GAM

Groundwater Availability Modeling

texas water development board

Agenda for Stakeholder Advisory Forum No. 4 - February 21, 2002

- Introduction
- Data collection and analysis update
- Groundwater depletion calculations
- Determination of agricultural pumping
- Questions/comments/input

Groundwater Availability Modeling (GAM) is the process of

developing and using computer programs to estimate the amount of water available in an aquifer. It is based on

- Hydrogeologic principles
- Actual aquifer measurements
- **Stakeholder guidance**

Purpose of the GAM is to...

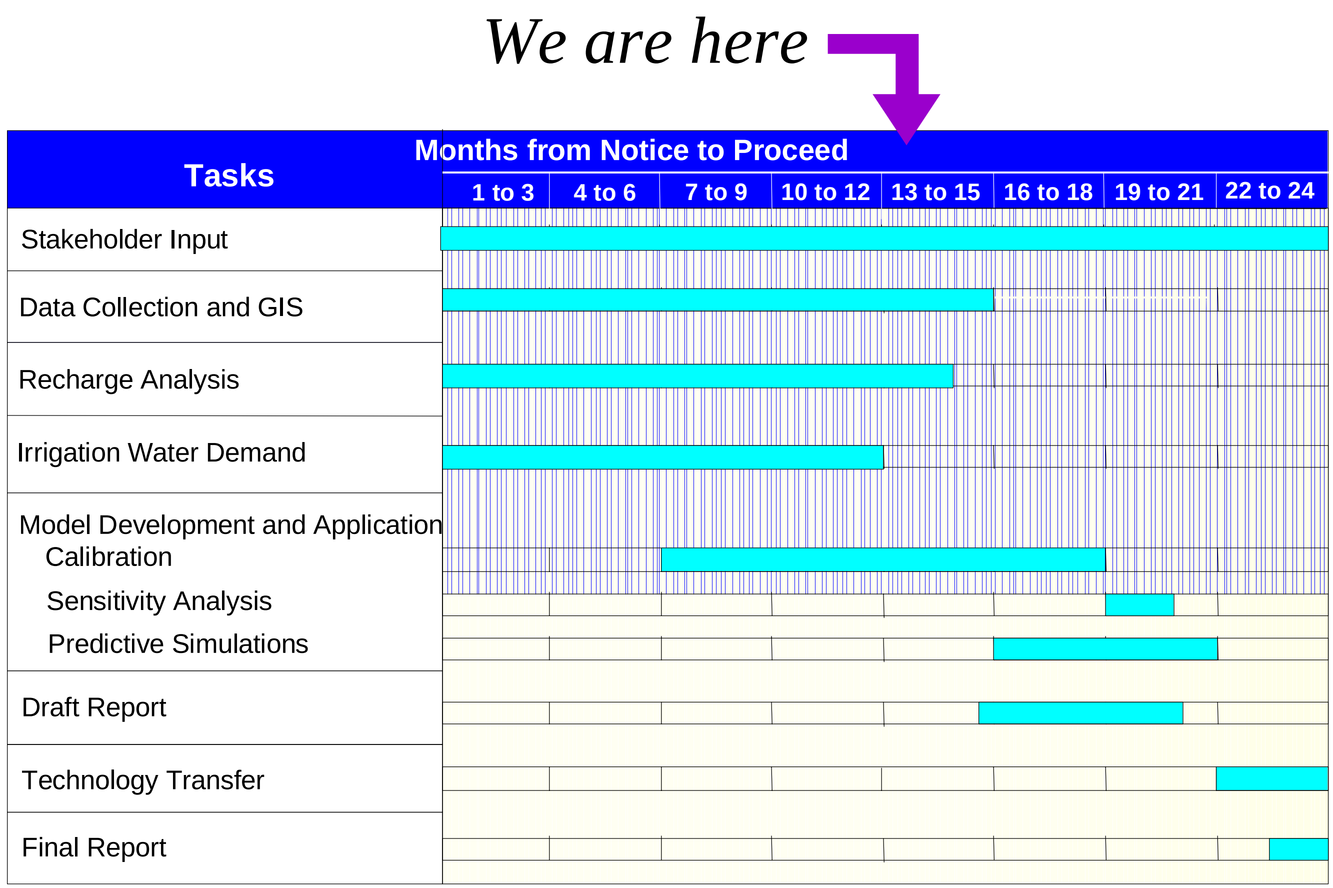
"provide reliable, timely data on groundwater availability ... to ensure adequacy of supplies or recognition of inadequacy of supplies throughout the 50-year planning horizon."

- Pederson, TWDB (1999)

The model will be used by

- Underground Water Conservation Districts (UWCDs), Regional Water Planning Groups (RWPGs), TWDB and other entities to evaluate the effects of water use alternatives
- The model and the data will be available to the public

Project Schedule



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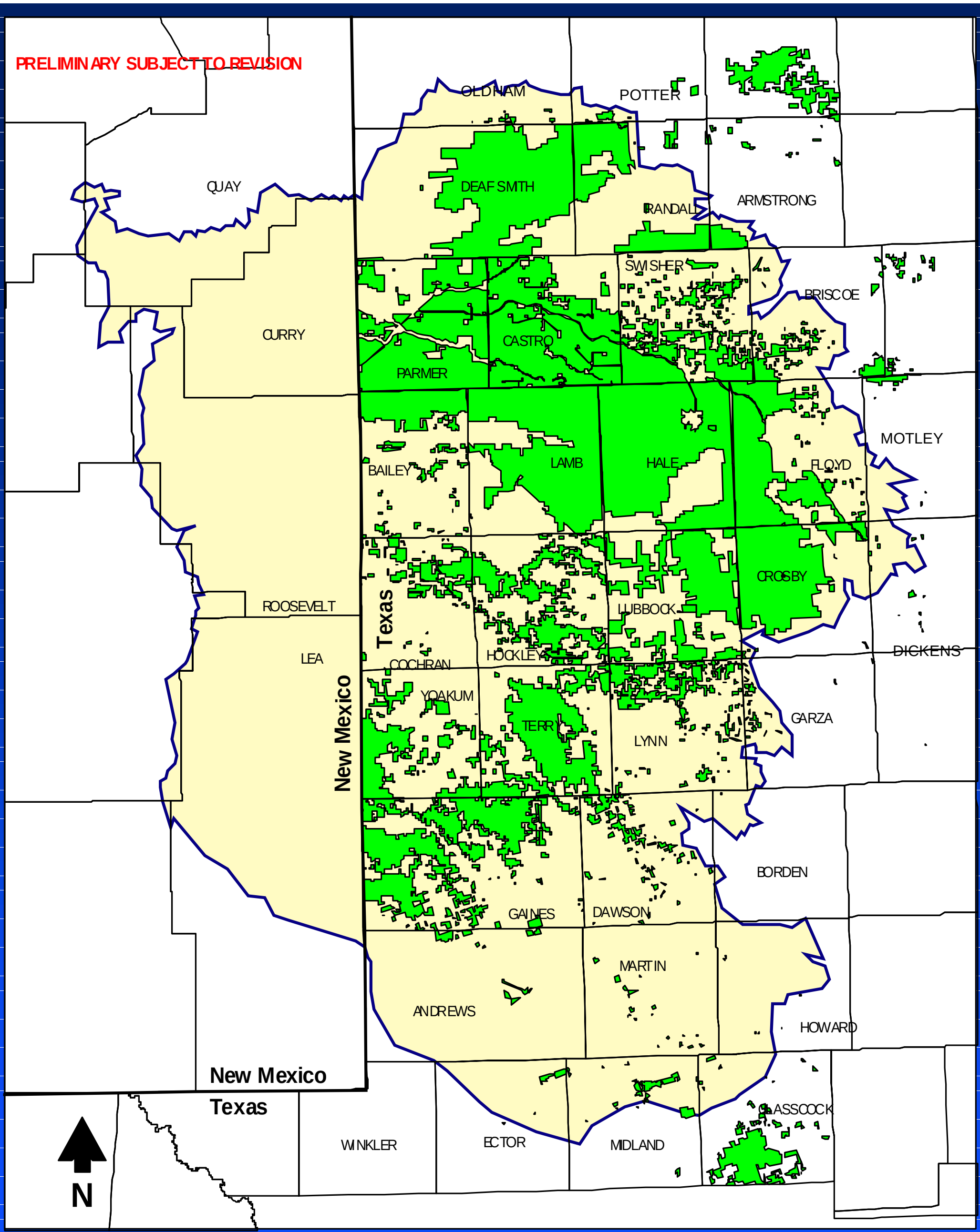
Irrigated Acreage Coverages

- Needed to assign pumping in the model
- Existing/in progress
  - 1994 - TWDB/Landsat
  - 1988 - TWDB
  - 1980 - USGS
- Additional
  - 2000 ? - USGS (June or July)
  - 1972 ? - Landsat

Irrigated Lands - 1994



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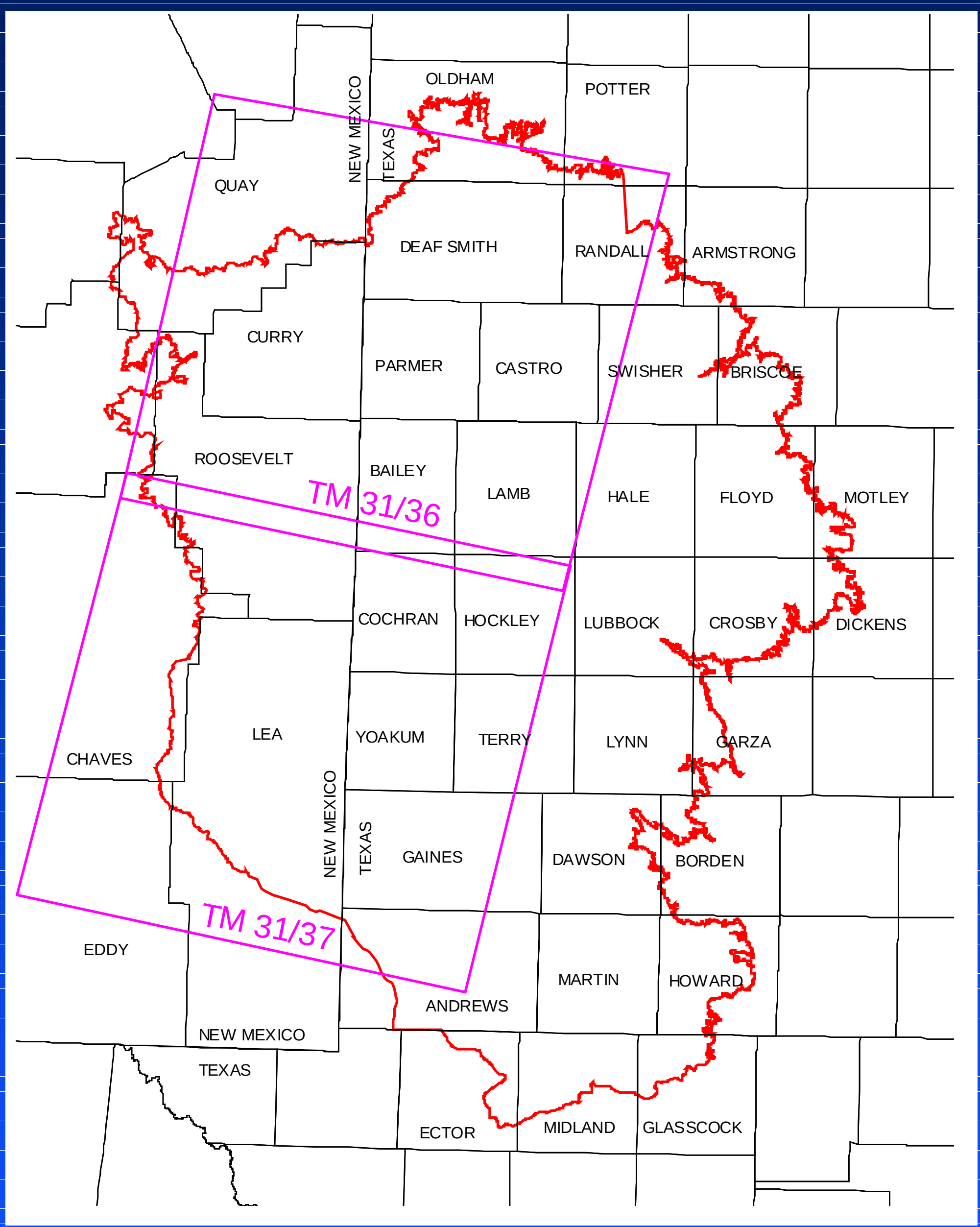
Landsat Scenes



