GAM

Groundwater
Availability
Modeling

texas water development board

Agenda for Stakeholder Advisory Forum (SAF) Meeting No. 3 November 9, 2001

- Data collection and analysis update
- Steady-state modeling approach
- Project schedule
- Determination of agricultural pumping
- Questions/comments/input

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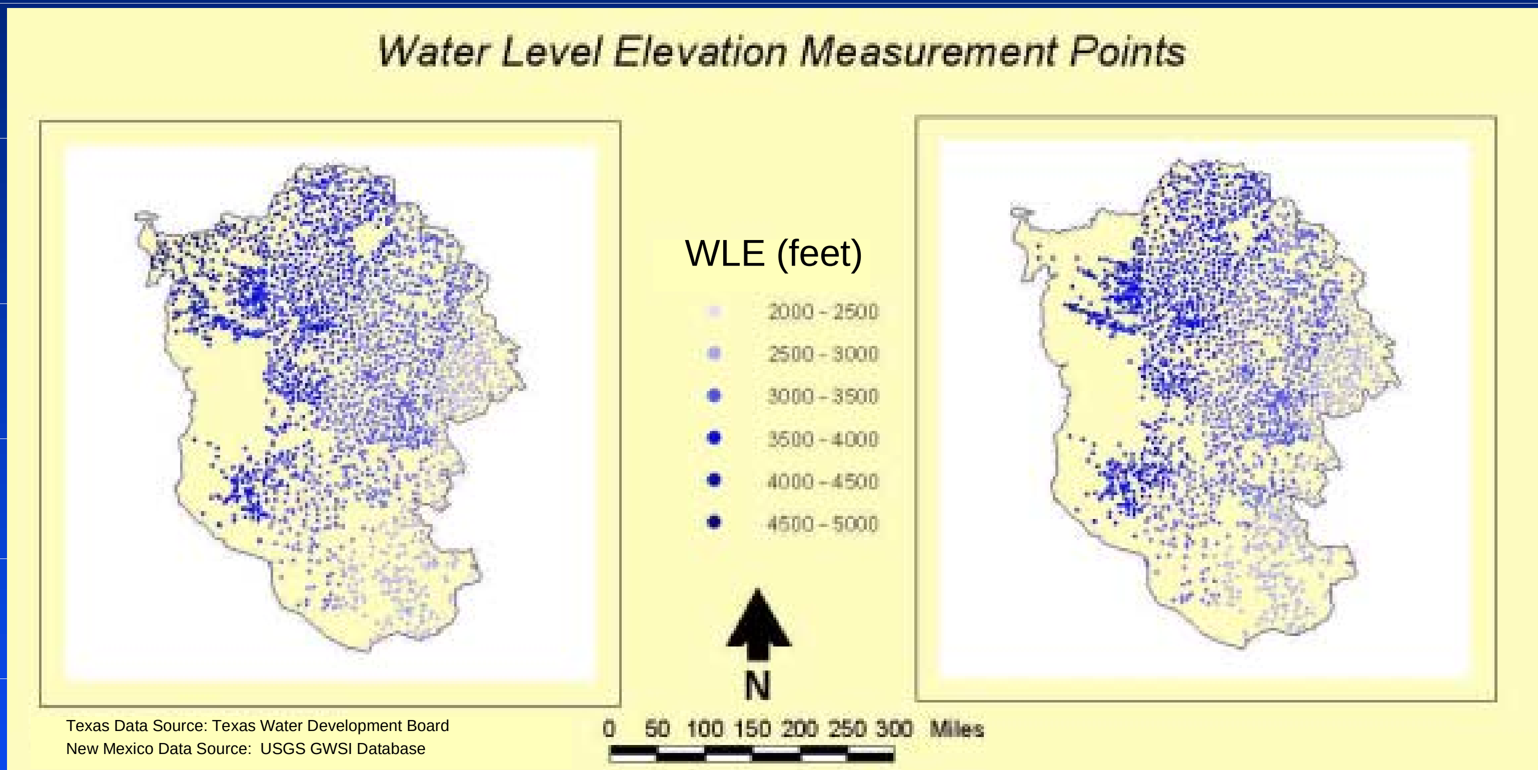
Purpose of the GAM is to...

"provide reliable, timely data on groundwater availability to the citizens of Texas to ensure adequacy of supplies or recognition of inadequacy of supplies throughout the 50-year planning horizon."

