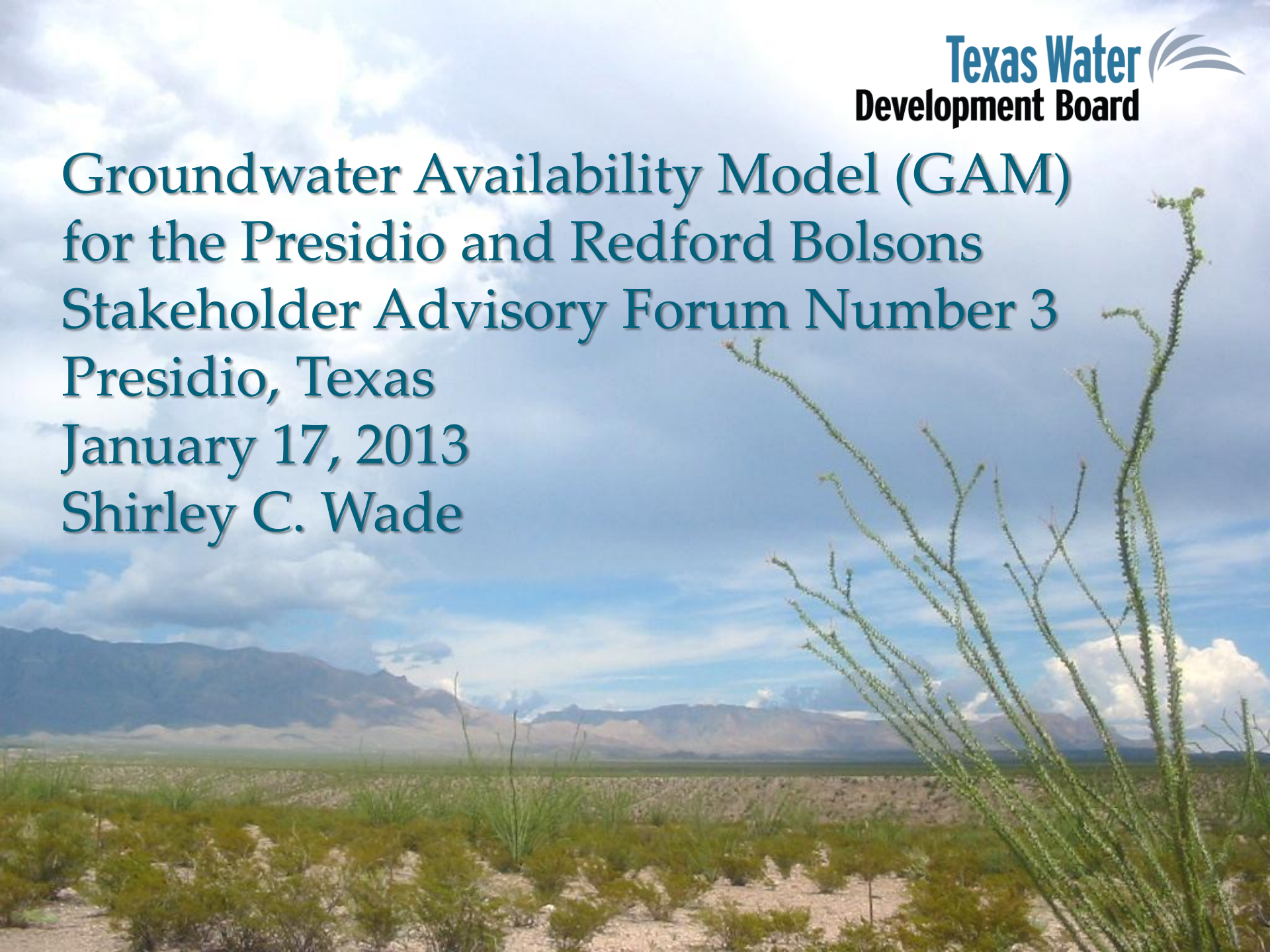


Groundwater Availability Model (GAM) for the Presidio and Redford Bolsons

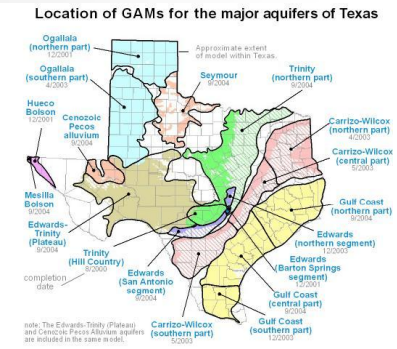
Stakeholder Advisory Forum Number 3
Presidio, Texas
January 17, 2013

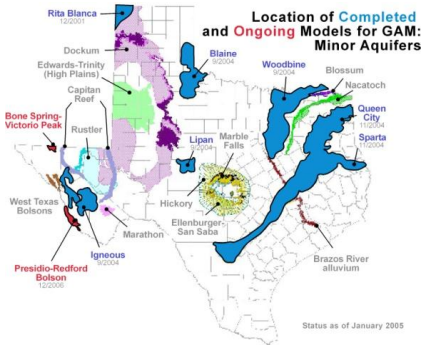
Shirley C. Wade

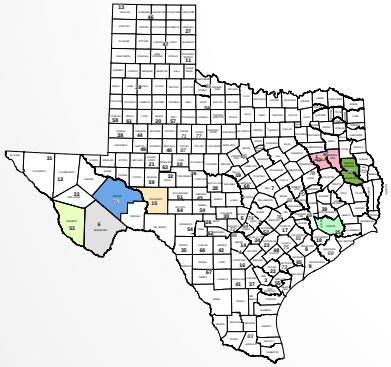
Outline

- TWDB Groundwater Availability Modeling Program
- Presidio and Redford Bolsons Study Area
- Conceptual Model
- Model Design
- Model Results
- Summary and Recommendations
- Schedule
- Questions

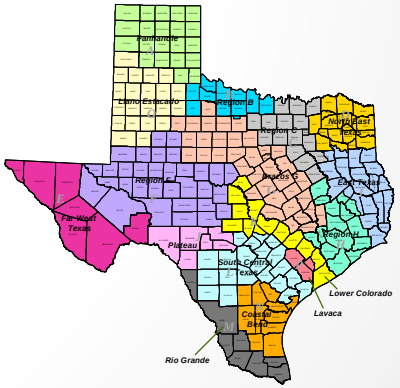
Groundwater Availability Modeling







Texas Water Development Board



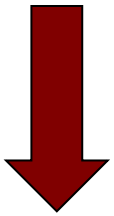
GAM Program

- **Purpose:** to develop groundwater flow models to help GCDs, RWPGs, and others with managing their groundwater resources
- **Public process**: encourage stakeholder participation in model development and model improvements
- **Freely available**: standardized, thoroughly documented, with reports available over the internet
- **Living tools**: periodically updated

What is Groundwater Availability?

Science + **Policy** = **Groundwater Availability**

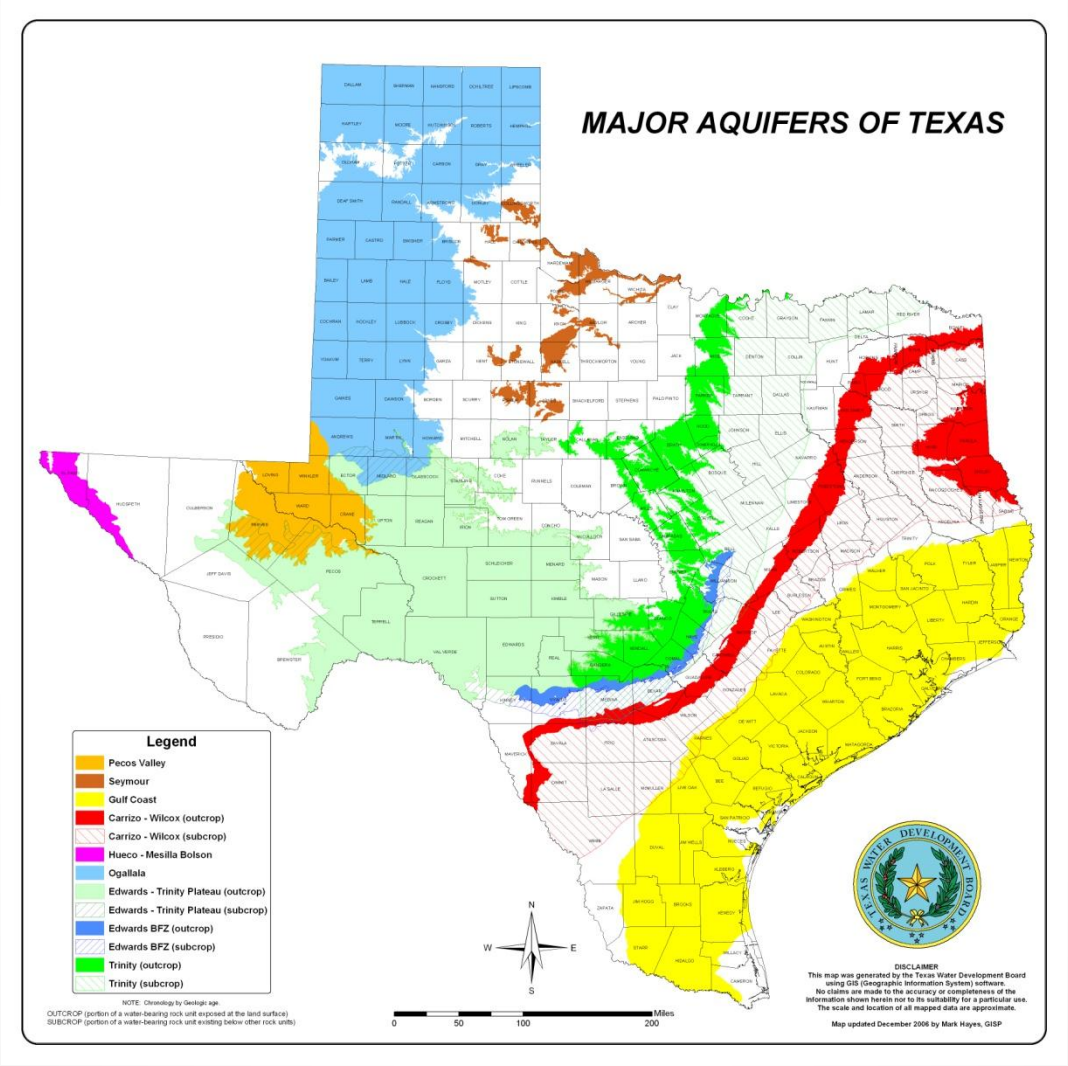




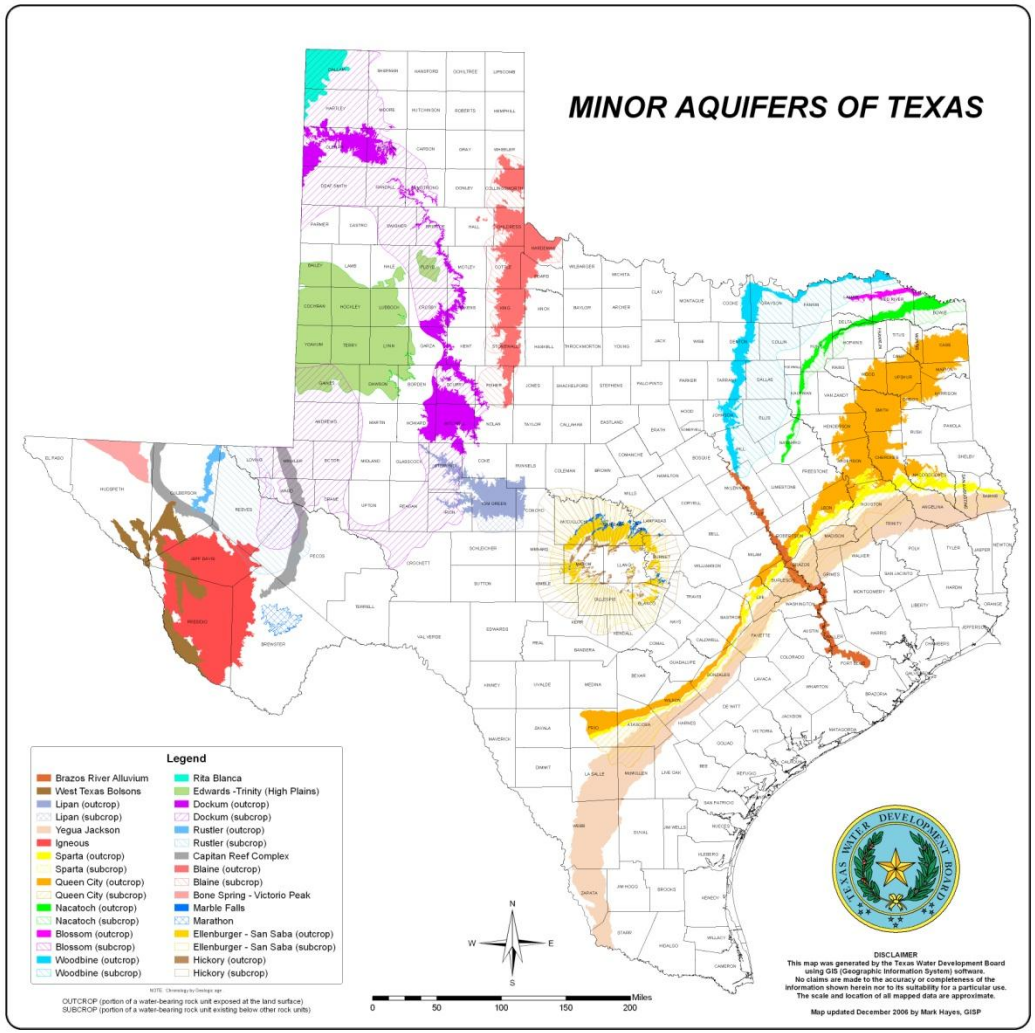
GAM or other tool + **Desired Future Conditions** = **Modeled Available Groundwater**