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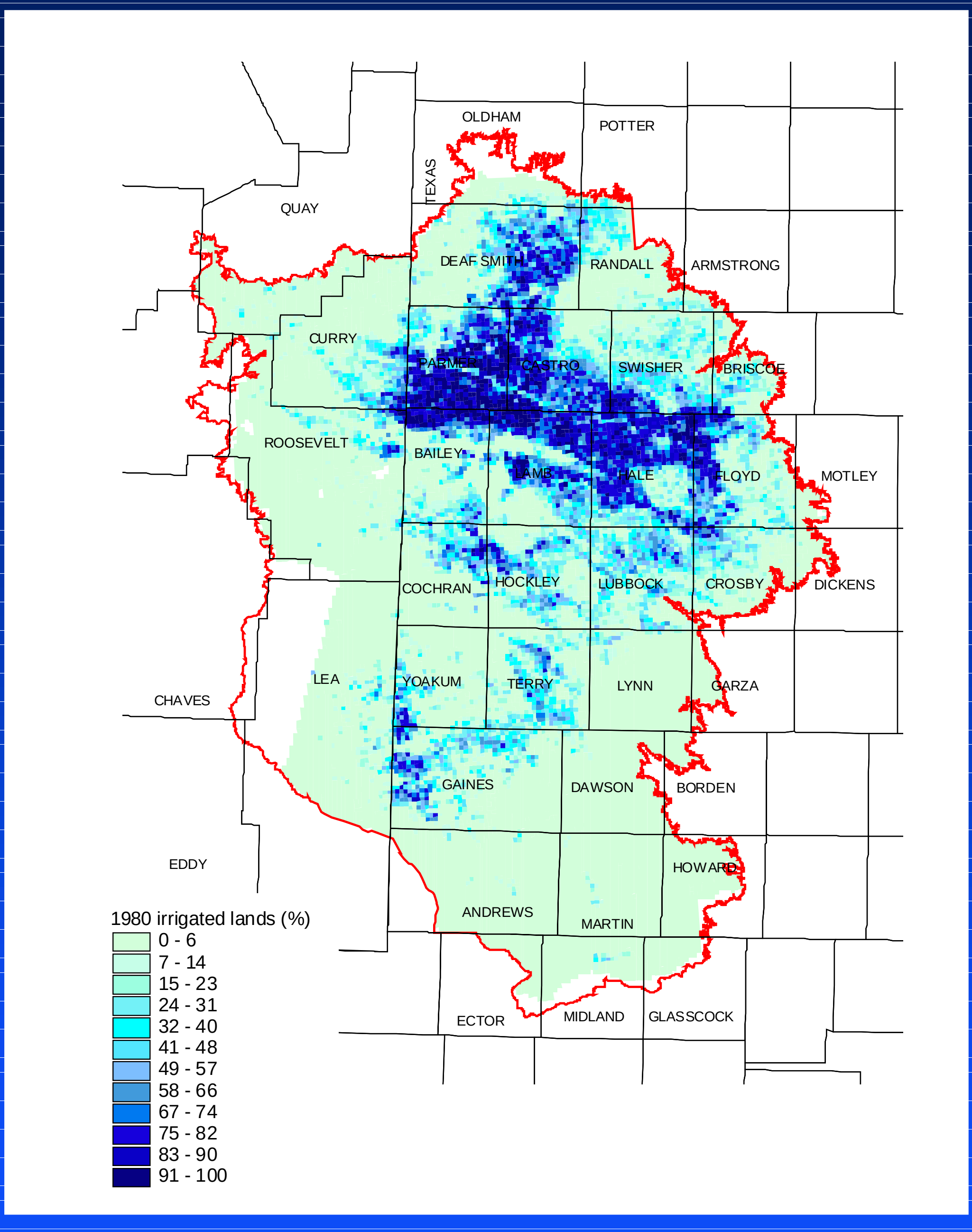
USGS 1980 Irrigated Lands



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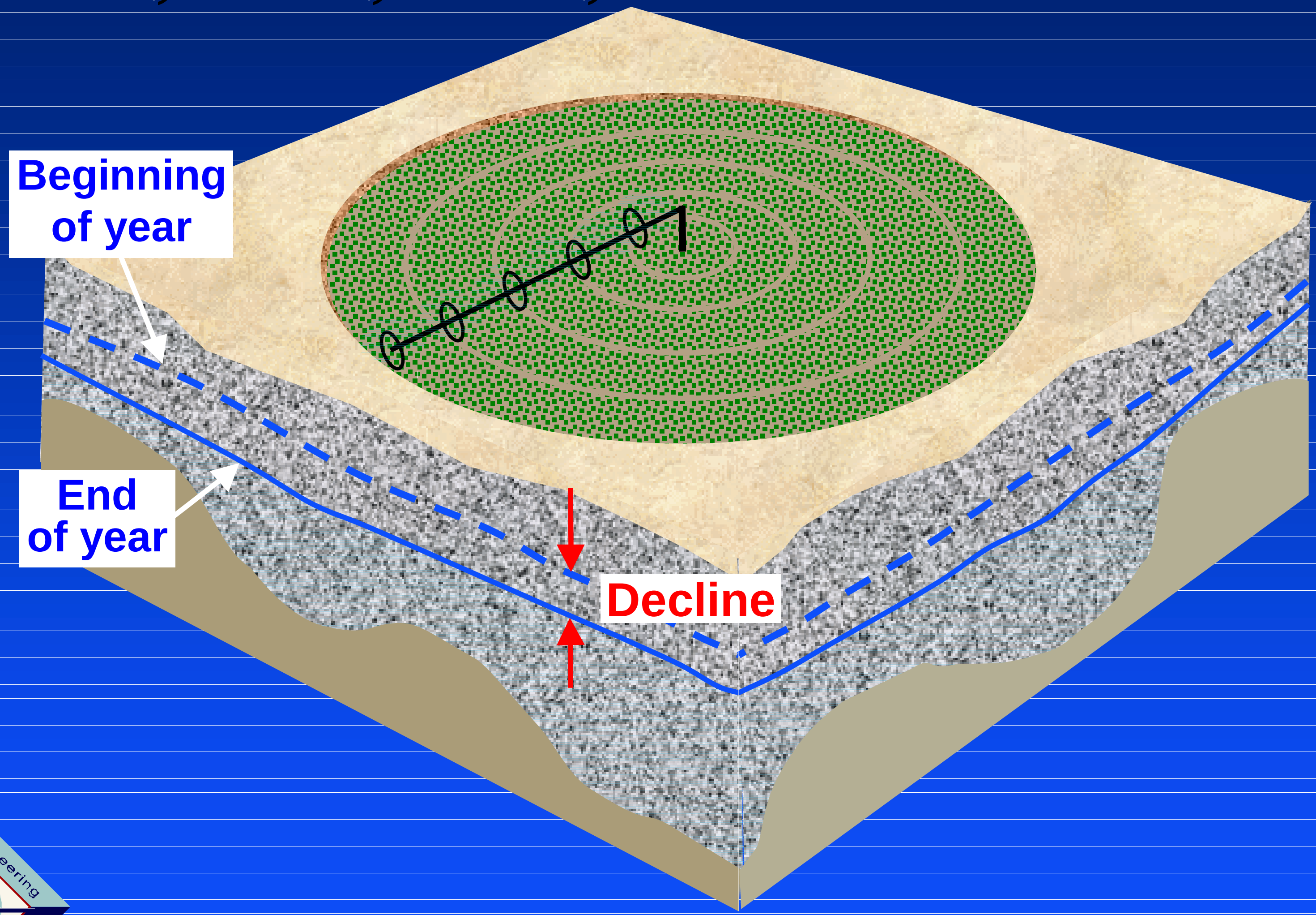
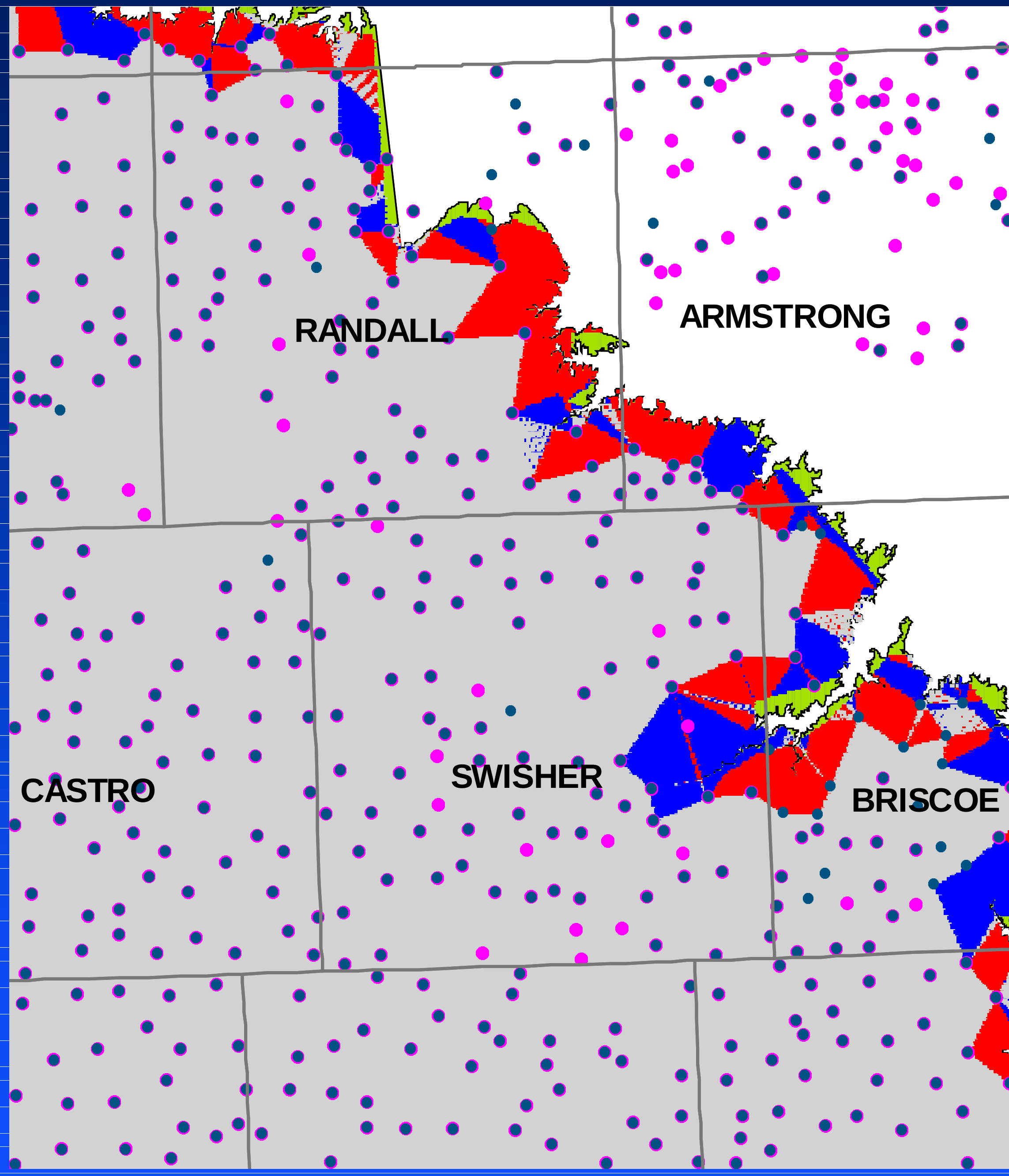
Depletion Calculations - 1982, 1987, 1992, 1997