- Pederson, TWDB (1999)

1992 Water Level Measurement Points



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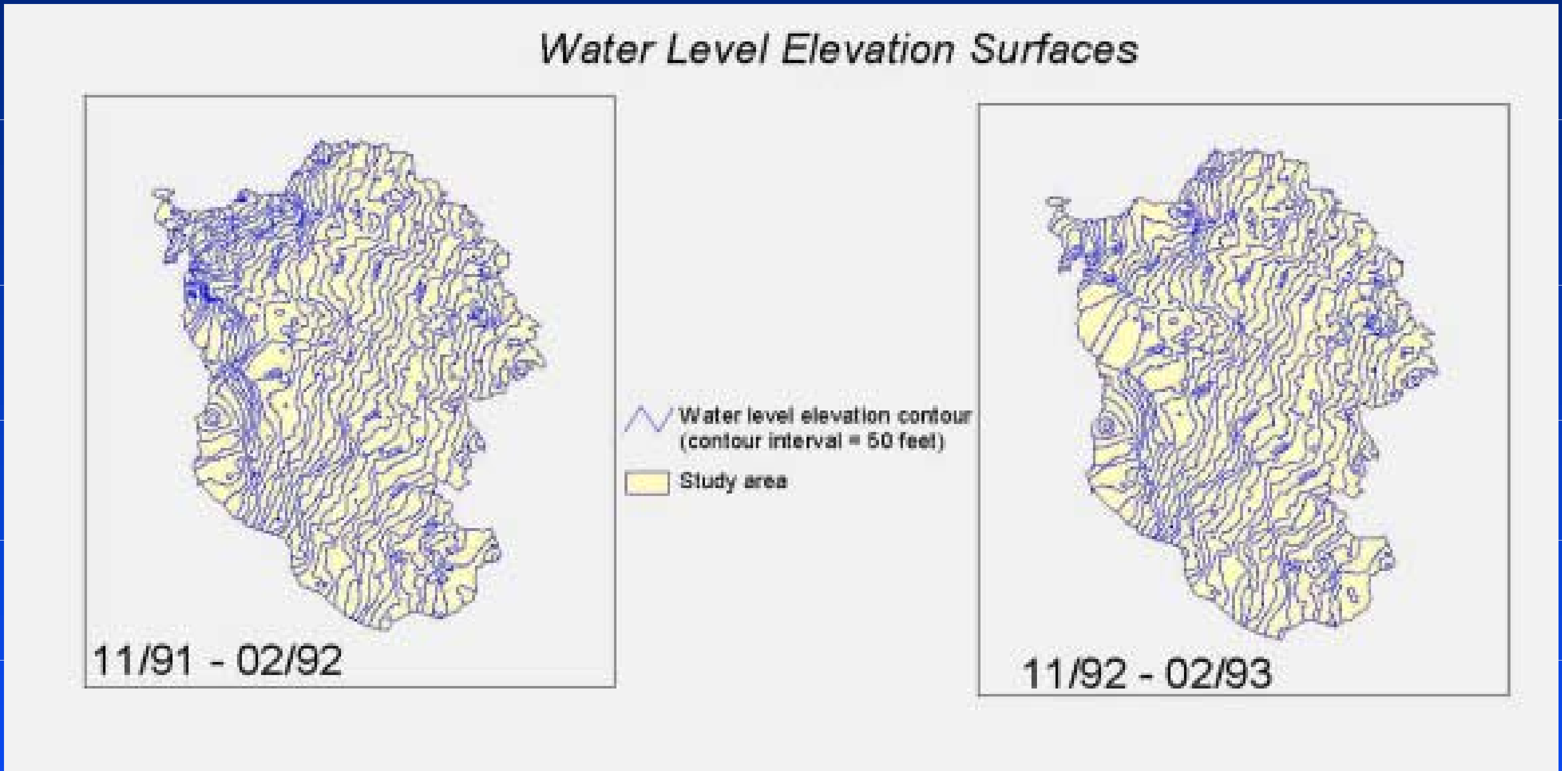
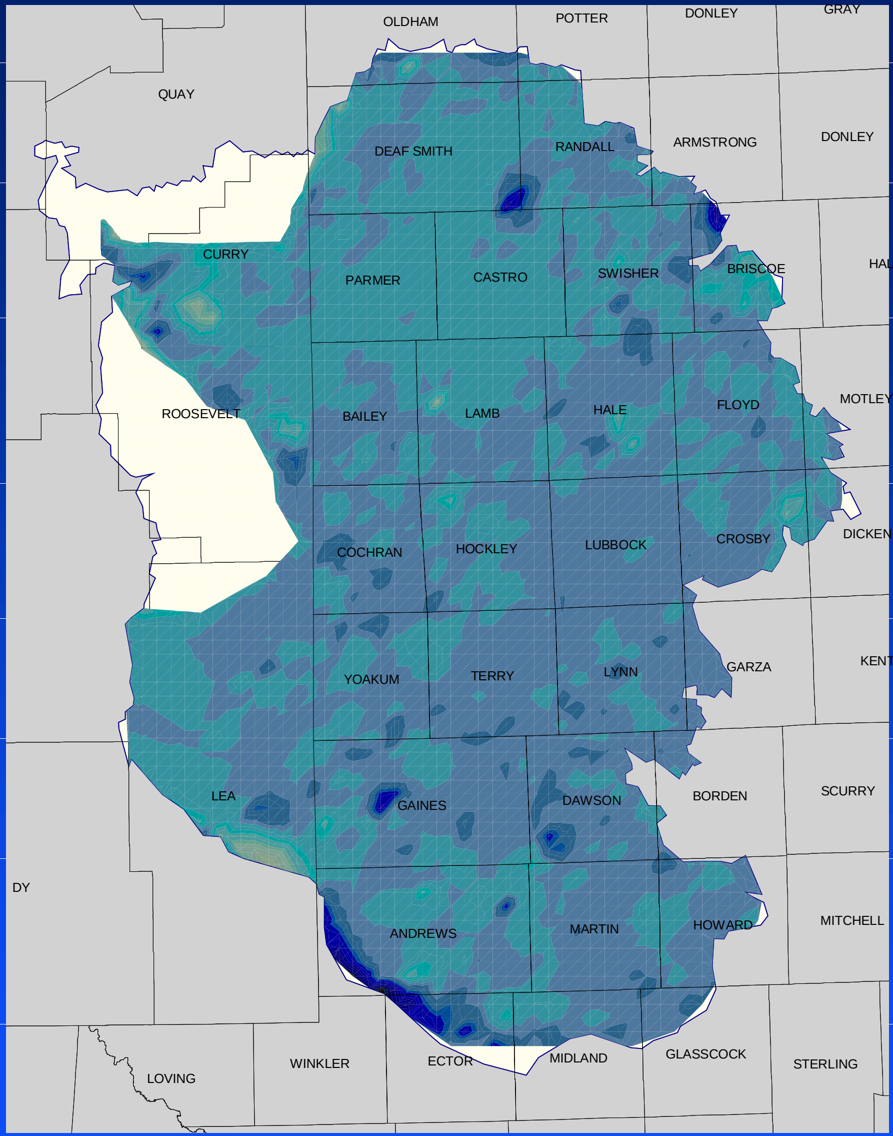
1992 Water Level Elevation Surfaces



