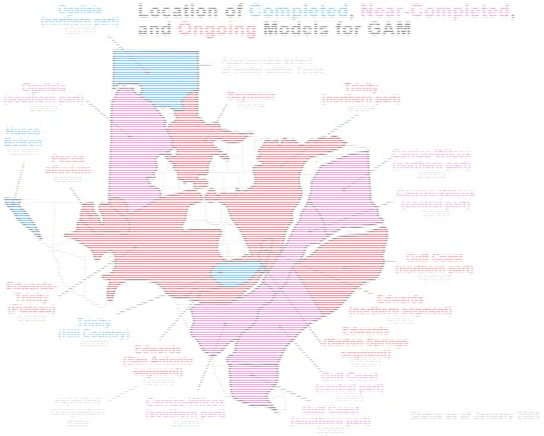
Groundwater
Availability Modeling (GAM)
Northern Gulf Coast Aquifer GAM

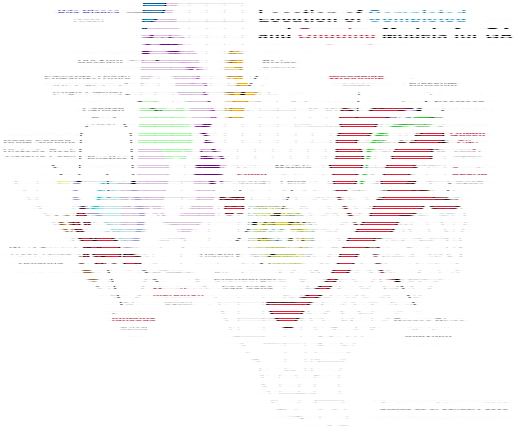
7th Stakeholder Advisory Forum

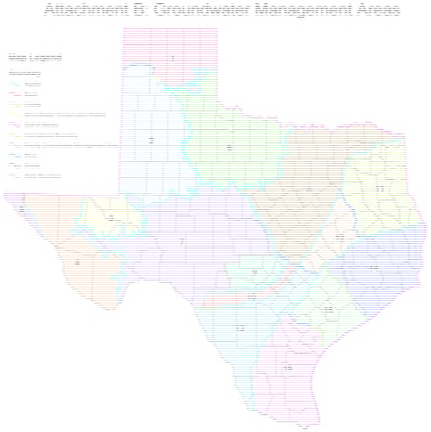
July 24, 2003

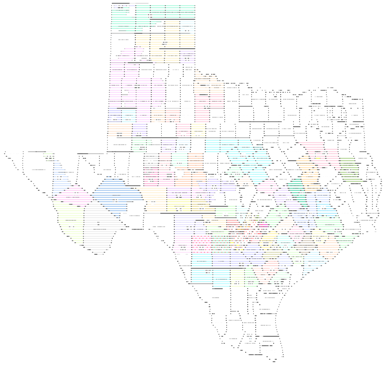
Contractor: USGS

Funding: TWDB, HGCSD &USGS



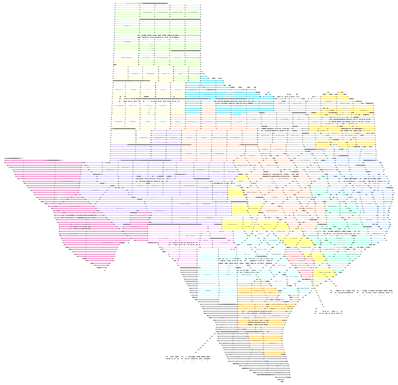




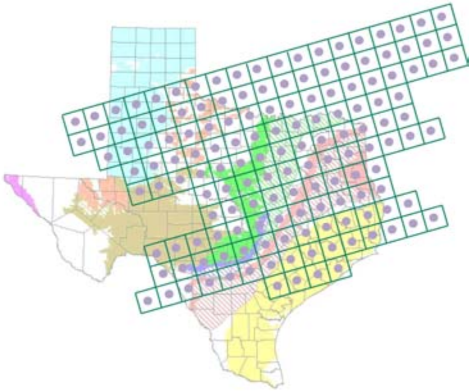


Contract Manager

Ali Chowdhury, Ph.D.



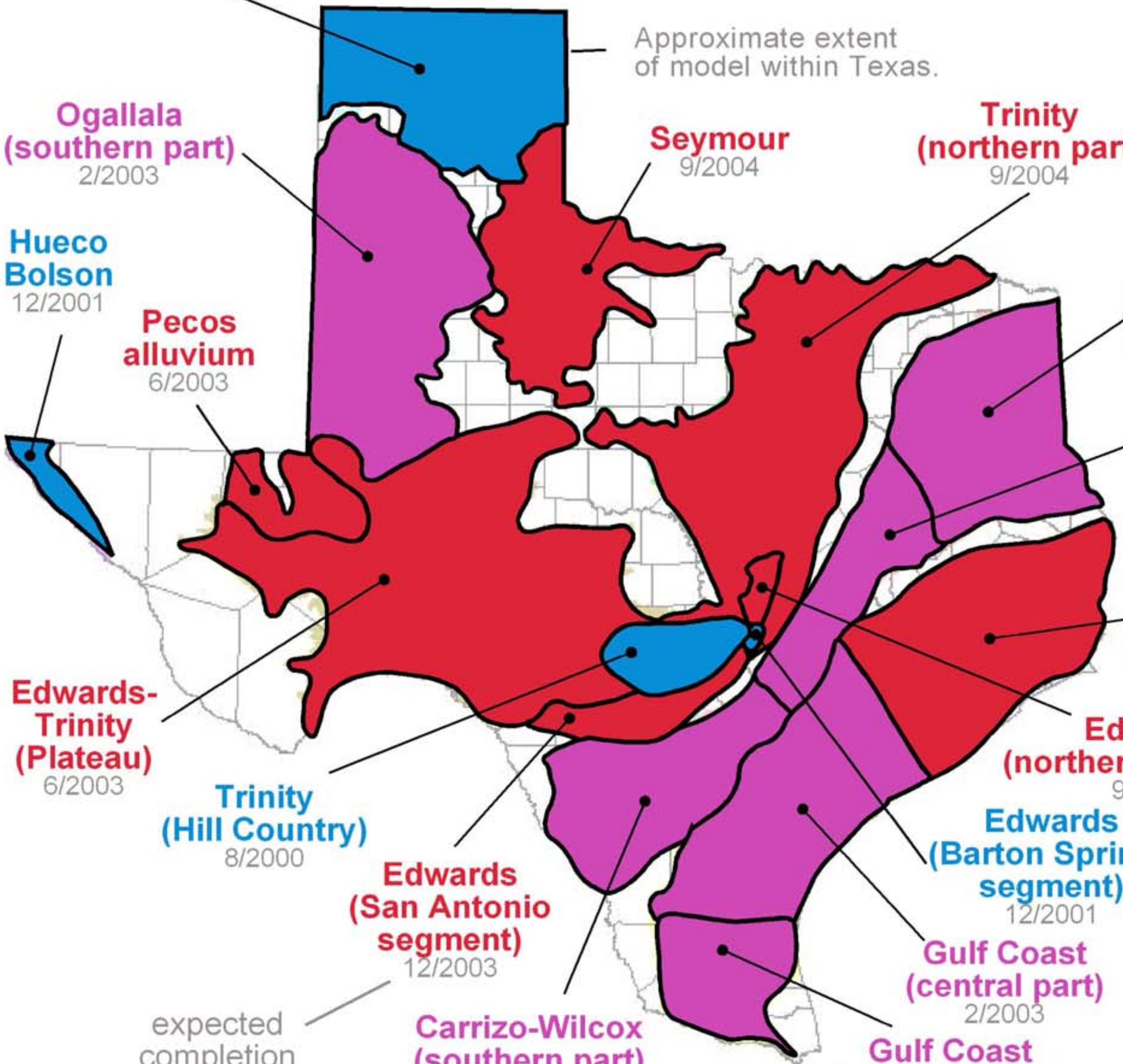
Texas Water Development Board



GAM

- Purpose: to develop the best possible groundwater availability model with the available time and money.
- Public process: you get to see how the model is put together.
- Freely available: standardized, thoroughly documented, and available over the internet.
- Living tools: periodically updated.

Location of Completed, Nearly-Completed, and Ongoing Models for GAM: Major aquifers



Ogallala
(northern part)
12/2001

Approximate extent
of model within Texas.

Ogallala
(southern part)
2/2003

Seymour
9/2004

Trinity
(northern part)
9/2004

Hueco
Bolson
12/2001

Pecos
alluvium
6/2003

Carrizo-Wilcox
(northern part)
2/2003

Carrizo-Wilcox
(central part)
3/2003

Gulf Coast
(northern part)
12/2003

Edwards-
Trinity
(Plateau)
6/2003

Edwards
(northern segment)
9/2002

Trinity
(Hill Country)
8/2000

Edwards
(Barton Springs
segment)
12/2001

Edwards
(San Antonio
segment)
12/2003

Gulf Coast
(central part)
2/2003

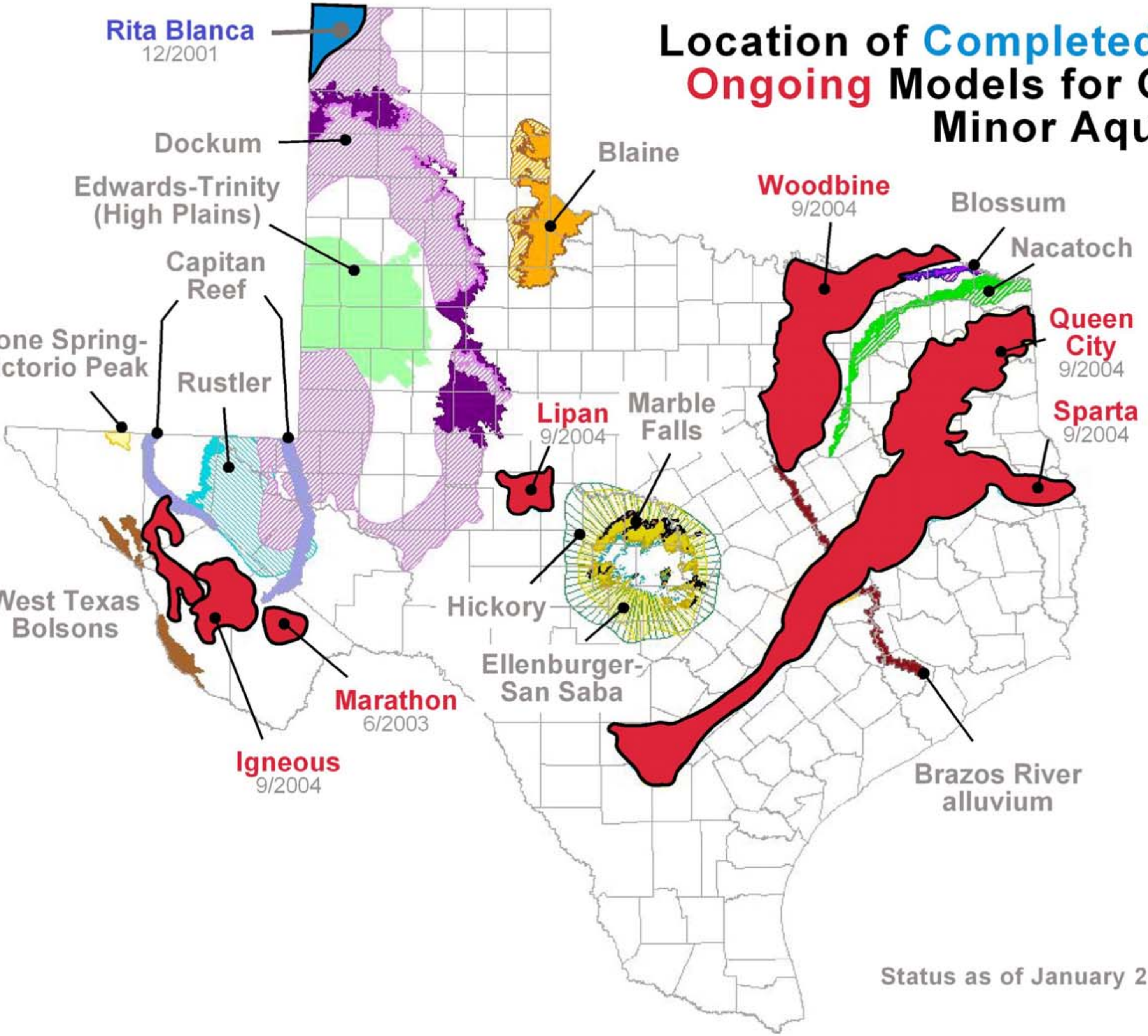
expected
completion
date

Carrizo-Wilcox
(southern part)
2/2003

Gulf Coast
(southern part)
3/2003

Status as of January 2003

Location of Completed and Ongoing Models for GAM: Minor Aquifers

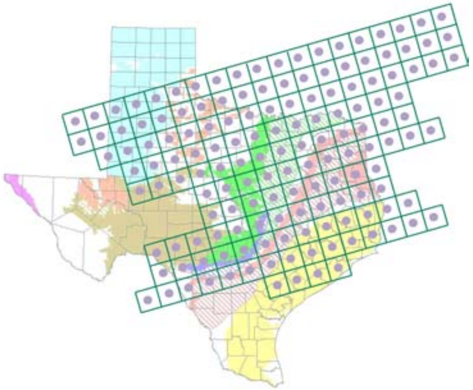


Status as of January 2003

What is a Groundwater Model?