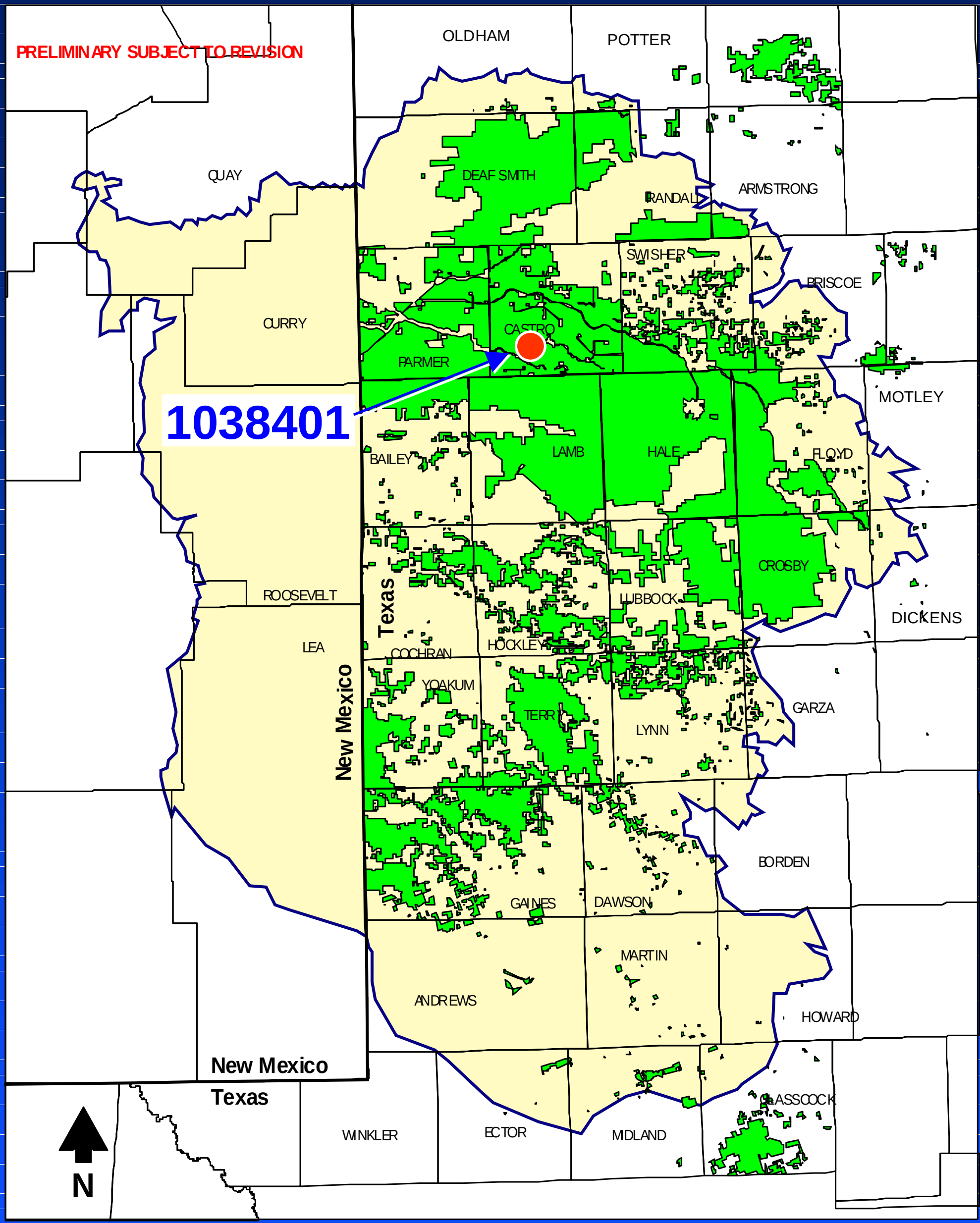
1992 Water Levels for Depletion Calculation



Groundwater Depletions - Acre-ft

	1982		1987		1992		1997	
	All Pts	Same Pts	All Pts	Same Pts	All Pts	Same Pts	All Pts	Same Pts
CASTRO	72,372	138,745	-19,077	6,301	12,119	12,119	118,000	109,448
PARMER	141,872	143,231	-35,546	-28,144	10,276	9,227	141,026	145,981