Goal: informed decision-making

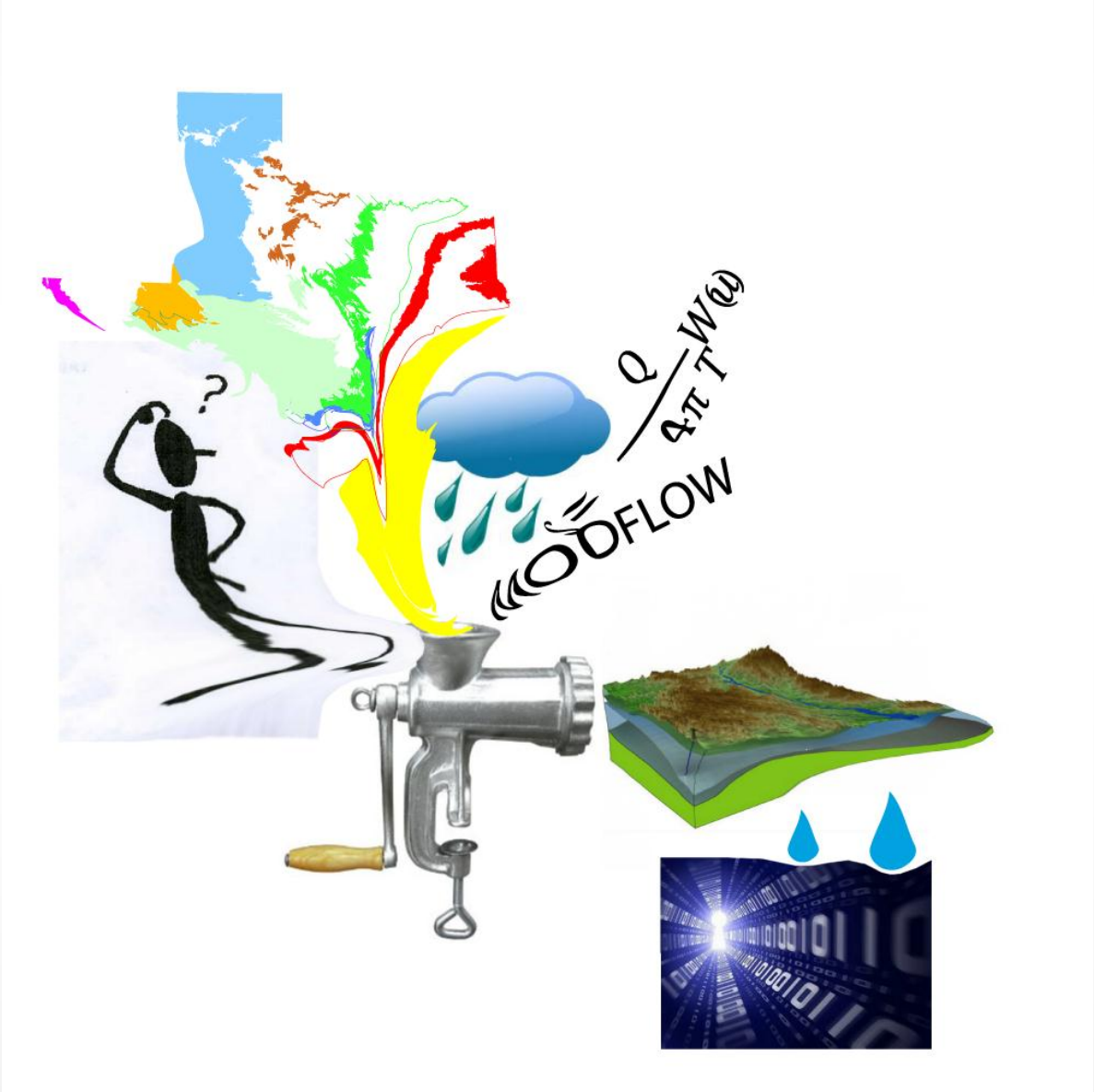
Major Aquifers



Minor Aquifers



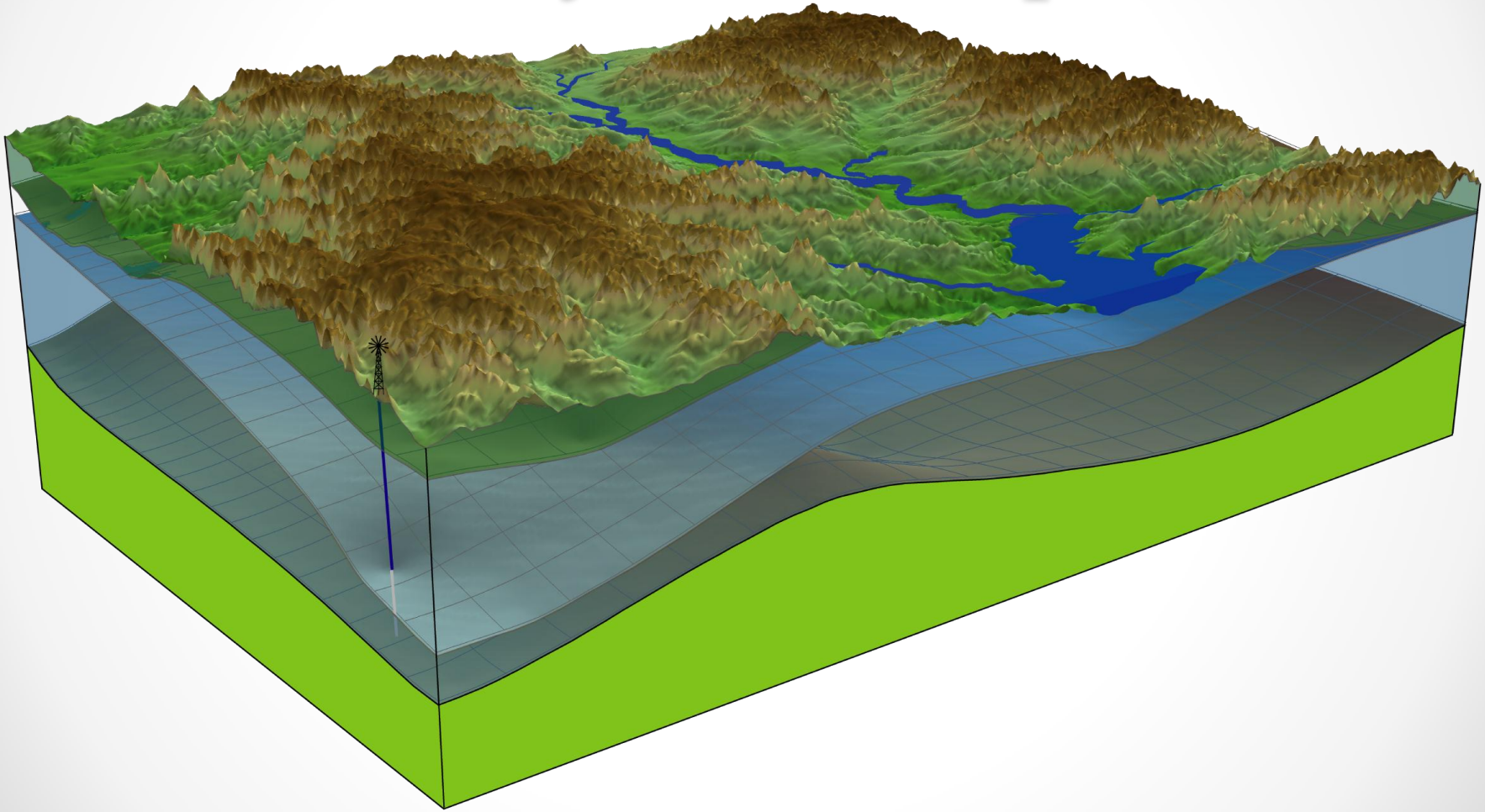
Building a Groundwater Model



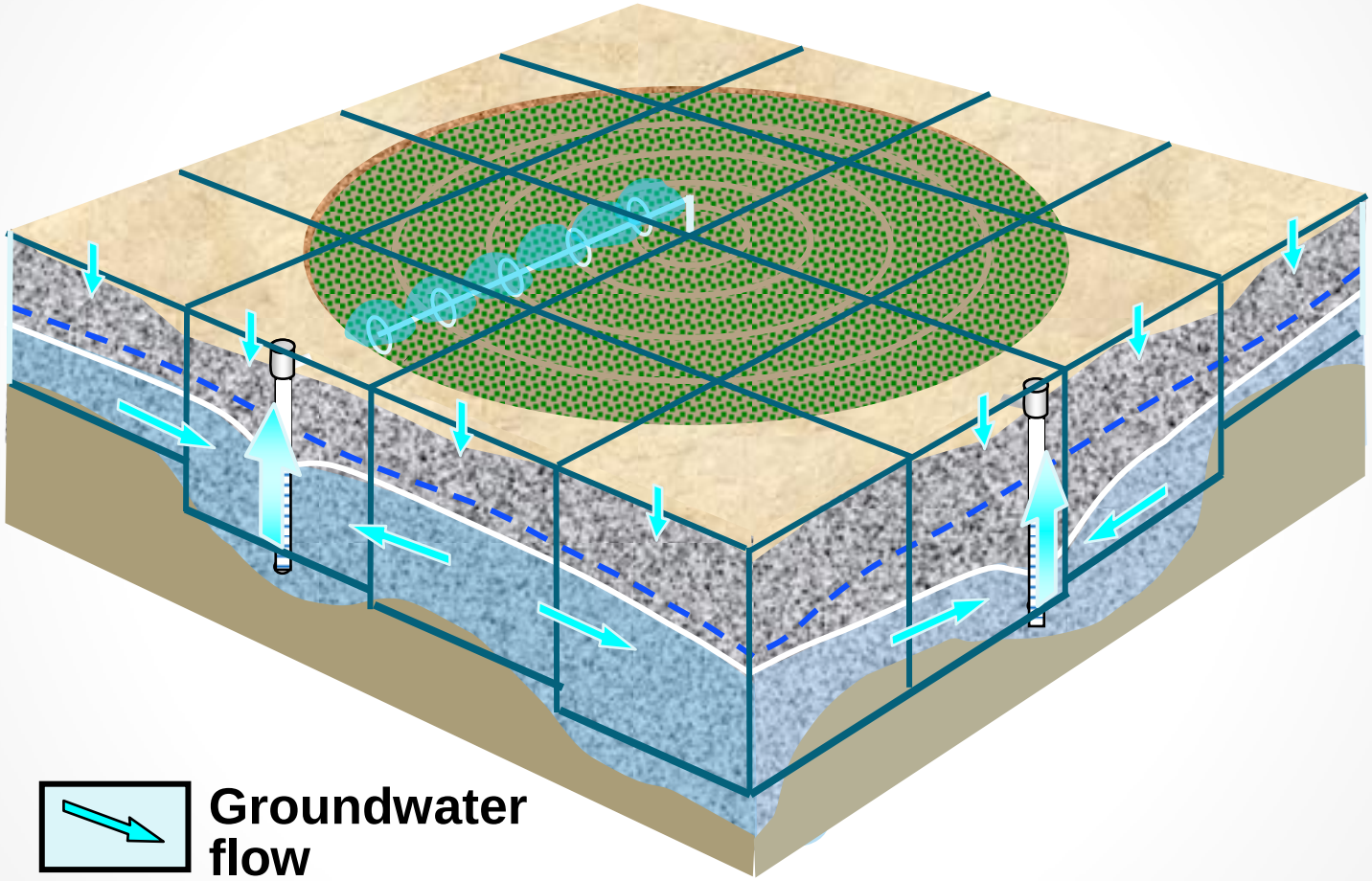
Groundwater Modeling

- Groundwater models are simplified representations of underground water systems (aquifers)
- They can be physical models such as sand tank models or they can be mathematical models
- We are using a mathematical modeling computer program called MODFLOW for our model
- Physical data describing the aquifer is used by the computer model to predict water levels and groundwater discharge
- History matching also known as model calibration is used to estimate some aquifer properties that are not well known

Determine Aquifer Geometry and Properties

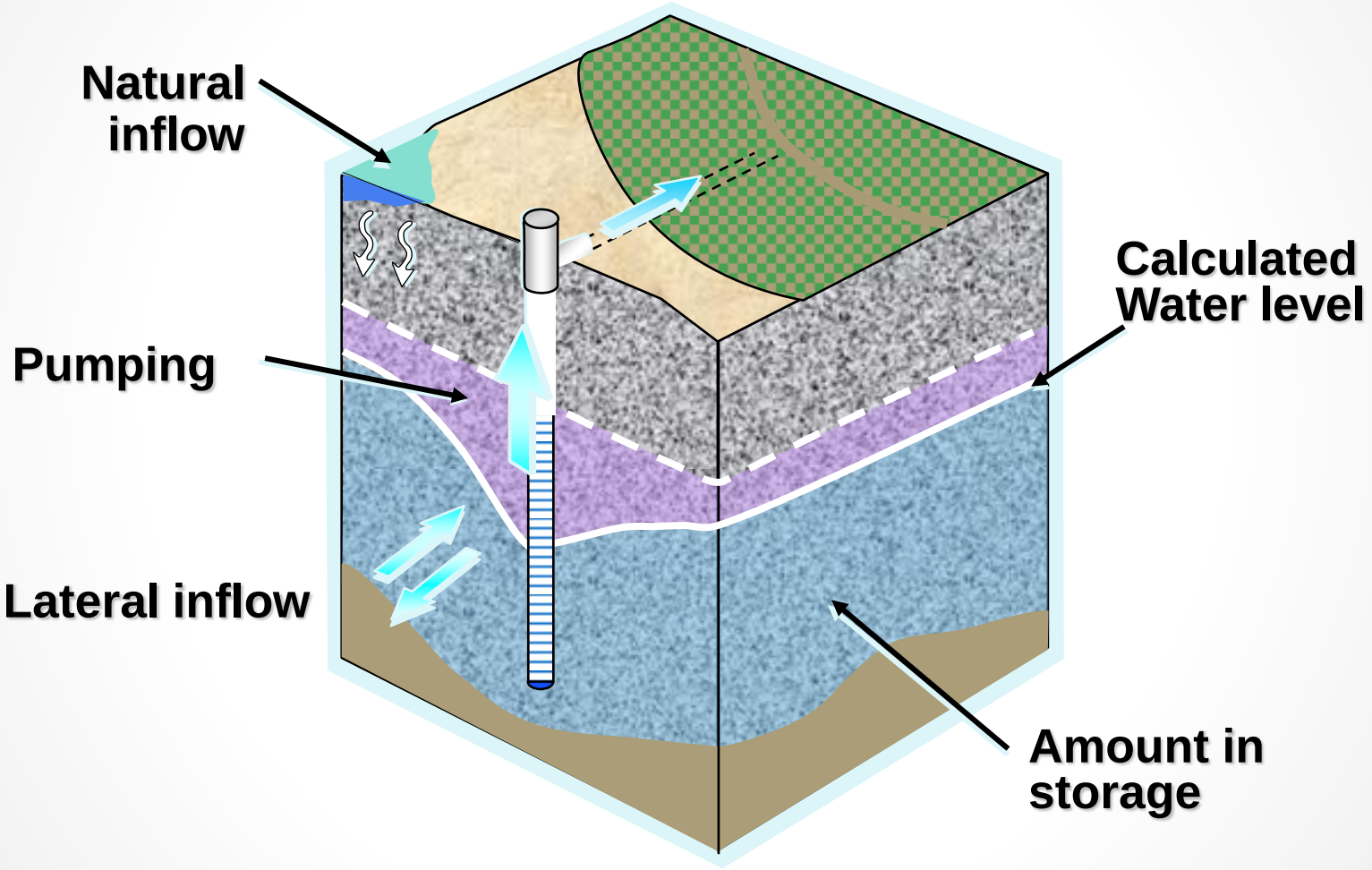


Overlay Grid



From, Daniel B. Stephens & Associates, Inc.

Assign Physical Properties



From, Daniel B. Stephens & Associates, Inc.

How we use Groundwater Models

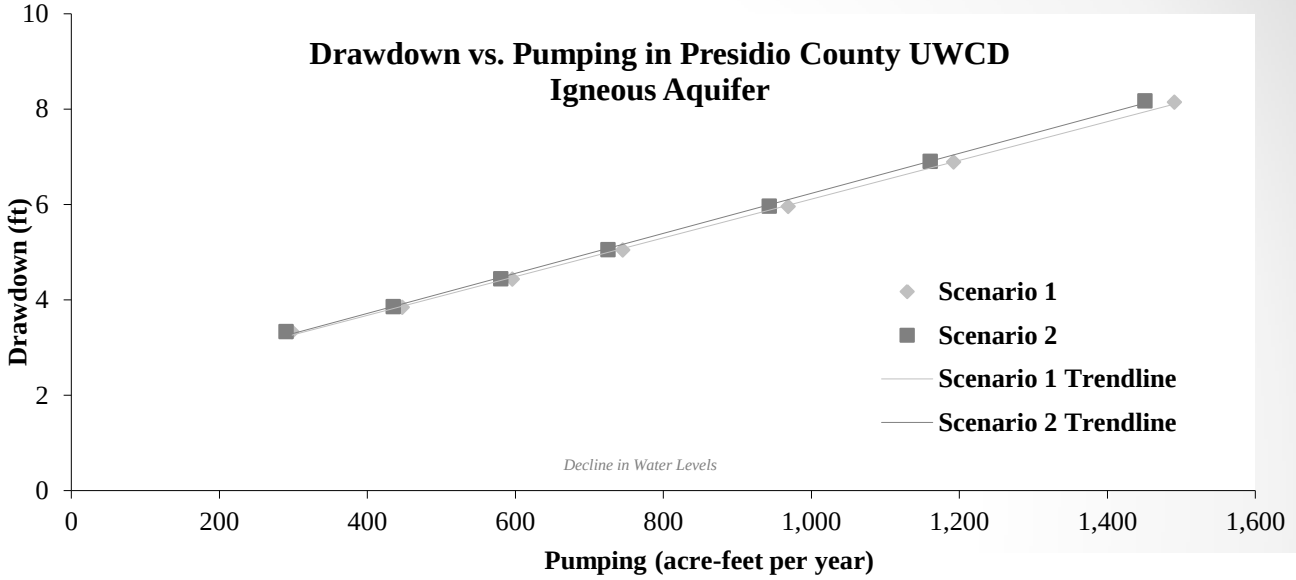
- Inform groundwater districts about historical conditions in the aquifer