- An aquifer in a computer, a tool to estimate field conditions
- Effective use of available data and account for complexities
- Expands our ability to better understand and manage the water resources
- Increases prediction accuracy of future events to a level far beyond “best judgement” decisions

Modeling Protocol



Purpose

Conceptual model

Numerical formulation

Model design

Calibration → Steady-State Model

Verification → Transient Model (1980-2000)

We are here!

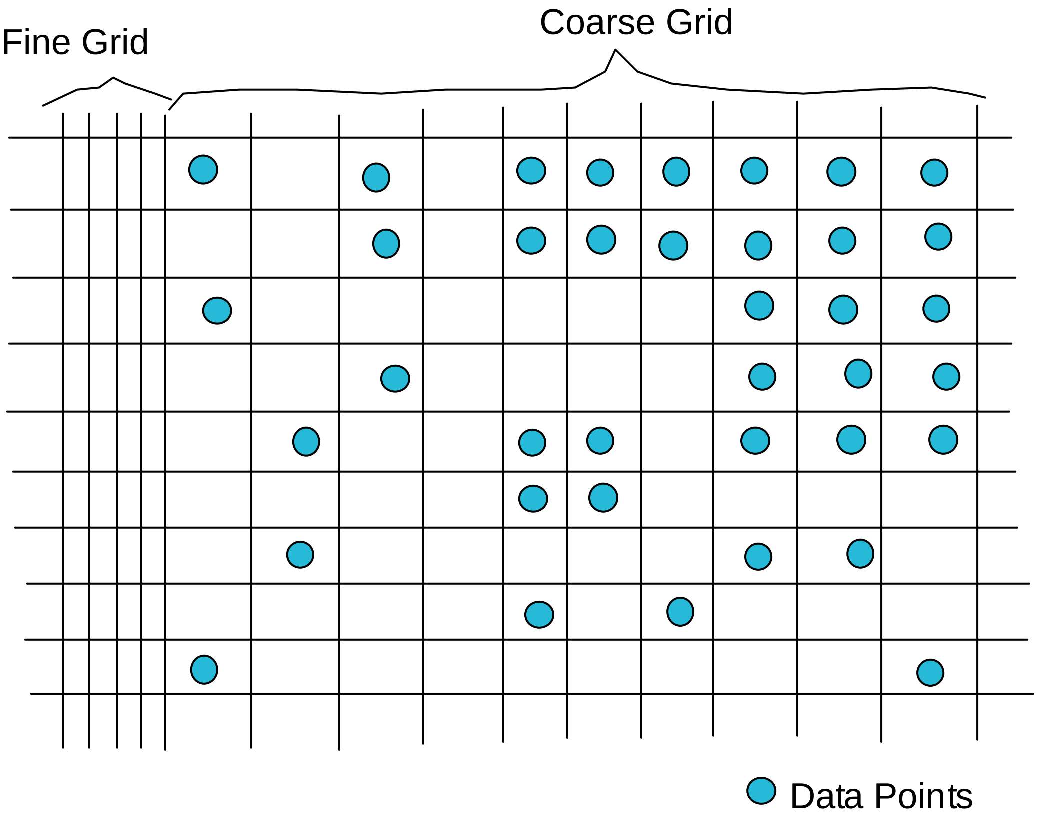
Prediction → Prediction Runs (2001-2050)

Postaudit

Comparison with field data → Calibration, Verification

Field data → Postaudit

Model Grid

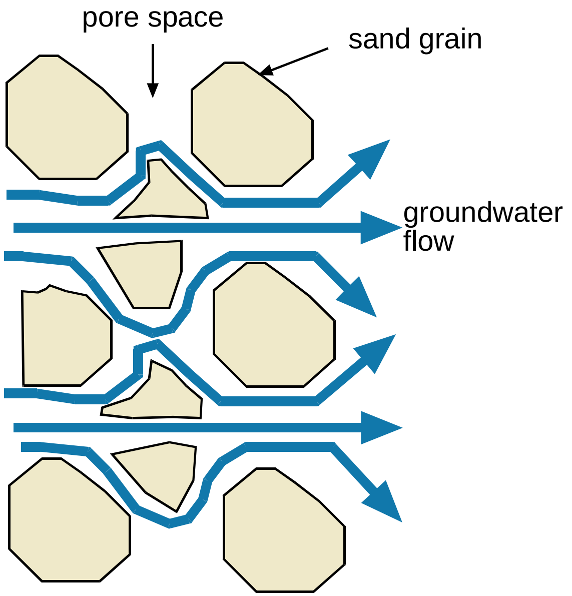


- model area discretized into cells
- cells are populated with field data which are sparse but each model cell needs a value
- data is interpolated (Kriging) between measured points where data is missing
- higher correlation between points at small sepration distance. kriging prserves the field value at the measurement point

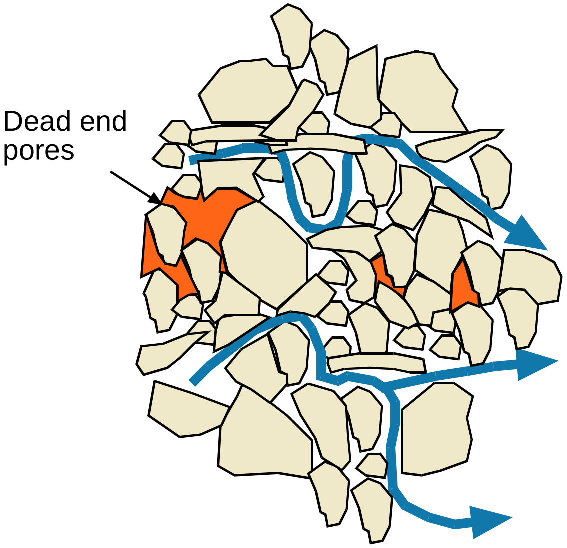
Porosity, Storage, and Hydraulic Conductivity

Porosity: pore space/total voids in a rock
Storage: volume of water released per unit decreases in head
Hydraulic conductivity: ability to transmit water

Sand

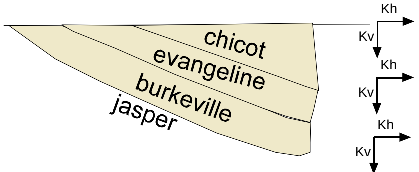


Clay

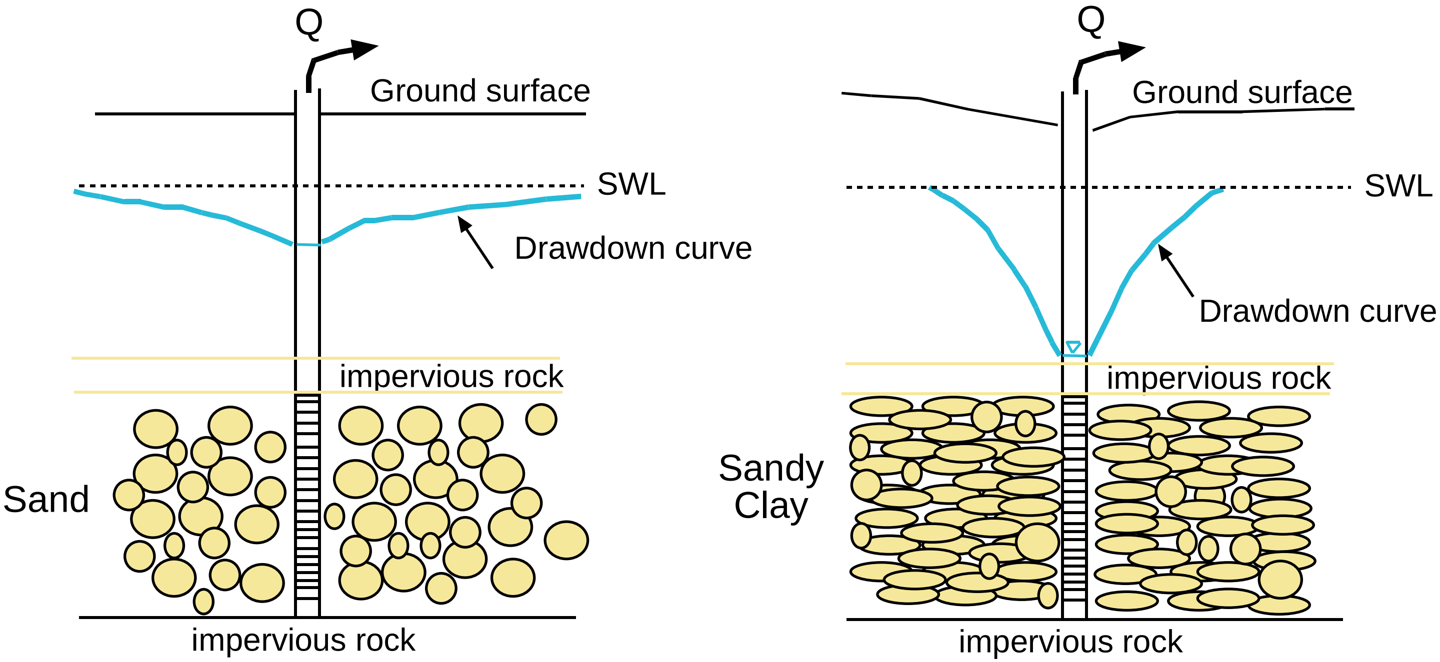


- High effective porosity/High K
- Storage
  - drainable (unconfined)
  - compressible (confined)
- High flow velocity
- Better water quality

- Low effective porosity/low storage
- Low K
- Low flow velocity
- Poor water quality

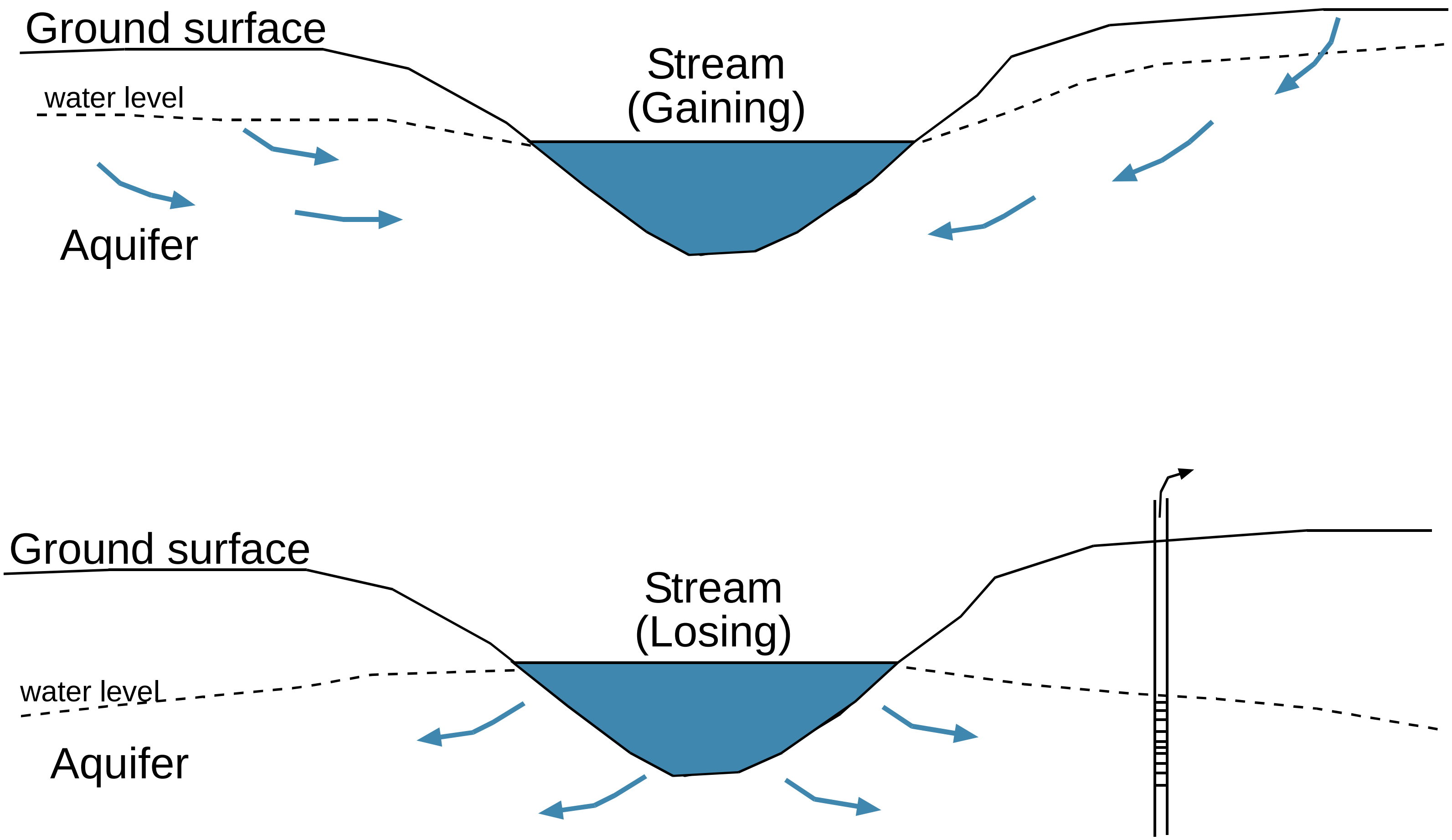


Drawdown Cones in Sand and Clays



- **Broad vs. Steep Drawdown Cones in Sandy vs. Clayey aquifer**
- **Subsidence due to clay compaction**

