Northern Trinity / Woodbine Groundwater Availability Model

Stakeholder Advisory Forum (SAF)

August 5, 2003

R. W. Harden & Associates, Inc.
Hydrologists – Geologists - Engineers

LBG

HDR

FREESE • NICHOLS

USGS
science for a changing world

GAM
Groundwater Availability Modeling

texas water development board

Meeting Outline

- General Information
- Physiography and Climate
- Geology/Hydrostratigraphy
- Structure
- Hydraulic Properties
- Water Levels & Regional Groundwater Flow
- Rivers, Streams, Springs, & Lakes
- Recharge
- Water Quality
- Discharge
- Modeling Approach
- Project Timeline/Questions & Answers

Goals of the GAM Program

- Include substantial stakeholder input
- Provide reliable groundwater availability information
- Predict groundwater conditions over a 50-year planning period
- Produce publicly available groundwater models and supporting data

GAM Project Team

- R.W. Harden & Associates, Inc.
  - Project lead, geology, hydrology, modeling, and reporting
- LBG-Guyton Associates
  - Aquifer characteristics and water levels
- HDR, Inc.
  - Groundwater – surface water interaction
- Freese & Nichols, Inc.
  - Climatic data and stakeholder/RWPG interfacing

Project Team – (continued)

- United States Geological Survey
  - Aquifer data and modeling expertise
- Dr. Joe Yelderman, Jr.
  - Conceptualization of aquifer
- TWDB Staff
  - Technical oversight and assistance
- Stakeholders
  - Real world experience and Project needs/Interests

Why is a Model Needed?

- Numerical model allows for more complex analysis than is possible with analytical methods
- Can be used to assess and interpret certain types of groundwater availability issues and/or concepts
- Allows for comparative analysis and testing and understanding of ‘what-if’ scenarios

Stakeholder Advisory Forum

- Stakeholder participation is important
- SAF Meetings
  - Held about once every four months
- Contact with Project Team encouraged
- SAF presentation materials and GAM information to be posted on TWDB website: http://www.twdb.state.tx.us/gam/trnt_n/trnt_n.htm