1992 Groundwater Depletion surface



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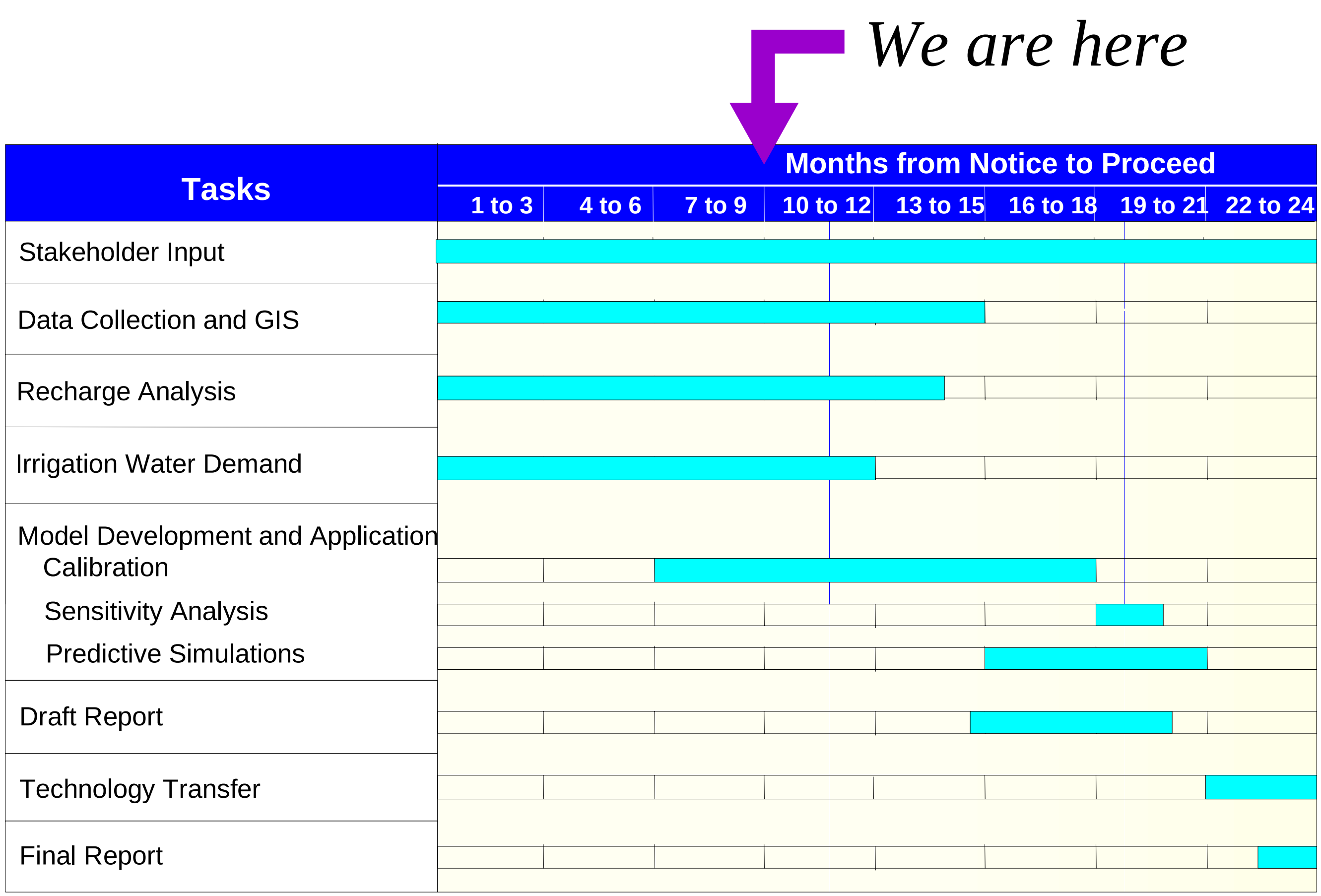
Project Schedule