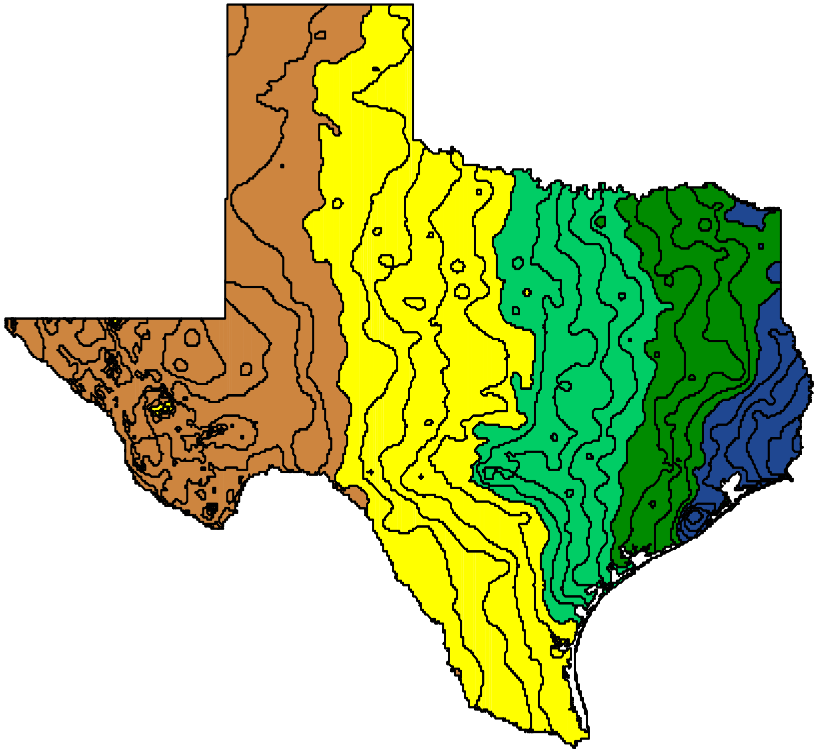
Gaining vs. losing stream



Recharge

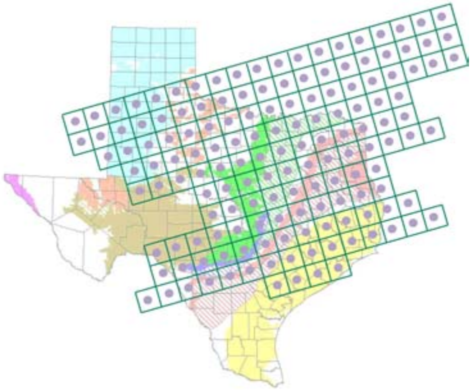
- *diffuse (direct) - precipitation or irrigation*
- *focused or localized - surface depressions, e.g. lakes or playas*
- *indirect recharge - beneath rivers, lakes*
- *recharge rate depends on rainfall, vegetation, soil type, topography*

Average annual rainfall map
60 inches in the east to 8 inches in the west



Recharge for the Gulf Coast aquifer

Source	**Recharge (in/yr)**
Groschen (1985)	0.06
Ryder (1988)	0 to 6
Dutton and Richter (1990)	0.1 to 0.4
Noble and others (1996)	6
Hay (1999)	.00004 to .04
Harden and Associates (2001)	0.1 to 0.2

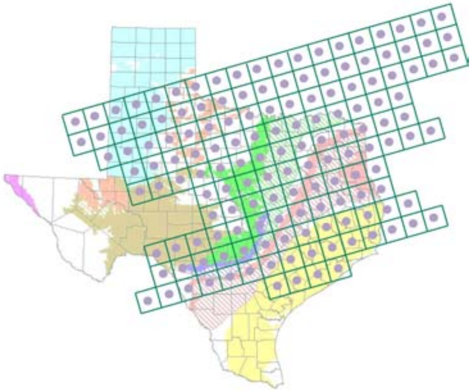


Pumping

- *Historical (pre-development, 1980-2000)*
- *Predictive (2000-2050)*

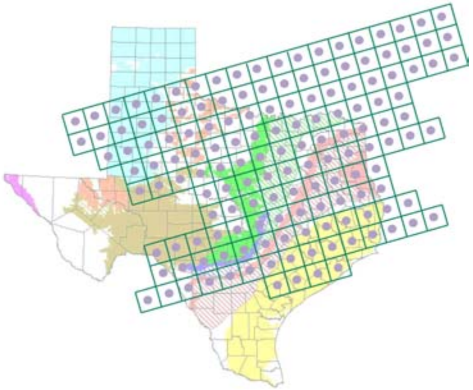
Categories

- *municipal*
- *manufacturing*
- *domestic*
- *irrigation*
- *livestock*



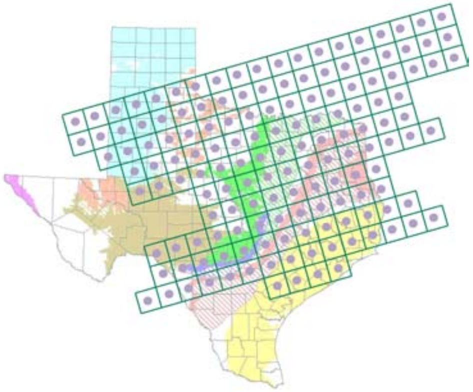
What is groundwater availability?

- …the amount of groundwater available for use.
  - safe yield
  - average recharge
  - recharge and change in storage
  - systematic depletion
- The State does not decide how much groundwater is available for use: GCDs and RWPGs decide.
- A GAM is a tool that can be used to assess groundwater availability once GCDs and RWPGs decide how to define groundwater availability.



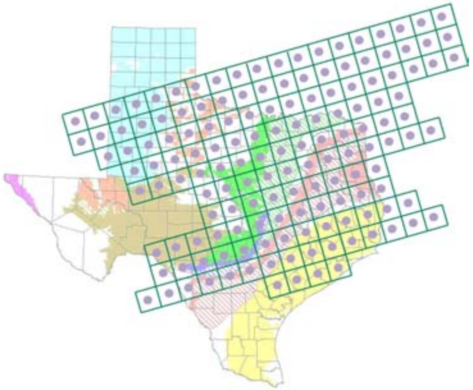
Do we have to use GAM?

- Water Code & TWDB rules require that GCDs use GAM information. Other information can be used in conjunction with GAM information.
- TWDB rules require that RWPGs use GAM information unless there is better site specific information available



How do we use GAM?

- The model
  - – predict water levels and flows in response to pumping and drought
  - – effects of well fields
- Data in the model
  - – water in storage
  - – recharge estimates
  - – hydraulic properties
- GCDs and RWPGs can request runs



Living tools

- GCDs, RWPGs, TWDB, and others collect new information on aquifer.
- This information can enhance the current GAMs.
- TWDB plans to update GAMs every five years with new information.

Comments:

Contract Manager

Ali.Chowdhury@twdb.state.tx.us

(512)936-0834

www.twdb.state.tx.us/gam

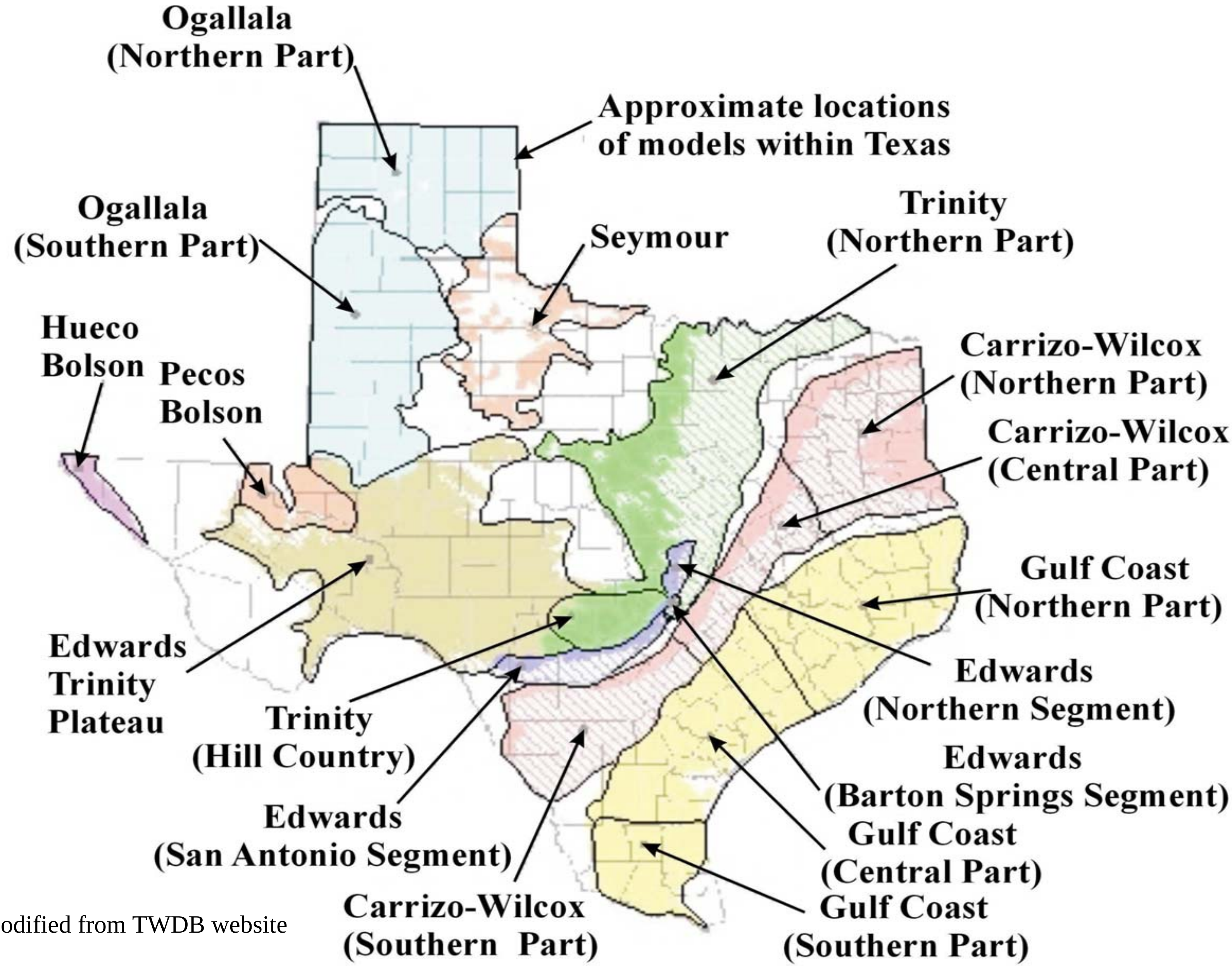
TEXAS WATER DEVELOPMENT BOARD

Hydrogeology, Simulation of Ground-Water Flow, and Land-Surface Subsidence in the Chicot, Evangeline, and Jasper Aquifers, Houston Area, Texas

Mark C. Kasmarek, James L. Robinson, and Eric W. Strom

In Cooperation with the Texas Water Development Board and the Harris-Galveston Coastal Subsidence District