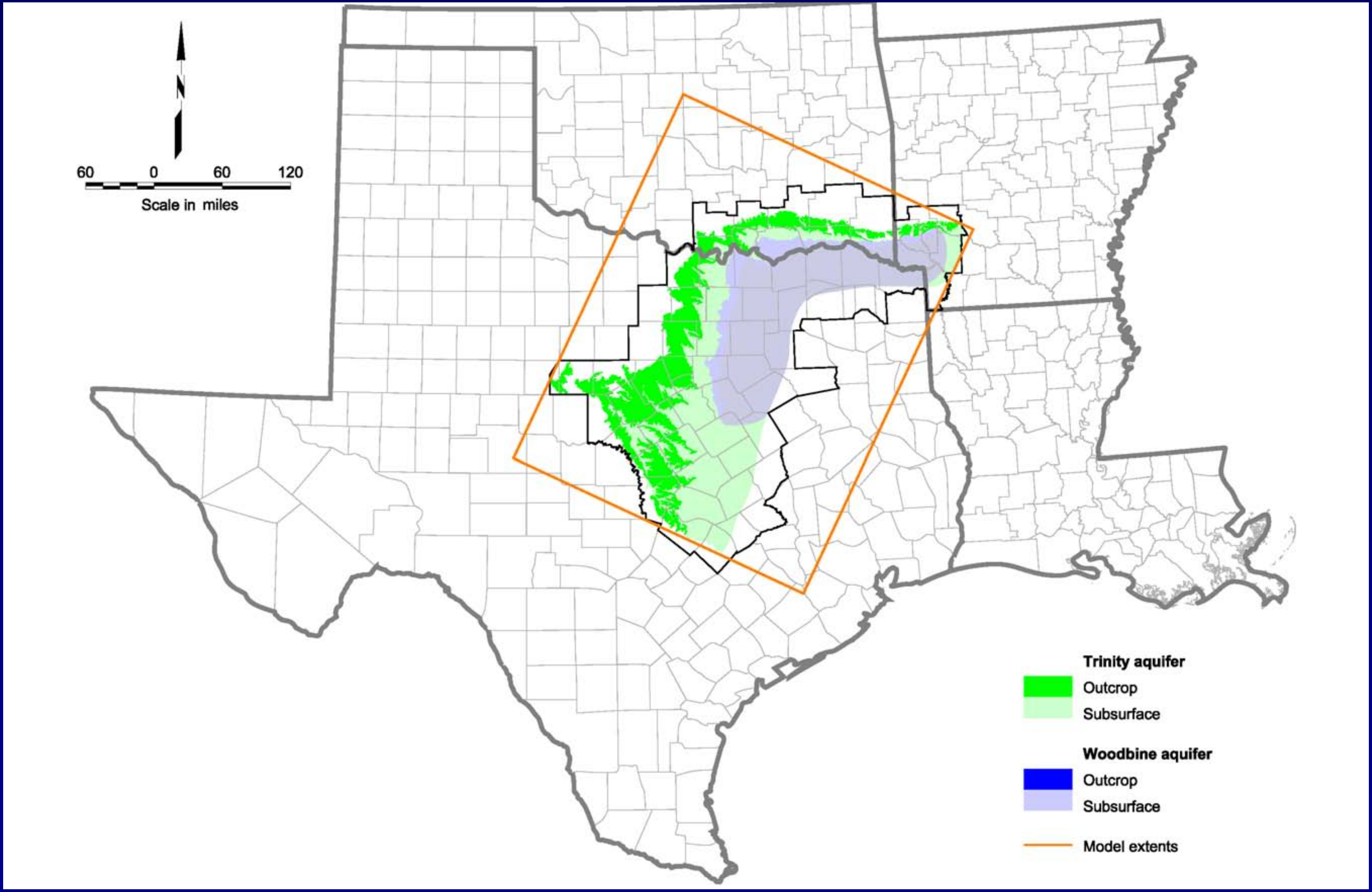
SAF Input

- Your Experiences
  - Historical use
  - Pumping tests
  - Water levels
- Your Interests
  - Identify needs of the model
  - Recognize uses of the model

Project Work Steps

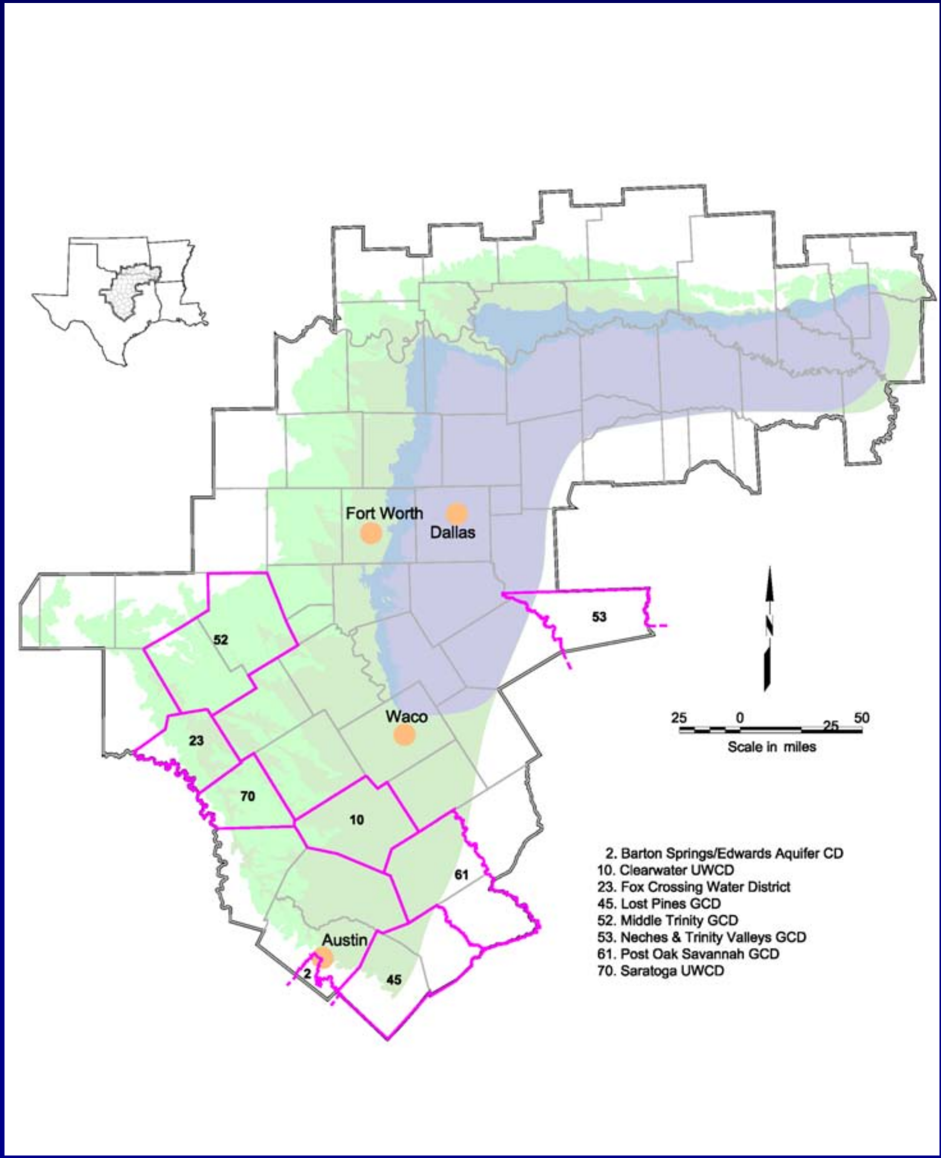
- Aquifer characterization
  - Data components of hydrologic cycle
  - Aquifer geometry and hydraulic characteristics
  - Historical pumpage and water levels
- Computer model development, calibration, and prediction
- Report and data presentation