Well 1038401 and 1994 Irrigated Lands



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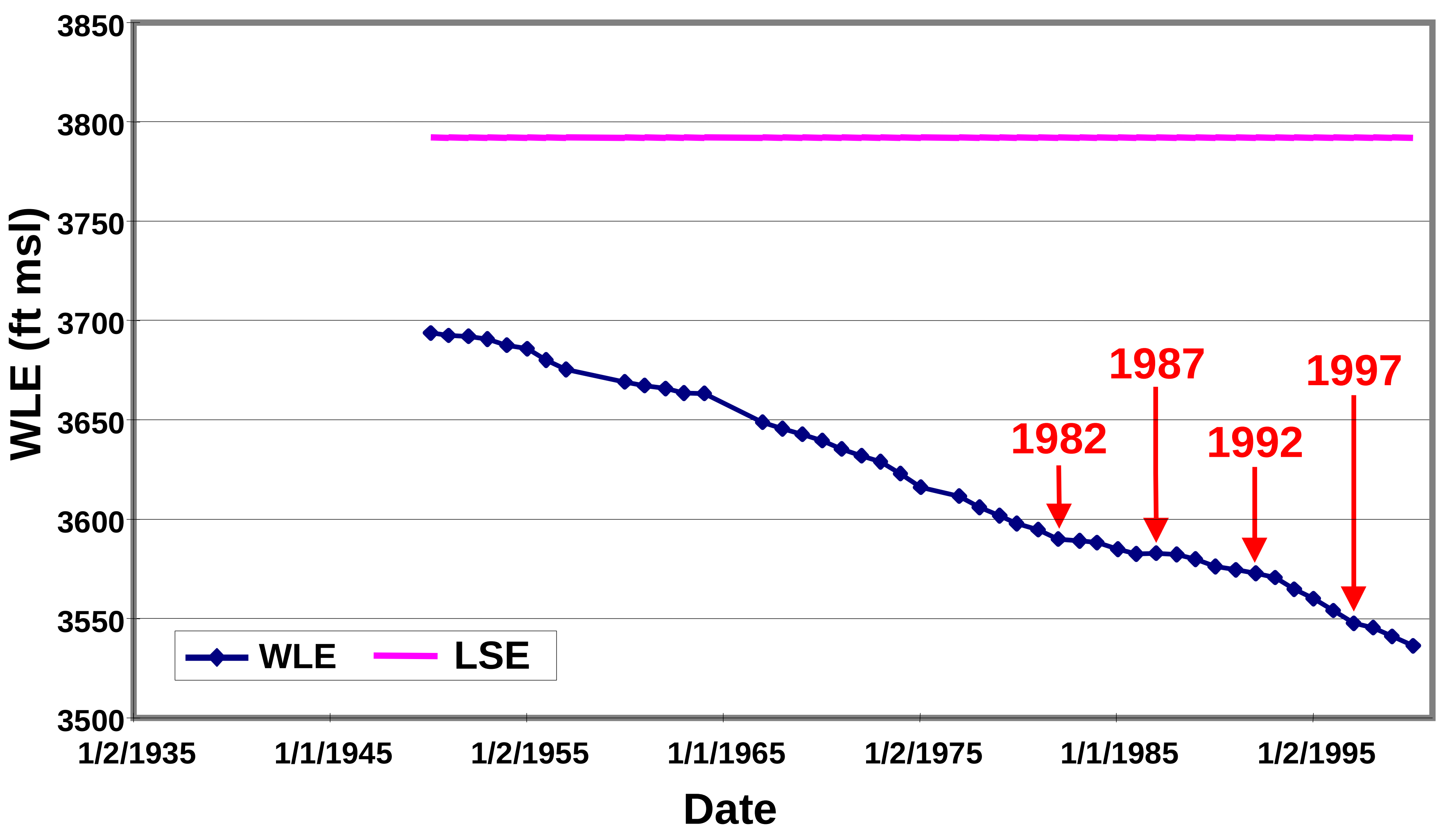
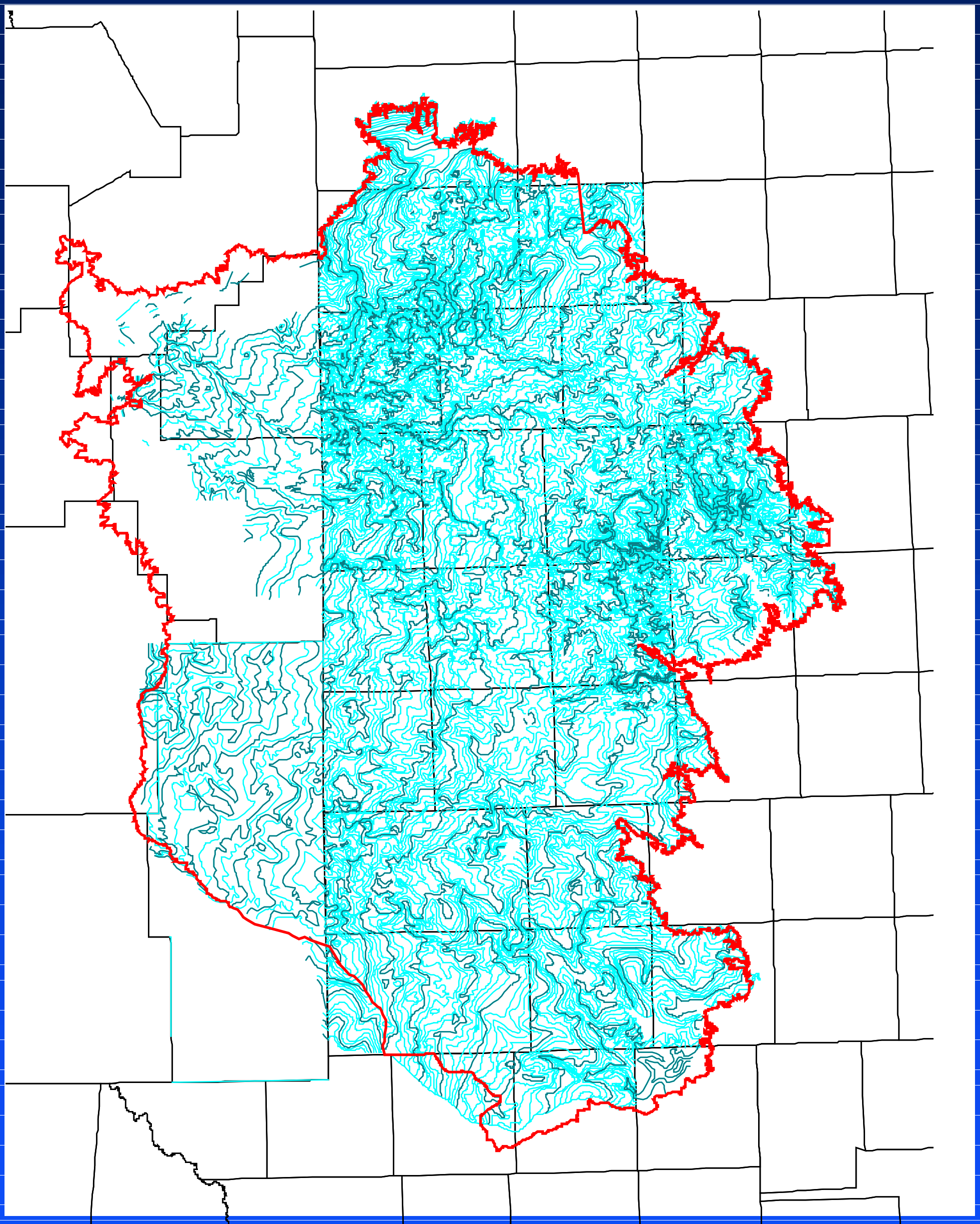
Well 1038401, Castro County



Groundwater Depletions - Acre-ft

	1982		1987		1992		1997	
	All Pts	Same Pts	All Pts	Same Pts	All Pts	Same Pts	All Pts	Same Pts
TERRY	-291,021	-113,868	-323,960	-322,894	-9,648	-7,345	82,376	50,881
GAINES	305,448	17,013	13,536	-39,392	-2,952	-3,204	219,479	94,556

Aquifer Bottom Elevation Contours



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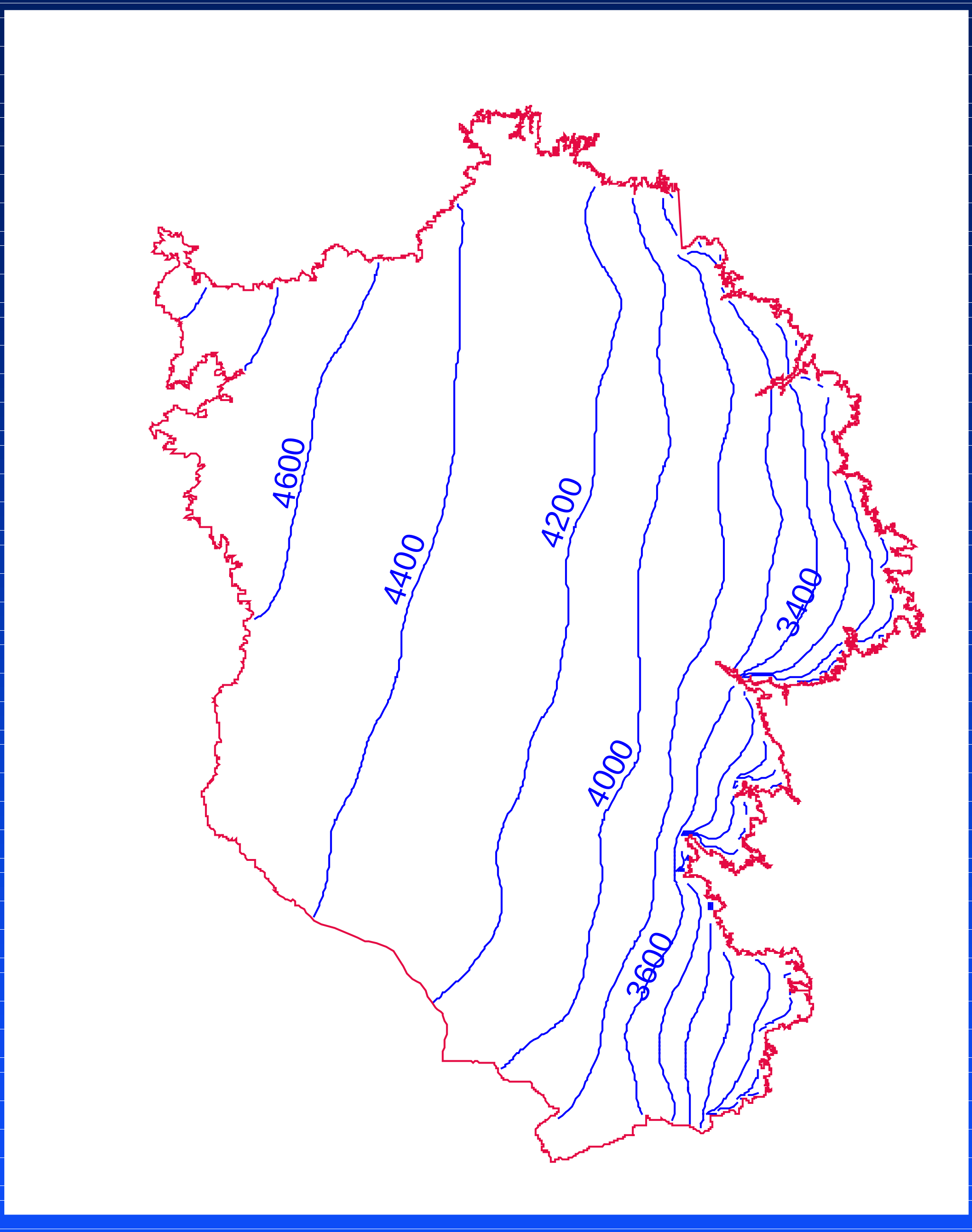
Steady-State Simulation Example