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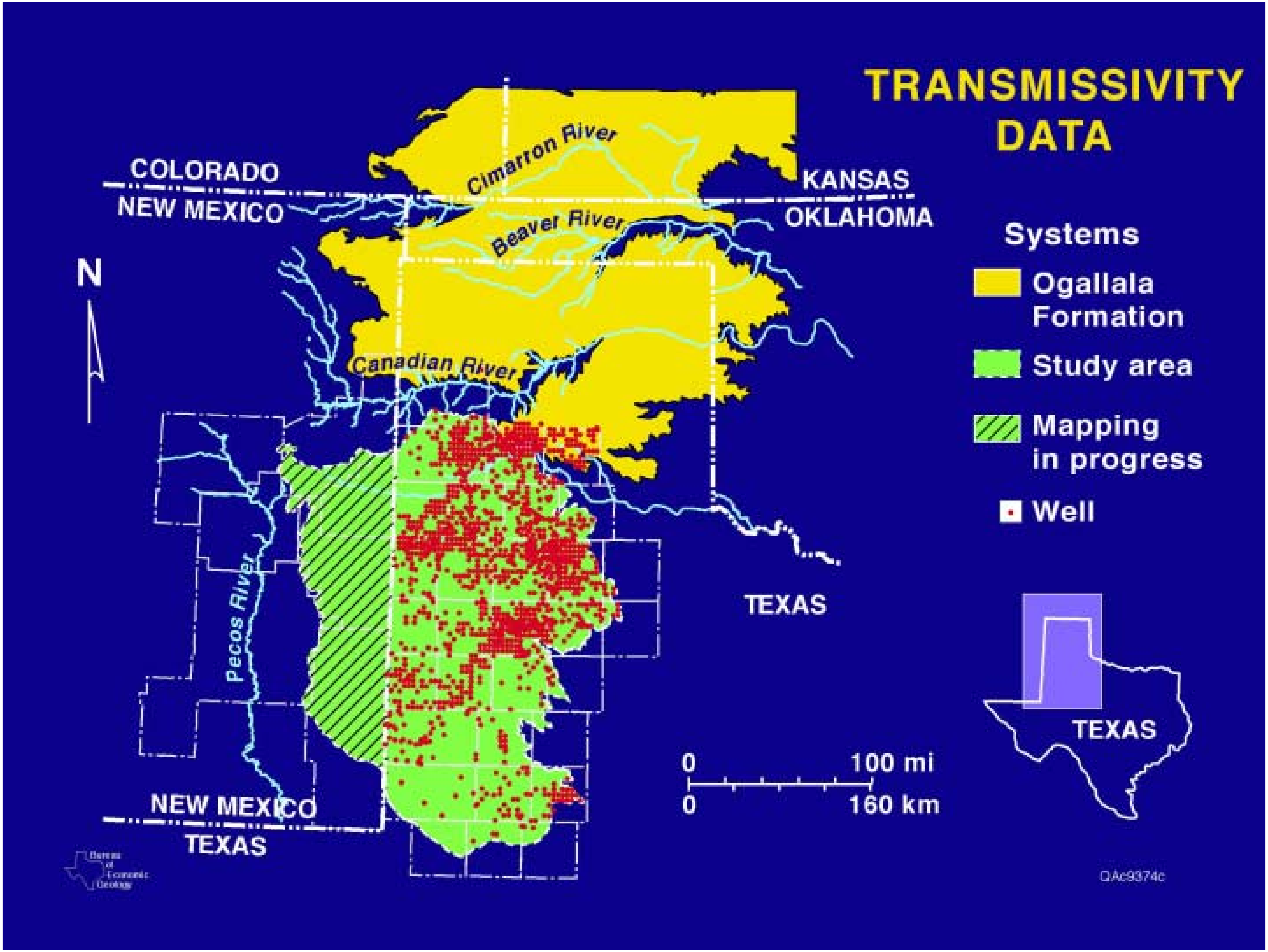
HYDRAULIC CONDUCTIVITY MAPPING

