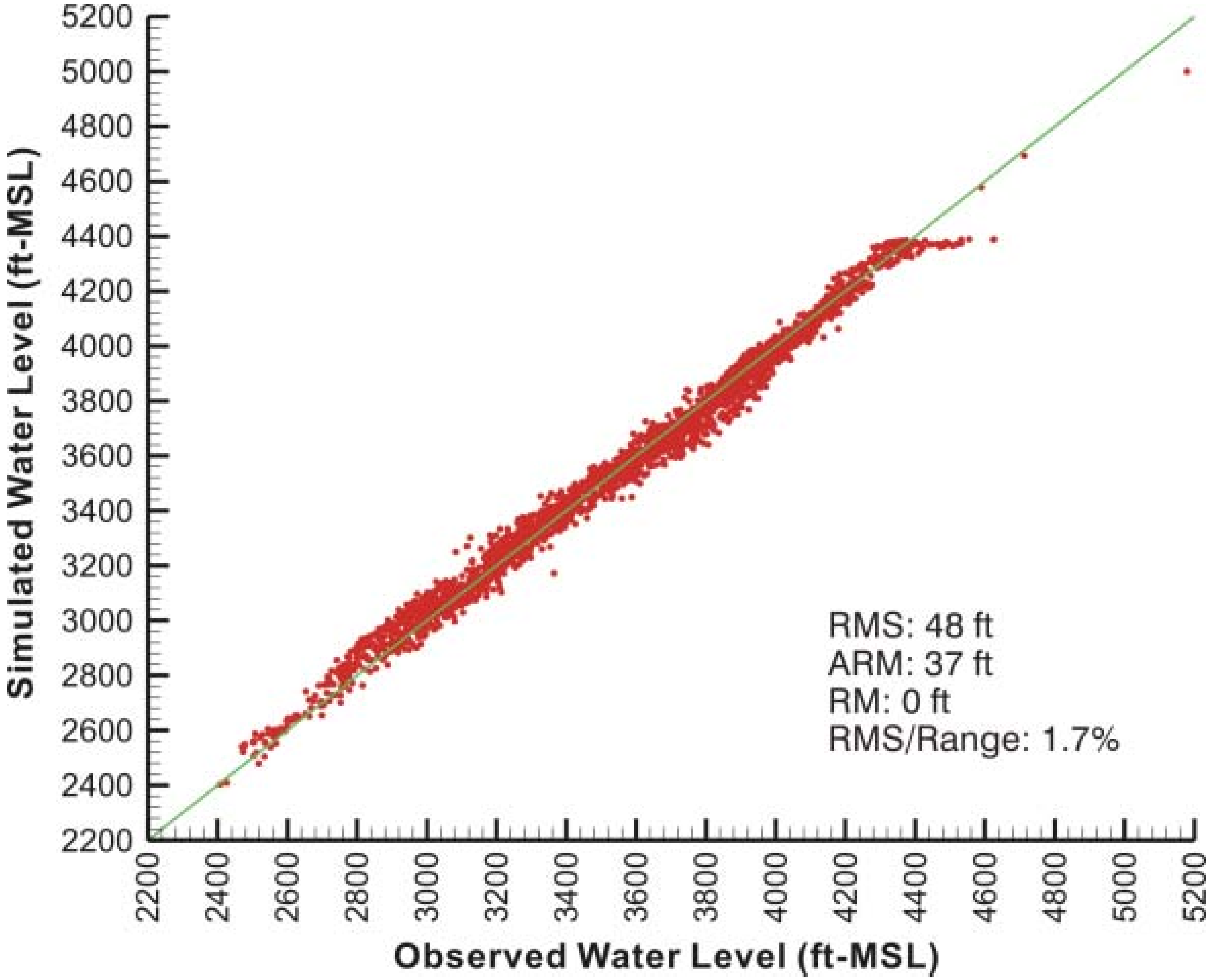
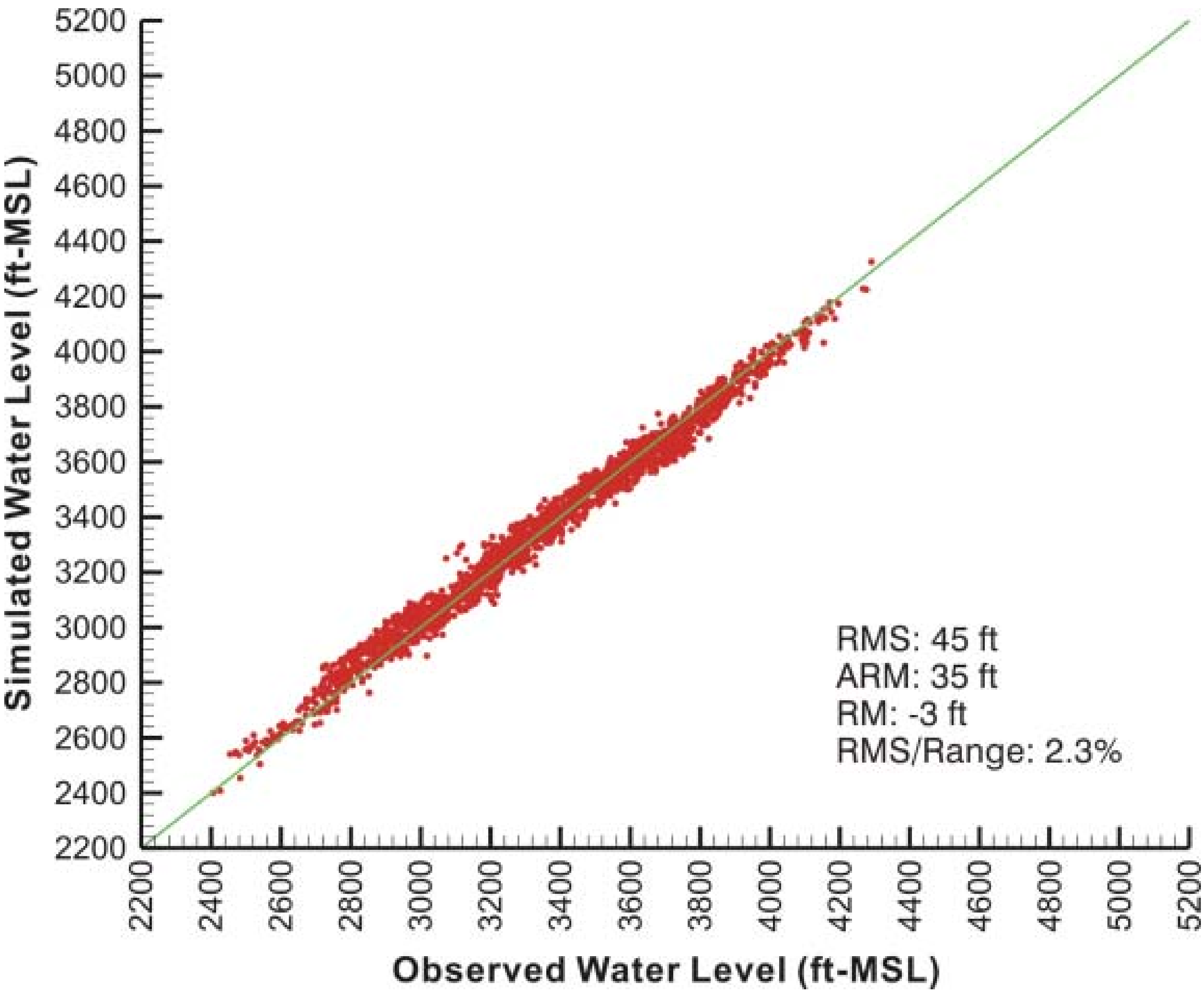
Water Level (ft msl)
1940
1950
1960
1970
1980
1990
2000
Year
Observed WL
Simulated WL