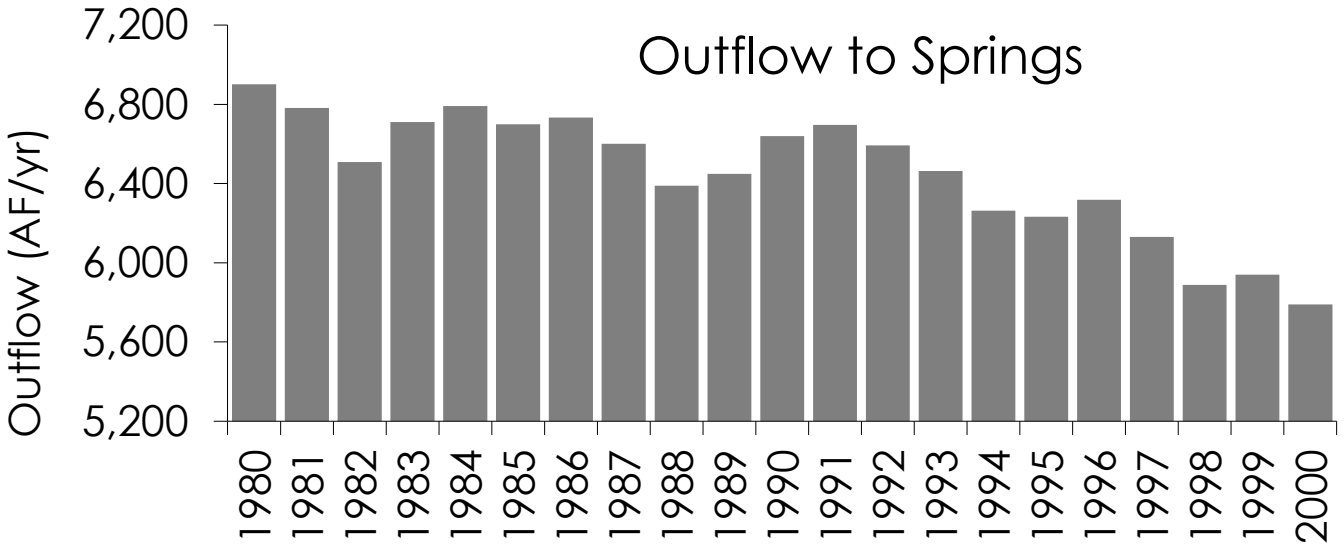
Management Plan requirement	*Aquifer*	*Results*
Estimated annual amount of recharge from precipitation to the district	Igneous Aquifer	9,409
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Igneous Aquifer	3,252
Estimated annual volume of flow into the district within each aquifer in the district	Igneous Aquifer	4,429
Estimated annual volume of flow out of the district within each aquifer in the district	Igneous Aquifer	1,783
Estimated net annual volume of flow between each aquifer in the district	From Igneous Aquifer into overlying West Texas Bolsons Aquifer	1,611
	From Igneous Aquifer into underlying Cretaceous and Permian units	5,909

How you use Groundwater Models

- Determine desired future conditions (DFCs)

DFC: Desired, quantified condition of groundwater resources (such as water levels, water quality, spring flows, or volumes) for a specified aquifer within a management area at a specified time or times in the future.

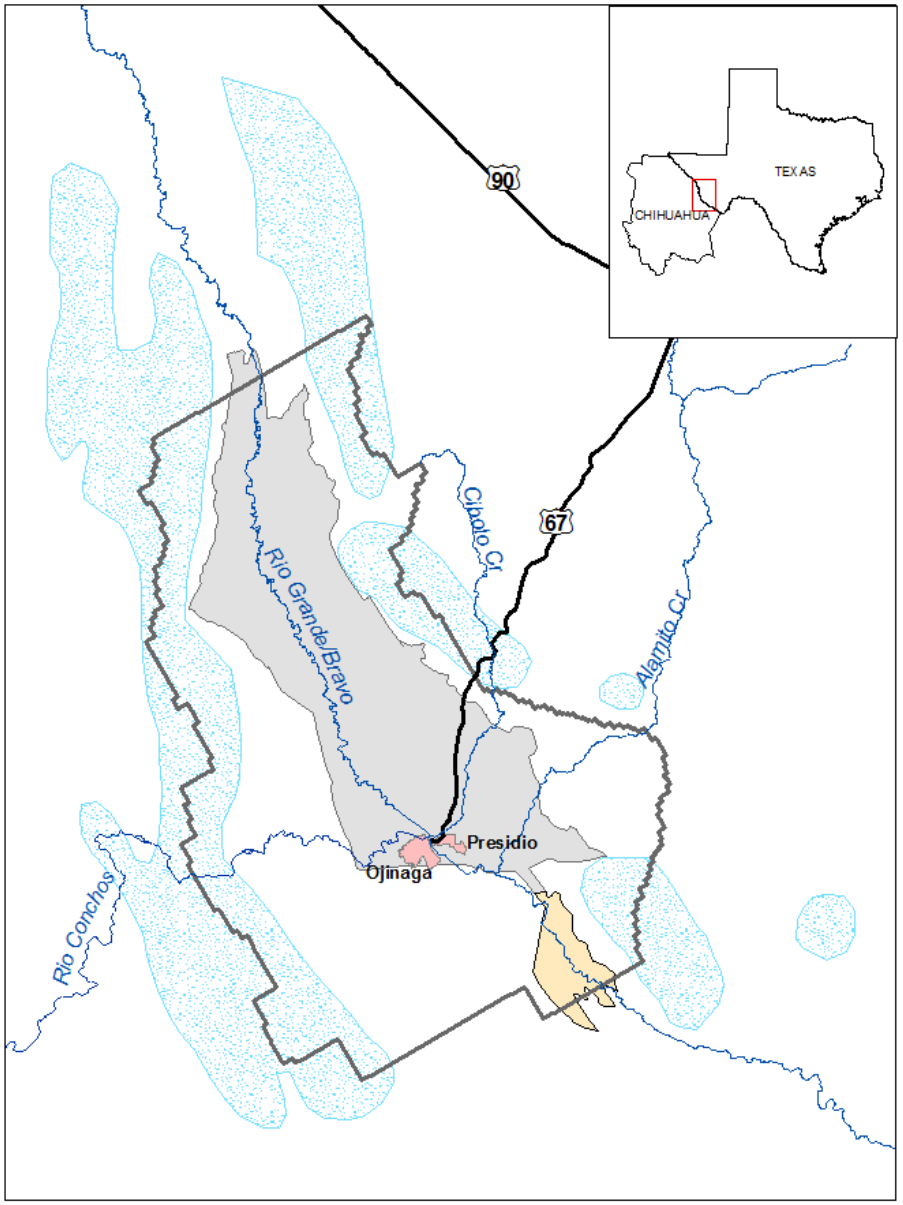




Stakeholder Advisory Forums

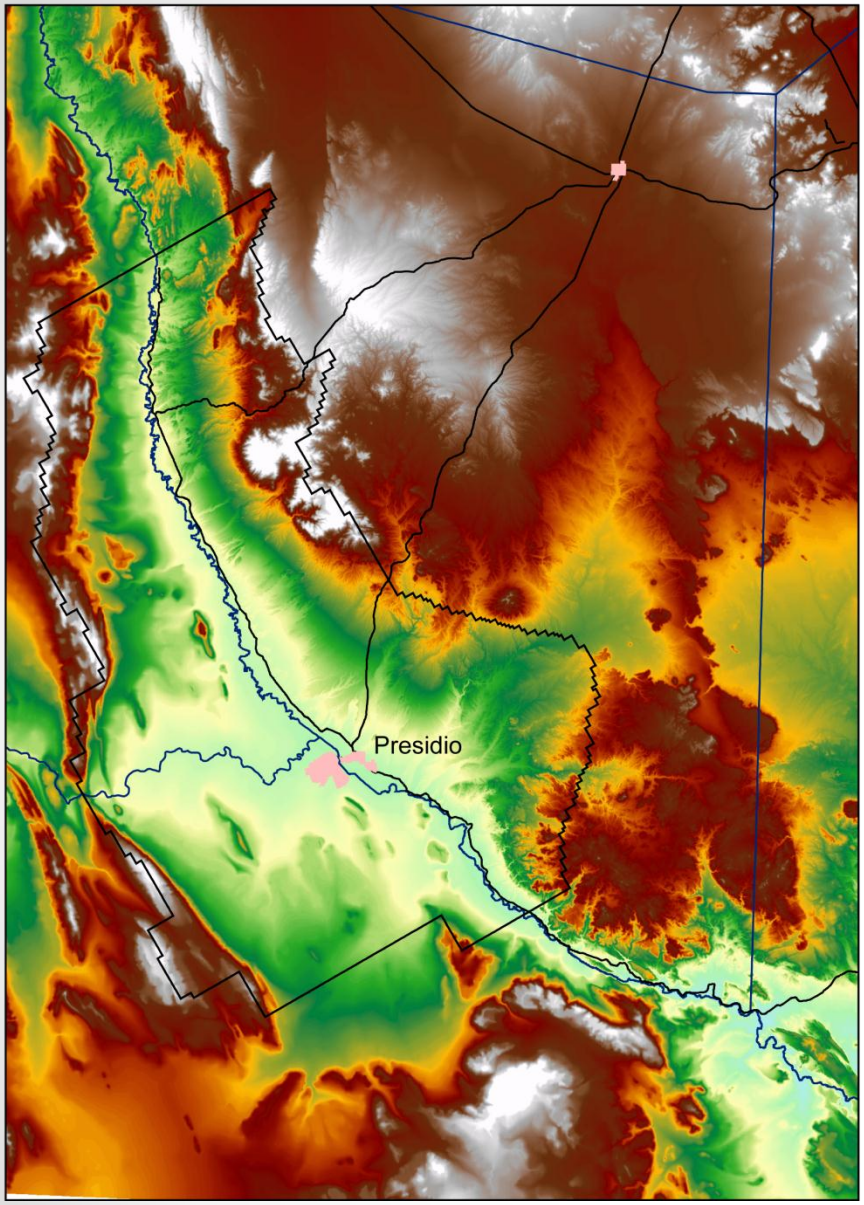
- Keep updated about progress of the model development
- Understand how the groundwater model can, should, and should not be used
- Provide input and data to assist with model development

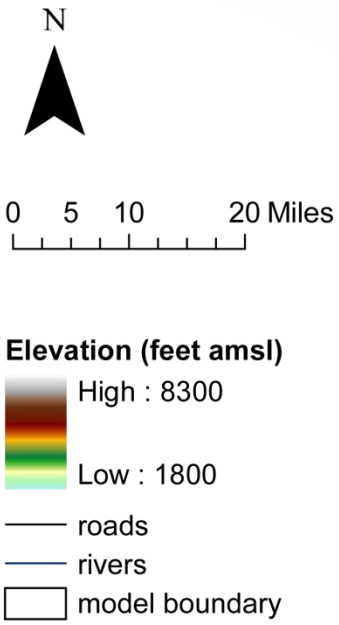
Study Area



Bolson outcrop after Henry (1979)
Mountain boundaries after Groat (1972)