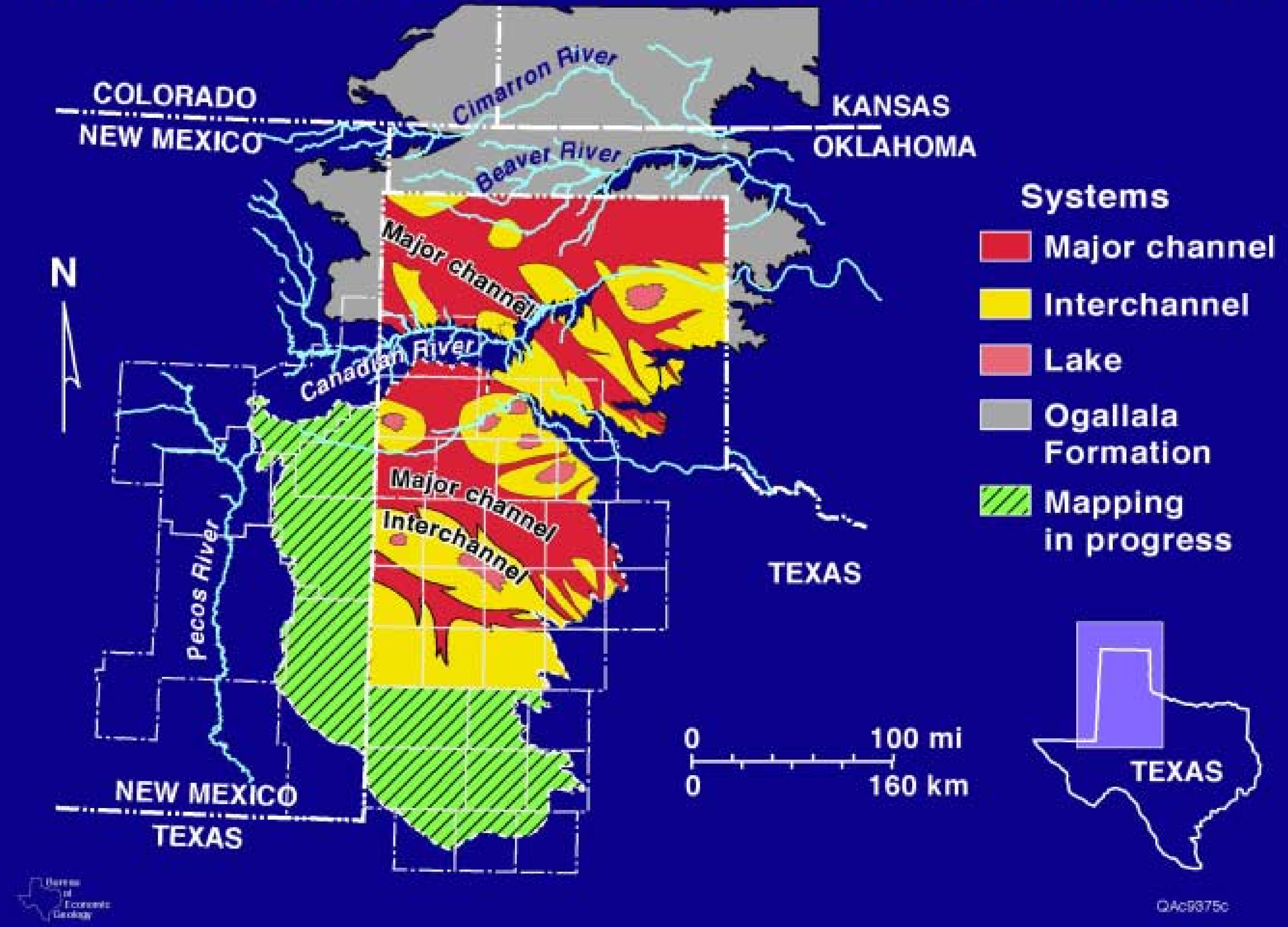
- Hydraulic conductivity data in Texas part of model compiled and map coordinates assigned
- In progress:
  - Statistical and geological analyses of data for assigning values to model grid
  - Preparation of cross sections
  - Geologic mapping of sand and gravel in the southernmost part of study area to extend the Seni (1980) maps as a basis for contouring hydraulic conductivity
  - Compilation of drillers' logs and hydraulic conductivity data for New Mexico

Recharge Studies

- USGS boreholes have been instrumented with SHP project equipment
- Sensors are yielding reasonable data; monitoring is underway to determine when the sensors have equilibrated with the subsurface


TRANSMISSIVITY DATA
COLORADO
NEW MEXICO
KANSAS
OKLAHOMA
Cimarron River
Beaver River
Canadian River
Pecos River
N
Systems
Ogallala Formation
Study area
Mapping in progress
Well
TEXAS
NEW MEXICO
TEXAS
0 100 mi
0 160 km
TEXAS
QAc9374c