Simulated vs. Observed Water Levels - 1990



Simulated vs. Observed Water Levels - 2000



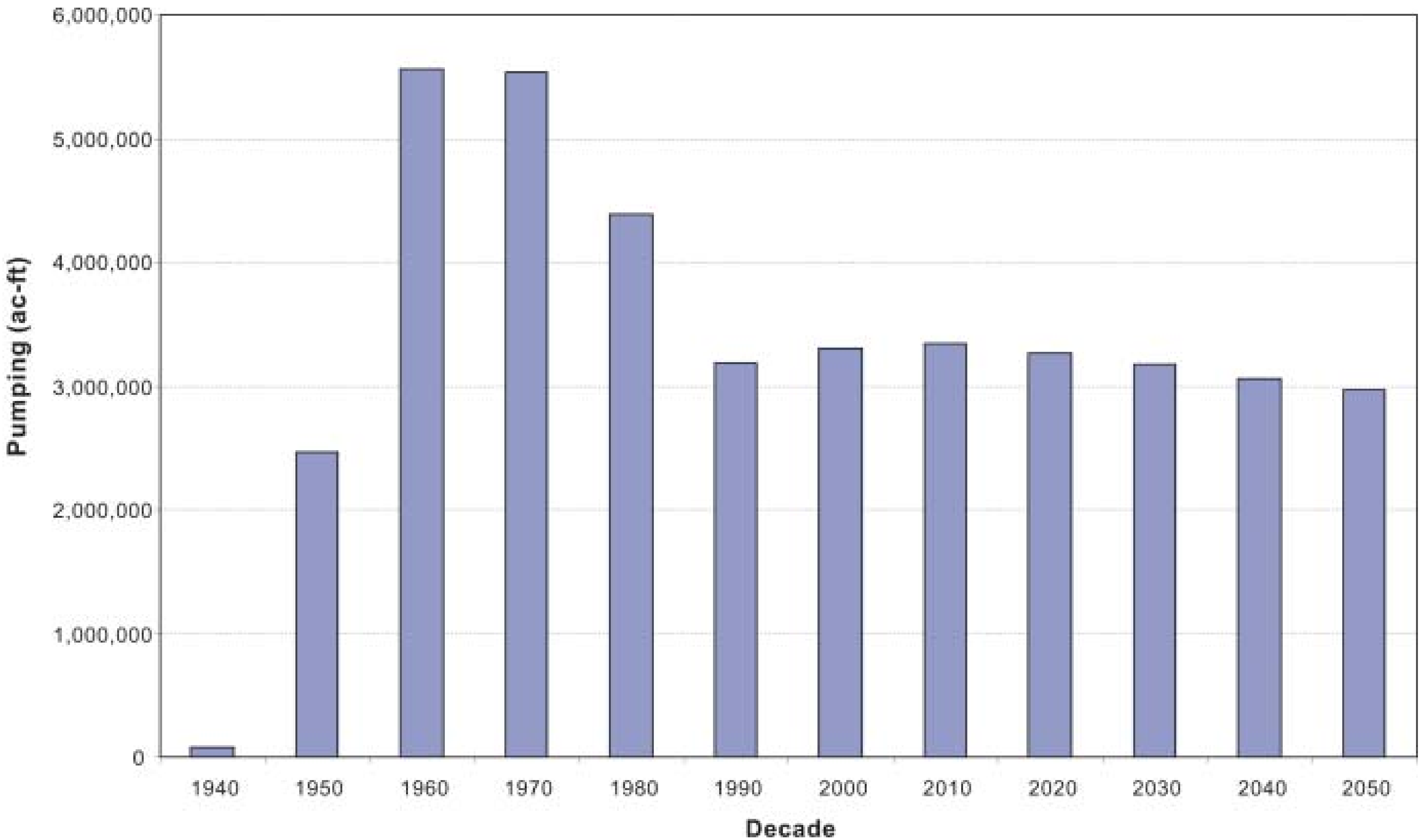
Predictive Simulations

- 2001-2050 - Average conditions
- Last 5 yrs - drought of record
  - 2001-2010
  - 2001-2020
  - 2001-2030
  - 2001-2040
  - 2001-2050
- 2001-2050 - Reduced pumping, 45-55%

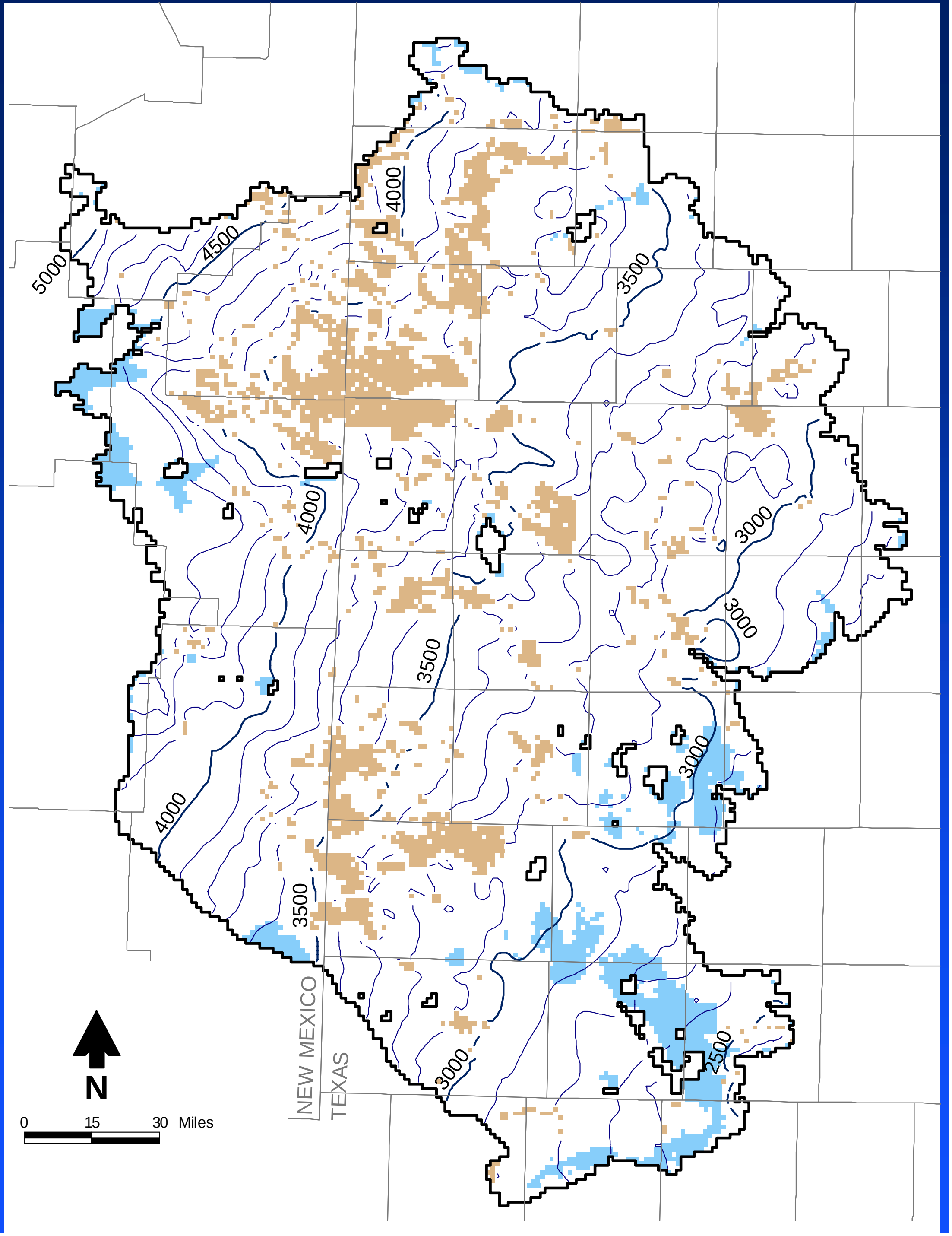
Predictive Simulations

- Agricultural pumping from TWDB spreadsheet
- Applied to 1994 ì footprintî
- Drought period = 5 years; increase in Q from Amosson calculations
- Non-ag pumping: use year 2000 footprint