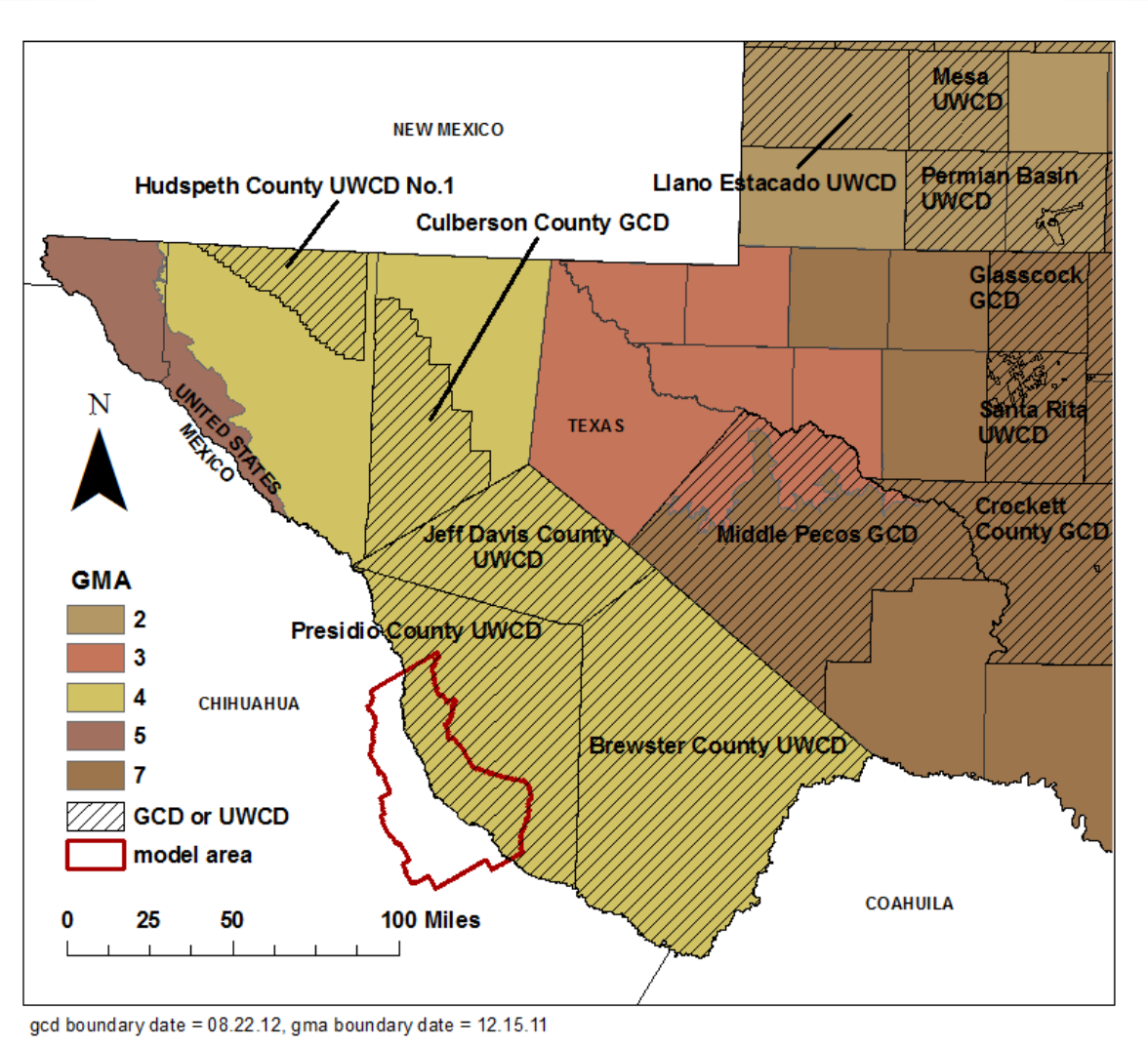
Model Area


Presidio

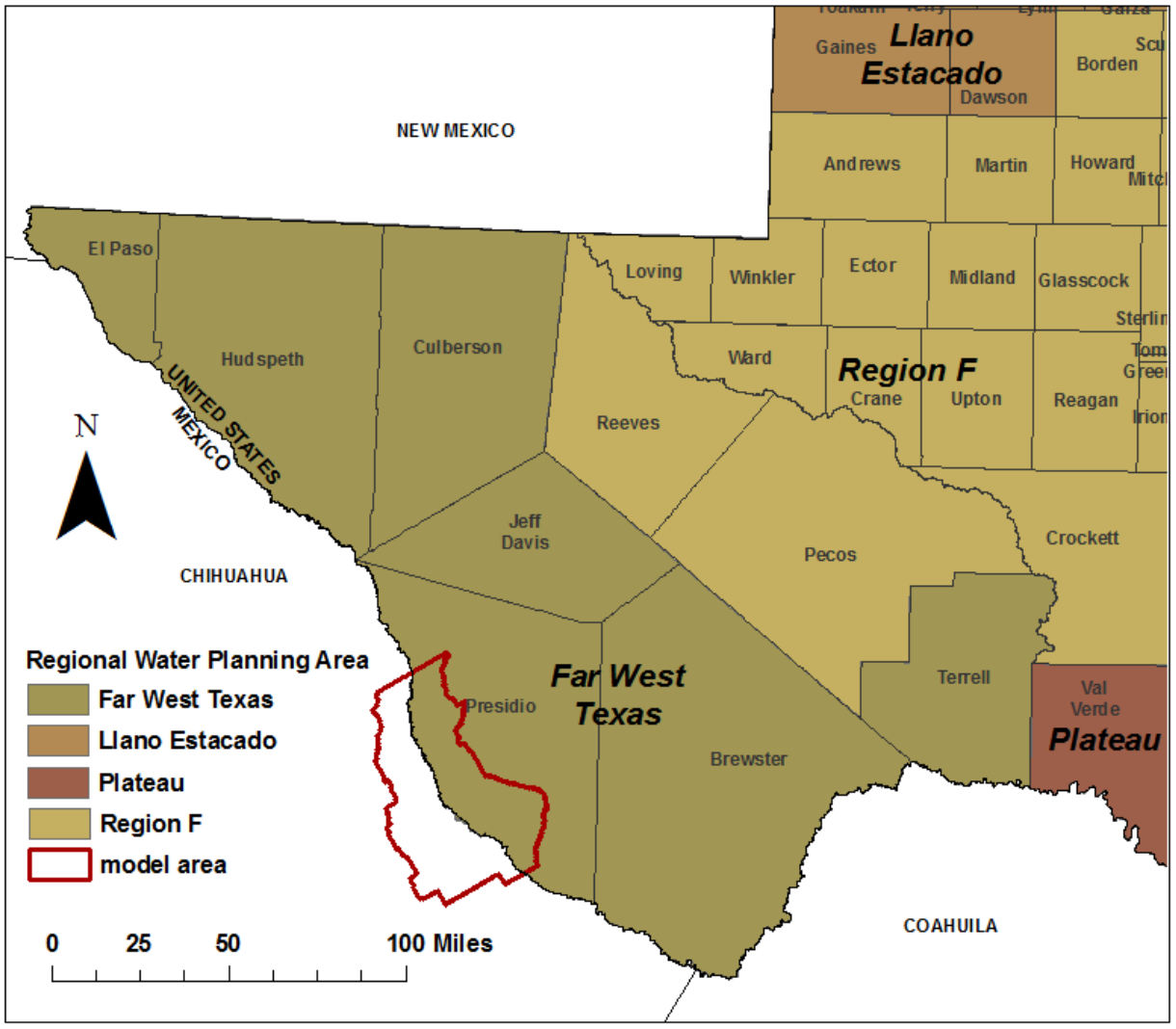

N
0 5 10 20 Miles
Elevation (feet amsl)
High : 8300
Low : 1800
roads
rivers
model boundary

Elevation

Groundwater Conservation Districts and GMAs

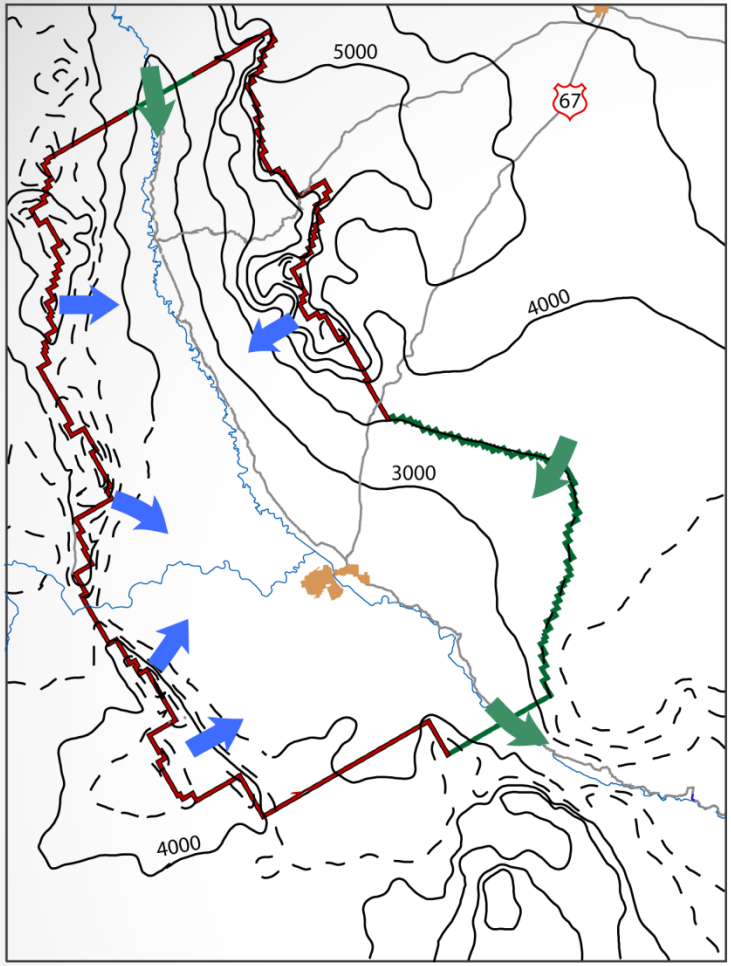


Regional Water Planning Areas



Conceptual Model

Water Levels and Groundwater Flow



internal flow away from flow divides

cross-boundary groundwater flow

towns

water level (500 feet contours)
dashed where approximated

rivers

roads

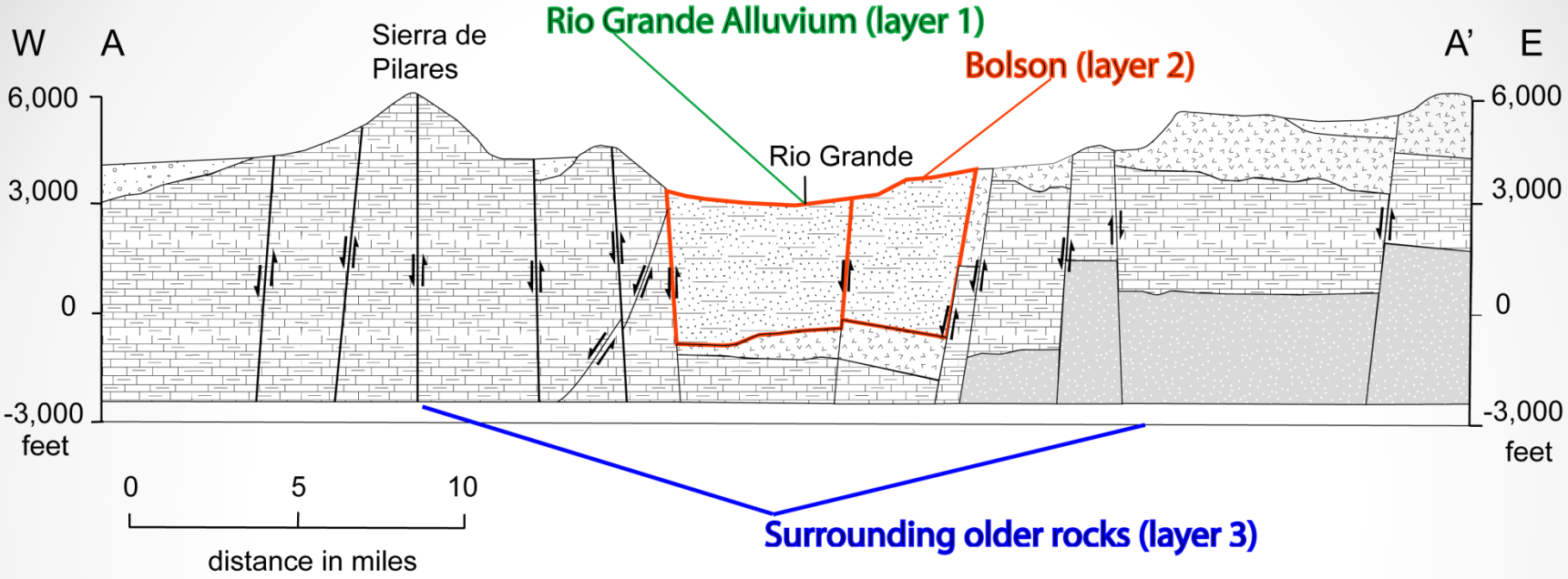
flow boundary

no-flow boundary

0 5 10 20 Miles

N

Geologic Cross-section



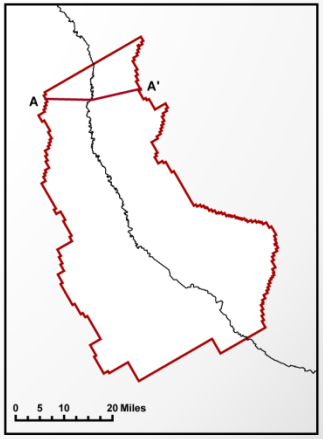
alluvium

basin fill

volcanic and volcaniclastic rocks,
mostly pre-basin and range faulting

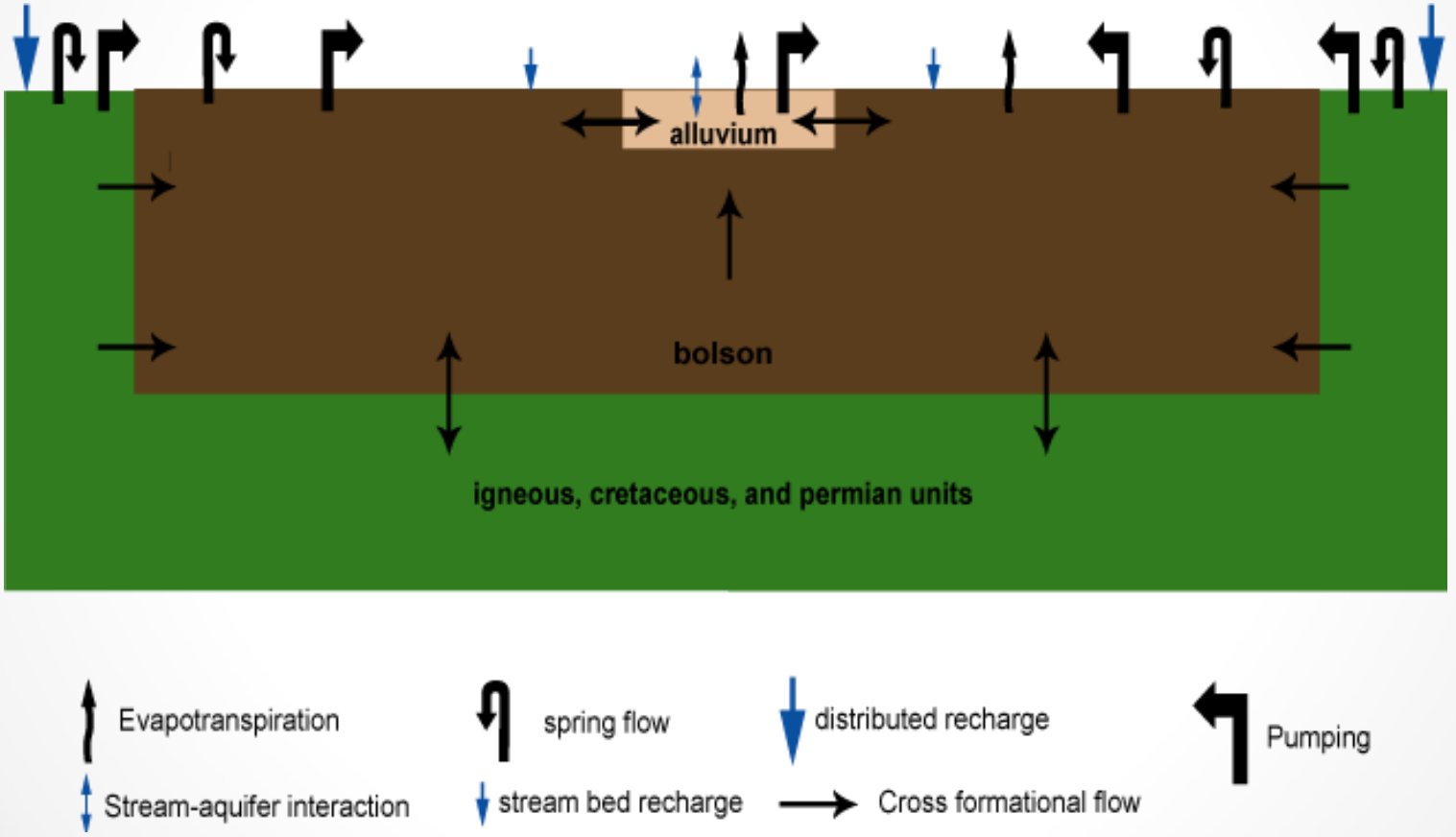
Mesozoic to early Eocene sedimentary rocks, mostly Cretaceous

Paleozoic sedimentary rocks, mostly Permian

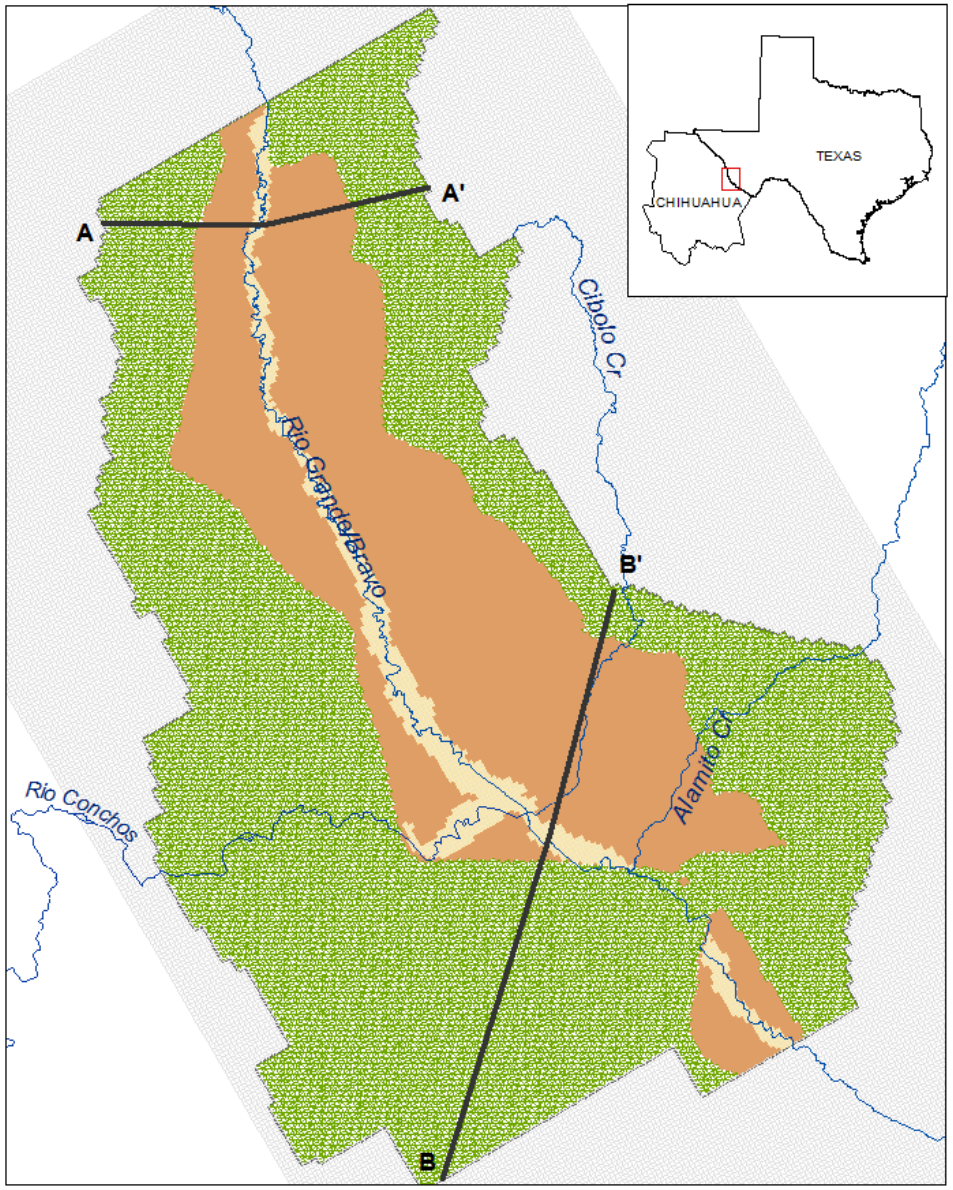


source: Henry (1979)