DEPOSITIONAL SYSTEMS, OGALLALA FORMATION



Steady-State (Predevelopment) Model

- Representative of average conditions for 1940 and earlier
- Determine natural recharge and hydraulic conductivity
- No pumping, irrigation return flow or specific yield
- Will be followed by transient calibration for 1940-2000

SAFE MEETING
IRRIGATION DEMAND PRESENTATION AGENDA

1. **Project team and why current methodology was selected.**

2. **Overview of methodology.**

3. **Preliminary Results of 1997 simulation.**

    Regional Level

    Selected County Level

4. **Identification of Drought of Record.**

IRRIGATION DEMAND PROJECT TEAM

Steve Amosson, TCE Professor and Management Economist

Thomas Marek, TAES Agricultural Engineer and Superintendent

Leon New, TCE Professor and Agricultural Engineer

Lal Almas, WTAMU Assistant Professor, Agricultural Economics

Fran Bretz, TAES Research Associate

IRRIGATION WATER DEMAND METHODOLOGY
WHY CHANGE??

- **Limit Human Error in Estimates**

- **Tie Methodology closer to Science rather than EWAG or WAG**

  -Year to year variations

- **Enhance ability to analyze "WHAT IF" Scenarios's**

  -Drought of record

  -Modifying crop composition

  -Evaluating other water saving policies

FSA COUNTY SURVEY -PERCENTAGE OF IRRIGATED LAND ABOVE OGALLALA

Contacted	% of Land Located On Ogallala	Comments
Oldham	100%	
Potter	100%	
Randall	80%	
Armstrong	1 %	
Briscoe	60%	No peanuts in 60%
Floyd	97%	
Motley	7 ½ %	No peanuts in 7 ½ %
Dickens	50%	
Crosby	100%	
Garza	100%	
Borden	100%	
Howard	100%	
Gladcock	8.5%	
Midland	30%	
Ector	100%	
Andrews	100%	
Lea	100%	
Quay	1%	

IRRIGATION DEMAND
ESTIMATING INPUT VARIABLES

Percentage Producers use of ET (P_T)

Determined by:

- AgriPartner Data
- Demonstration Data
- Water District Estimates
- Producer Interviews
- Consultants Interviews
- By crop

Effective Rainfall (EF)

- Engineering Standards
- Historical Rainfall Records - TWDB quad data

Soil moisture extracted from profile (ssm)

- Supported by soil type - GIS survey

IRRIGATION DEMAND
ESTIMATING INPUT VARIABLES

Crop Evapotransporation (E_T)

- Derived from weather station data
  - NPET, South Plains Network, NCDC

- Factors analyzed
  - Solar radiation
  - Minimum and maximum temperatures
  - Wind speed
  - Precipitation

- Crops analyzed
  - Corn
  - Cotton
  - Grain Sorghum
  - Hay
  - Pasture
  - Peanuts
  - Soybeans
  - Wheat

IRRIGATION DEMAND
ESTIMATING INPUT VARIABLES

- **Irrigated acreage**
  - **-Data sources**
    - **TASS data**
    - **Ag census data**
  - **-Border acreage modifications**
    - **FSA survey**

- **Food for thought–when establishing irrigated acreage baseline for projecting into the future—**
  - **-Incorporate FSA estimates into determining irrigated acreage baseline.**

DROUGHT OF RECORD

- **Simulate the impact of a recurrence of a "Drought of Record"**

- **Question is: Define Drought of Record**
  - **-Worst rainfall year?**
  - **-Three worst consecutive years?**
  - **-Five worst consecutive years?**

- **Determined from TWDB Quad Data (1940-1998)**
  - **-Worst year - 1956**
  - **-Worst three year period - 1952-1954**
  - **-Worst five year period - 1952-1956**

Average Annual Rainfall (GAM), 1940-1998

YEAR	ANNUAL
1940	15.34
1941	37.45
1942	20.41
1943	13.49
1944	19.71
1945	14.50
1946	18.25
1947	14.41
1948	15.27
1949	25.71
1950	21.25
1951	16.41
1952	12.71
1953	13.72
1954	13.44
1955	16.52
1956	10.48
1957	22.24
1958	20.91
1959	19.77
1960	23.64
1961	18.41
1962	17.67
1963	15.72
1964	13.06
1965	16.80
1966	17.86
1967	15.40
1968	20.46
1969	24.03
1970	13.70
1971	19.57
1972	21.56
1973	19.05
1974	23.50
1975	19.16
1976	16.98
1977	16.08
1978	19.68
1979	19.77
1980	17.93
1981	21.83
1982	19.35
1983	15.77
1984	20.28
1985	23.78
1986	27.99
1987	20.70