Study Area

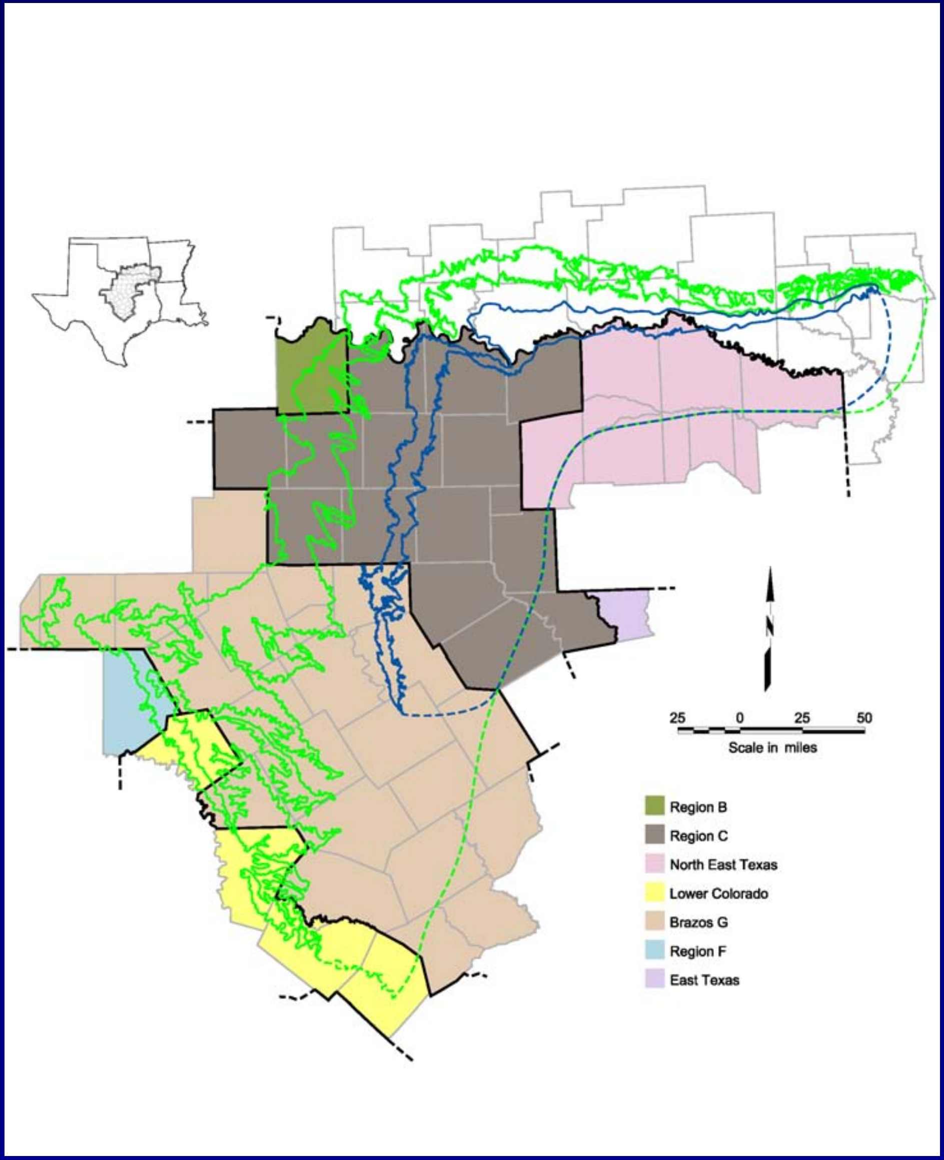


60
0
60
120
Scale in miles
Trinity aquifer
Outcrop
Subsurface
Woodbine aquifer
Outcrop
Subsurface
Model extents