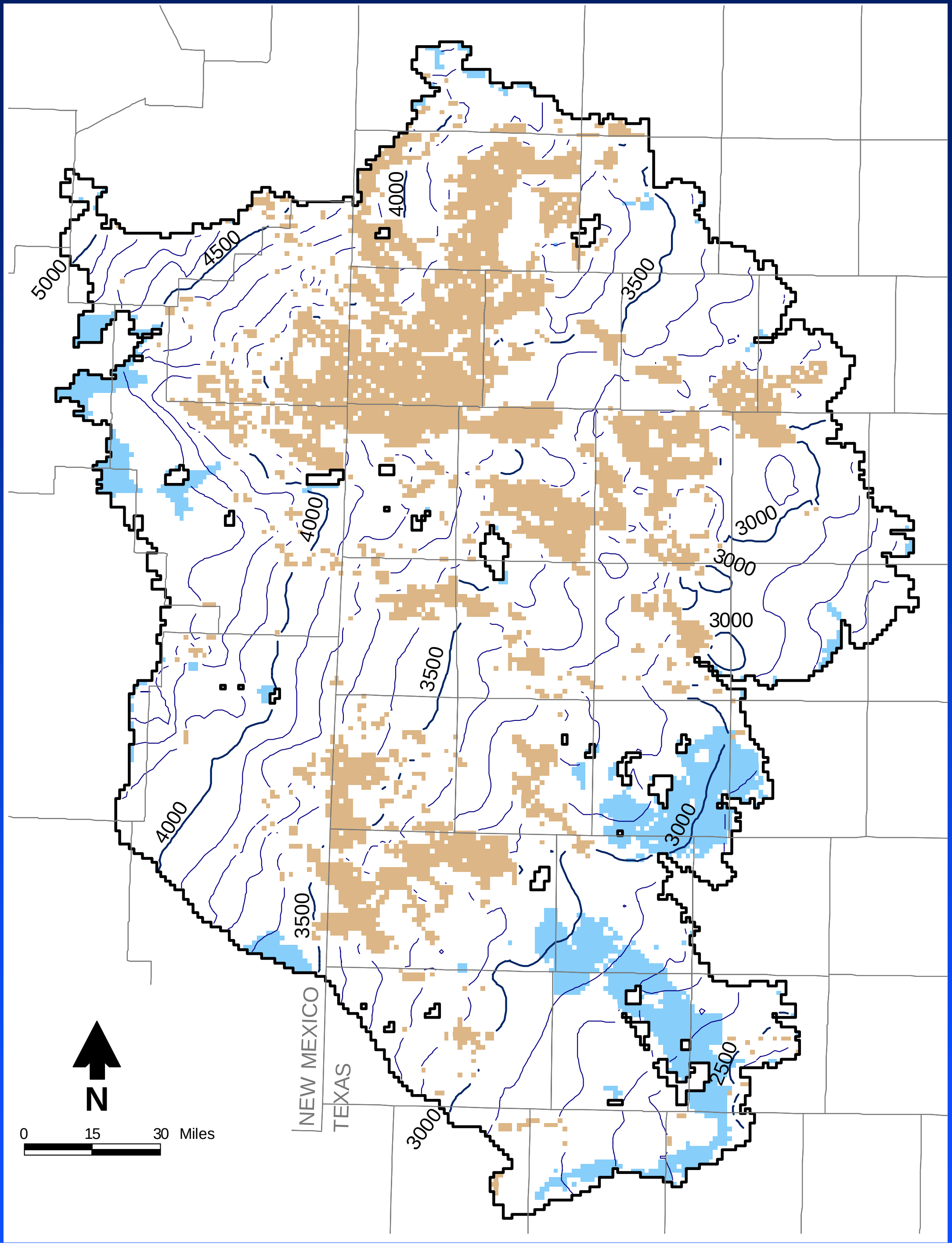
Historical and Future Pumping



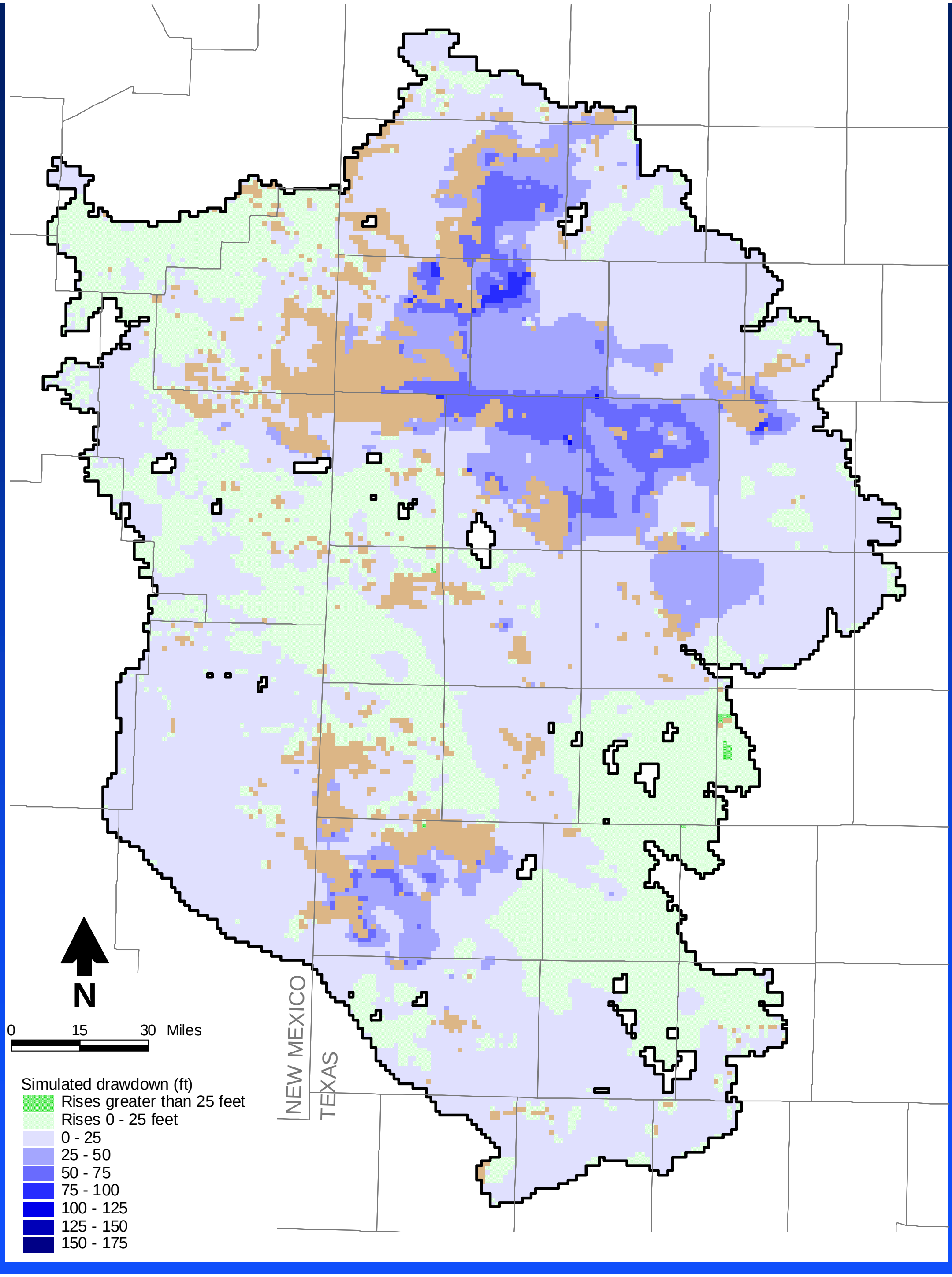
Simulated Water Levels for 2020



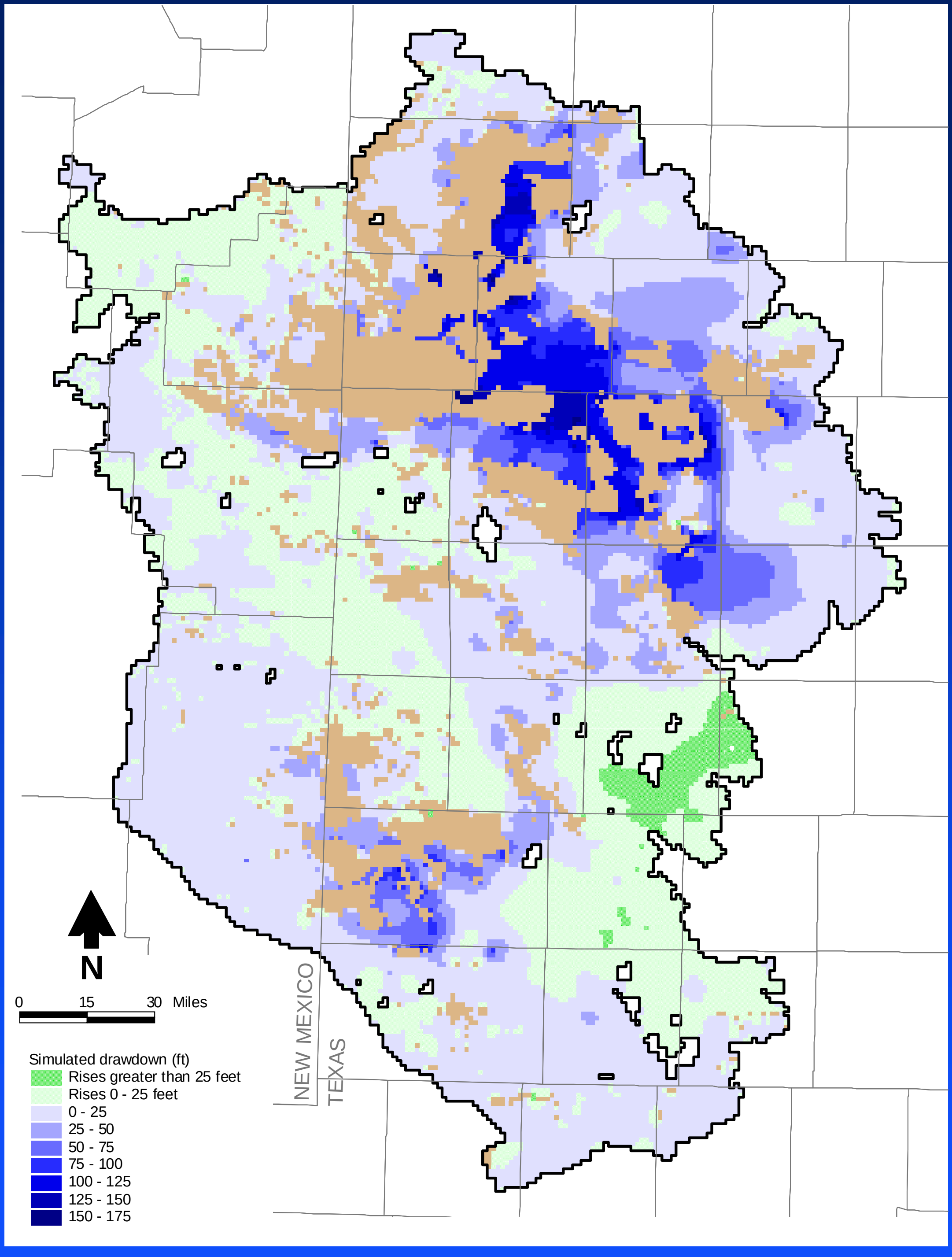
Simulated Water Levels for 2050



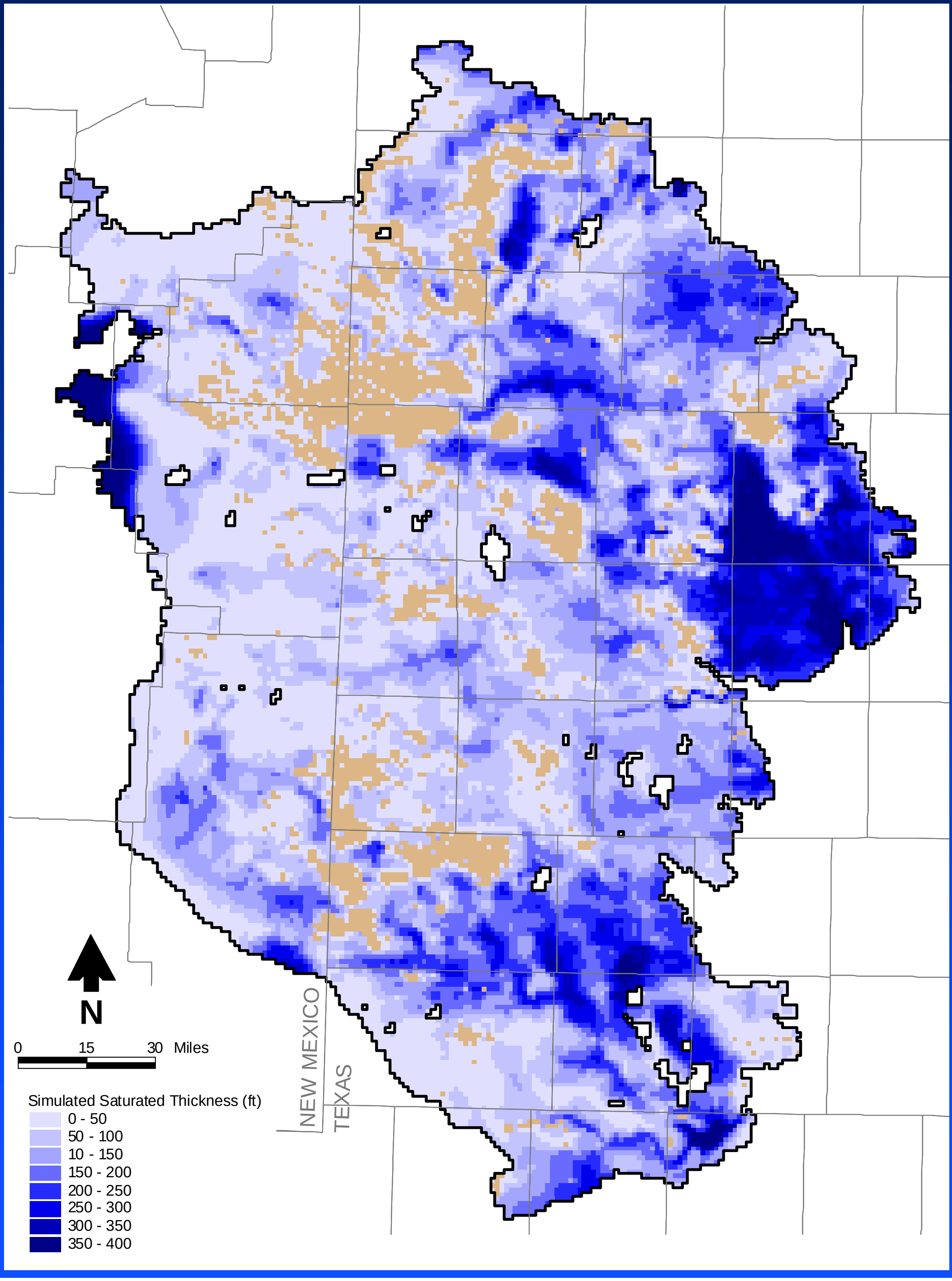