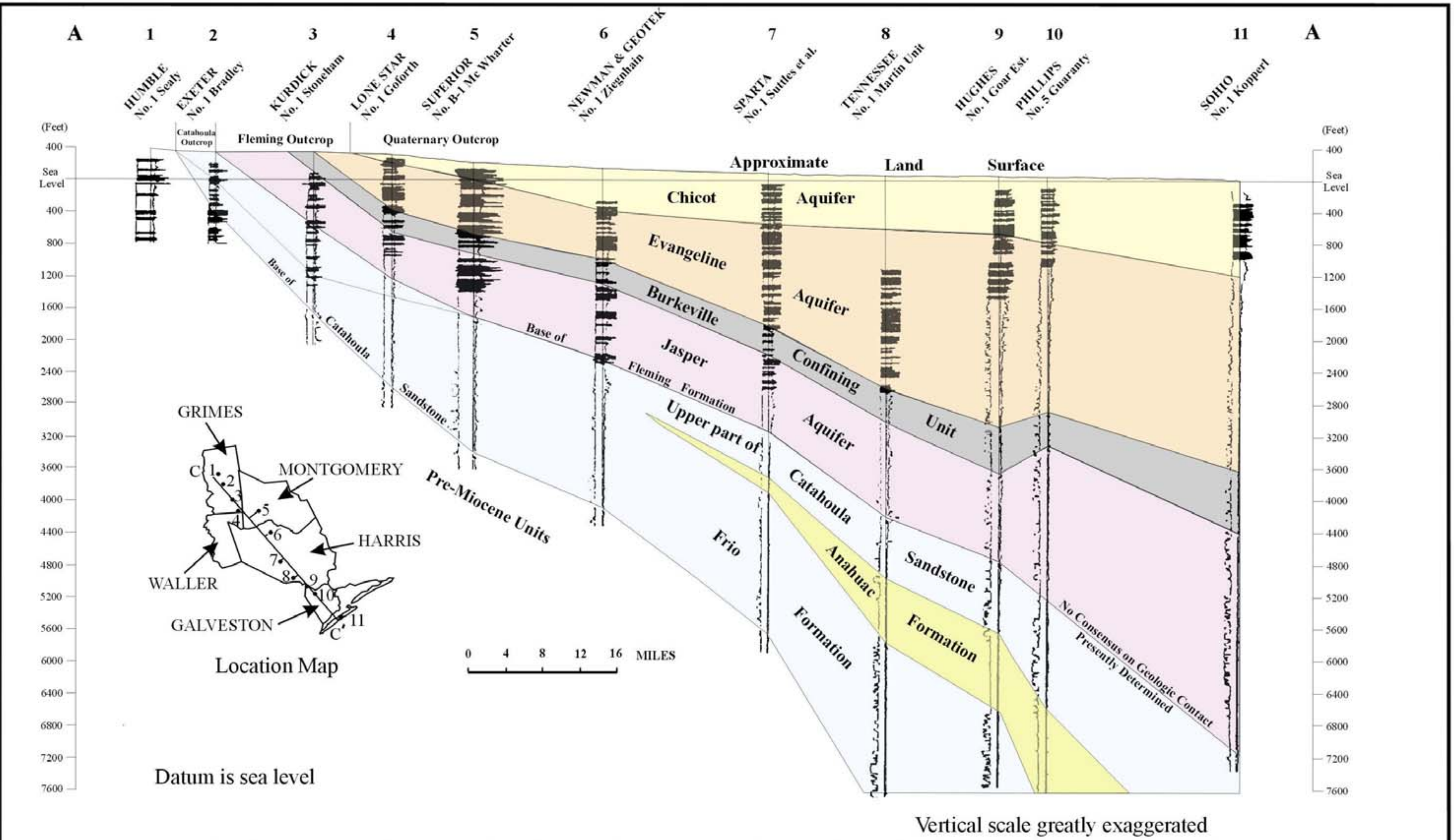
TWDB Ground-Water Availability Models in Texas



Modified from TWDB website

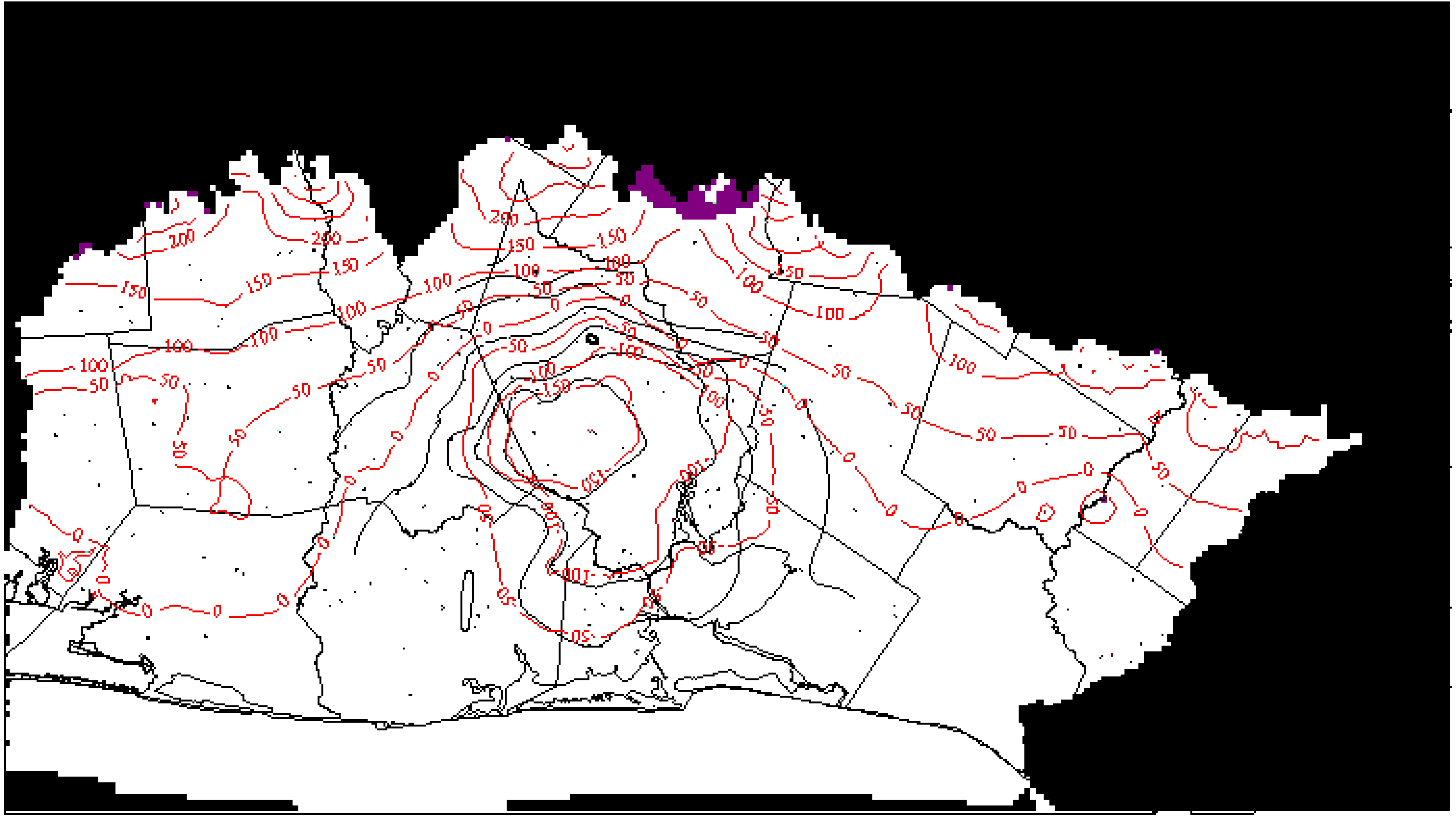
GAM Upper Gulf Coast Aquifer Outcrops

Stratigraphic and Hydrologic Sections

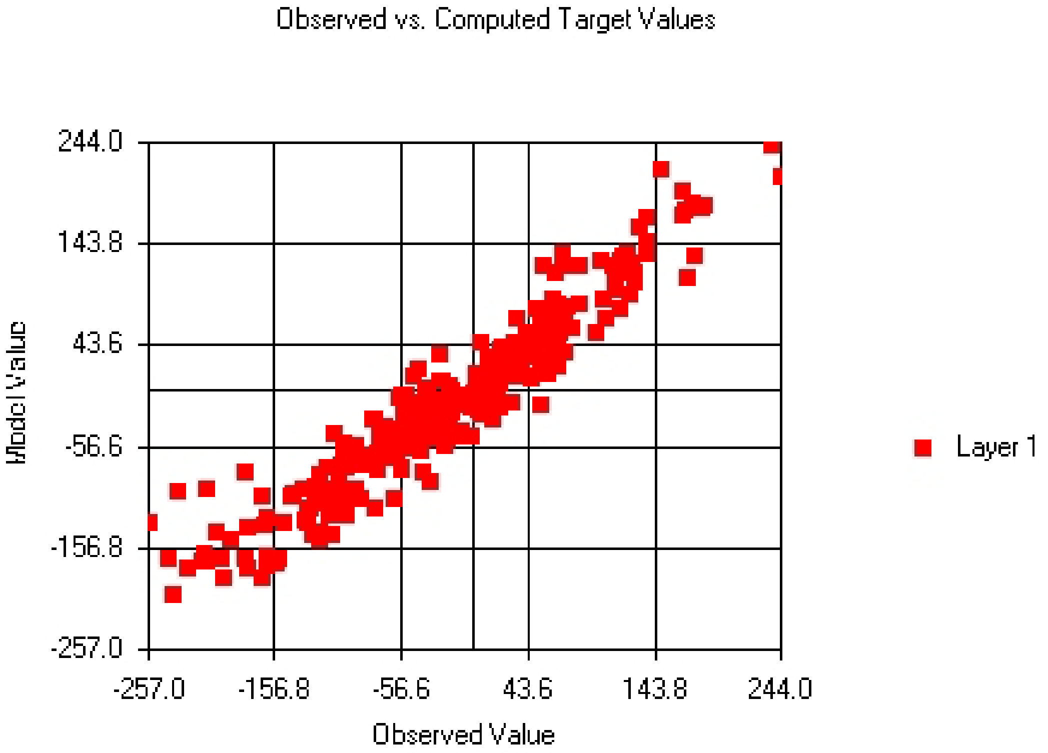


Geologic cross section showing the northwest to southeast dip and relation of stratigraphic and hydrologic units (modified from Baker, 1986).