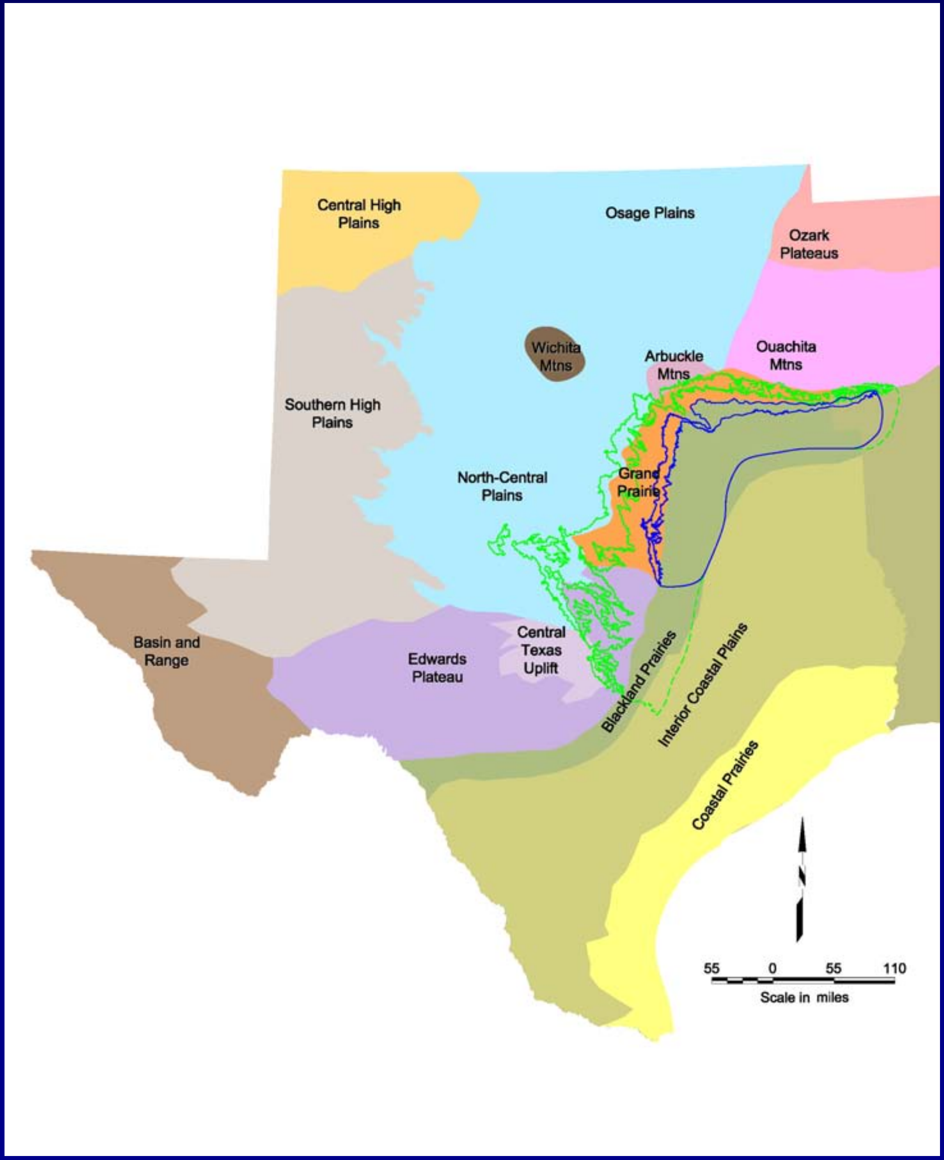
Groundwater Conservation Districts



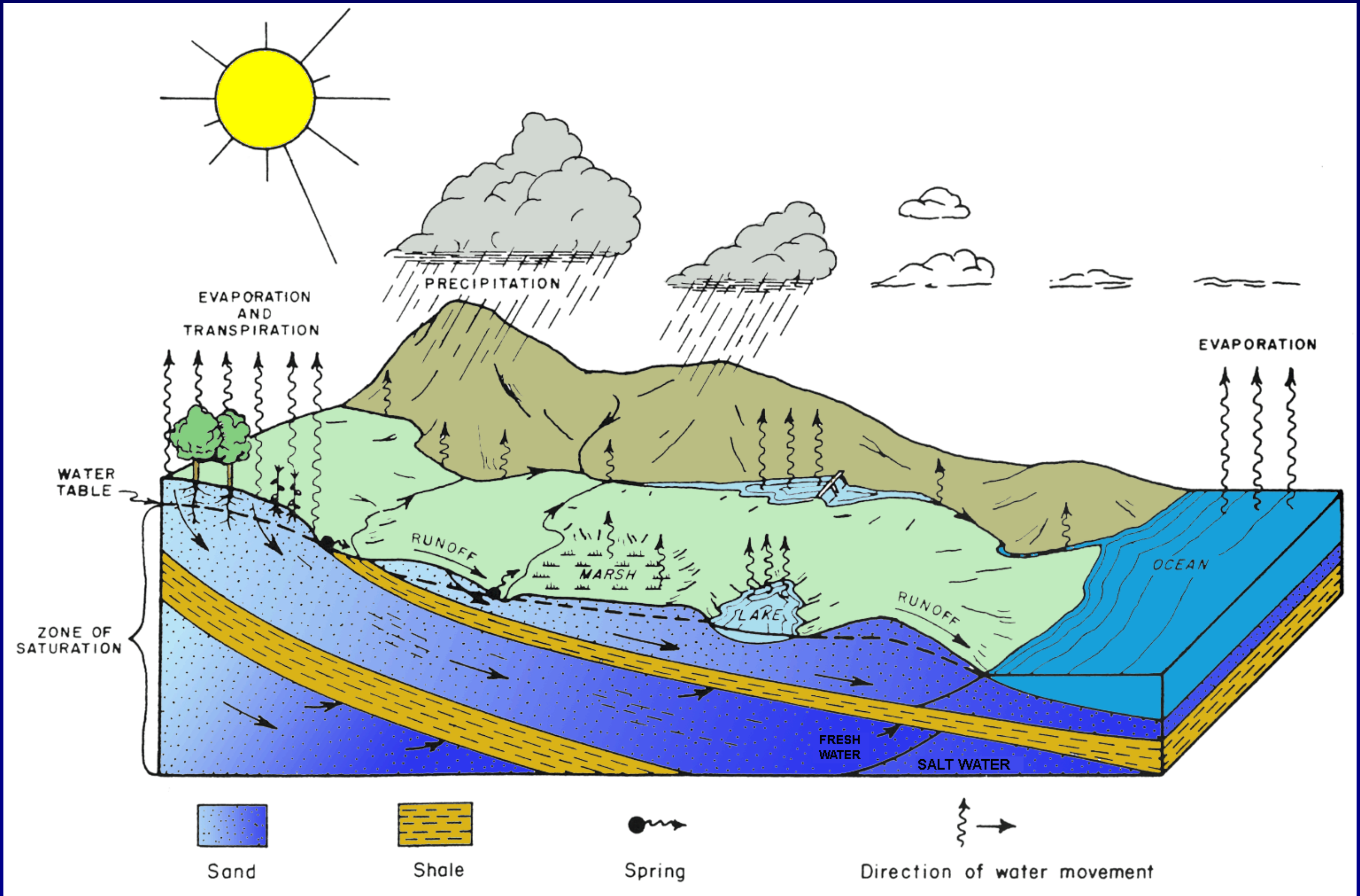
Regional Water Planning Groups



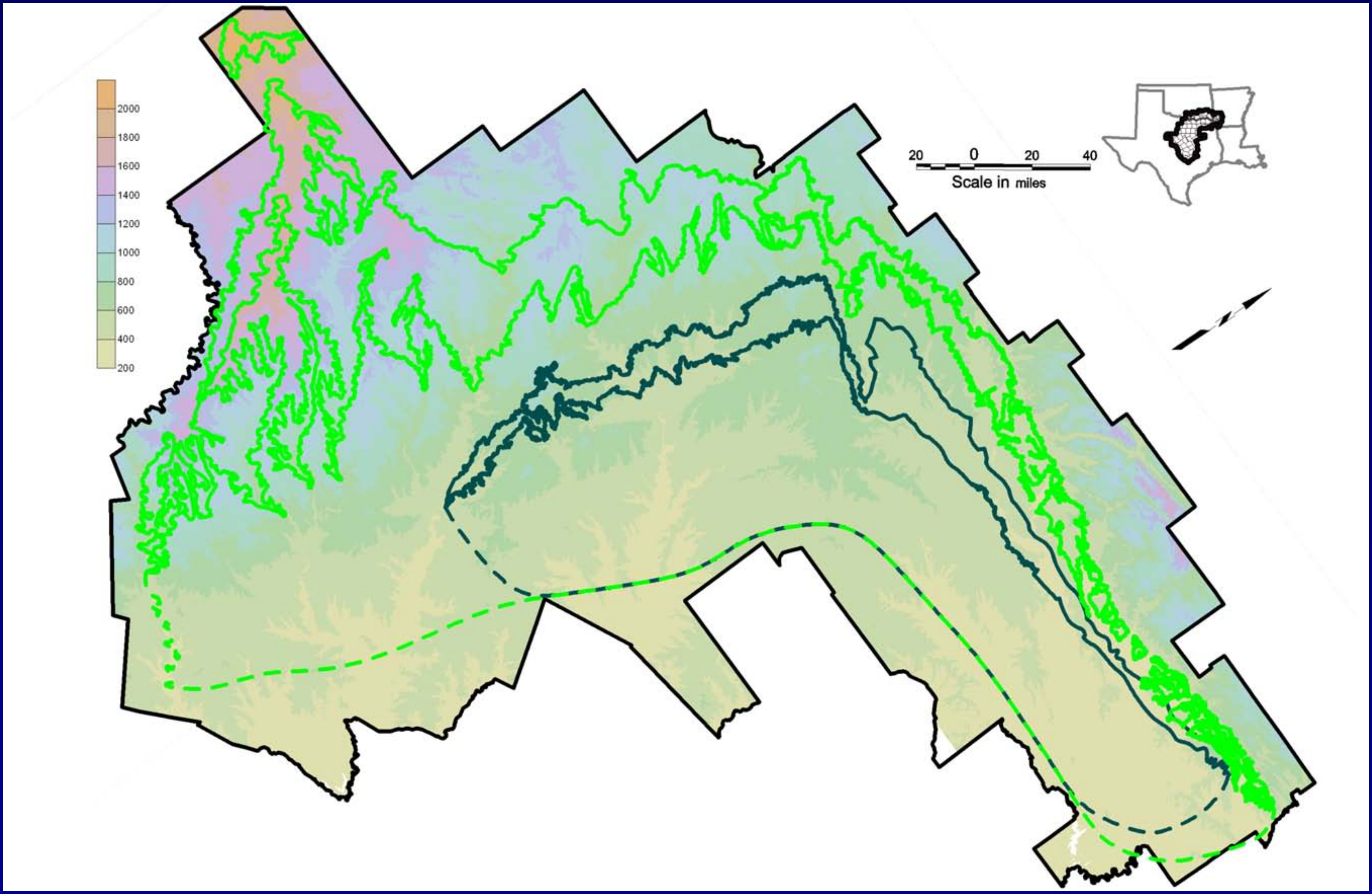
Physiographic Provinces