Conceptual Model of Groundwater Flow



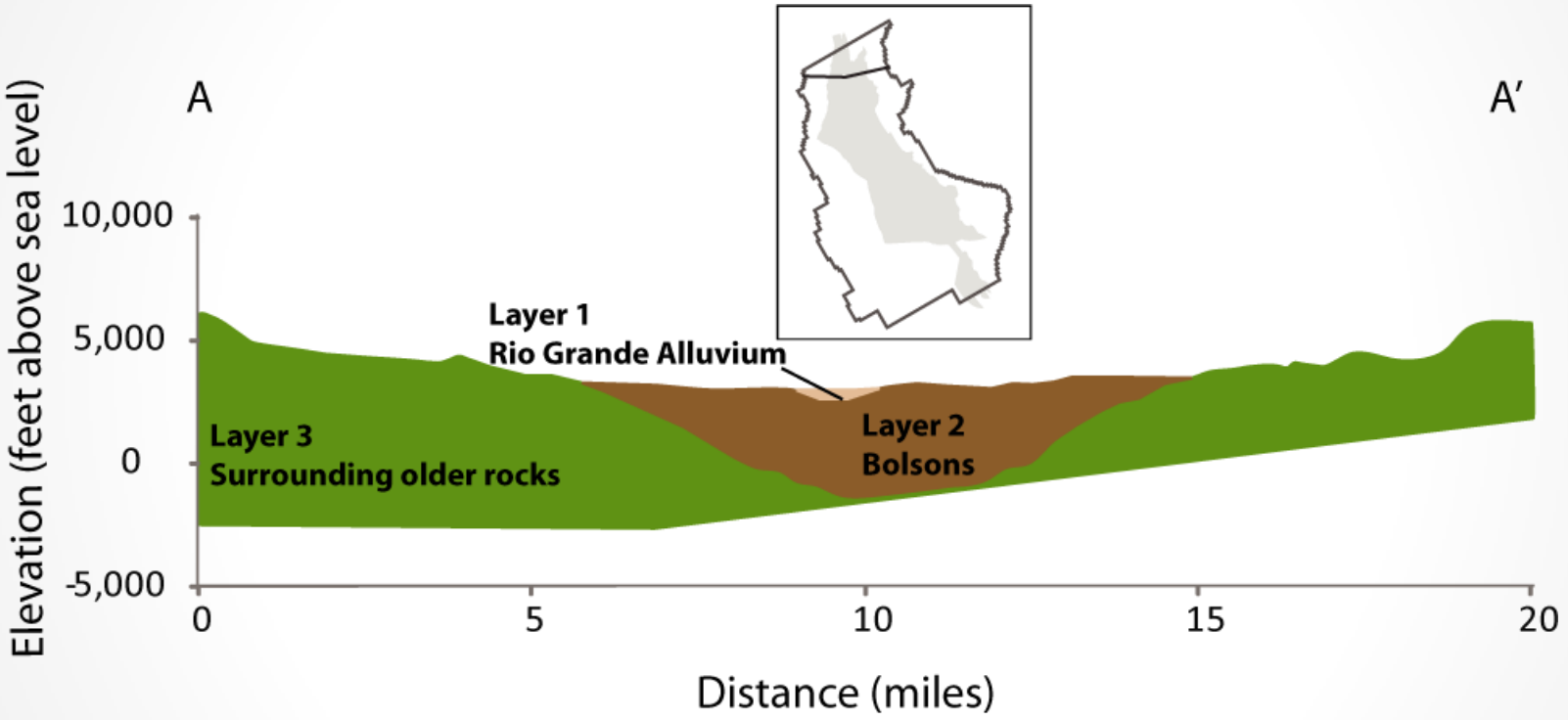
Model Design



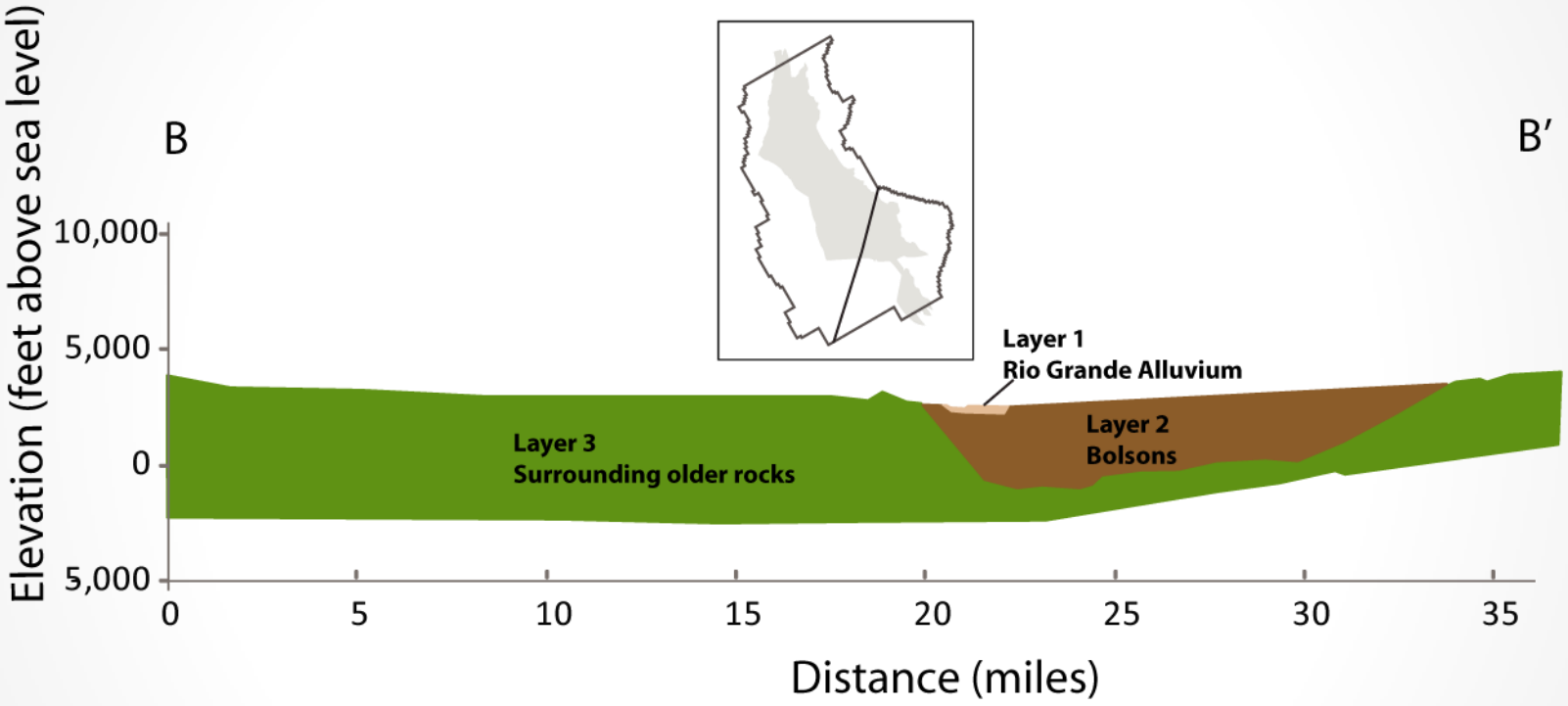
Grid and Layers

Model includes 3 layers

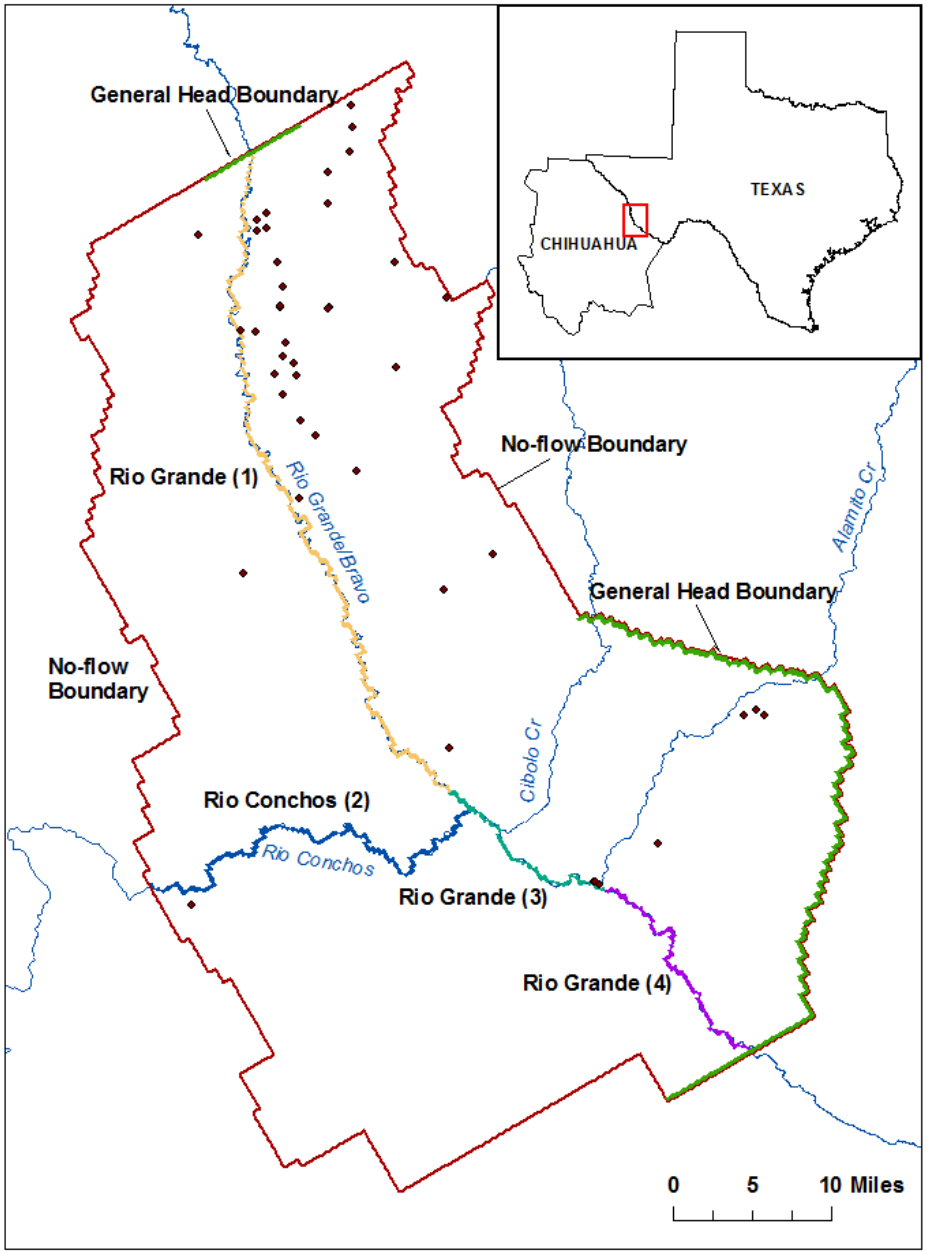
- Rio Grande Alluvium (layer 1)
- Bolson (layer 2)
- Underlying/surrounding volcanic and Cretaceous sedimentary rocks (layer 3)



Northern Cross-Section



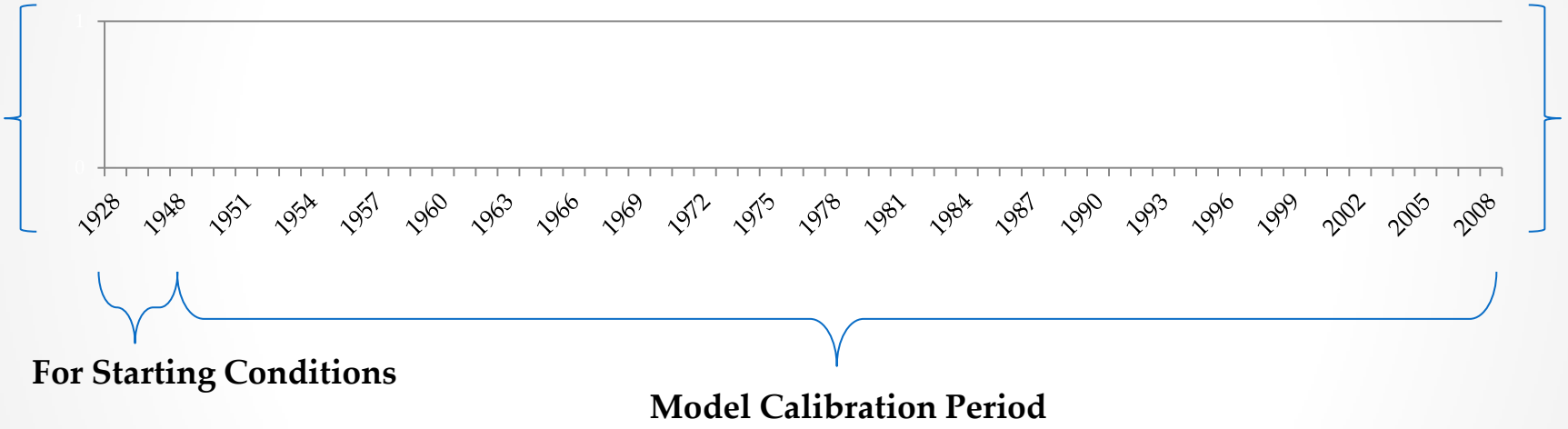
Southern Cross-Section



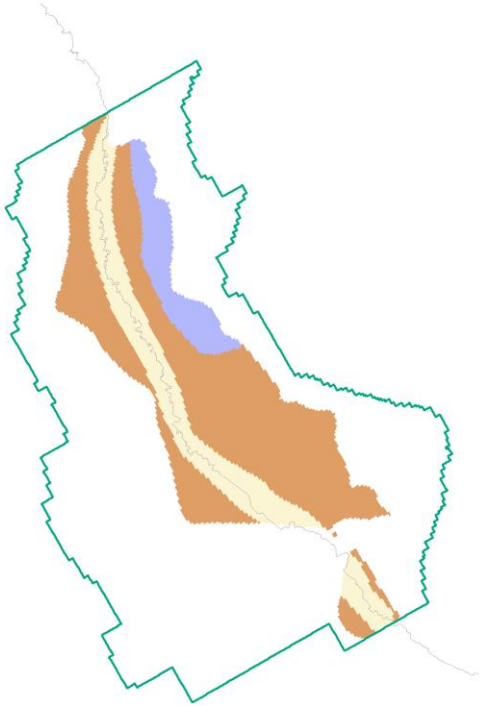
Rivers, Springs, and Boundary Flows

- The River discharge in the model represents net evapotranspiration and river loss

Model Time Period



Model Results



area where Bolson deposits missing zone to provide connection between layers 1 and 3