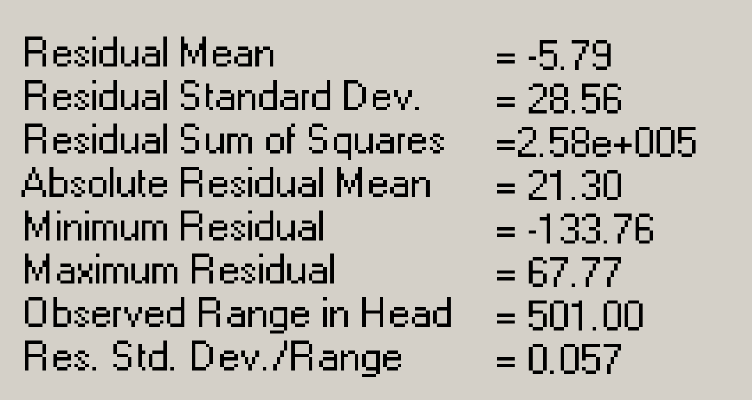
2000 Chicot Water-Level Altitude



2000 Chicot Observed vs. Simulated Target Heads



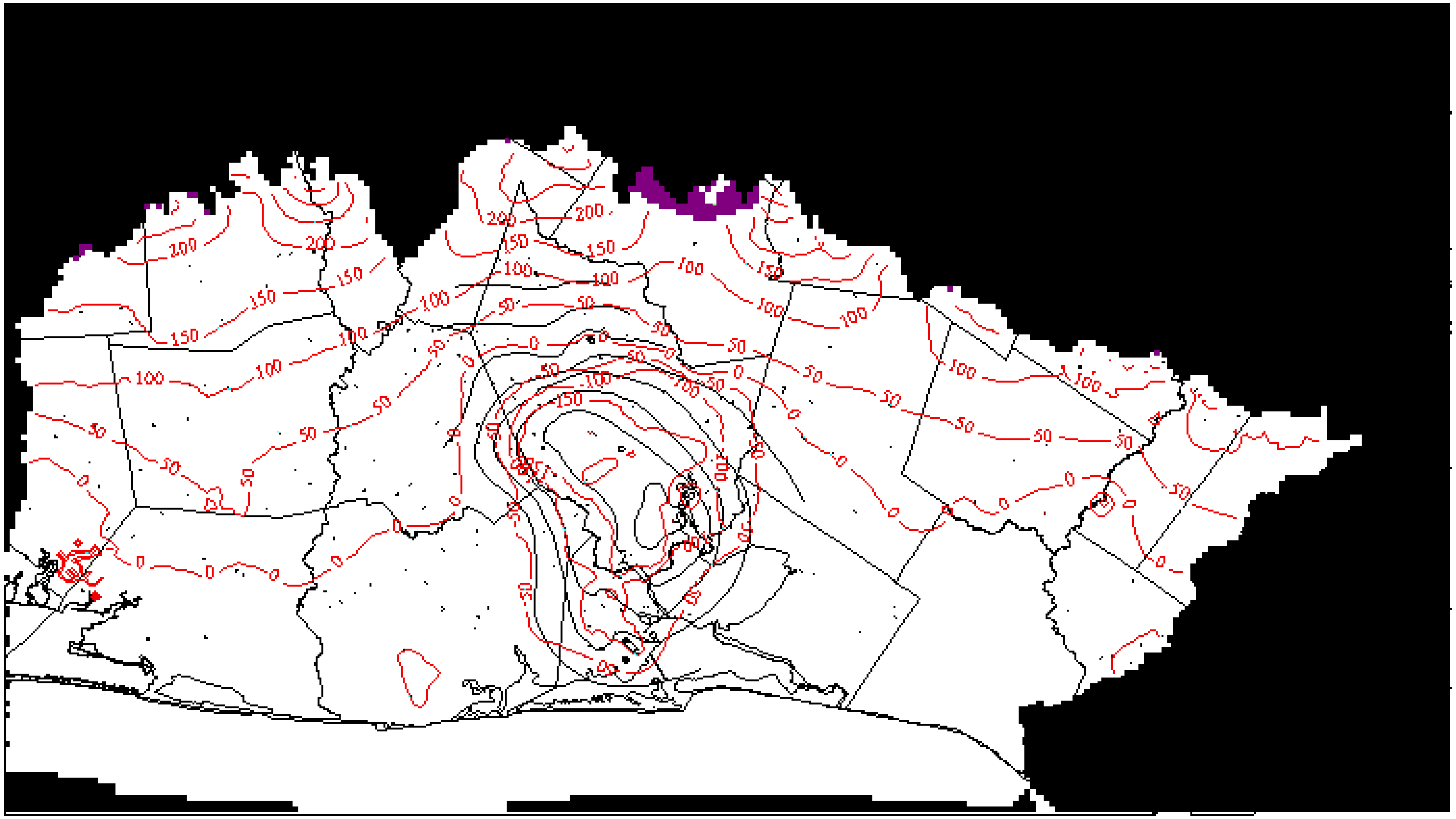
2000 Chicot Statistics



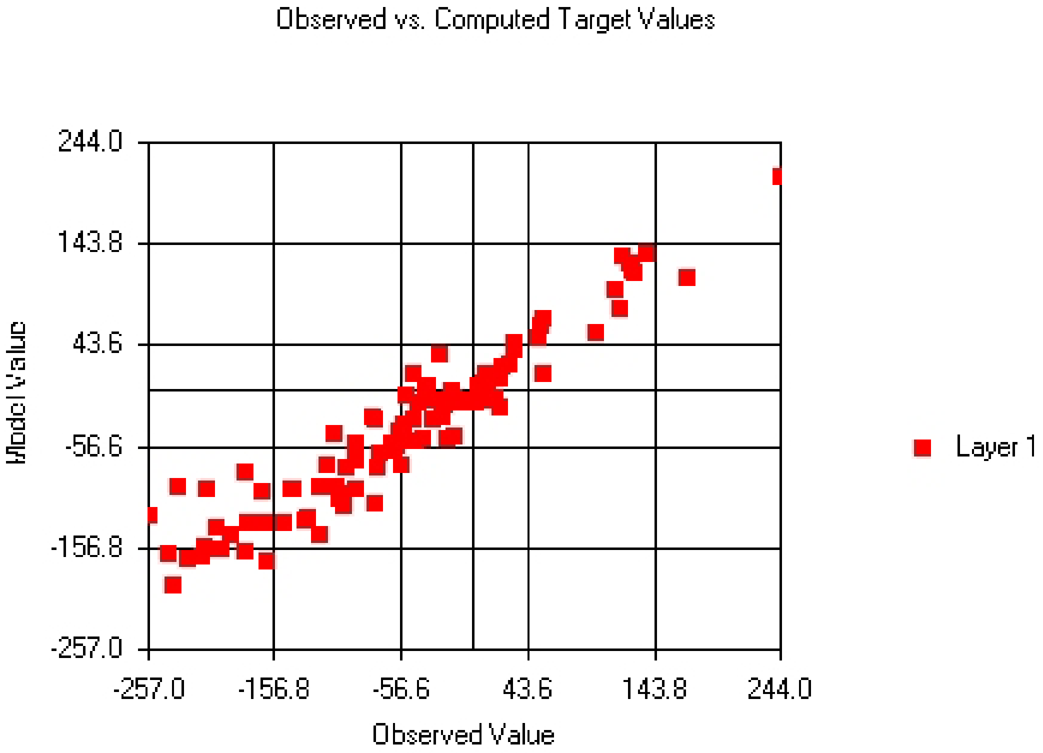
```
Residual Mean                = -5.79
Residual Standard Dev.       = 28.56
Residual Sum of Squares      =2.58e+005
Absolute Residual Mean       = 21.30
Minimum Residual             = -133.76
Maximum Residual             = 67.77
Observed Range in Head       = 501.00
Res. Std. Dev./Range         = 0.057
```

- **The root mean square error was 24.47 feet between the measured and simulated hydraulic head.**
- **The maximum hydraulic-head drop across the model layer was 780 feet.**

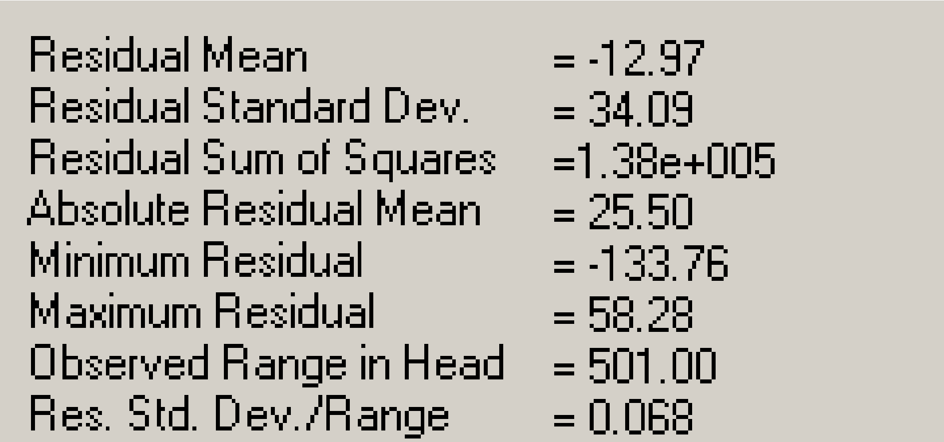
1977 Chicot Water-Level Altitude



1977 Chicot Observed vs. Simulated Target Heads



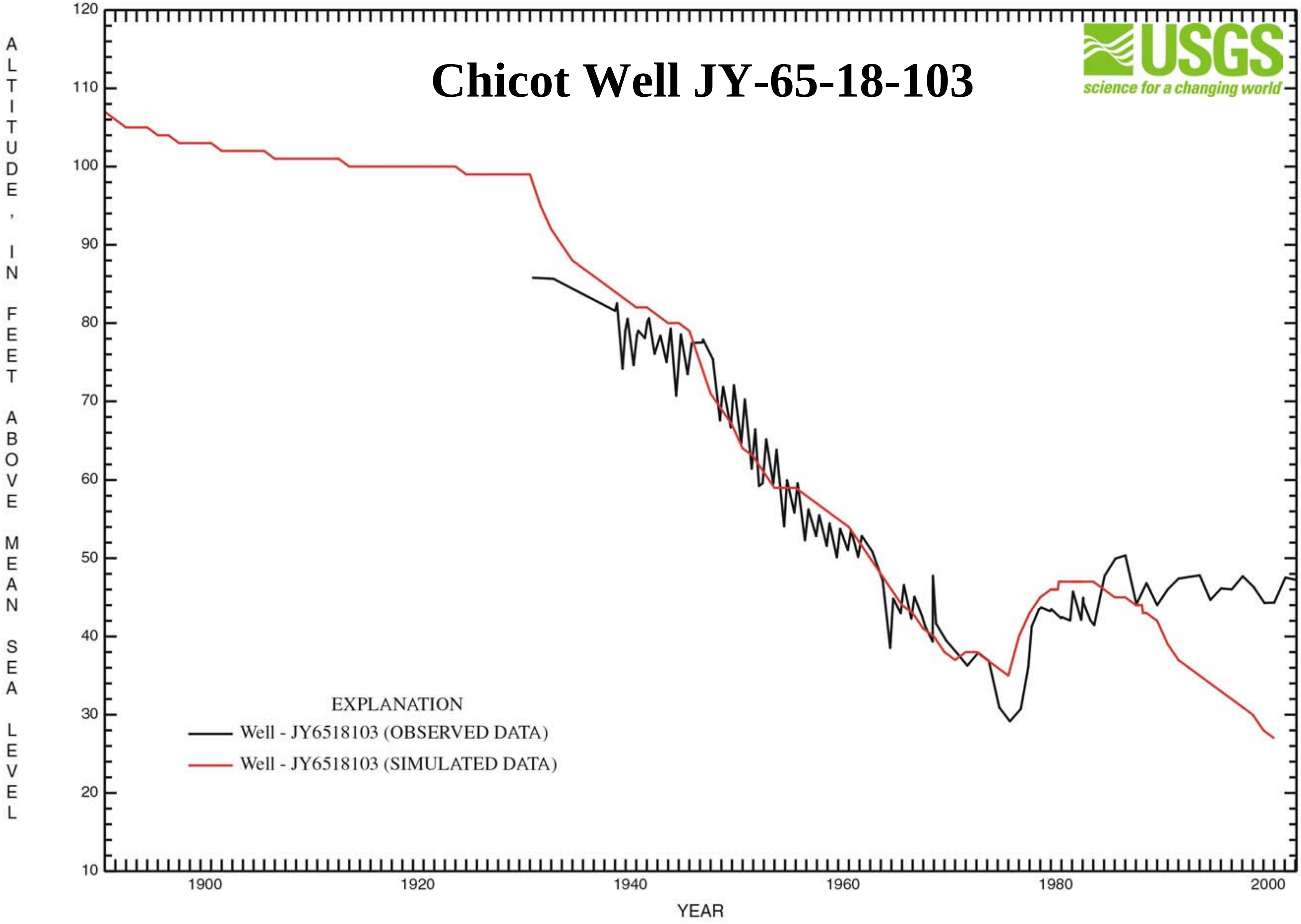
1977 Chicot Statistics



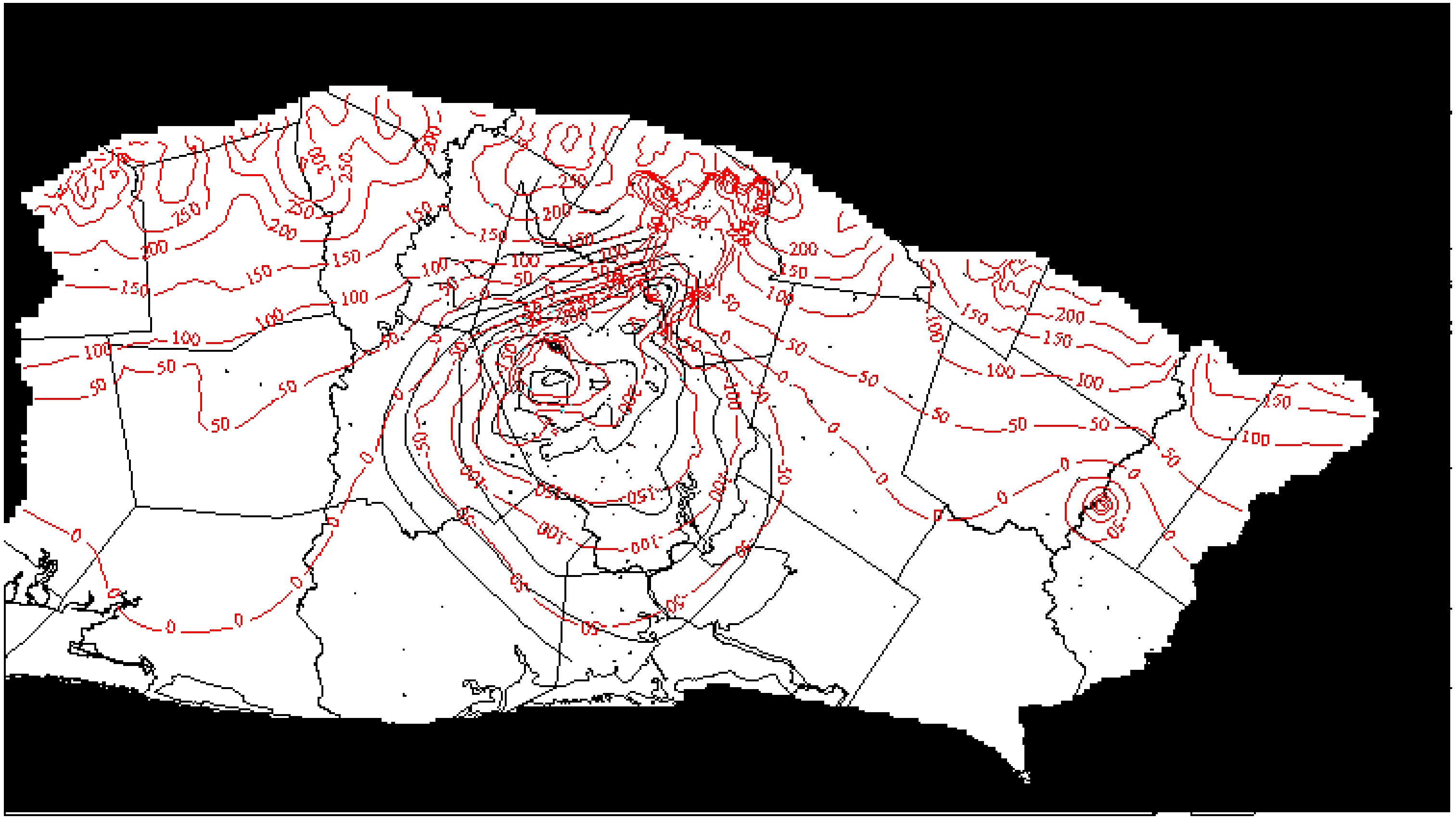
```
Residual Mean                 = -12.97
Residual Standard Dev.        = 34.09
Residual Sum of Squares       =1.38e+005
Absolute Residual Mean        = 25.50
Minimum Residual              = -133.76
Maximum Residual              = 58.28
Observed Range in Head        = 501.00
Res. Std. Dev./Range          = 0.068
```

- **The root mean square error was 36.30 feet between the measured and simulated hydraulic head.**
- **The maximum hydraulic-head drop across the model layer was 599 feet.**