Simulated Drawdown for 2020



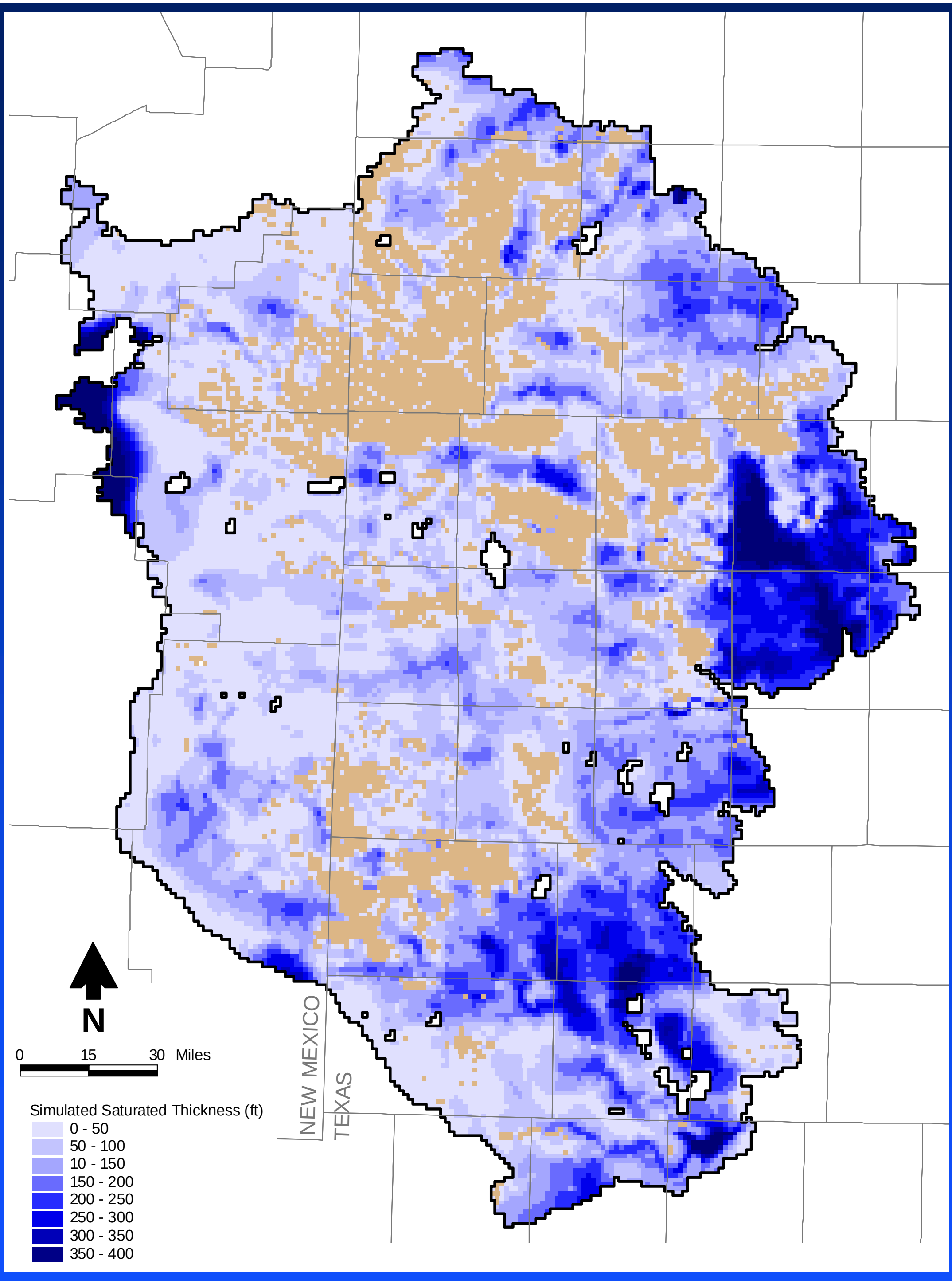
Simulated Drawdown for 2050



Simulated 2020 Saturated Thickness



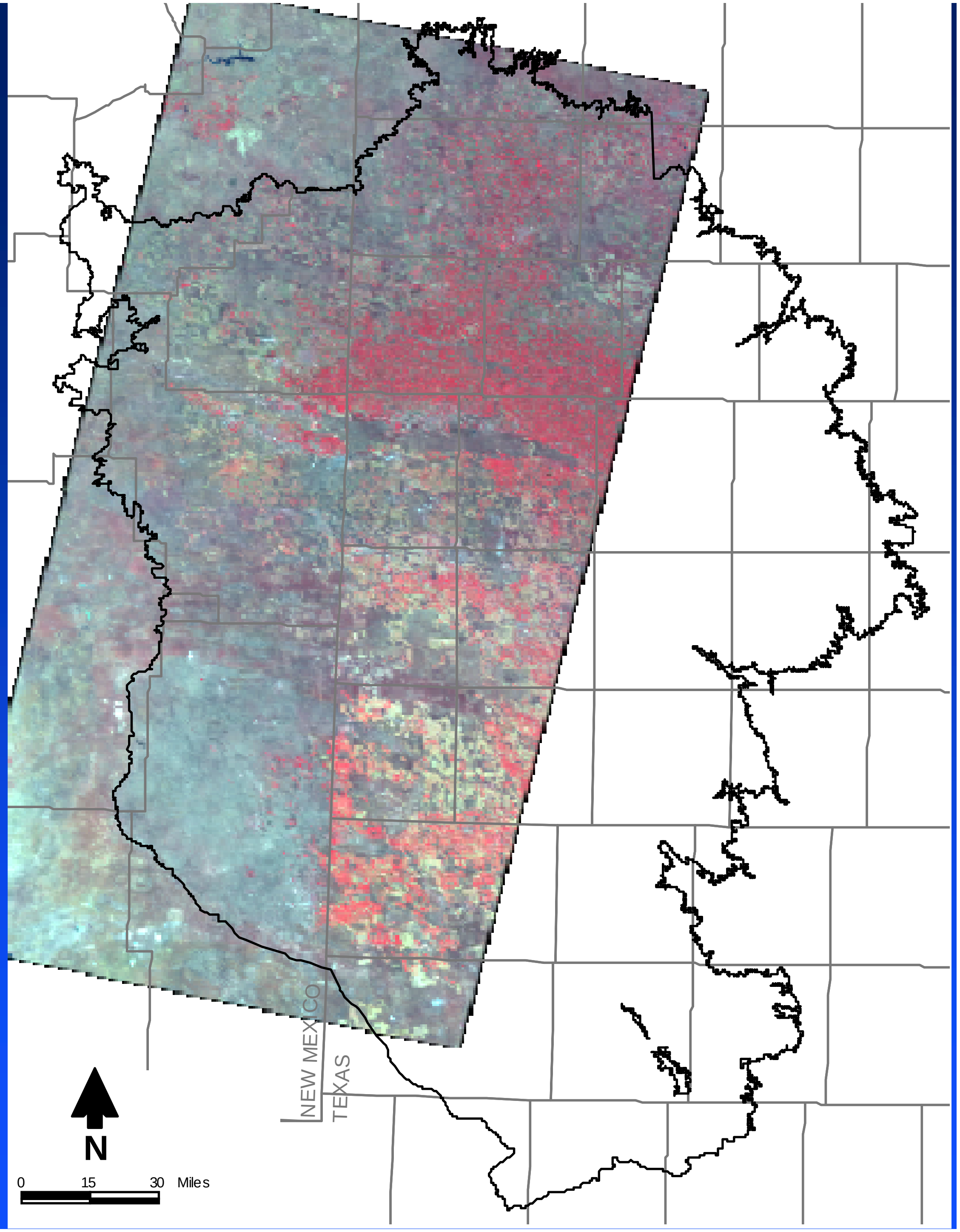
Simulated 2020 Saturated Thickness



Conclusions

- Significant water level declines over the 50 year planning horizon
- Greatest declines in the north, but there are potential problem areas in the south
- Water use in the south likely to continue as it has historically; water use in the north will likely change
- No significant differences between drought and average scenarios