Layer 1
S = 0.1
Kh = 100 ft/day

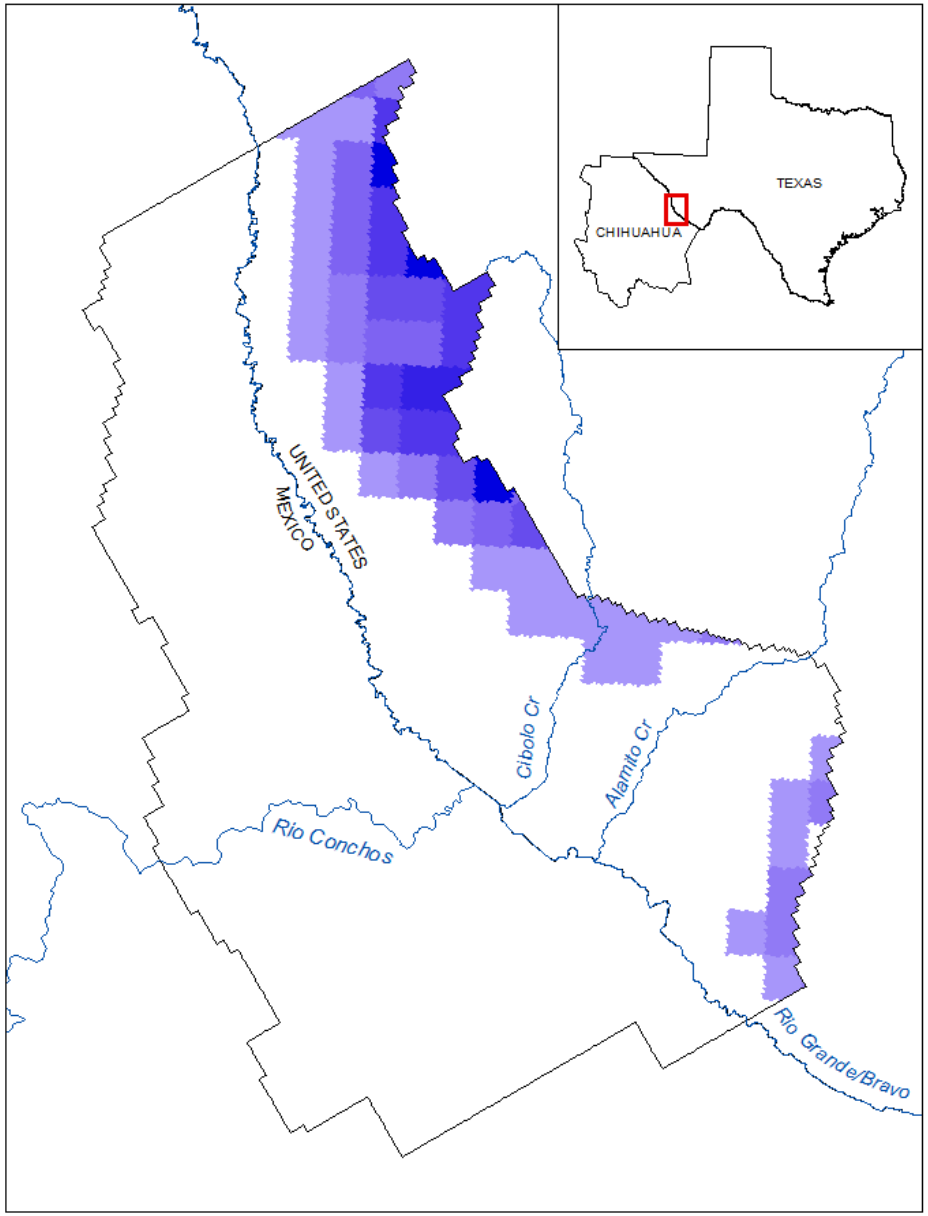
Layer 2
S = 0.005
Kh = (0.06 to 4.1 ft/day)

Layer 3
S = 0.0001
Kh = 0.15 ft/day

Hydraulic Properties are zoned

Recharge Approach

- Recharge applied as a percentage of precipitation with a minimum threshold rainfall amount for recharge to occur.
- More details are given in the report.

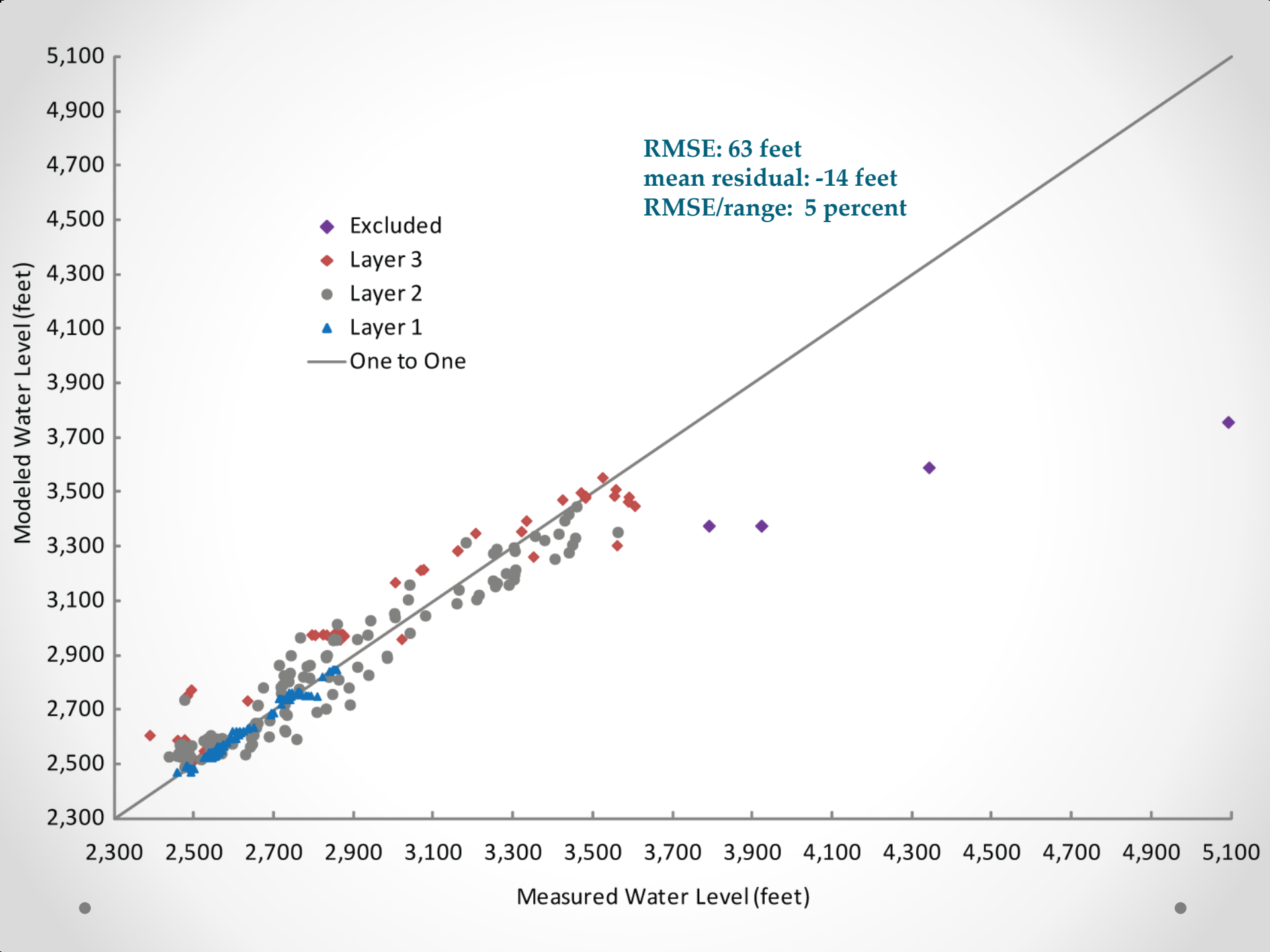


Average Recharge (inches/year)

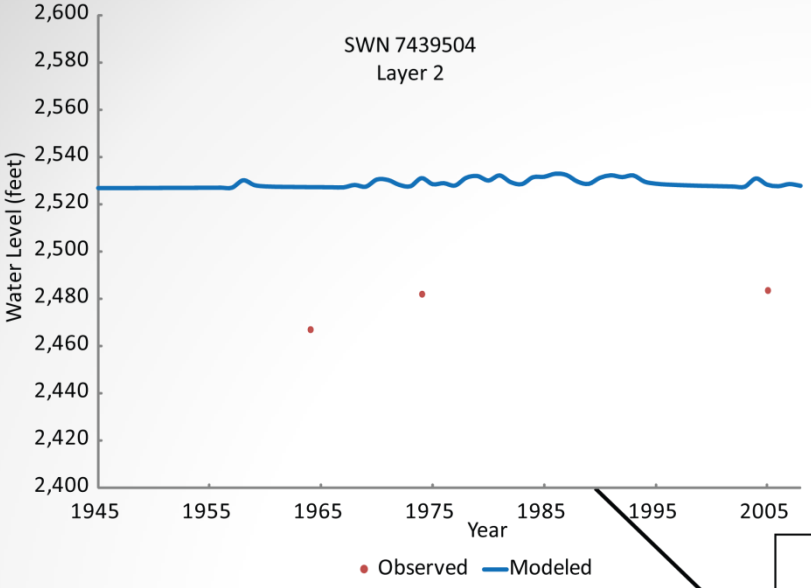
0.00	1.31 - 1.40	1.61 - 1.70
0.01 - 1.20	1.41 - 1.50	1.71 - 1.80
1.21 - 1.30	1.51 - 1.60	1.81 - 1.90

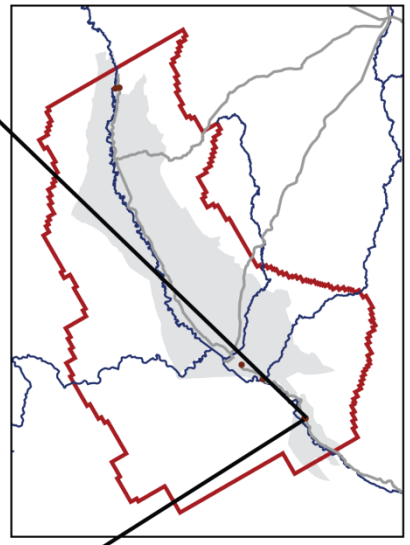
0 5 10 Miles

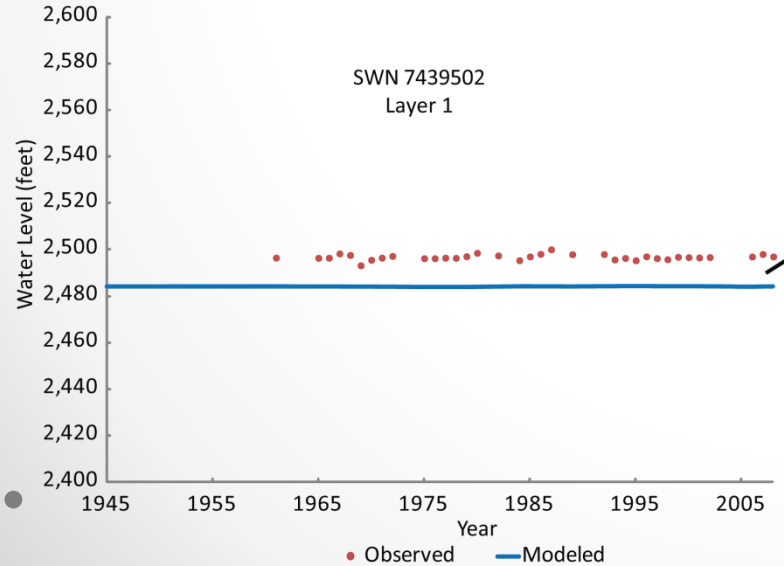
Recharge pattern for average rainfall


RMSE: 63 feet
mean residual: -14 feet
RMSE/range: 5 percent
Excluded
Layer 3
Layer 2
Layer 1
One to One
Modeled Water Level (feet)
Measured Water Level (feet)
5,100
4,900
4,700
4,500
4,300
4,100
3,900
3,700
3,500
3,300
3,100
2,900
2,700
2,500
2,300
2,300
2,500
2,700
2,900
3,100
3,300
3,500
3,700
3,900
4,100
4,300
4,500
4,700
4,900
5,100