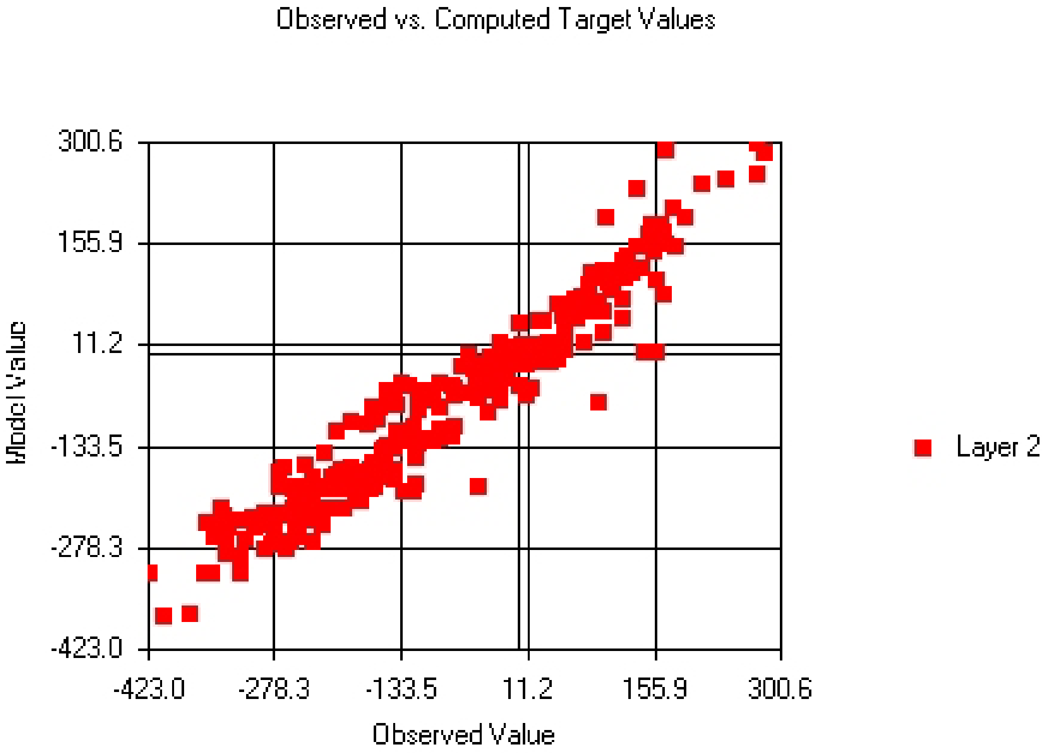
Chicot Well JY-65-18-103



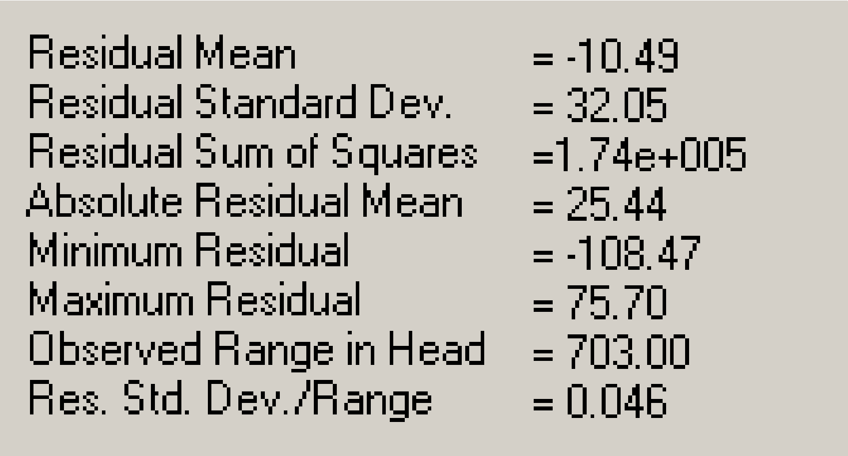
2000 Evangeline Water-Level Altitude



2000 Evangeline Observed vs. Simulated Target Heads



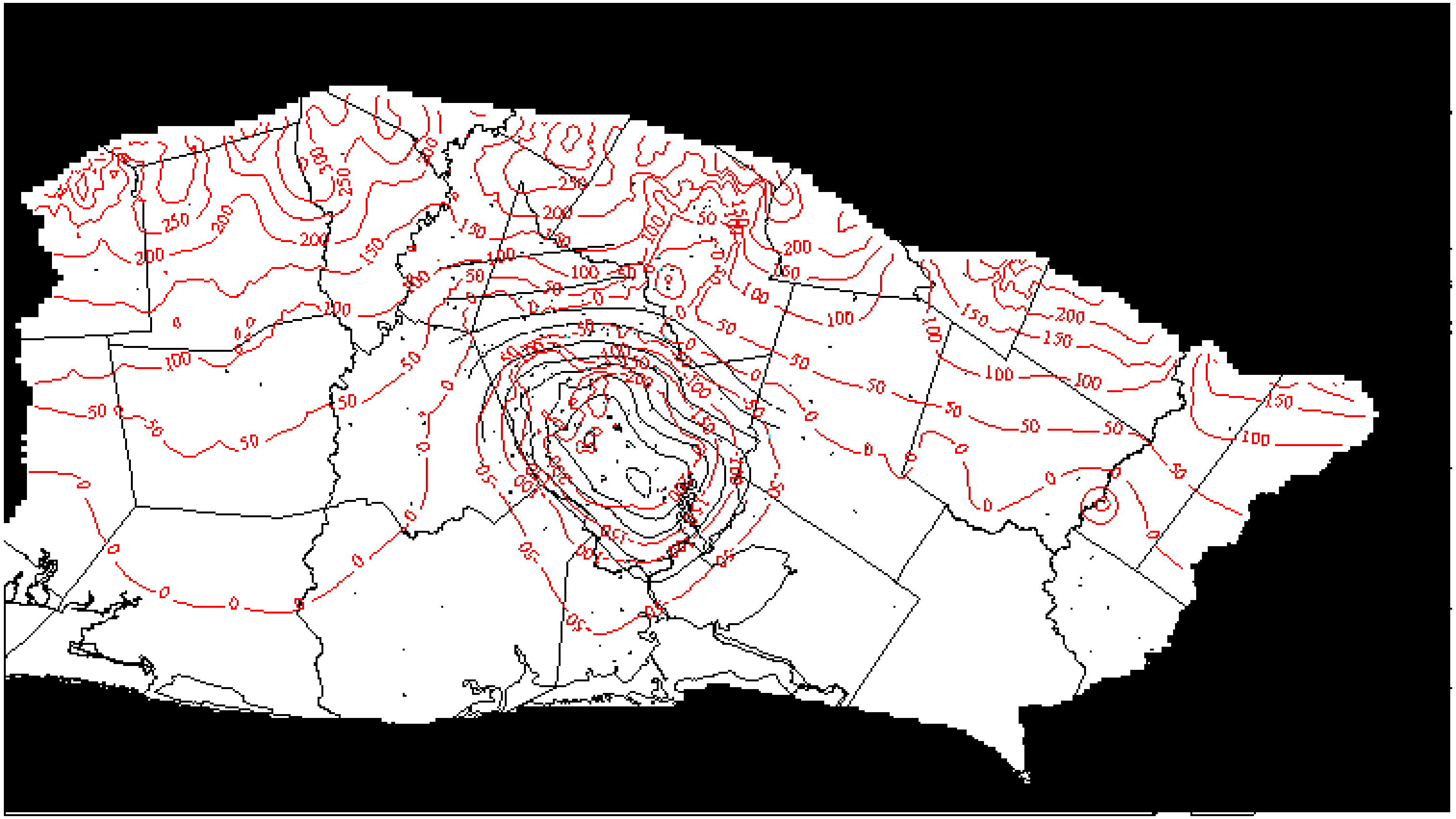
2000 Evangeline Statistics



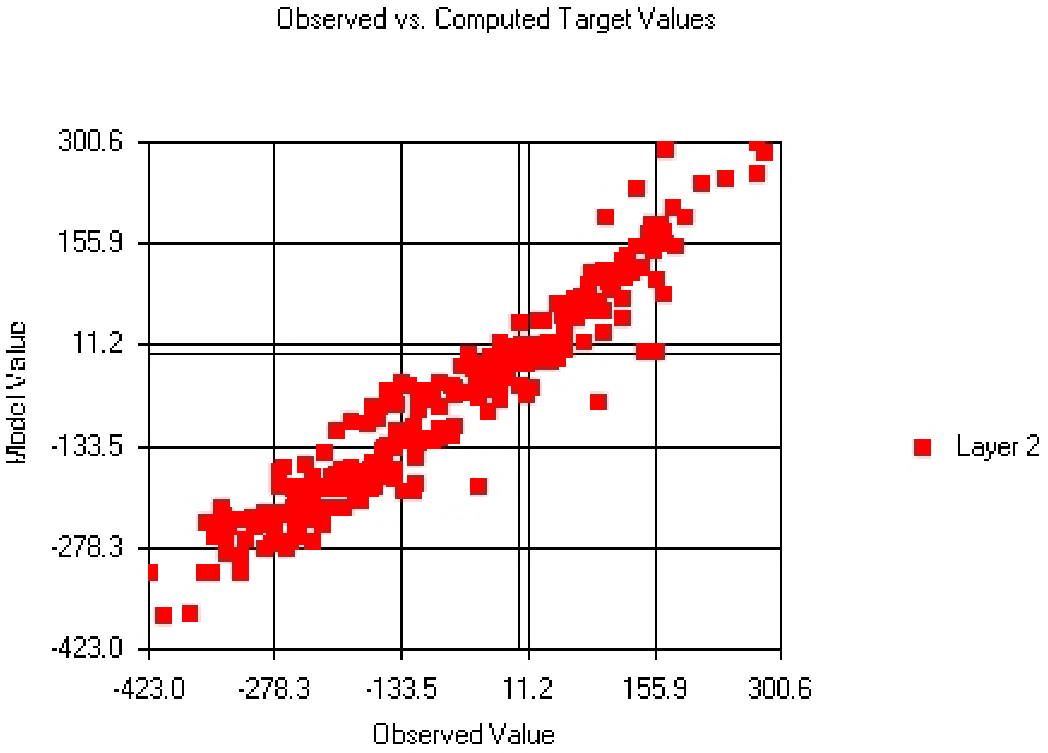
```
Residual Mean                 = -10.49
Residual Standard Dev.        = 32.05
Residual Sum of Squares       =1.74e+005
Absolute Residual Mean        = 25.44
Minimum Residual              = -108.47
Maximum Residual              = 75.70
Observed Range in Head        = 703.00
Res. Std. Dev./Range          = 0.046
```

- **The root mean square error was 33.72 feet between the measured and simulated hydraulic head.**
- **The maximum hydraulic-head drop across the model layer was 594 feet.**