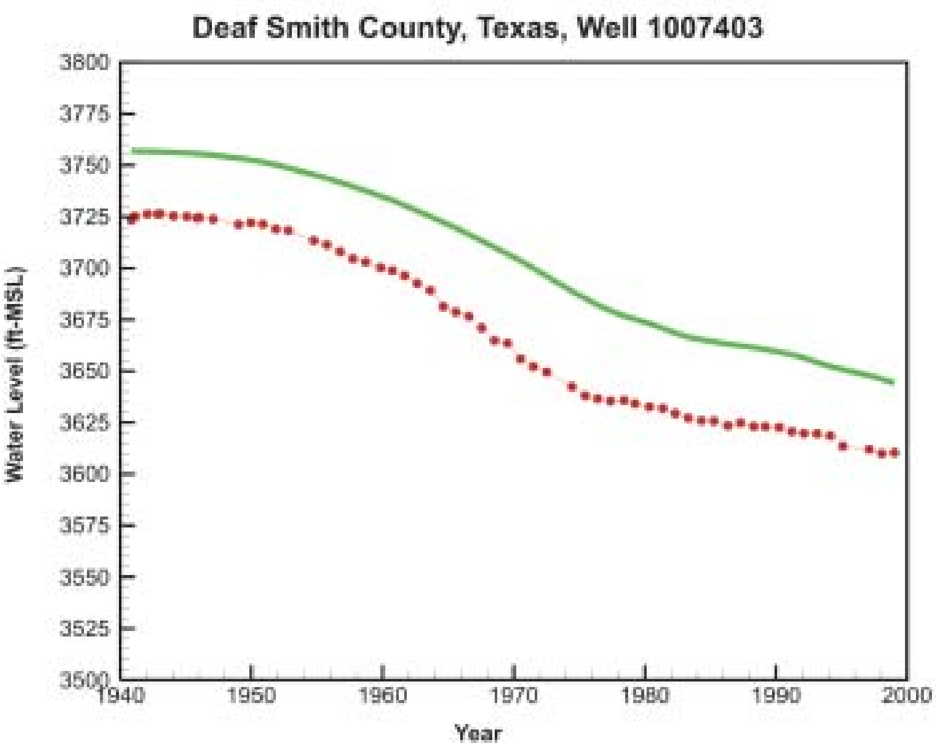
1994 LandSat Image of Irrigated Lands

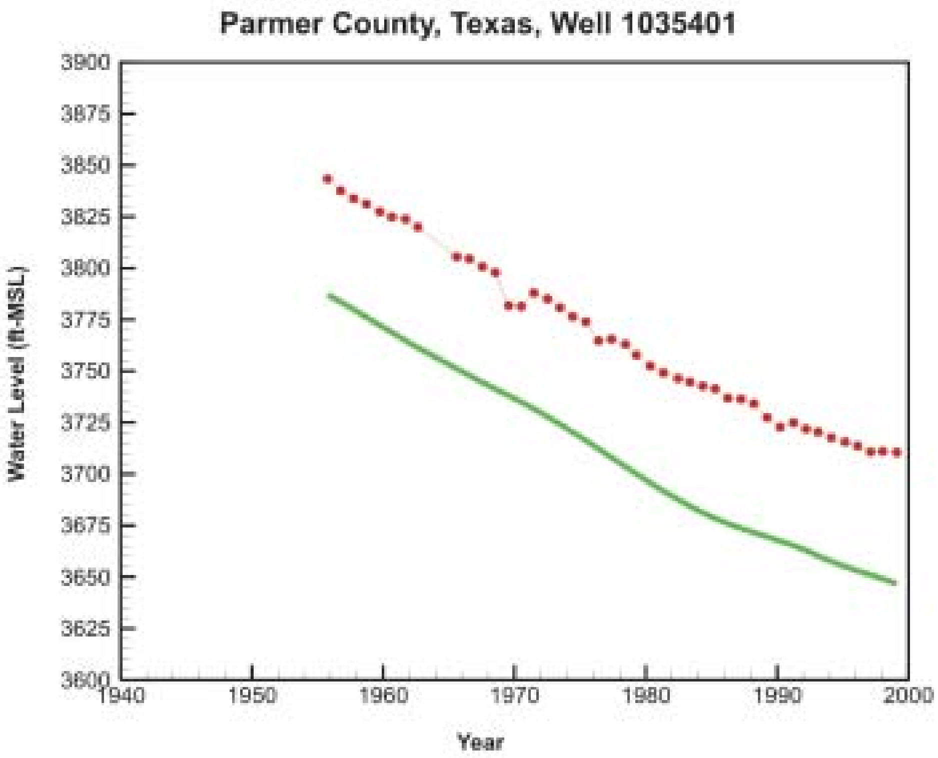


Model Limitations

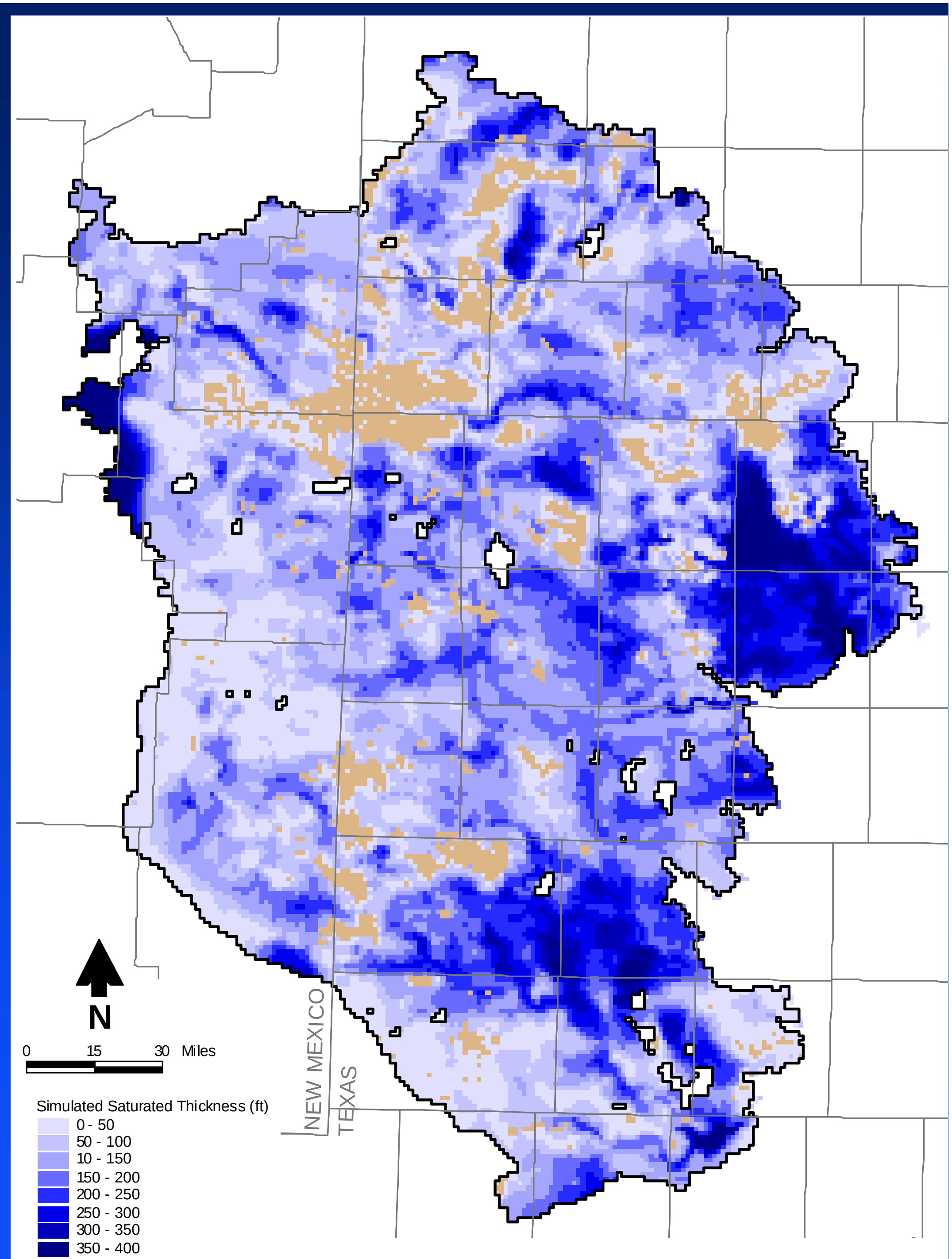
- Starting water levels can not be ëperfectlyí simulated
- Enhanced recharge is not well-known from field studies - more work is needed here
- Uncertainty in other model inputs, such as hydraulic conductivity and specific yield