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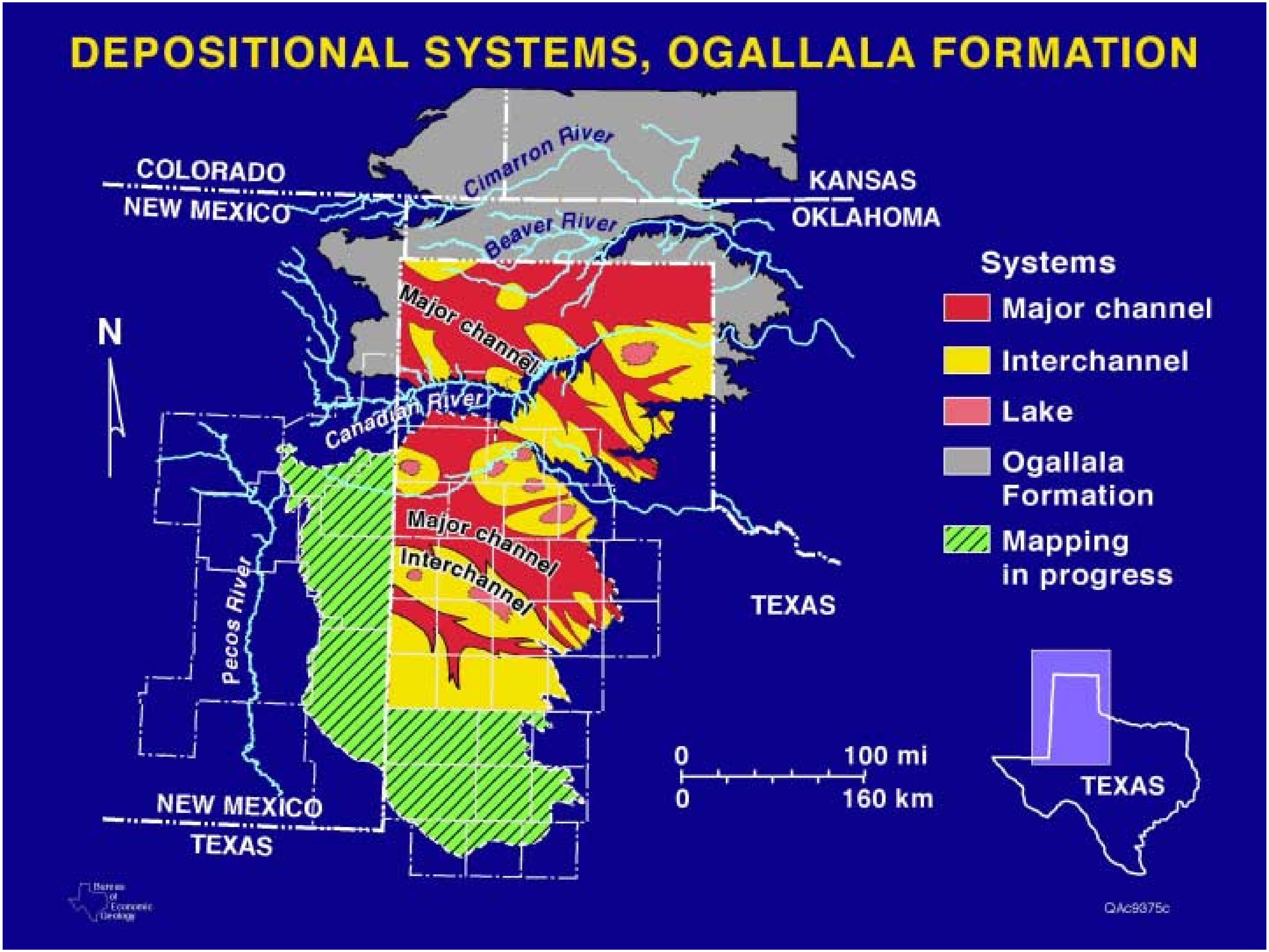
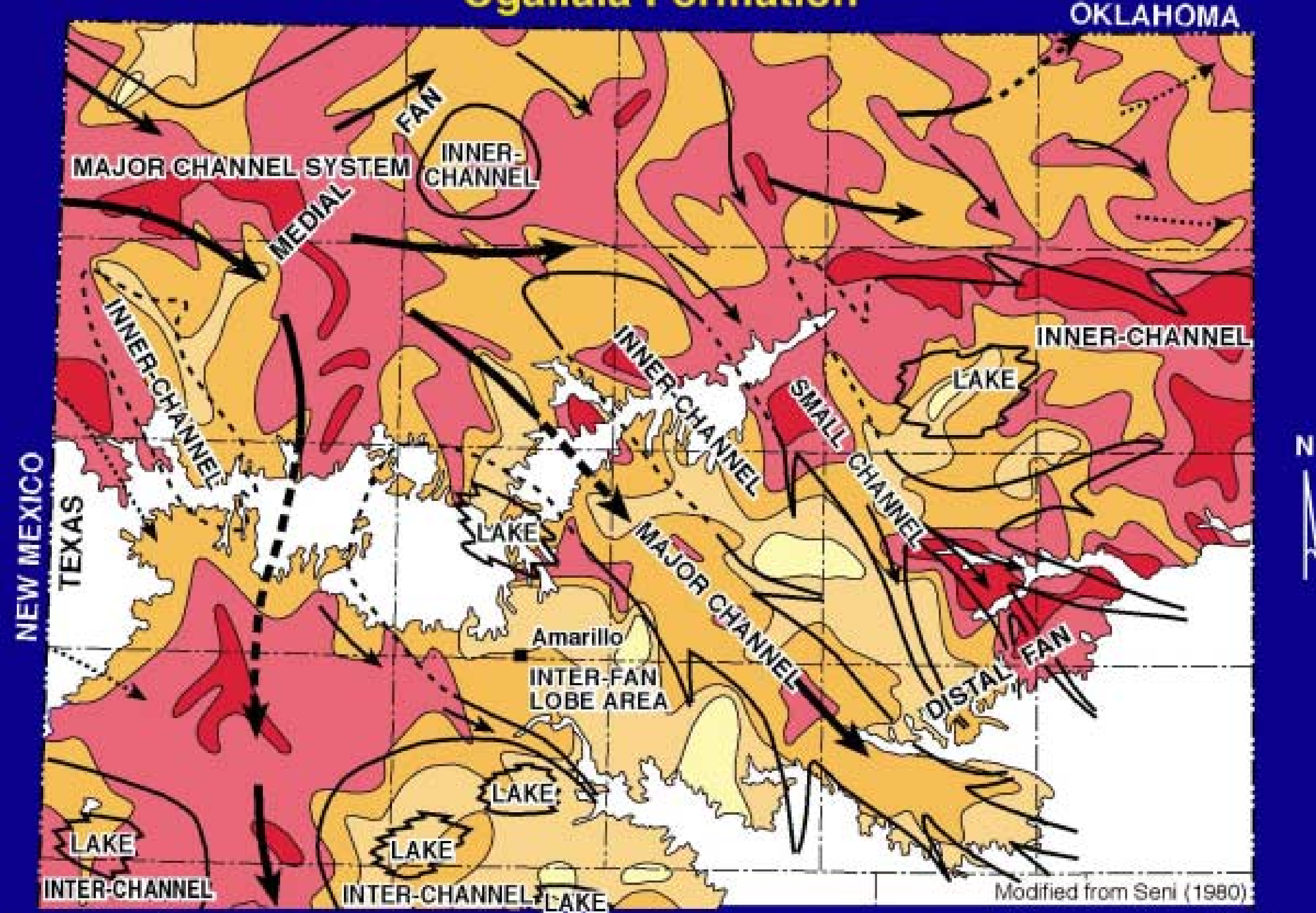
Hydraulic Conductivity

HYDRAULIC CONDUCTIVITY DATA

- Few wells with long-term pumping tests (the best data)
- Many 100s of wells with specific-capacity tests
- Specific capacity is the amount of water yield for unit drawdown
- Hydraulic conductivity can be estimated from specific capacity (Thomasson and others, 1960; Theis, 1963; Eagon and Johe, 1972; Razack and Huntley, 1991; Mace, 2001)


DEPOSITIONAL SYSTEMS, OGALLALA FORMATION
COLORADO
NEW MEXICO
KANSAS
OKLAHOMA
Cimarron River
Beaver River
Canadian River
Pecos River
Major channel
Major channel
Interchannel
N
TEXAS
NEW MEXICO
TEXAS
Systems
Major channel
Interchannel
Lake
Ogallala Formation
Mapping in progress
0
100 mi
0
160 km
TEXAS
QAc9375c

PERCENT SAND AND GRAVEL
Ogallala Formation



- 80 – 100
- 60 – 80
- 40 – 60
- 20 – 40
- 0 – 20
- Ogallala not present

Lower Ogallala contact dashed where covered by younger deposits

0 — 40 mi
0 — 60 km

Contour interval 20 percent

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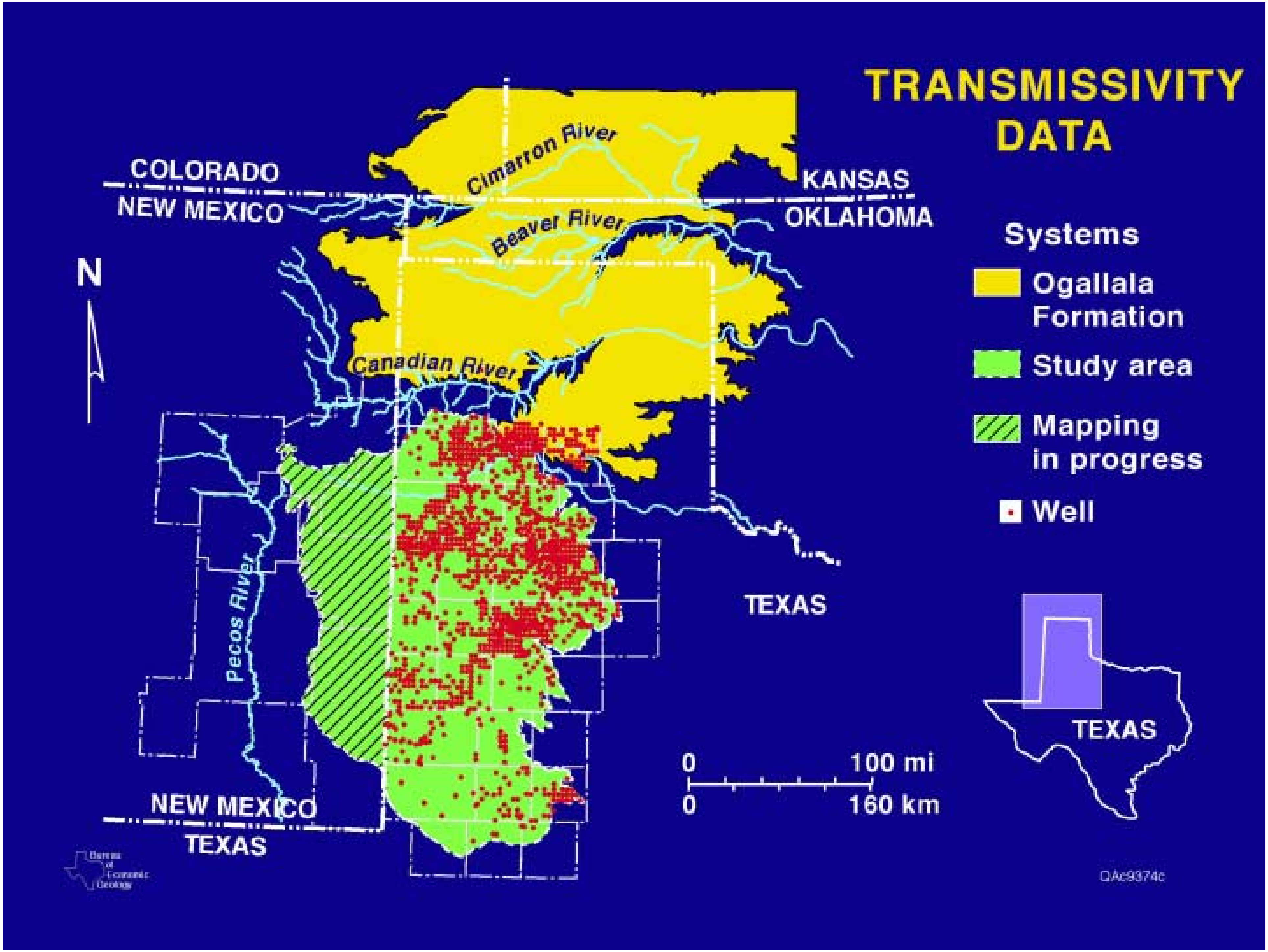
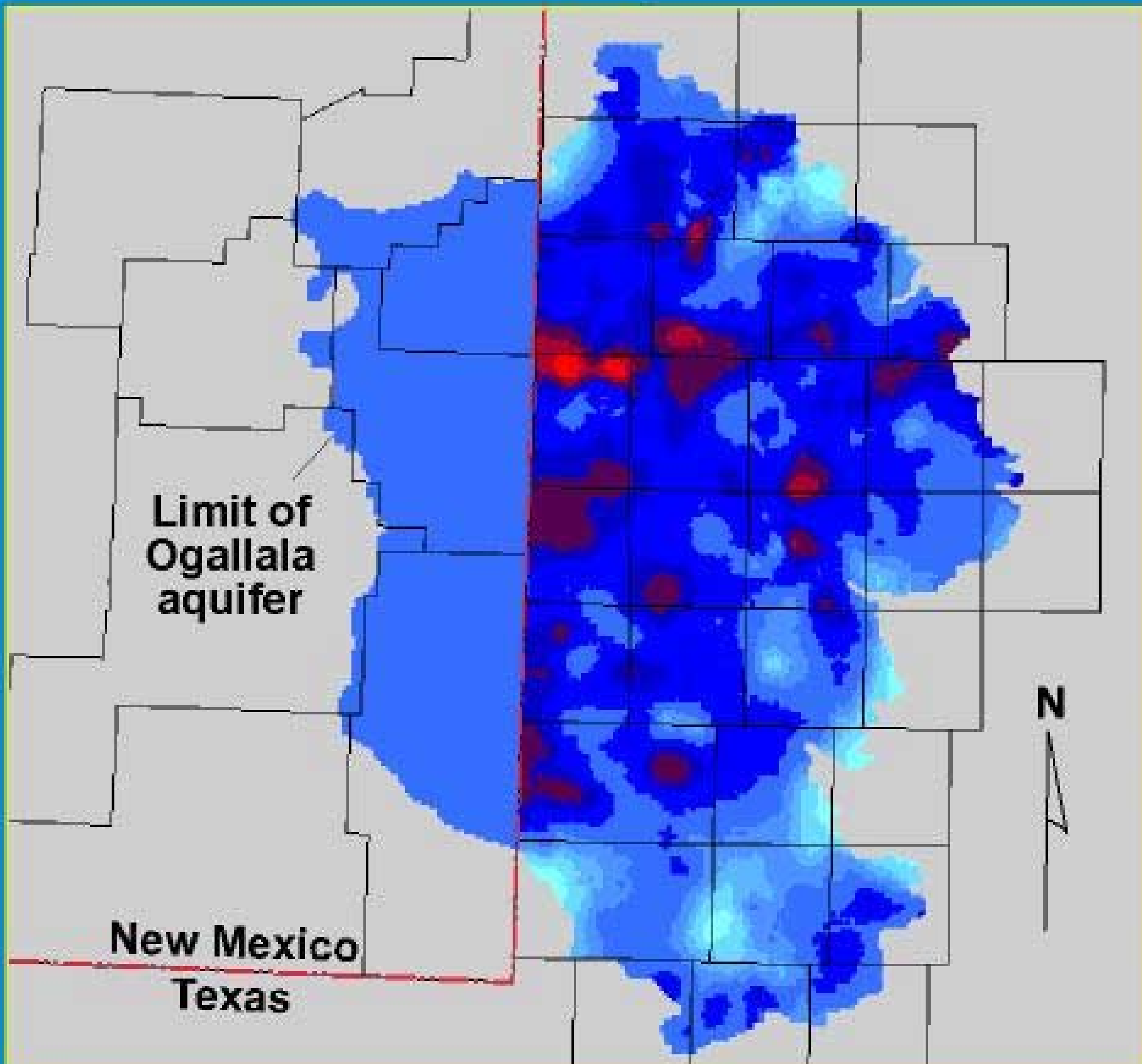