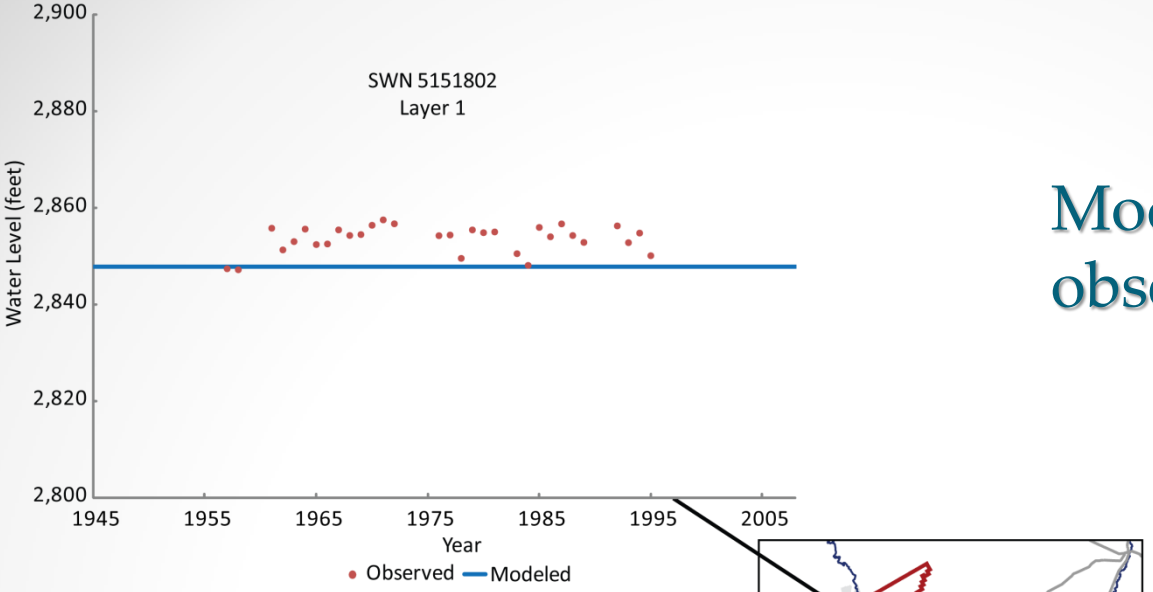
Modeled versus observed water levels

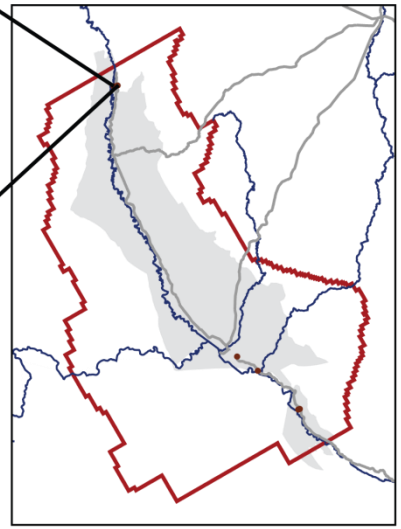


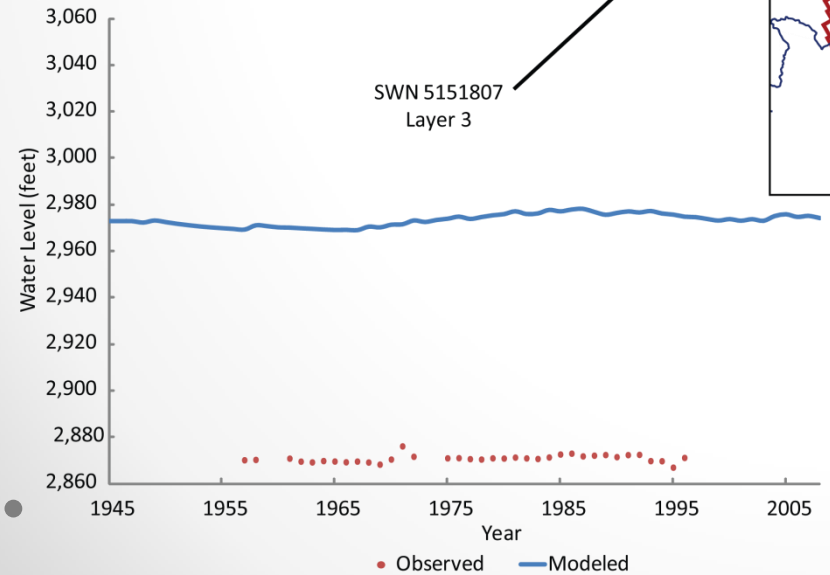




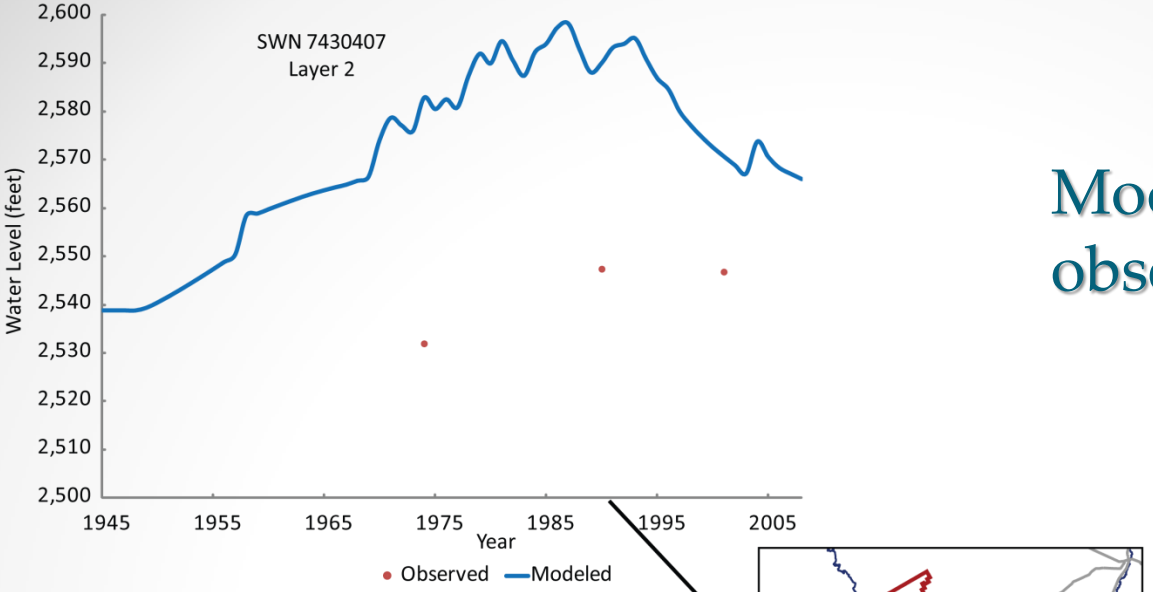
Modeled versus observed water levels

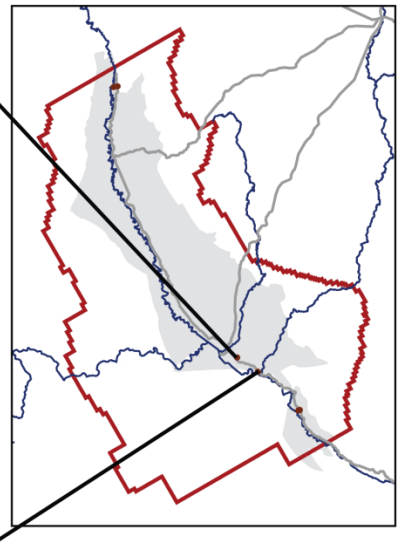


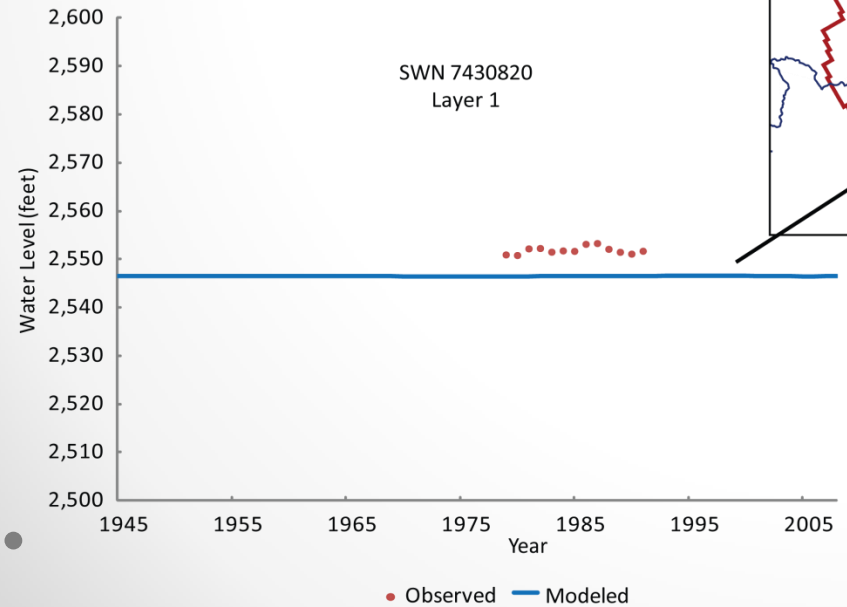




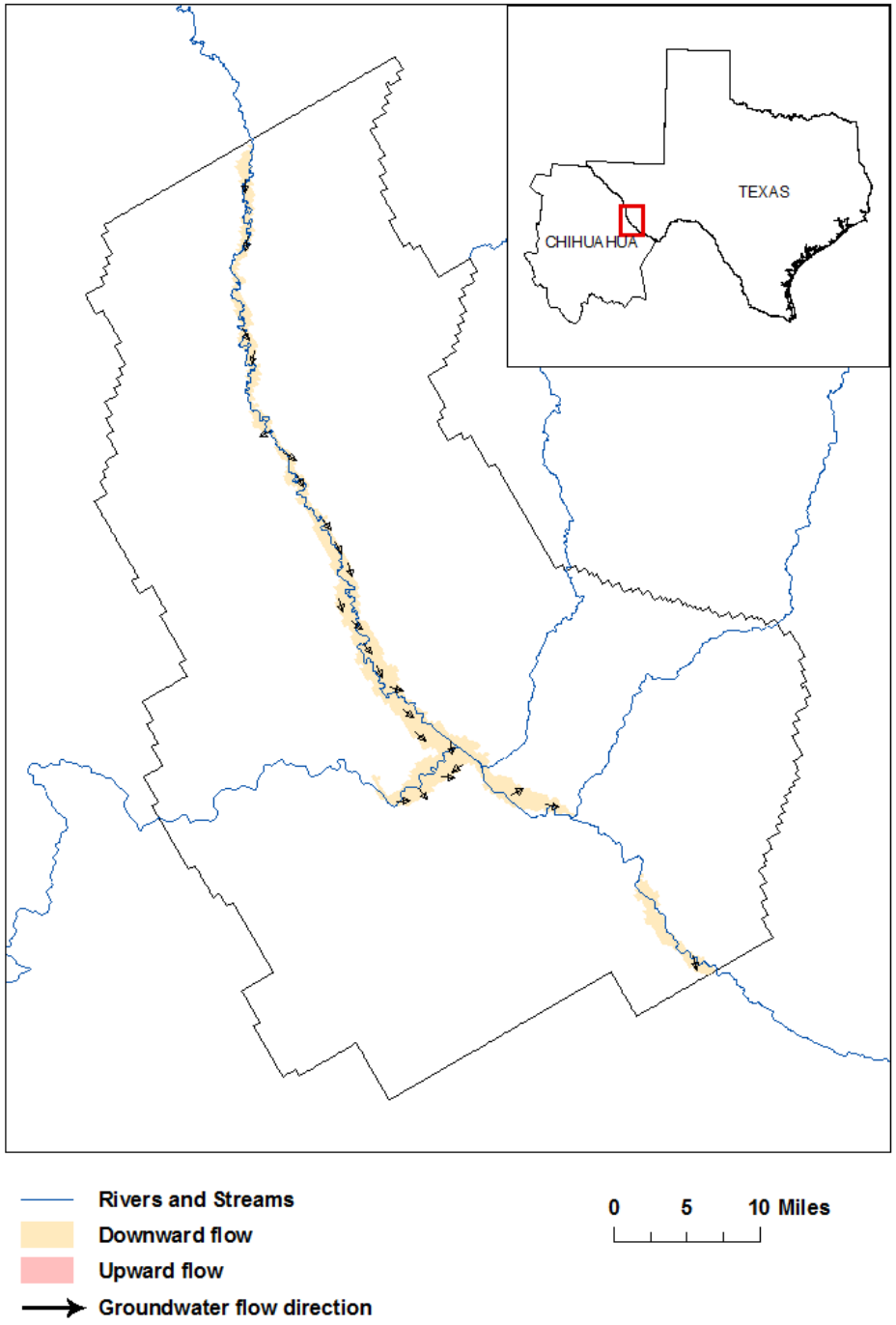
Modeled versus observed water levels



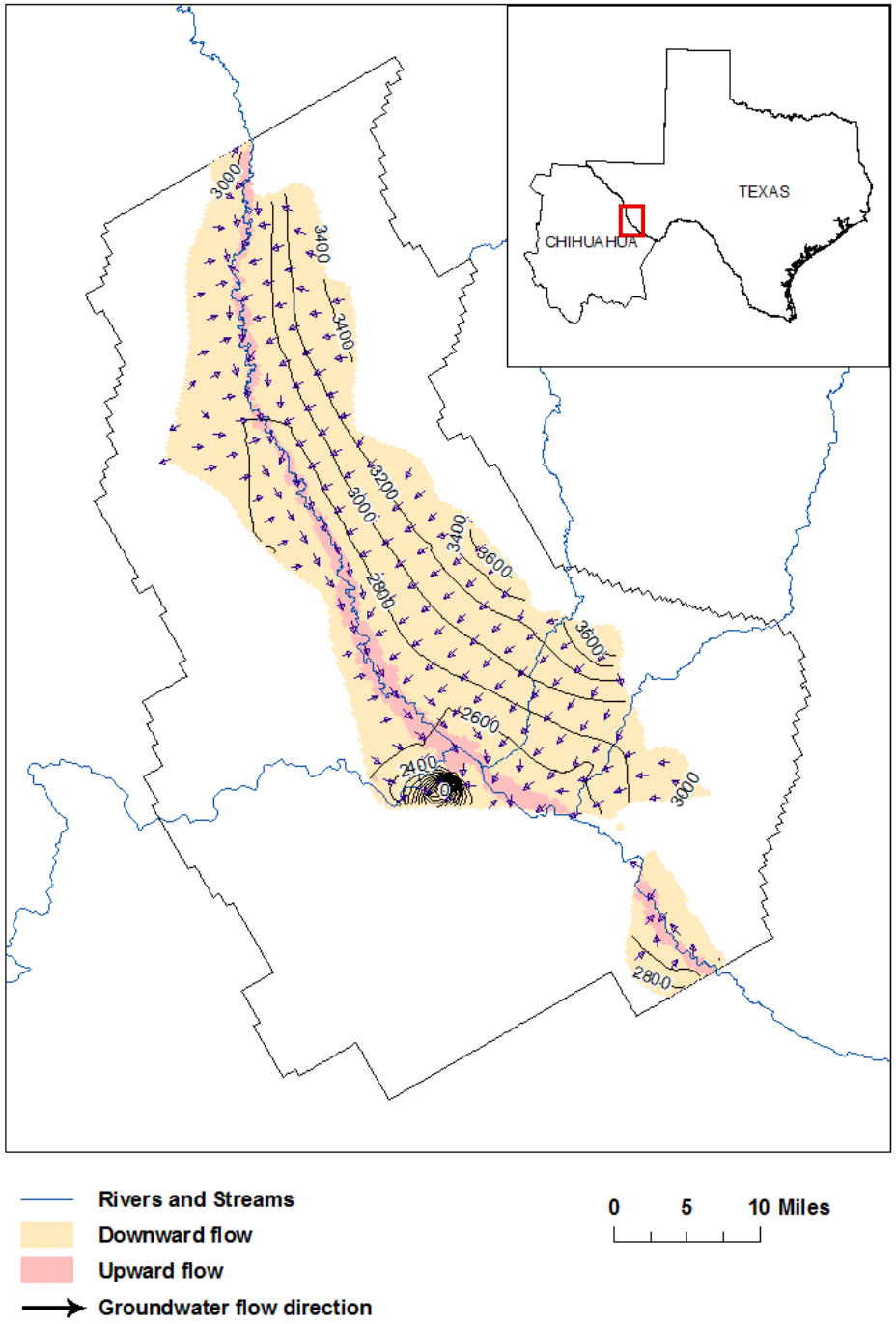




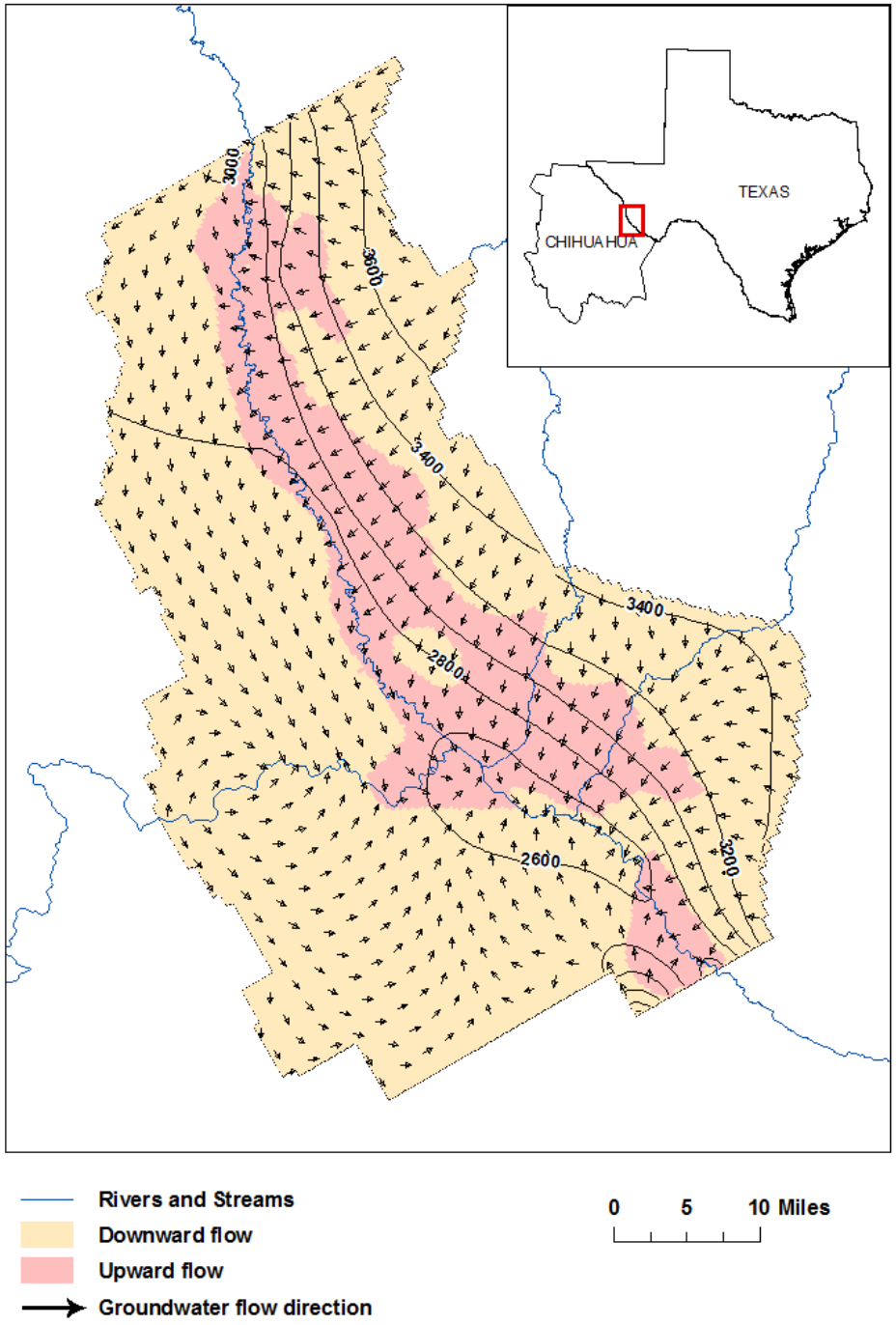
Groundwater Flow Directions – layer 1



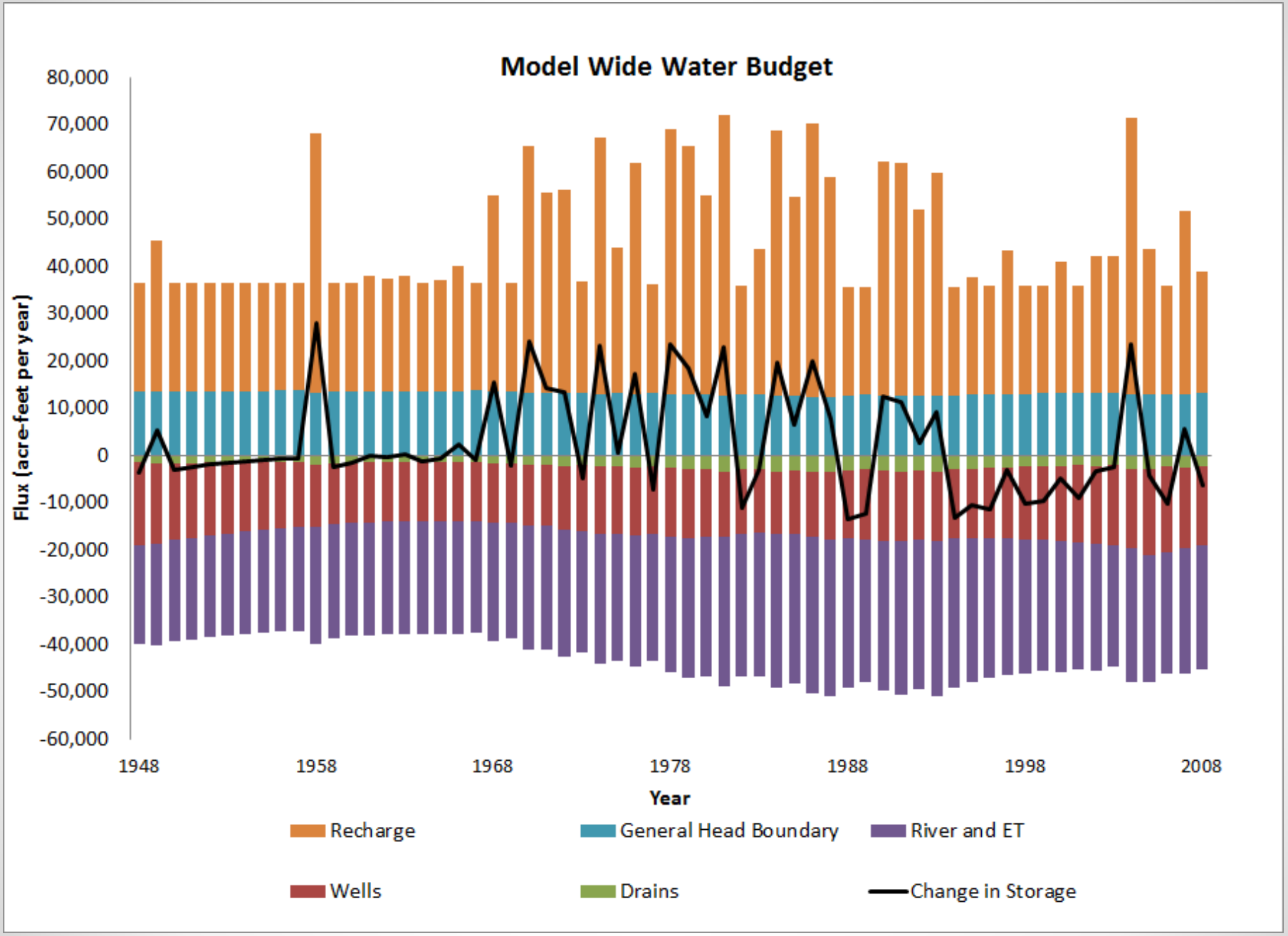
Groundwater Flow Directions – layer 2



Groundwater Flow Directions – layer 3



Water Budget


Model Wide Water Budget
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
-10,000
-20,000
-30,000
-40,000
-50,000
-60,000
Flux (acre-feet per year)
1948
1958
1968
1978
1988
1998
2008
Year
Recharge
General Head Boundary
River and ET
Wells
Drains
Change in Storage

Summary and Recommendations

- We have developed and calibrated a draft groundwater flow model for the Presidio and Redford Bolson portion of the West Texas Bolsons Aquifer.
- On average the modeled water level is 14 feet greater than the measured water level and the RMSE is 5 percent of the range in heads.
- Because of limited historical data to a certain extent this model is interpretive rather than predictive.
- It is critical to update the model as more data become available.

Tentative Schedule

- January 31 – comments on draft model report due
- February 28 – Final Report posted on the TWDB website

Contact Information

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Texas Water Development Board
1700 North Congress Avenue
P.O. Box 13231
Austin, Texas 78711-3231

Web information:

http://www.twdb.texas.gov/groundwater/

http://www.twdb.texas.gov/groundwater/models/gam/prbl/prbl.asp

Questions

Stakeholder Advisory Forum Number 3
Groundwater Availability Model for the
Presidio and Redford Bolsons
January 17, 2013

Name	Affiliation
Patt Sims	Presidio ISD
Jim Mustard	Presidio Water Board
David Williams	Presidio Water Board
Zhuping Sheng	TAMU
Dick Gill	
Paul Hunt	Presidio County Judge
Alberto Halpern	Big Bend Sentinel and Presidio International newpapers
Carlos E. Nieto, MPH	Board President – Presidio ISD Chariman - Presidio County App. District Vice Chair - Presidio County UWCD
Mike Gershon	Presidio County UWCD Lloyd Gosselink
Sandy Bruce	RGMC
Charles Roberts	Texas GLO
David H. Lewis	TPWD
Obed Escontrias	Mayor, City of Presidio
David W. Beebe	City of Marfa
Pam Tarelle	Skinner's Well Service
Allan Standen	Presidio County UWCD
Radu Boghici	Texas Water Development Board
Shirley Wade	Texas Water Development Board

Questions and Discussion for the Stakeholder Advisory Forum Number 3 Groundwater Availability Model for the Presidio and Redford Bolsons – January 17, 2013

Q: New farmlands have been developed across the river in Mexico. To what extent does Mexico's water usage, which may not be measured, impact our water availability for the future?

A: If they do pump more in Mexico, then water will flow across the boundary underneath. In the model we do not consider the river a cut-off boundary. The model does allow, account for flow underneath the Rio Grande. It is important for us to get a good estimate of how much water is used there. We have applied pumping in Mexico, but it was just an estimate based on the permit data that they have posted on the CONAGUA (Comisión Nacional del Agua) website.

Q: Then it is possible that if we use our water intelligently, but our neighbors to the south use it unwisely, we could find ourselves with less water available for the population on the Texas side?

A: Yes and no. It is important for us to collect the data to know what the impact is. Right now we can speculate about it. We have, in our model, applied pumping in Mexico. It's not an impermeable boundary definitely, so anything they do on the western side will affect what you all do here.

Q: Any generalities you can make over the last ten years, the droughts, and the water levels?

A: From the data we have, we don't really see that. The main thing that's going to affect the levels is the pumping, more than the drought, because it's already a dry climate anyway. The droughts cause people to pump more though.

Q: Has the recharge rate been affected over time?

A: We have the estimates from the model, and it shows that in the mountains recharge is affected by the amount of rainfall. It takes a long time for it to reach where the pumping goes on, so yes and no.

Q: Where does your rainfall data come from?
A: It's PRISM data from Oregon State University. They take the raingauge data from around the state and all of the country, and they have a numerical routine that estimates, contours all the rainfall data using, topographic information. So it gives a spatial representation. For the area we've got it from 1948 to 2008.

Q: Do you know where the datapoints are that are affecting the interpolation process?

A: There's a gauge in Candelaria, there's a gauge in Marfa, and one in Presidio. It uses the actual measurements in these gauges and things like topography to interpolate between those. It's not a lot of data.

Q: Did you say earlier you were using discharge data from Ojinaga?

A: CONAGUA has a website where you can go and get the permit info, and I downloaded that. It's data about permitted users in the Ojinaga area. When we were doing the model calibration, we adjusted it within plus or minus 50 percent because there's still uncertainty. On these permits we went up to 150 percent, so we estimated 50 percent more than what they're permitted -- the model said this matched the data the best. It ended up being actually proportions of populations: the estimate for Presidio County was the same proportion of population for Ojinaga.

Q: For that proportionality to be as similar as you describe, and assuming it applies to urban use in Ojinaga, the municipal would make a big difference.

A: Yes, that proportion would apply only for municipal uses.

Q: On the graph showing the water levels you had some wells in there. My question to you is: are the wells the City of Presidio uses for their water included [in the model]?

A: The pumping certainly is. When we collect water-level data they usually are collected under the scenario that there's not any pumping, so we want to measure the wells when they haven't been pumping them. I don't know if our people measure the city wells.

Q: Marfa reports their water use. Does the City of Presidio report their water use?

A: Yes, the TWDB has a database with water use data from all the municipalities that report it.

Q: What would you consider the application of this [GAM} if Presidio wanted to study the impact of all this? If you were to look at the city's water well field and do predictive analyses – do you think there is enough information to really do a predictive analysis?

A: Probably [would use] an analytical model, if there were a decent estimate of hydraulic conductivity. There is specific capacity data in the conceptual model that we report. I don't think there's any pump test, it's all based on specific capacity – but this can be used in an analytical model. You mean water level drawdowns in the well field? Yes, this model can certainly be used for that, just keeping in mind the uncertainties, particularly on the Mexico side. Most of the data is from the wells of the Presidio well field. It's a fairly small grid cell, quarter-mile grid cell, so it could be used for that, along with an analytical model.

Q: Was there any evidence in what you've studied – since you're not predicting – of drawdown?

A: Not at the (current) levels of pumping.. Not long-term through the historical period, but in certain local areas such as Ojinaga. Again, this is just based on limited information, based on the permitting information. There is a little bit of drawdown, see the (contour) lines (on the water level map). In areas where there's less pumping, there's not as much drawdown.

Q: In your figure it shows the springflow has dropped about one-third. Is all occurring in your side or all area?

A: That figure is not for this model. That was just an example on how to use the models.

Q: Do you see any decrease in springflow in this model area?