Model Limitations

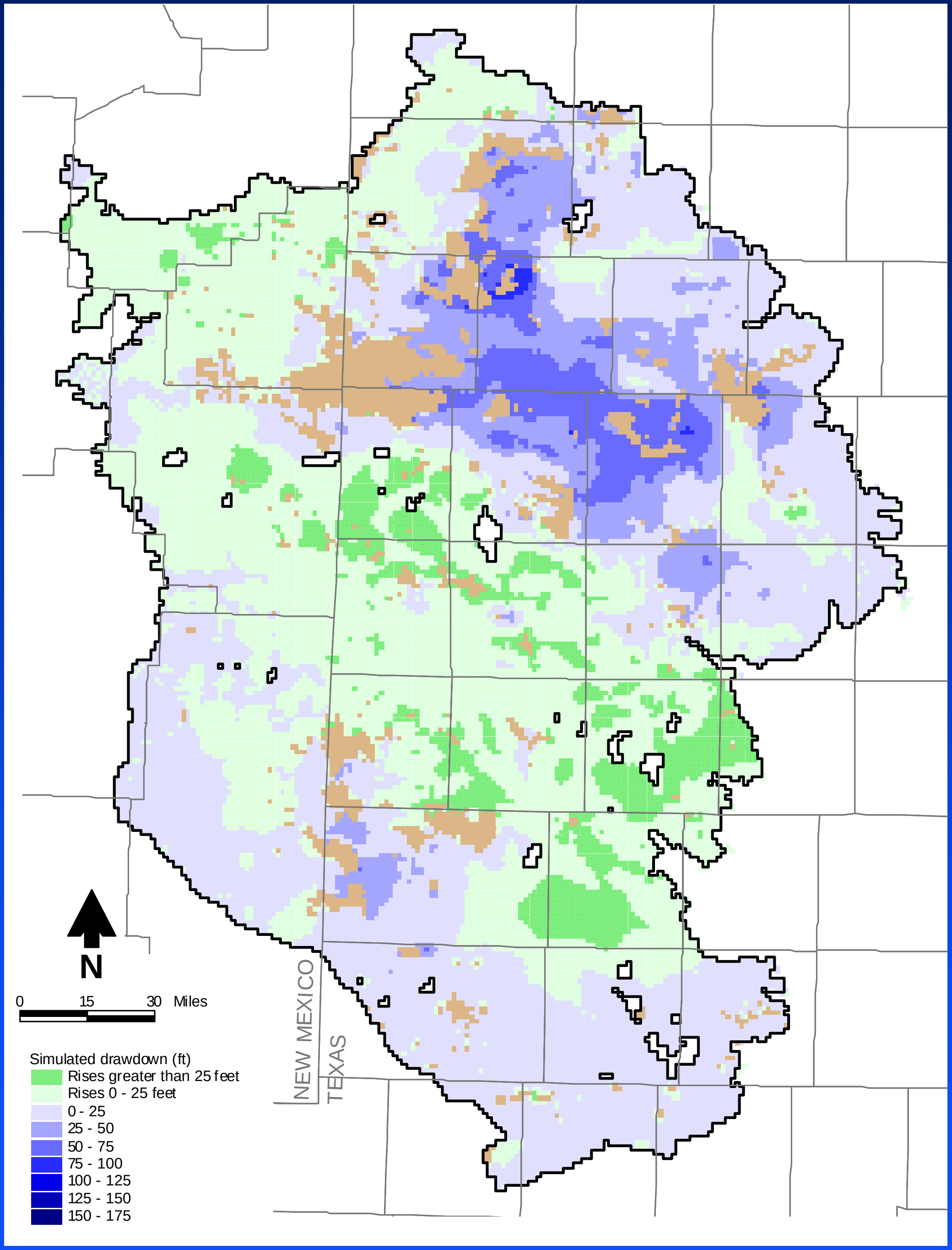




Simulated 2050 Saturated Thickness for Reduced Pumping Conditions



Simulated Drawdown for 2050 Reduced Pumping Conditions



Where Next?

- Next SAF - Training on model application. November or December.
- Comments received - November 8
- Final study deadline - January 30, 2003

Southern Ogallala Stakeholder Advisory Forum No. 7
November 4, 2002

List of Attendees

Name	Affiliation
Richard Smith	TWDB
Jason Coleman	South Plains UWCD
Don McReynolds	High Plains UWCD No. 1
Scott Orr	High Plains UWCD No. 1
Bruce Rigler	High Plains UWCD No. 1
Clyde R. Crumley	LEUWCD
Jim Conkwright	High Plains UWCD No. 1
Harvey Everheart	Mesa UWCD
Ferrel Wheeler	Garza County Underground and Fresh Water Conservation District
Dana Porter	TAES
Ches Carthel	City of Lubbock
David Turnbough	Sandy Land UWCD
Gary Walker	Sandy Land UWCD
Ronald Bertrand	Texas Department of Agriculture
Judy Reeves	Arcadis
Kevin Hopson	Daniel B. Stephens & Associates, Inc
David Boes	Daniel B. Stephens & Associates, Inc.
Neil Blandford	Daniel B. Stephens & Associates, Inc. (presenter)

Stakeholder Advisory Forum No. 7
November 4, 2002
High Plains Underground Water Conservation District No. 1
Lubbock, Texas

Questions & Answers Concerning Groundwater Availability Modeling (GAM) of the Southern Ogallala Aquifer

1. In addition to the predevelopment recharge, you added the enhanced recharge values to either the dry land or the irrigated areas. Is that correct?