TRANSMISSIVITY DATA
COLORADO
NEW MEXICO
KANSAS
OKLAHOMA
Cimarron River
Beaver River
Canadian River
Pecos River
N
Systems
Ogallala Formation
Study area
Mapping in progress
Well
TEXAS
0 100 mi
0 160 km
TEXAS
NEW MEXICO
TEXAS
Bureau of Economic Geology
QAc9374c

HYDRAULIC CONDUCTIVITY MAPPING

- Use objective contouring methods
  - Geostatistical analysis
  - Kriging
- Hand contouring of hydraulic conductivity using additional geological data as a guide

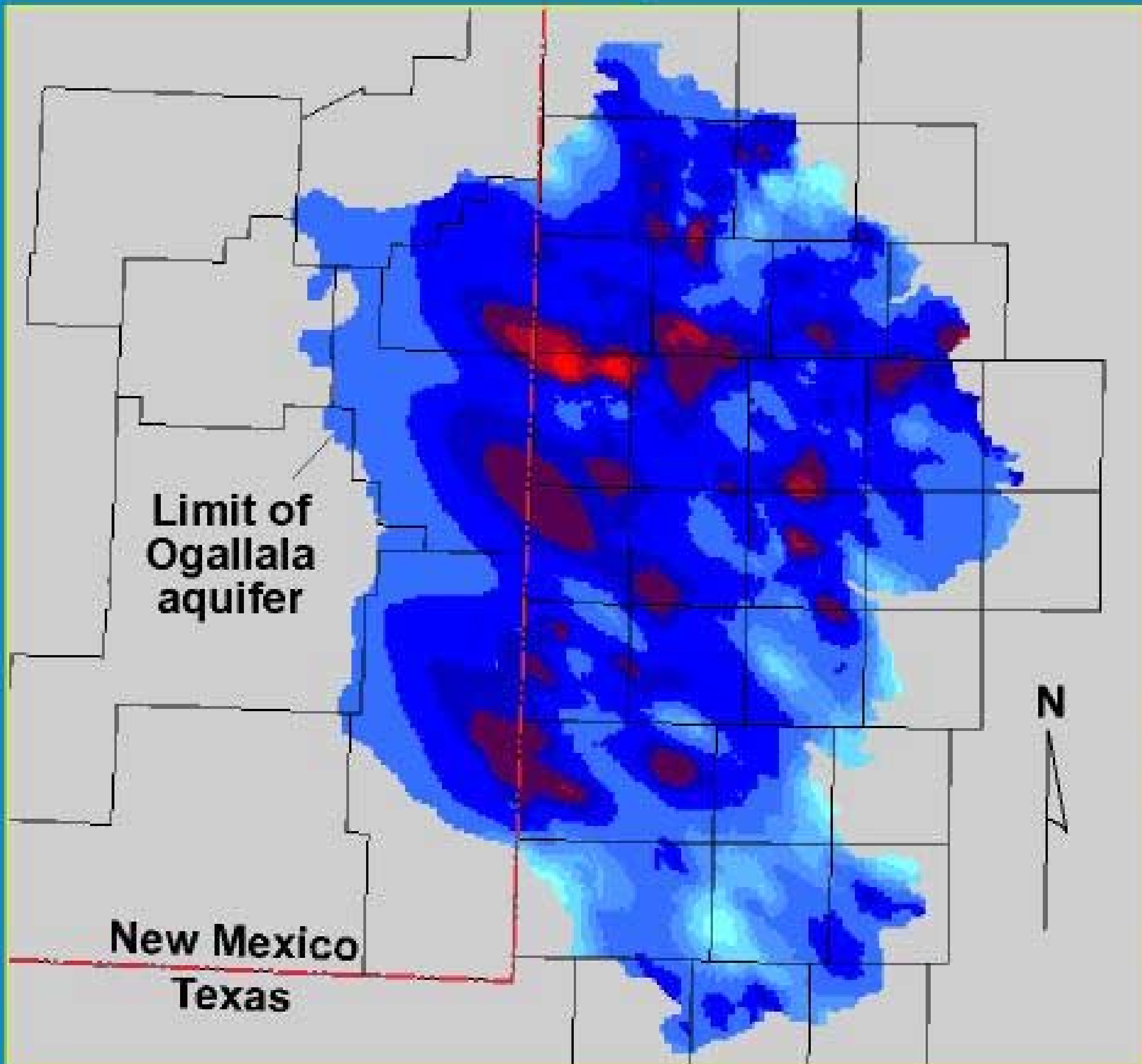
HYDRAULIC CONDUCTIVITY OF THE OGALLALA AQUIFER, SOUTHERN HIGH PLAINS



Kriged version

Oriented 0°
Anisotopy =1.0
Exponential variogram

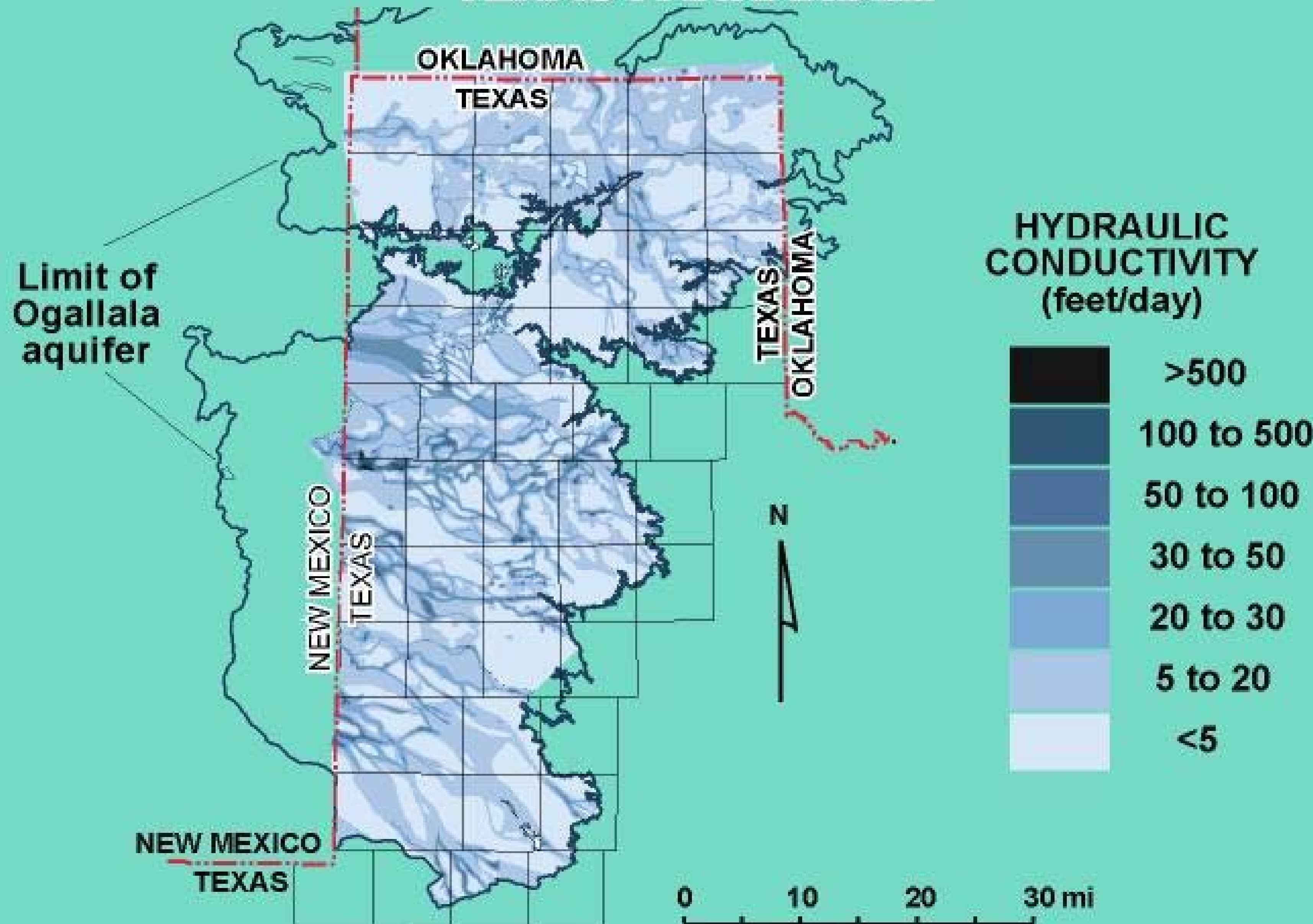
HYDRAULIC CONDUCTIVITY OF THE OGALLALA AQUIFER, SOUTHERN HIGH PLAINS



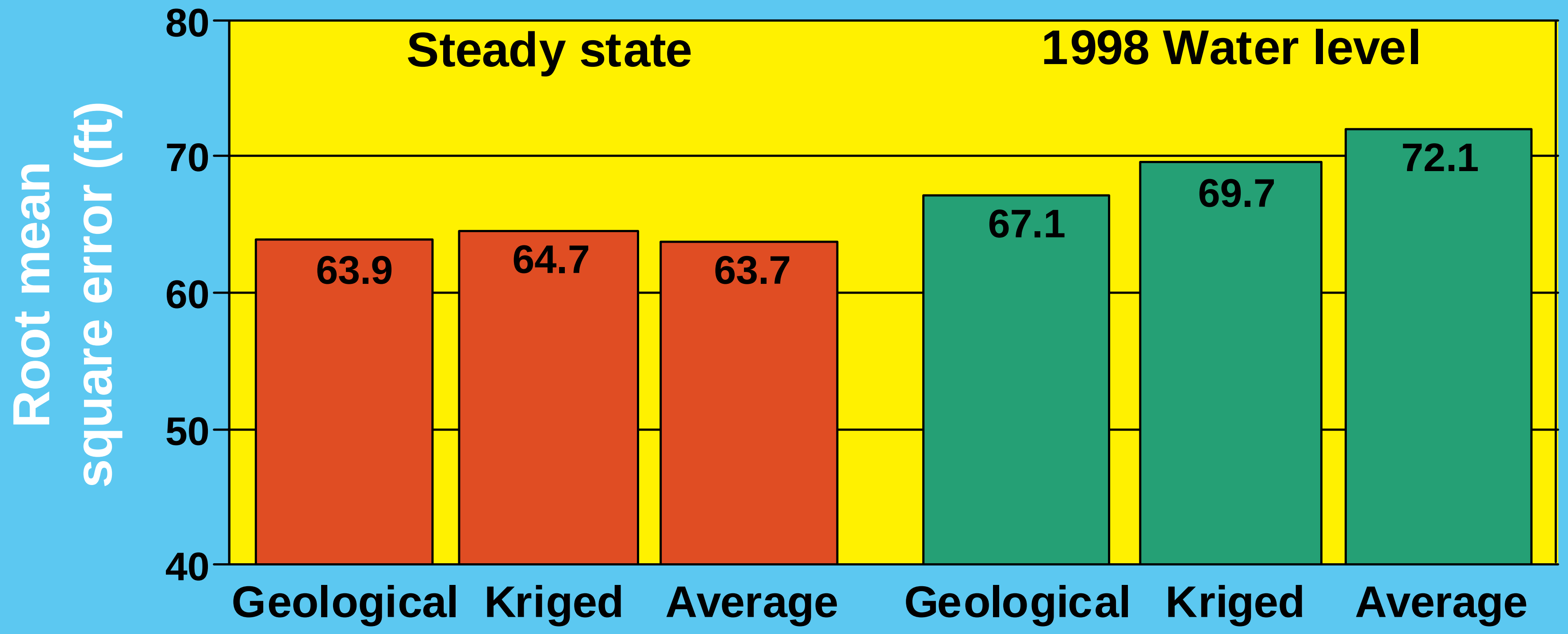
Kriged version

Oriented 45°
Anisotopy = 2.0
Exponential variogram

HYDRAULIC CONDUCTIVITY OF THE OGALLALA AQUIFER, TEXAS PANHANDLE



HYDRAULIC CONDUCTIVITY SENSITIVITY



SAFE MEETING

IRRIGATION DEMAND PRESENTATION AGENDA

1. Project Team and why Current Methodology was Selected

2. Overview of Irrigation Demand Methodology

3. Preliminary Results of 1997 Simulation

    Regional Level

    Selected County Level

4. Other Simulation Results

    Long Term Average (LTA)

    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

IRRIGATION WATER DEMAND
GENERAL METHODOLOGY

$$IRR_C = ET_C(P_T) - ER - SSM_D$$

P_T = Percentage of crop evapotranspiration applied on a seasonal basis, (mm)

ET_C = Crop evapotranspiration (or water use) for maximum production potential, (mm)

IRR_C = Irrigation applied on a seasonal basis to a crop, (mm)

ER = Effective rainfall computed from seasonal rainfall occurring during the crop season, (mm), and

SSM_D = Differential seasonal soil moisture used in crop production which is extracted from the soil profile, (mm).

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	**Pasture**
Cotton	**Peanuts**
Grain Sorghum	**Soybeans**
Hay	**Wheat**

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

- **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.**

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%	

Grower Factors
1997

Crop	Heavy Soil	Light Soil
Corn	0.87	0.87
Cotton	1.00	1.20
Hay	0.95	0.95
Pasture	0.80	0.80
Peanuts	1.40	1.40
Sorghum	0.85	0.85
Soybeans	0.78	0.78
Wheat	0.78 (Full)	0.60 (Cover)

Grower Factors Long-Term Average

Crop	Heavy Soil	Light Soil
Corn	0.87	0.87
Cotton	1.00	1.00
Hay	0.95	0.95
Pasture	0.80	0.80
Peanuts	1.00	1.00
Sorghum	0.85	0.85
Soybeans	0.78	0.78
Wheat	0.78 (Full)	0.60 (Cover)

DROUGHT OF RECORD

OBJECTIVE: Select the worst consecutive five year period of rainfall for the Region