A: Not really. It's in equilibrium. The data – we only have an only an average log-term measurement for the spring. So we can't really make a statement about what's been happening with the springs.

Q: Is the data from 2003? [barely audible]

A: They are from all periods of time, a lot of it is from Christopher Henry study in 1979, so they're from as long back as that.

Q: The table 14 is specific for county-wide. This model area does not contain Mexico flow [inaudible], right? Figure 23 describes model-wide water budgets, figure 24 describes county-wide model budgets…

A: The model-wide budget would be the sum of all the flows in and out of the boundaries. For just Presidio County, it does take into account what goes in and out of this boundary. [Dialogue went on along with pointing at various boundaries on the map].

Q: Has the water quality issue been addressed in terms of contaminants, or particulates in the water?

A: Not for this study. The TWDB in cooperation with USGS did a study in 1980, Gates and White where they look at the water quality. It looks like through time the salinity has gone up, probably due to irrigation.

Q: Nothing recent?

A: No. When we [TWDB] do the water sampling program every 4 years or so, but no one has done a county-level study of water quality. […]This model does not take into account water chemistry. We review the water chemistry, but the model does not track water chemistry.

Q: Is IBWC (International Boundary Waters Commission) involved in any of this work?

A: They are not involved directly. When we started the project, we requested their help to get data through CILA (Comision Internacional De Limites Y Aquas), they've attended some meetings. This is a State of Texas project.

Q: But this is about the water shared by the communities that are on the border. What can be done, maybe through IBWC having representatives on both sides, so that we have better information on Mexico's usage, which impact water availability in Texas?

A: Anything that would encourage everybody to participate would be good. Part of the [problem] might be the lack of geological data on the Mexican side. […] There were more data available in the El Paso/Juarez area.

Q: Is the reach of the Rio Grande [in the GAM] a gaining reach, or a losing reach?

A: From Candelaria to Presidio is probably net losing. South of Presidio definitely and maybe Rio Conchos is probably gaining. The groundwater still is discharging, but probably plants are getting a lot of it.

Q: What is the thickness of the bolson areas shown on your maps based on? Is it based on wells, or seismic data, or what kind of criteria were used to establish the thickness?

A: It was based on wells drilled. There was a geothermal study done by Keller and Mraz from UT Austin and BEG. They had core data from wells, not a lot of wells just a few, they hit the basement rock, and showed the bolson being about 5,000 feet thick.

Q: You alluded to Alamito Creek, but never mentioned Cibolo Creek [as far as] water flow…

A: We looked at the hydrographs, and the gauges show flow in it when there's rain. It is not always flowing, so we didn't include [them]. Not high flows… There's definitely, at the brief periods of time of high flow, recharge to the bolson. It's part of the conceptual view, that there's recharge to the bolson through alluvial channels. Our model is based on annual inputs, so we include things that happen on regular basis, rather than episodic.

Q: Can you expand the study to include areas that can impact the City of Presidio? Expand to include new wells?

A: As we get more data, we can move the model in time and (add) these new wells as data points. As we get any additional data, that's something definitely we can do.

Q: Did you have any data in north Presidio County, in the Marfa area?

A: We do, [but] we won't expand this model, because we have another model covering that area.

Q: If fracking becomes an issue in the Marfa gas Basin, do you have good data on the water?

A: We gave water levels. As far as amounts of water used in the fracking, we don't have this information anywhere in the state – that's a big issue. We have a good handle of municipal operations because they report [to us], we have certain ways of estimating domestic and livestock [uses] but any industrial uses, but things like industrial operations […] are not required to report that.

Q: Any association between population levels […] for Presidio and Ojinaga and relationship to water use over time?

A: They seem to be similar proportions, but that also included agriculture, so it's kind of rough. For Ojinaga I made the comparison as a check. I had population for Presidio for Ojinaga, I had water use estimates for Presidio and for Ojinaga, and they had roughly the same ratios. But that's not how I got the pumping numbers. I used the CONAGUA website.

Q: No association between acres of cultivation on either side?

A: That analysis I did not do. I'd have to do a […] or a satellite – we have satellite maps, we can see the difference in the areas.

Q: How often do you get those satellite photos?

A: I don't know how often we get those.

Q: Does Village Farms report to you their water use? [tomato hothouse near Marfa]

A: I am not sure they are required. It's entirely voluntary, we send them a survey, some return it with data.

Q: Were the estimates shown in table 6 modeled on population?

A: The pumping rates? That was a proportion, so if I know what the Ojinaga population is at this point in time and what the Presidio population is, I will use that same ratio to go back in time, and that has a lot of uncertainty in it, so it's like a starting point.

Q: For the side that's unconfined alluvium, that's a specific yield, right?

A: The storage coefficient, yes.

Q: But the middle one, is it specific storage, or [inaudible]?

A: That's storage coefficient, kind of confined. It's not specific storage, no.

Q: This looks lower for the bolson, it may affect your simulations when you calibrate the model. How do you define the second layer base or the confined layer.

A: It's semiconfined, yeah. It's confined because it's not uniform sand. And it's going to be clay lenses, the bolson is heterogeneous, and the vertical conductivity will be lower than [horizontal].

Q; So, between layers 2 and 3 do you see separations, whether clay layers, or whatever separations?

A: The 3rd layer is actually Cretaceous and Tertiary, but it's not a full blown confining layer, no. It grades down from the bolson deposits to the igneous, and it is kind of fractured, so it's probably pretty good connection between the two, I guess.

Q: For the Igneous Aquifer, you've treated it as a porous media, rather than fractured media.

A: Right, it's igneous rock, but it's volcaniclastic, it's permeable, porous media, part of it is. So it's not like a basalt, or something like that.

Q: How often do you make these reports on the updates?

A: It varies from model to model. Right now, we're wrapping up this model – it's the draft final – and when get more information to update the mode, if we're doing a phase II for it, we'll have a stakeholder meeting at that point. There is not a fixed [timeframe].

Q: What will trigger another study, sooner rather than later?

A: More data. If we got more data… But it'll also have to be high-priority. Right now, this [model] meets the data we had at the time.

Q: What are the hotspots in the state? Where there's activity in the courtroom?

A: I don't know. There's a lot of people for a limited amount of water. Right now the modeling is driven by the GMA or other issues that are coming up. We want to have models for all the GMAs.

Q: What is the DFC for the City of Presidio area, not the whole county? Are we expecting dramatic changes in water demands? What are Mexico's future DFCs that may affect aquifer-wide conditions?

A: For Presidio County, the DFC is an average drawdown of water levels for the bolson throughout the county of 72 feet. (Later correction – DFC for Presidio is 5 feet average drawdown for the Presidio and Redford Bolsons. 72 feet is for the other portions of the West Texas Bolsons in Presidio County)

Q: Was STATSGO used for the recharge?

A: No. We calibrated using precipitation data, and selected a percentage that best calibrated the model.