YEAR	ANNUAL
1956	10.48
1952	12.71
1998	12.80
1964	13.06
1954	13.44
1943	13.49
1970	13.70
1953	13.72
1994	14.39
1947	14.41
1945	14.50
1948	15.27
1940	15.34
1993	15.39
1967	15.40
1989	15.59
1963	15.72
1983	15.77
1996	15.98
1977	16.08
1951	16.41
1955	16.52
1965	16.80
1976	16.98
1962	17.67
1966	17.86
1980	17.93
1946	18.25
1961	18.41
1990	18.45
1973	19.05
1975	19.16
1988	19.25
1982	19.35
1971	19.57
1978	19.68
1944	19.71
1979	19.77
1959	19.77
1984	20.28
1942	20.41
1968	20.46
1987	20.70
1958	20.91
1950	21.25
1992	21.45
1972	21.56
1981	21.83

1988	19.25
1989	15.59
1990	18.45
1991	24.83
1992	21.45
1993	15.39
1994	14.39
1995	23.98
1996	15.98
1997	24.01
1998	12.80

1957	22.24
1974	23.50
1960	23.64
1985	23.78
1995	23.98
1997	24.01
1969	24.03
1991	24.83
1949	25.71
1986	27.99
1941	37.45

Stakeholder Advisory Forum
November 9, 2001

List of Attendees

Name	Affiliation
David Turnbough	Sandy Land Underground Water Conservation District
Robert Mace	TWDB
Steve Amosson	TAES (presenter)
Stefan Schuster	TWDB
Jason Coleman	SPUWCD
Ches Carthel	City of Lubbock
Fran Bretz	TAES
Thomas Marek	TAES (presenter)
Leon New	TAES
Dicky Wallace	Garza Underground and Fresh Water Conservation District
Kenneth Dierschke	Region F, San Angelo
Joan Glass	Texas Parks and Wildlife
Scott Orr	High Plains UWCD No. 1
Don McReynolds	High Plains UWCD No. 1
Clyde R. Crumley	LEUWCD
Steve Musick	TNRCC
Dan Krieg	Texas Tech
Robert Lascano	Cropping Research Systems Lab, Lubbock
Ronald Bertrand	TDA
Lloyd Urban	Texas Tech University, Water Resources Center
Ken Rainwater	Texas Tech University, Water Resources Center
Richard Smith	TWDB
H.P. Swarz	Region O
Dana Porter	TAEX
John Grant	Region F
Bo Brown	Chairman, Llano Estacado RWPG
Neil Blandford	Daniel B. Stephens & Associates, Inc. (presenter)
David Boes	Daniel B. Stephens & Associates, Inc.

Stakeholder Advisory Forum No. 3
November 9, 2001
High Plains Underground Water Conservation District No. 1
Lubbock, Texas

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

1. **What is the Board doing with modeling of the minor aquifers?**

Response: *The last legislative session didn't allow the Water Development Board money to develop models for the minor aquifers. The internal thinking of the Water Development Board is that once the major aquifer models are completed then budgeting inertia will allow for minor aquifer modeling to begin.*

2. **What might be the cause of the rise in documented groundwater levels in Dawson County?**

Response: *Dawson County is located on the southern edge of the Caprock and the Ogallala isn't present in a large part of the county. In some places the depth to groundwater is less than fifty feet from the surface. The area soils are very sandy and can have a very high recharge rate. With sandy soils and a shallow depth to water, groundwater levels can show big changes. Another possibility is varying quality and consistency of data from year to year. It is not uncommon, in the Southern High Plains, to double the average annual rainfall in one year. This could also be a factor.*

3. **In previous times, irrigation practices were not as efficient as they are now. Do you take this into account when calculating data?**

Response: *Yes we do.*

4. **Is error analysis performed on values and information used in your calculations and can you provide a range of values instead of reporting a value down to a one-hundredth of an inch, which is a lot of times based on assumptions?**

Response: *We were not asked to provide that information.*

5. **How are your numbers affected if data is wrong? For example, what happens if reported acreage is off by 20% from actual acreage?**

Response: *It could be significant. In some counties, depending how much acreage and how much pumping occurs, it could make a big difference. In some cases it's a relatively small difference.*

6. Does the percent PET remain the same throughout a range of years, or does it change?

Response: *Both. It does change and it does stay constant. We have come to find out that a specific grower does not change his habit much over time, but his well production can't increase much over time either. Even in our area (Region A), if growers experience an extremely dry year they can pump a little more, but they can't overcome it. I assume that this is the situation in this area (Region O), if not, you could pump water all year and never fall off.*

7. How are numbers gathered to calculate PET?

Response: *Technicians in the field monitor and record what producers around the region pump and what they apply. Soil water, rainfall, and irrigation are all added together in relation to full PET. Soil monitors at three (3) feet are monitored at the beginning and end of the growing season. We then calculate out soil water by soil type. We measured the rainfall at the site, and along with the grower we monitor the amount of water applied for that crop, for that season.*