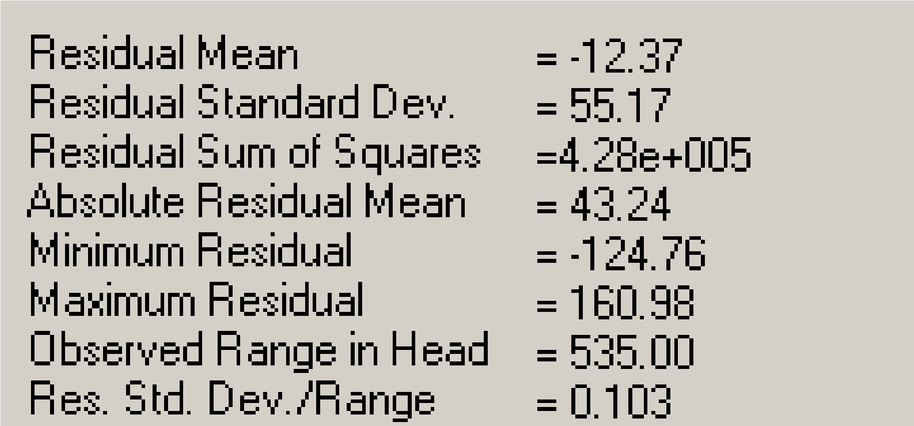
1977 Evangeline Water-Level Altitude



1977 Evangeline Observed vs. Simulated Target Heads



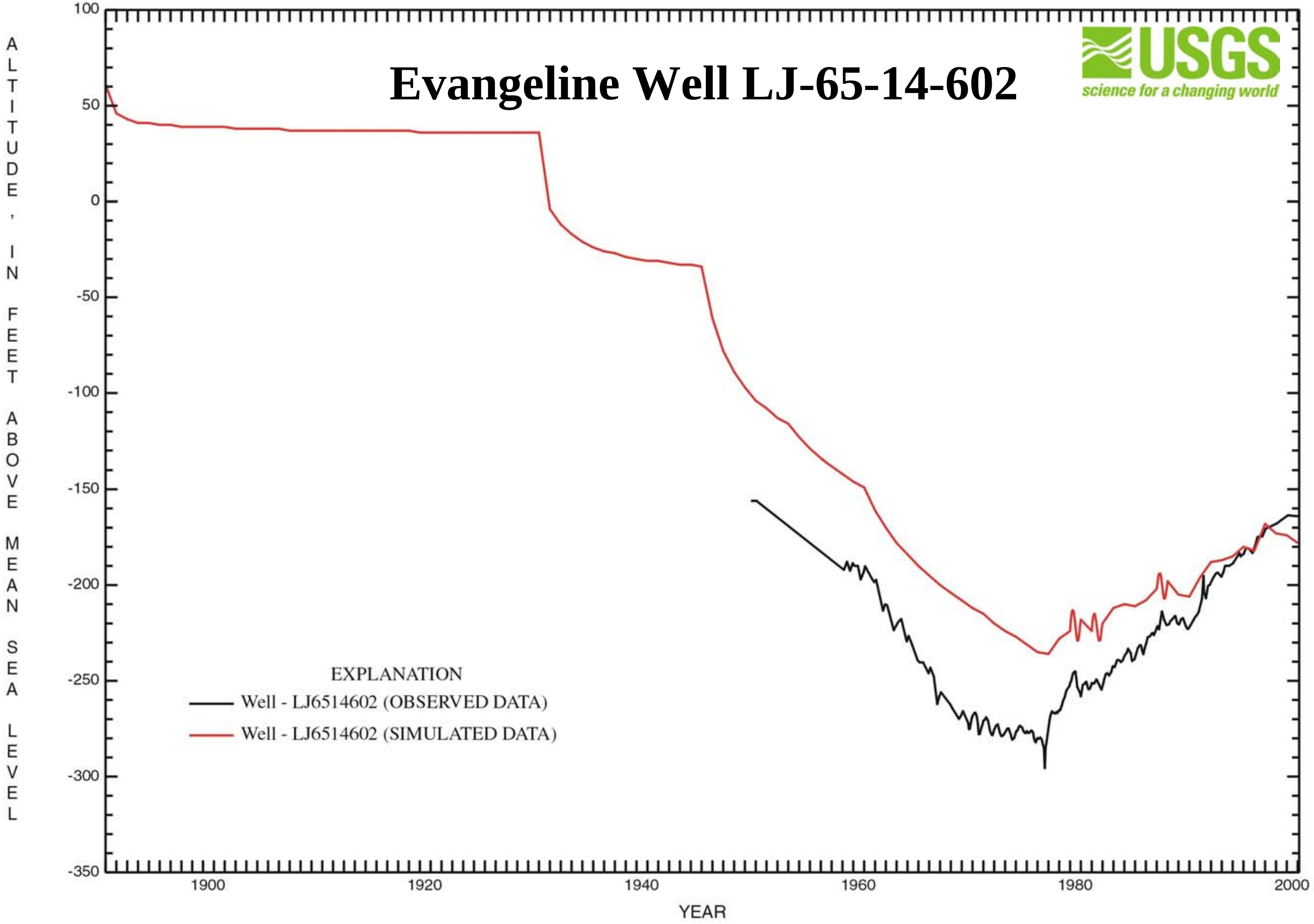
1977 Evangeline Statistics



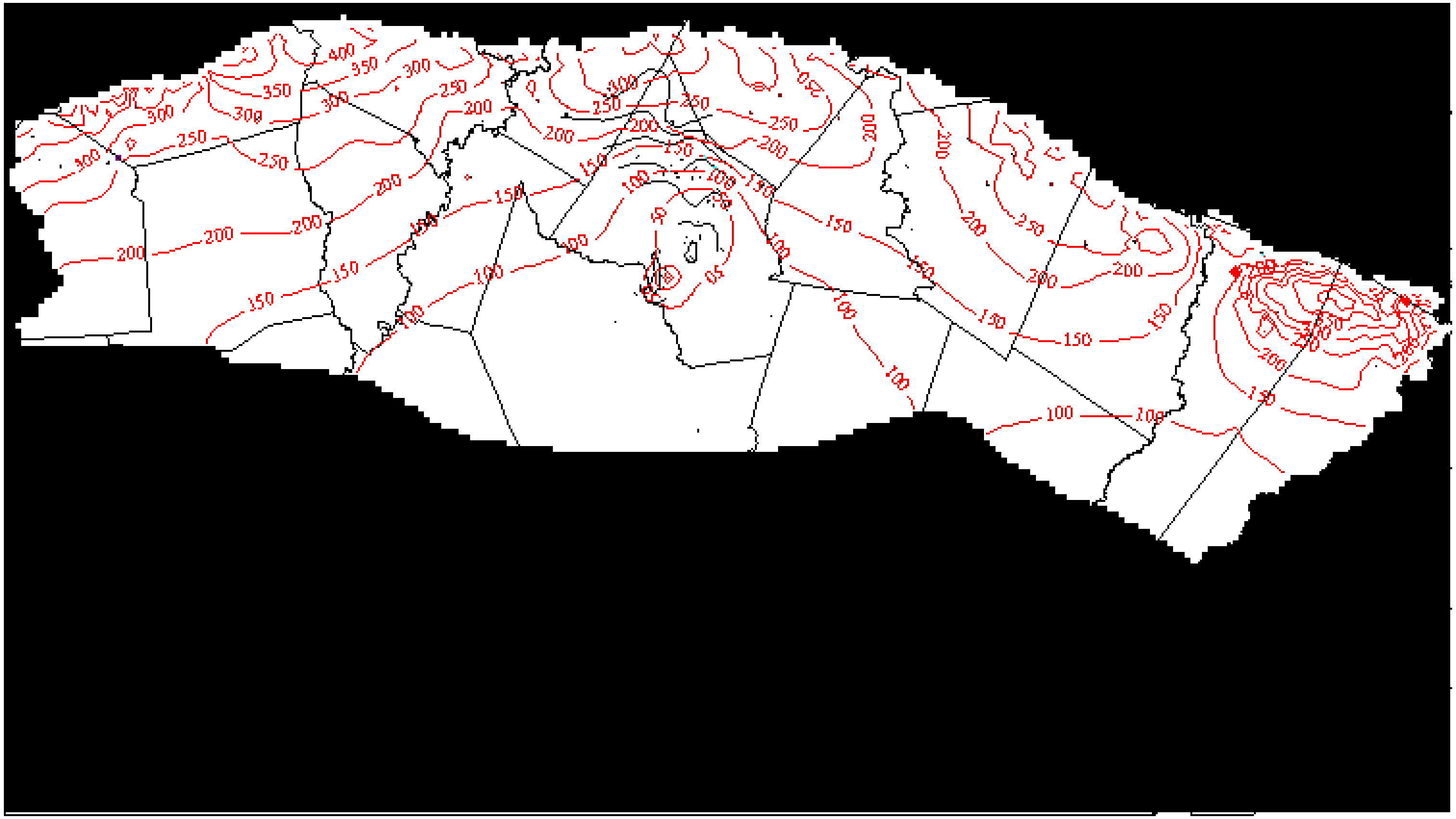
```
Residual Mean              = -12.37
Residual Standard Dev.     = 55.17
Residual Sum of Squares    =4.28e+005
Absolute Residual Mean     = 43.24
Minimum Residual           = -124.76
Maximum Residual           = 160.98
Observed Range in Head     = 535.00
Res. Std. Dev./Range       = 0.103
```

- **The root mean square error was 56.54 feet between the measured and simulated hydraulic head.**
- **The maximum hydraulic-head drop across the model layer was 681 feet.**