Drought will be used to determine impacts of similar drought occurrences in future Years

Drought Period Selected

1952	12.71
1953	13.72
1954	13.44
1955	16.52
1956	10.48
Average	13.37

Two Additional Three Year Droughts That Actually Occurred in the 80S and 90S will be Simulated to assist in Validating the Ground Water Model

Year	Annual Rainfall		Year	Annual Rainfall
1980	17.21		1990	19.71
1981	21.03		1991	23.31
1982	21.10		1992	21.39
1983	17.33		1993	19.51
1984	18.81		1994	18.11
1985	26.51		1995	28.73
1986	24.60		1996	22.06
1987	23.47		1997	27.20
1988	21.56		1998	19.47
1989	21.40		1999	No data
1980, 1981, 1982	19.78		1990, 1991, 1992	21.47
1981, 1982, 1983	19.82		1991, 1992, 1993	21.40
1982, 1983, 1984	19.08		1992, 1993, 1994	19.67
1983, 1984, 1985	20.88		1993, 1994, 1995	22.12
1984, 1985, 1986	23.31		1994, 1995, 1996	22.97
1985, 1986, 1987	24.86		1995, 1996, 1997	26.00
1986, 1987, 1988	23.21		1996, 1997, 1998	22.91
1987, 1988, 1989	22.14			

Seasonal Months

Crop	Heavy Soil	Light Soil
Corn	4.0	4.0
Cotton	5.0	5.0
Hay	7.0	7.0
Pasture	7.0	7.0
Peanuts	6.0	6.0
Sorghum	5.0	5.0
Soybeans	5.0	5.0
Wheat	8.5	5.0

Grower Pumpage Factor

Used Stored Soil Moisture

Crop	Heavy Soil	Light Soil
Corn	2.00	2.00
Cotton	5.00	2.00
Hay	1.50	1.00
Pasture	2.50	2.50
Peanuts	2.50	1.50
Sorghum	2.50	1.50
Soybeans	3.00	1.50
Wheat	3.50	0.50

DRAFT

County	1997 PIA, acres	1997 Total Irr Demand,ac-ft		County	1997 PIA, acres	1997 Total Irr Demand,ac-ft	
ANDREWS COUNTY	12,271	17,309	ok	MIDLAND COUNTY	3,718	6,151	ok
ARMSTRONG COUNT	95	63	ok	MOTLEY COUNTY	387	406	ok
BAILEY COUNTY	95,402	93,040	ok	OLDHAM COUNTY	30,182	32,632	ok
BORDEN COUNTY	5,000	5,864	ok	PARMER COUNTY	232,819	214,388	ok
BRISCOE COUNTY	19,137	14,455	ok	POTTER COUNTY	28,219	2,971	ok
CASTRO COUNTY	275,907	282,039	ok	RANDALL COUNTY	37,484	51,903	ok
COCHRAN COUNTY	76,250	93,997	ok	SWISHER COUNTY	138,876	103,085	ok
CROSBY COUNTY	134,835	155,669	ok	TERRY COUNTY	172,031	170,468	ok
DAWSON COUNTY	77,405	95,400	ok	YOAKUM COUNTY	105,909	131,643	ok
DEAF SMITH COUNTY	197,993	284,505	ok	CURRY COUNTY	117,695	92,905	ok
DICKENS COUNTY	4,683	6,524	ok	LEA COUNTY	34,291	46,921	ok
ECTOR COUNTY	1,313	3,542	ok	QUAY COUNTY	335	397	ok
FLOYD COUNTY	184,046	138,604	ok	ROOSEVELT COUNTY	93,048	99,103	ok
GAINES COUNTY	230,872	305,859	ok	Total ac-ft	3,357,876	3,462,395	
GARZA COUNTY	12,500	14,748	ok				
GLASSCOCK COUNT	4,496	6,395	ok				
HALE COUNTY	360,763	229,009	ok				
HOCKLEY COUNTY	159,594	201,801	ok				
HOWARD COUNTY	3,000	3,733	ok				
LAMB COUNTY	226,262	230,078	ok				
LUBBOCK COUNTY	217,338	250,474	ok				
LYNN COUNTY	55,830	66,131	ok				
MARTIN COUNTY	7,890	10,184	ok				