8. Has the information gathered from the metered plots been calibrated against the data you have aquired? Does it agree?

Response: *Yes it has. Yes it does.*

9. Were the meters used to calculate the Percent PET?

Response: *The meters are used to calculate PET for 1998 and after. The meters were not installed until 1998. We are compiling cumulative data for previous year's calculations.*

10. What happens to the deficit for a year's crop.

Response: *The deficit for a year's crop becomes the replacement requirement for the next year's crop***.**

11. Are you taking the total irrigation demand and using it to calculate depletion for the next decade.

Response: *Yes.*

12. Is that number compared to the actual well measurements and calculated volume completion?

Response: *We take that number and the municipal, the industrial, steam generation, and basically every other documented water use information for the year. Then we compare that to depletion for that year.*

13. What do you intend to do with the total irrigation demand number?

Response: *That will be the irrigation demand number in acre-feet. It will be plugged into the model and distributed across the well grid for a given year. This number, as well as a time sequence number for other years, will show what happens with the decline or rise, in many cases, for that particular county.*

14. Don't you really want to calculate these numbers over a 10-year period?

Response: *We are calculating numbers for 1982, 1987, 1992, and 1997.*

15. Are those years averaged into the model?

Response: *No. They are time sequenced in a temporal fashion within the model.*

16. Those years are not representative of typical years. Why are they used?

Response: *These are years from which information is available. These are years in which the census was performed.*

17. When you go back to years 1982, 1987, 1992, and 1997, your water demand for individual crops should stay constant, shouldn't it?

Response: *Yes. They will be fairly constant. The acreage will change.*

18. What you will do is take a time increment and adjust the acreage and rainfall?

Response: *In the model we have five (5) year increments. We will either interpolate in between those years linearly, or we could look at rainfall and determine if pumping should be higher or lower. Remember that we only have the irrigated acreage footprint for every five years and they don't correspond with the census years. We are trying to get additional information to use on top of the 1994 irrigation footprint, which is the only one avaulable electronically. There may be only three or four irrigation coverages to work with between 1940 and 2000. We will need to go in between each one. These inputs form only one piece of the entire model. You also have return flow from irrigation that occurs and hydraulic conductivity of the* *aquifer. We have uncertainties in all these things at least on the order of magnitude of irrigation pumping. It's very easy to have an error on one term that cancels out an error on another term, and never know it. That's a real problem with predictions. That's why, in our approach, we tried to do things independently. We wanted to determine irrigation pumpage outside the model instead of within the model. Some people have adjusted irrigation pumpage when calibrating a model, which is okay, but you could adjust the irrigation pumpage, the hydraulic conductivity, or specific yield. The error in all these terms is such that you don't know which to adjust. Our approach is to try to determine model inputs independently and not change them once we put them into the model. Once all the terms are in the model,we will attempt to only change the inputs that were not determined independently. We are trying to minimize correlation and non-uniqueness as best we can.*

19. Are you going to look at multiple demand scenarios?

Response: *In the predictive runs, there is various demand scenarios that are prescribed by the Water Development Board. The most important aspects of the model are the predictive runs. What I am really focussed on now is trying to get accurate historical data, because what we put in for irrigation pumpage historically is going to determine the recharge, return flow, hydraulic conductivity, and all these other terms. If the historical terms aren't right then the errors propagate into any future simulation.*

20. If you go back to your early data, the early 1980 data in these northern counties, you are well above 100% PET, because your inefficiency and surface irrigation was such that you had a whole lot of waste. Isn't that right. Isn't that what you are doing?

Response: *Yes that's right.*

21. When you run the model, are you going to use PET to calibrate the model?

Response: *The model will be calibrated from a period between 1940 and 1990. The model will be validated between 1990 and 2000. Once the model is validated then it will be used to predict.*

22. You are going to create this model, and then you are going to present it to us to see what we think? Will we have an opportunity to compare the PET values with what we had for our original projections?

Response: *Once the model is calibrated and validated, it's really simple to make predictive runs depending on what numbers you come up with. You may decide you want us to come up with a range of projected amounts of* *irrigation pumping for the next fifty (50) years. It is really easy at that point to stick that into the model and make those predictions.*

23. How is the drought of record figured for the model?

Response: *What we do is look at the Palmer Drought Indices and usually it really clearly shows the drought of the 1950's as being the worst. There are years within the period of record which were certainly drier years, but if you look at duration and amount of rainfall, the drought of the 50's ends up being the drought of record for most of the state.*

24. What regions does the model cover?

Response: *The model will cover potions of Regions A, O and F.*

25. How will the drought of record be cycled into the model?

Response: *The drought of record will be cycled in each run at the end of the specified decade. For example, we will calculate the model through the year 2010 and cycle the five (5) year drought of record into the last five (5) years of the decade. The next run will be through to 2020 with the five (5) year drought of record cycled into the last five (5) years of that decade, and so on. Each run will have one drought of record cycled in the last five (5) years of the last decade modeled.*