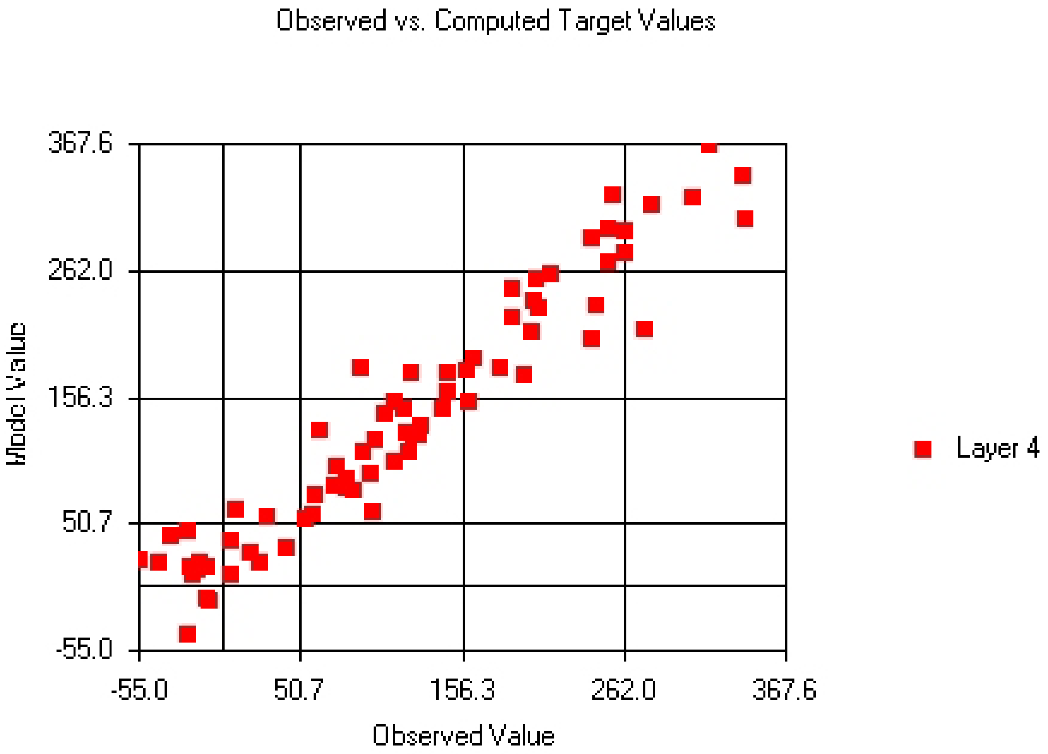
Evangeline Well LJ-65-14-602



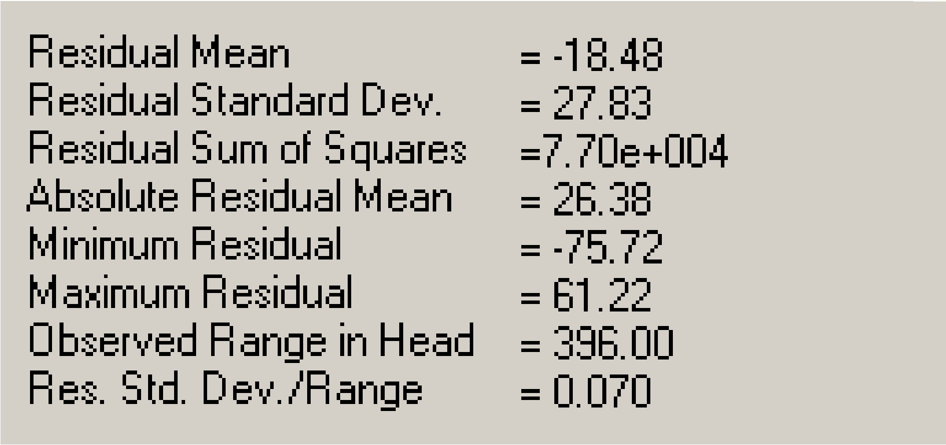
2000 Jasper Water-Level Altitude



2000 Jasper Observed vs. Simulated Target Heads



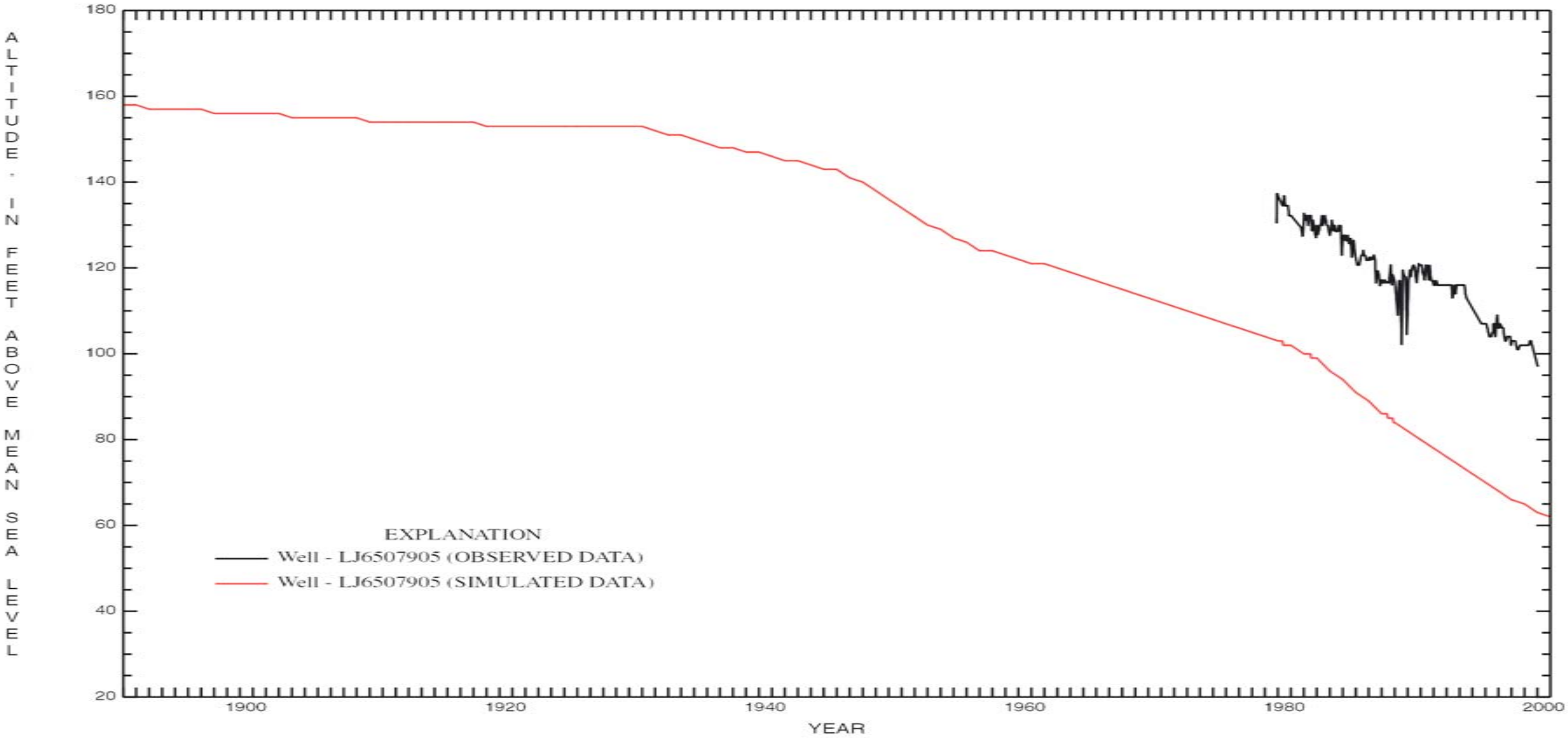
2000 Jasper Statistics



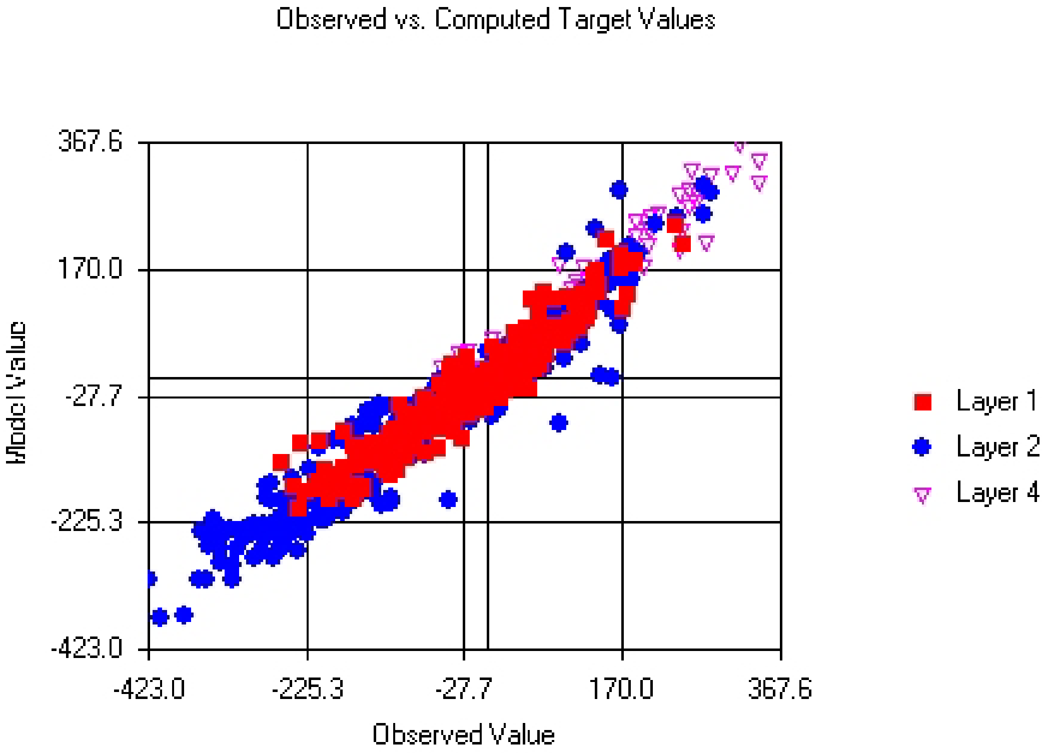
```
Residual Mean                = -18.48
Residual Standard Dev.       = 27.83
Residual Sum of Squares      =7.70e+004
Absolute Residual Mean       = 26.38
Minimum Residual             = -75.72
Maximum Residual             = 61.22
Observed Range in Head       = 396.00
Res. Std. Dev./Range         = 0.070
```

- **The root mean square error was 33.41 feet between the measured and simulated hydraulic head.**
- **The maximum hydraulic-head drop across the model layer was 586 feet.**

Jasper Well LJ-65-07-905

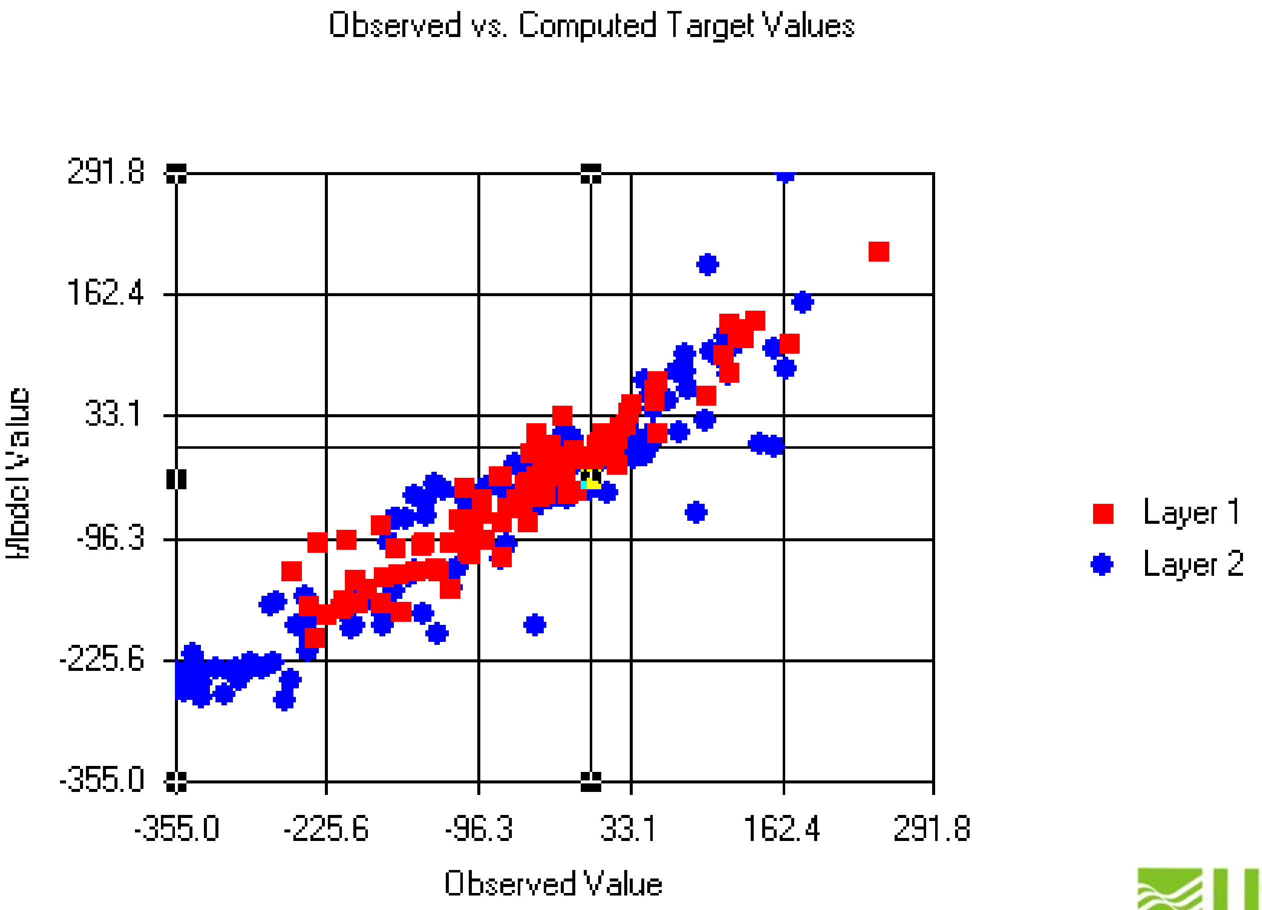


2000 Composite of Observed vs. Simulated Target Heads



USGS
science for a changing world

1977 Composite of Observed vs. Simulated Target Heads



USGS
science for a changing world

```
●  VOLUMETRIC BUDGET FOR ENTIRE MODEL AT END OF TIME STEP  1 IN STRESS PERIOD 69
   CUMULATIVE VOLUMES      L**3                RATES FOR THIS TIME STEP      L**3/T
                IN:                                            IN:
   STORAGE = 848642637824.0000                 STORAGE = 22069346.0000
•  CONSTANT HEAD = 0.0000                      CONSTANT HEAD = 0.0000
•  WELLS = 0.0000                              WELLS = 0.0000
•  HEAD DEP BOUNDS = 1.2630E+13                HEAD DEP BOUNDS = 100652320.0000
•  INTERBED STORAGE = 378706395136.0000        INTERBED STORAGE = 6822997.0000
•  TOTAL IN = 1.3857E+13                       TOTAL IN = 129544664.0000

•               OUT:                                           OUT:
•   STORAGE = 621177274368.0000                STORAGE = 1331763.375
•   CONSTANT HEAD = 0.0000                     CONSTANT HEAD = 0.0000
    WELLS = 2.2251E+12                         WELLS = 114226888.0000
•   HEAD DEP BOUNDS = 1.1006E+13               HEAD DEP BOUNDS = 13902051.0000
•   INTERBED STORAGE = 4949088768.0000         INTERBED STORAGE = 126298.7891
•   TOTAL OUT = 1.3857E+13                     TOTAL OUT = 129587000.0000
•   IN - OUT = 306184192.0000                  IN - OUT = -42336.0000

•   PERCENT DISCREPANCY = 0.00                 PERCENT DISCREPANCY = -0.03
```

Hydrogeology, Simulation of Ground-Water Flow, and Land-Surface Subsidence in the Chicot, Evangeline, and Jasper Aquifers, Houston Area, Texas

Mark C. Kasmarek, James L. Robinson, and Eric W. Strom

In Cooperation with the Texas Water Development Board and the Harris-Galveston Coastal Subsidence District

Attendance at the 7th Stakeholder Advisory Forum, Northern Gulf Coast GAM

Participant	Affiliation
Jim Adams	SJRA
Bob Pickens	Region K, Colorado County
Ali Chowdhury	TWDB
Eric Strom	USGS
Mark C. Kasmarek	USGS
Mark Lowry	TC&B; H, K and P RWPGs
Haskell Simon	Coastal Plains GCD
Michael Klaus	Citizen
John Nelson	LBG-Guyton Associates

Q & A’s at the 7th Stakeholder Advisory Forum, Northern Gulf Coast aquifer Groundwater Availability Model, July 24, 2003

Question: Are all of the rivers or just some stretches are gaining in the model area?

Response: The recently completed USGS baseflow study suggests that all of the rivers are gaining within the model area. This observation is also supported by model results. USGS will distribute the baseflow study report to the stakeholders who requested the document.

Question: How manufacturing pumpage is spatially distributed for the predictive runs?

Response: Based on demand numbers provided by the RWPG and distributed around historical uses.

Question: The statute and the TWDB rules require that the GCDs and RWPGs use GAM. In the rules “shall” is used, is it being modified by the legislature to offer more flexibility for the GCD’s? Who would be the honest arbiter for deciding what model to use?

Response: TWDB approves management plans for the GCDs. The rules allow use of GAM in conjunction with other information. If model results with detailed site-specific information are available that was not included in the GAM, a GCD can provide this for TWDB consideration.

Question: Why drawdown presented in Wharton County is not the same as was produced by Dutton model? Drawdown should be presented in the report to make it easier for people to compare water level decline between different time periods.

Response: The map shows altitude of water levels but not drawdown. Drawdown maps that would be constructed should show the same levels of drawdown. Drawdown will be reported for each layer by decade.

Question: Is the transient calibration complete?

Response: Transient calibration is complete unless predictive runs produce results that require revisiting the transient calibration.

Question: Is low transmissivity or low storage causing no fluctuations in the hydrographs?

Response: We ran simulations with a wide range of transmissivity and storage values and selected the model that produced the best RMS.

Question: Can the next SAF meeting after the draft report is submitted so that stakeholders can provide feedback to the consultant after reading the report?

Response: Yes. The next SAF meeting will be held after the draft report is submitted at the end of September to facilitate review comments and feedback from the stakeholders. The draft report will also be posted on the web.

Question/Comment: One stakeholder stated that some RWPG’s maintain that no additional groundwater models are necessary, as GAMs have already been developed for their area. It was discussed how best to improve the model. Most agreed that model improvements can best occur by collecting more data and populate the data to a finer grid to address local well issues. Models get better as new data is collected and our understanding of the flow system improves.