DRAFT

GAINES COUNTY							
Crop	1997 Total Irr H2O Used, in/pia	1997 Total Water Used, in/pia	Crop Acreage, ac / county	Total Irr Demand, ac-ft			
Corn:	17.70	29.85	1,600	2,360			
Cotton:	14.91	26.54	144,000	178,900			
Hay:	36.90	53.64	0	0			
Pasture and Other:	26.93	45.17	3,272	7,342			
Peanuts:	20.03	33.12	64,600	107,802			
Sorghum:	10.15	21.66	6,700	5,669			
Soybeans:	7.43	21.29	0	0			
Wheat - Cover Crop	4.25	8.36	10,700	3,786			
Total				305,859			

DRAFT

County	LTA PIA, acres	LTA Total Irr Demand,ac-ft		County	LTA PIA, acres	LTA Total Irr Demand,ac-ft	
ANDREWS COUNT	12,271	14,051		MIDLAND COUNTY	3,718	5,089	
ARMSTRONG COU	95	94		MOTLEY COUNTY	387	499	
BAILEY COUNTY	95,402	128,592		OLDHAM COUNTY	30,182	32,556	
BORDEN COUNTY	5,000	9,055		PARMER COUNTY	232,819	295,996	
BRISCOE COUNTY	19,137	23,777		POTTER COUNTY	28,219	3,416	
CASTRO COUNTY	275,907	411,125		RANDALL COUNTY	37,484	65,662	
COCHRAN COUNTY	76,250	79,734		SWISHER COUNTY	138,876	161,748	
CROSBY COUNTY	134,835	121,345		TERRY COUNTY	172,031	172,157	
DAWSON COUNTY	77,405	80,954		YOAKUM COUNTY	105,909	104,474	
DEAF SMITH COUN	197,993	382,944		CURRY COUNTY	117,695	118,523	
DICKENS COUNTY	4,683	6,505		LEA COUNTY	34,291	46,745	
ECTOR COUNTY	1,313	3,534		QUAY COUNTY	335	499	
FLOYD COUNTY	184,046	188,617		ROOSEVELT COUN	93,048	98,687	
GAINES COUNTY	230,872	248,450		Total ac-ft	3,357,876	3,879,509	
GARZA COUNTY	12,500	11,211					
GLASSCOCK COU	4,496	4,798					
HALE COUNTY	360,763	334,295					
HOCKLEY COUNTY	159,594	161,837					
HOWARD COUNTY	3,000	3,112					
LAMB COUNTY	226,262	297,598					
LUBBOCK COUNTY	217,338	201,952					
LYNN COUNTY	55,830	51,468					
MARTIN COUNTY	7,890	8,411					

DRAFT

DAWSON COUNTY				
Crop	LTA Total Irr H2O Used, in/pia	LTA Total Water Used, in/pia	Crop Acreage, ac / county	Total Irr Demand, ac-ft
Corn:	23.25	34.00	0	0
Cotton:	12.17	22.95	52,000	52,748
Hay:	39.07	53.64	0	0
Pasture and Other	29.10	45.17	1,105	2,680
Peanuts:	14.04	25.12	16,700	19,540
Sorghum:	12.10	22.76	4,800	4,840
Soybeans:	14.57	26.31	0	0
Wheat - Cover Crop	4.91	8.36	2,800	1,146
Total			77,405	80,954

DRAFT

Leon's Summary Sheet						
North Counties			**Cotton**			
	TAES Irr	TAES Eto	TAES GF	TAES Irr	TAES Eto	TAES GF
	1997	1997	1997	LTA	LTA	LTA
Bailey	10.94	23.32	1.00	14.23	24.82	1.00
Castro	8.76	24.49	1.00	12.07	26.63	1.00
Floyd	9.11	22.65	1.00	11.46	23.85	1.00
Hale	6.74	23.38	1.00	9.36	24.88	1.00
Lamb	10.99	23.38	1.00	13.47	24.88	1.00
Parmer	7.20	22.72	1.00	9.82	24.12	1.00
Swisher	7.59	24.68	1.00	10.93	26.69	1.00
Averages	8.76	23.52	1.00	11.62	25.12	1.00
South Counties						
	TAES Irr	TAES Eto	TAES GF	TAES Irr	TAES Eto	TAES GF
	1997	1997	1997	LTA	LTA	LTA
Cochran	15.57	22.50	1.20	12.12	23.53	1.00
Crosby	14.16	22.12	1.20	10.76	22.95	1.00
Dawson	14.32	22.12	1.20	12.17	22.95	1.00
Gaines	14.91	22.12	1.20	12.39	22.95	1.00
Hockley	15.50	22.44	1.20	12.04	23.43	1.00
Lubbock	14.29	22.25	1.20	10.93	23.14	1.00
Lynn	14.16	22.12	1.20	10.76	22.95	1.00
Terry	10.79	22.18	1.00	11.69	23.05	1.00
Yoakum	15.15	22.12	1.20	11.61	22.95	1.00
Averages	14.32	22.22	1.18	11.61	23.10	1.00

Southern Ogallala Stakeholder Advisory Forum No. 4
February 21, 2001

List of Attendees

Name	**Affiliation**
David Turnbough	Sandy Land Underground Water Conservation District
Richard Smith	TWDB
Steve Amosson	TAES (presenter)
Alan Dutton	Bureau of Economic Geology (presenter)
Jason Coleman	SPUWCD
Lloyd Urban	Texas Tech University, Water Resources Center
Scott Orr	High Plains UWCD No. 1
Don McReynolds	High Plains UWCD No. 1
Thomas Marek	TAES (presenter)
Leon New	TAES
Carmon McCain	High Plains UWCD No. 1
Gene Montgomery	Oxy Permian
Larry Sanders	Region F
Clyde R. Crumley	LEUWCD
Ferrel Wheeler	Garza County Underground and Fresh Water Conservation District
Jim Conkwright	High Plains UWCD No. 1
Paul Winn	SPS Jones Station, Lubbock
Ches Carthel	City of Lubbock
Harvey Everheart	Mesa UWCD
John Glenz (spelling?)	Brownfield
Neil Blandford	Daniel B. Stephens & Associates, Inc. (presenter)
Kelli Krebs	Daniel B. Stephens & Associates, Inc.

Stakeholder Advisory Forum No. 4
February 21, 2002
High Plains Underground Water Conservation District No. 1
Lubbock, Texas

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

1. Is the red boundary line significant in defining the whole area?

Response: *Yes, it represents study area wherein we are doing work.*

2. Have you tried to find more information in New Mexico or is not available?

Response: *We have, the data is not there in New Mexico, Texas has more legal requirements then New Mexico related to well completion testing. We will use whatever data there is available in New Mexico. Water records go back to 1954 in Texas. Roosevelt county is not a declared underwater basin by the state, so they don't have to file well reports, in the other counties they do but they don't require the driller to do a pump test and have draw down measurements on all wells, they file a log but not the other piece.*

3. How did you get the red and blue areas to depict the aquifer, why is there more blue then red areas?

Response: *The aquifer has been retreating westward over the last thousand of millions of years, the edge of the Ogallala is over 25 million years, and over the years it has eroded to the point it is now. We are losing water the, direction of flow is recognized as being sort of southeasterly, its like the aquifer goes on up.*

4. How about the Geology department at New Mexico Tech, do they have any data at all?

Response: *Yes, I have been looking and talking with the appropriate people, such as State Engineer staff. We will have what is available out there to do our research.*

5. When you look at the map can you see specific wells?

Response: *You can see well with specific points for well capacity. There is no GPS so its not highly accurate for well locations. It is somewhere within that 2.5 minute box. So we have had to average down the measurements, the average wells are 2 to 3 specific capacity tests within that 2.5 minute area.*

6. I don't understand the difference between light soil and heavy soil?

Response: *One type is sand and one type is clay, that makes the difference between light and heavy soil, respectively.*

7. So everyone of those crops has the same ET, is that because of the sand and clay? Does that sound logical?

Response: *Well obviously they made the distinction because they get the soil type, your going to go after it the same way whether it is heavy soil or light soil. Need to make a differenation.*

8. Would you call those years, 80 to 92 droughts, or are they just the lowest three year averages?

Response: *I would just call them the lowest three year average, because they are virtual and I don't know what you are going to do, it says actual and I am going by contract, your supposed to do the three actual consecutive years, the lowest. I don't know how we are going to handle that. Those years will be simulated to assist in validating the groundwater module.*

9. Could you explain again what that 5 inches means?

Response: *That is inches it has available for crop growth during the entire season that is on these records. This is records acquired through used stored soil moisture blocks.*

10. So we are talking about the plains?

Response: *That's exactly right, it gets contributed therefore its reduced against the crop and rainfall and I will show you.*

11. The rainfall ssm in your equation is what?

Response: You take the percentage times the crop demand and we take off two and that is what is left over for irrigation. And we like to go back and see how that property has grown and look some of that up. This is the process we go through and hopefully that clears up what we have done here.

12. Some of these numbers from county to county are the same, like the Peanut number, its been the same on four charts, cotton has been at 26.54,

Response: But it bounces around. Its just the way the numbers worked out, we did not, it has to do with the weather pattern, I have a little summation on what we are going to see growth factors and ET and your going to see that based on the weather parameters.

13. Is the area that you are using to calculate the ET based on the availability of weather stations information in which case it is more then one county?

Response: In some cases it is and in some cases right now throughout the entire region we have about 22 weather stations and you look at the data and we need wind speed and ratio and so forth, those we got started on that effort back in 1992, and right now we are in an effort to work with the South Plains Network, out of the Lubbock, La Mesa, Seminole, half way stations to take care of that and the problem is getting respectable data to qa/qc. in some cases there might be erroneous data and I think that has been the problem with all of it. The only thing worse then lack of data is lack of good data. Just because you get a number it can confuse you more, and that is one of the things that has helped us with the guys, with some of the meter reading that they have, we have the best perception of what the producers are doing in that county and I know its curious to some people they don't ever want to see the meter reading, but in the end it has been my contention that your going to be better off knowing what is going on then something happening.

14. You have to have at least 23.54 inches to grow peanuts, there is no way you can grow peanuts without it. Could it be that the data on peanuts somewhat skewed as well, as opposed to ...

Response: We work on it every year we are in that ballpark, for the longer term, we are allowing 25 inches.

15. See that is what I can't understand, you have to absolutely have the applications, right isn't that what the IR is?

Response: This happens to be one particular year rainfall, indicates that the average rainfall and the average ET and we are saying you can expect, in this case, to look at a *little better then 25 inches, if you are going to grow peanuts, you can't short them, if you do you short yourself.*

16. What I don't understand is how you got the average?

Response: The difference here and here is the climate of that year, in other words this is ET that was required to grow peanuts for this year, and this time if it was not as hot, a milder season, it requires less, when we look at it over the long term, what your expecting to see overall the long haul, your going to have the 25 inches. And you can expect to use the irrigation quantities to meet this based upon that average rainfall.