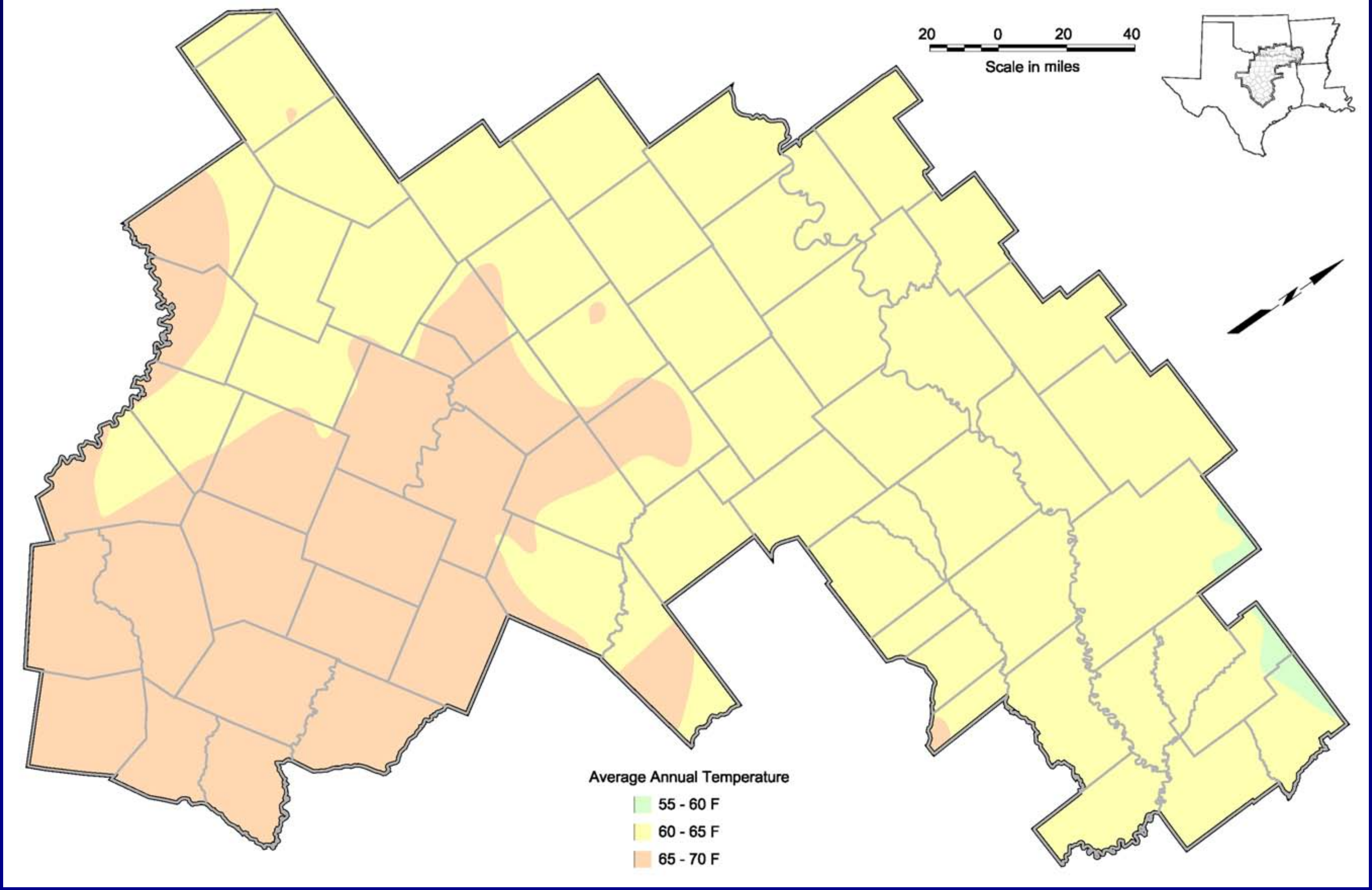
Hydrologic Cycle



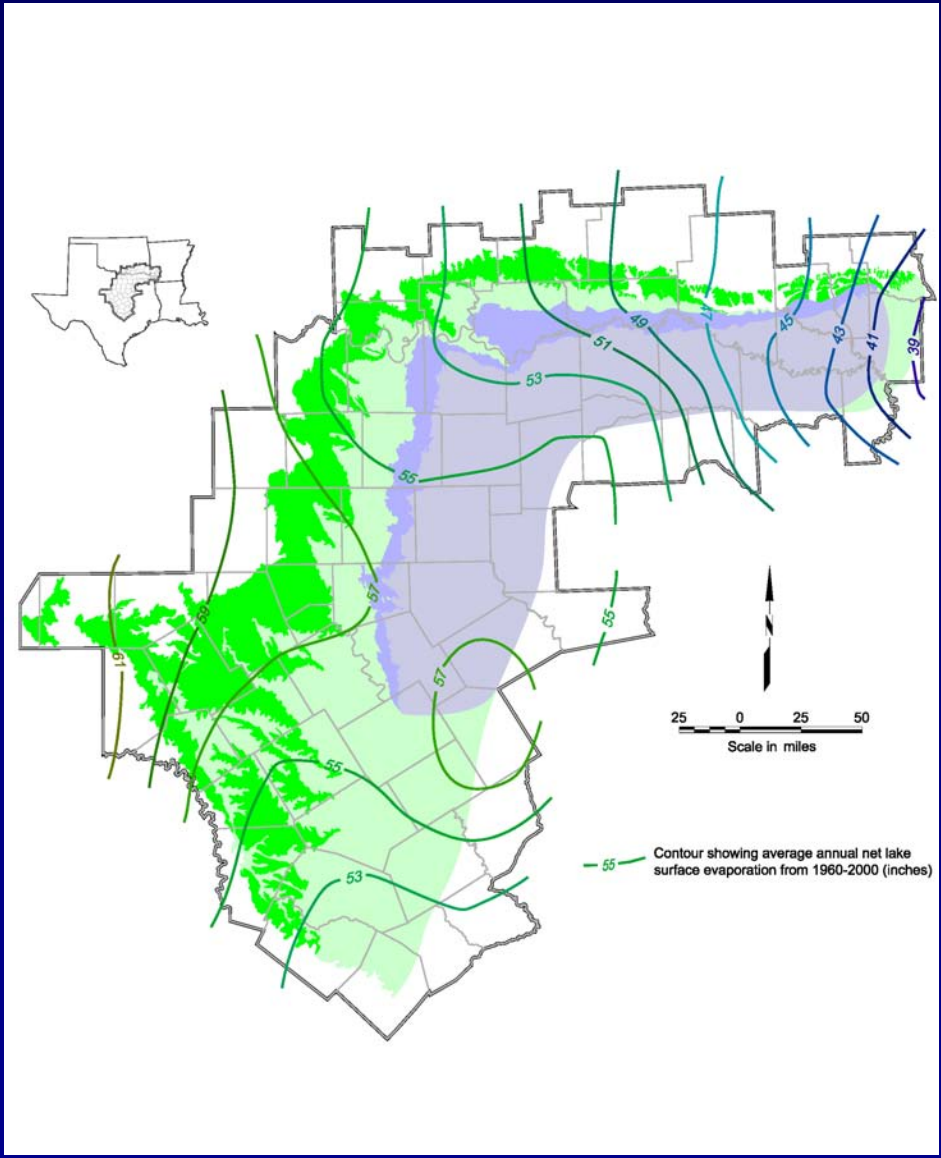
Land Surface Topography



Average Annual Temperature



Average Annual Evaporation



Evapotranspiration