Response: *It has not been added to that, these are the rates. In an area where we have a recharge rate of 2.5 inches per year, instead of adding 2.5 inches plus a pre-development recharge rate of 0 .007 inches, we didn't worry about the 0.007 inches. The 2.5 inches per year is the full rate of recharge.*

2. Is that 0.007 inches per year recharge rate a miss-print? It seems very low.

Response: *No, that's actually what we have. To remind you, under pre-development conditions the vast majority of recharge is assumed to have occurred in playas and therefore, where you have lower permeability soils you get more run-off to the playas and more recharge. That is why we have higher values in the north and lesser values in the south.*

3. What is County/Other/Total pumpage?

Response: *That would be what I call a municipal non-point. It represents public consumption, but it's not associated with a specific well field or a point that we know of. We didn't have a specific well field or point to assign it to we distributed it based on the population census data across the study area, excluding municipalities that had well fields associated with them. So, the greater the population of a given region the higher percentage of that pumping would be assigned to that area.*

4. Can you explain why we have greater than 20-25 ft of difference from your 1940 starting point on the hydrograph? It seems like the calibration should be tighter, especially at the starting point.

Response: *Our root mean squared error is on the order of 36 ft, which is just over 1% of the total head drop across the entire basin, which is far less than the Texas Water Development Board criterion were for calibration. We are dealing with over 2,500 ft of total head drop. We are following the GAM requirements for our modeling. Looking at the entire regional* *system in time as well as space, I think this is a good calibration. The statistics that we have are far less than other GAM models that I have looked at. To get closer we would have to go in and start adjusting locally within a county. There is really no justification for making those adjustments.*

5. So, you are saying that you made adjustments across the board to make the model fit, instead of adjusting in localized areas. Correct?

Response: *We changed regional rates that we could tie to something we knew. For example, recharge we could tie to soil type or where we had irrigated acreage, and we made changes on that basis. In the southern part of the area we did do some adjustments to hydraulic conductivity, but we did it based on geologic zones. We would make the adjustment within that zone only. We could go in locally and pick cells and decrease recharge to drop the simulated water levels directly onto the observed water levels, but I have no basis for doing that. I don't think that's a good way to calibrate the model.*

6. Isn't the reality the red line on your trend plots?

Response: *Yes, and the model does represent reality very well. The model is simulating the same trend. The point is that if I don't know what to adjust, it will effect the predictive simulation. If the wrong input parameter is changed to get a better match between observed and simulated water levels, it could adversely affect simulated future water levels during the predictive runs.*

7. What would be wrong with simply calibrating the model and the data with respect to the later dates where you had more confidence with the application rates and the actual land use patterns?

Response: *The reason we start with the pre-development is so we can identify pre-development recharge and hydraulic conductivity. If you begin in the middle somewhere, to do the model calibration you are dealing with hydraulic conductivity, enhanced recharge, agricultural pumping, irrigation return flow, specific yield, all of which can have a similar effects. It is not known in many cases which of these one is most appropriate to change. At least with the pre-development calibration, you set hydraulic conductivity and pre-development recharge. You take those two things out of the equation and then during the transient we change specific yield, pumping, and recharge. So, we have less possible input parameters to adjust.*

8. Is the final study deadline a legislative deadline?

Response: Yes.

9. Is the report posted on the internet?

Response: Yes.

10. You said that in the drought year that rainfall was 30% less. Would you figure 30% less on irrigated lands as well?

Response: It would be 30% less uniformly. For the predictive simulation the recharge that I showed is different from the irrigation return flow. We assume that a certain portion of water will return to the aquifer from applied irrigation. For most of the predictive simulations that's only 5% of the water. From previous discussions we talked about how that may be a larger percent of the water early on, but as irrigation efficiency increased with time, that amount as been reduced. It has been reduced in the model as well. We end up with about 10% of the water returning from the period of 1996-2000, then we reduced it to 5% for the predictive modeling.

11. In your model, you weighted the contribution to the average hydraulic conductivity from the Cretaceous section according to the entire thickness of that section from the Fallin report. This is different from the approach taken in previous models. This will underestimate the average hydraulic conductivity because of the thickness used in the weighting (i.e. the high hydraulic conductivity of the Ogallala sediments will not be as highly weighted as they should be).

Response: I will check with Alan Dutton on exactly how the thickness of the Cretaceous section was handled. In the model, the base of aquifer maps from previous studies were used, and these maps include portions of the Cretaceous section that were believed to be in direct hydraulic communication with the Ogallala Formation sediments.

12. Would it be possible to calculate the absolute water table elevations using the model trend?

Response: I would use the simulated trend in water levels for local areas rather than the actual simulated water levels. You do it by adding or subtracting the difference in the curve and not by changing your initial conditions at some point in time.

13. You said that the simulated water levels start out lower than observed levels for predictive simulations, and therefore the simulated dewatering of the

aquifer occurs prematurely. Is that categorical? In other words are you going to have dry cells?

Response: *No. Everywhere the simulated water level starts lower you are not going to have dry cells. In some cases you are going to have dry cells where you start lower. Where that happens, the model simulates that it happens sooner than where you don't start lower than observed values.*

14. Given another year or two to work on the project, what areas would you want to continue to work on?

Response: *Recharge. It would be nice to have some constraints on the numbers. The other thing is agricultural pumping. There is a lot of work that goes into estimating it. The other thing we don't have a good handle on is the distribution of agricultural pumping within a county based on crop type.*

15. With water demand within a county, is the county treated as a homogeneous unit?

Response: *The agricultural pumping is assigned to areas mapped with irrigated land. There is one adjustment that we made. We took all the model cells that included irrigated acreage and we computed the transmissivity of those cells. For the lowest 5% of the cells we didn't assign any pumping. For 5-50% value of the transmissivity we assigned 75% of the average pumping and whatever was left over we put in the higher transmissivity cells, so the total volume of estimated pumping was assigned, but it was weighted according to transmissivity.*

16. Do you think that using your approach you have over-estimated the amount of irrigation in future years?

Response: *I don't think so. We took the estimated irrigation numbers from the planning groups. We cross checked the numbers with other studies. With the exception of Gaines County, the numbers were all similar.*

17. Can you talk about the lack of discrepancy between your drought of record simulations as opposed to the base line simulations?

Response: *It is due to two things. It's (the drought period) a relatively short period for one. For two, of you look at the results locally rather than the whole area at once, I am sure there would be some differences. The difference in pumping varies by county on the order of about 20-30%. In a lot of the areas that are most heavily pumped to begin with, they go dry. About 10% of the total pumping is removed from decade to decade due to dry cells* *that occur in the model. When you get to the later times in the simulations, some of the regions of heaviest pumping have already gone dry prior to the drought of record simulation period, so you don't see the effects of increased pumping.*

18. Are you satisfied with those results? Are you working to include that? That's one of the reasons for the model, to show what would happen if a drought of record occurred.

Response: *These are predictive runs. So, what comes out, comes out. It is nothing that I have changed or adjusted. What concerns me looking at the future period of 50 years is not a drought of record, but rather the aquifer's ability to sustain projected pumping rates over the long term.*

19. Why have recharged rates increased so much since the 1940's?

Response: *It is believed that the recharge rates have increased due to land use practices - namely dry-land and irrigated farming.*

20. Why does the model show rising water levels in Dawson County? Recently, monitor wells have indicated declining water levels.

Response: *The model simulates water level rises throughout much of Dawson County due to the recharge rates applied to match water level rises observed historically. I would expect water levels to continue to rise in many of these areas unless the volume and location of pumping expands significantly, or recharge decreases significantly, although I am not sure why it would.*

21. Monitor wells 27-07-901 and 28-26-206 in the northern and southern portions of the Dawson County, respectively, would make better observation wells for model calibration than the two that were selected.

Response: *These observation wells can be added to those used for model calibration.*

23. I need a model that will give me the amount of water in storage based on the change in water levels from year to year. Will this model do that?

Response: *The GAM model is intended to project the availability of water on a regional basis over a planning horizon of decades. To get the most accurate estimates of water in storage and changes in storage annually, on a county-by-county basis, other tools and software that can approximate the water table surface based on observed data might be more appropriate.*