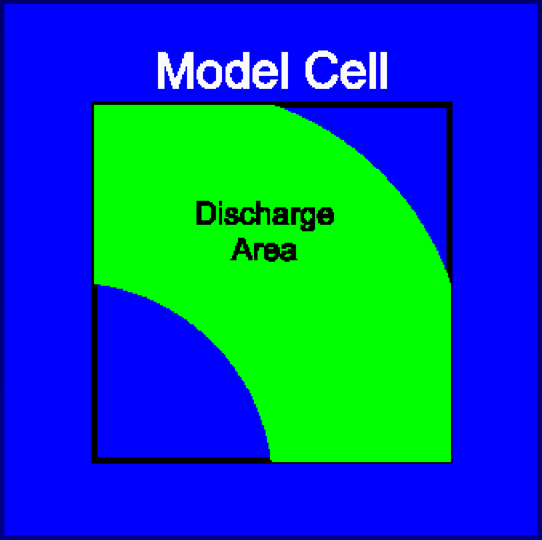
- Supporting Data
  - PET data
  - Pan/Lake Surface Evaporation
  - Land use / Soils mappings
  - Water Table / Topography analytical methods
  - Root Depths
- Data inconclusive to groundwater ET

Evapotranspiration Approach

- Will use available data
  - Root zone depths
  - PET rates
- Adjust PET rates by area analysis

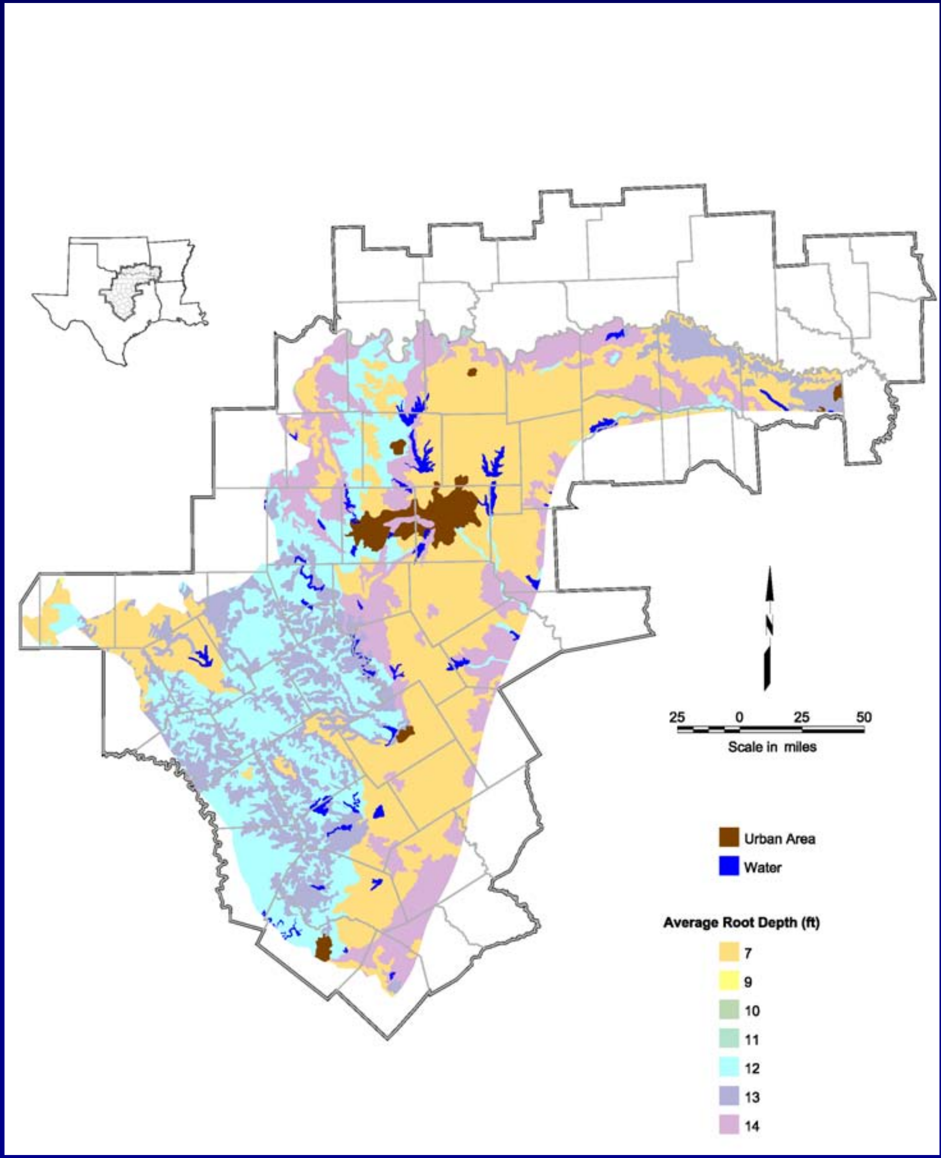
Model Cell ET Rate

- Model cell ET rate is proportional to the ratio of discharge area and model cell area



$$\text{Model ET}_{\text{rate}} = \frac{\text{Discharge Area}}{\text{Model Cell Area}} \times \text{Discharge Area ET}_{\text{Rate}}$$

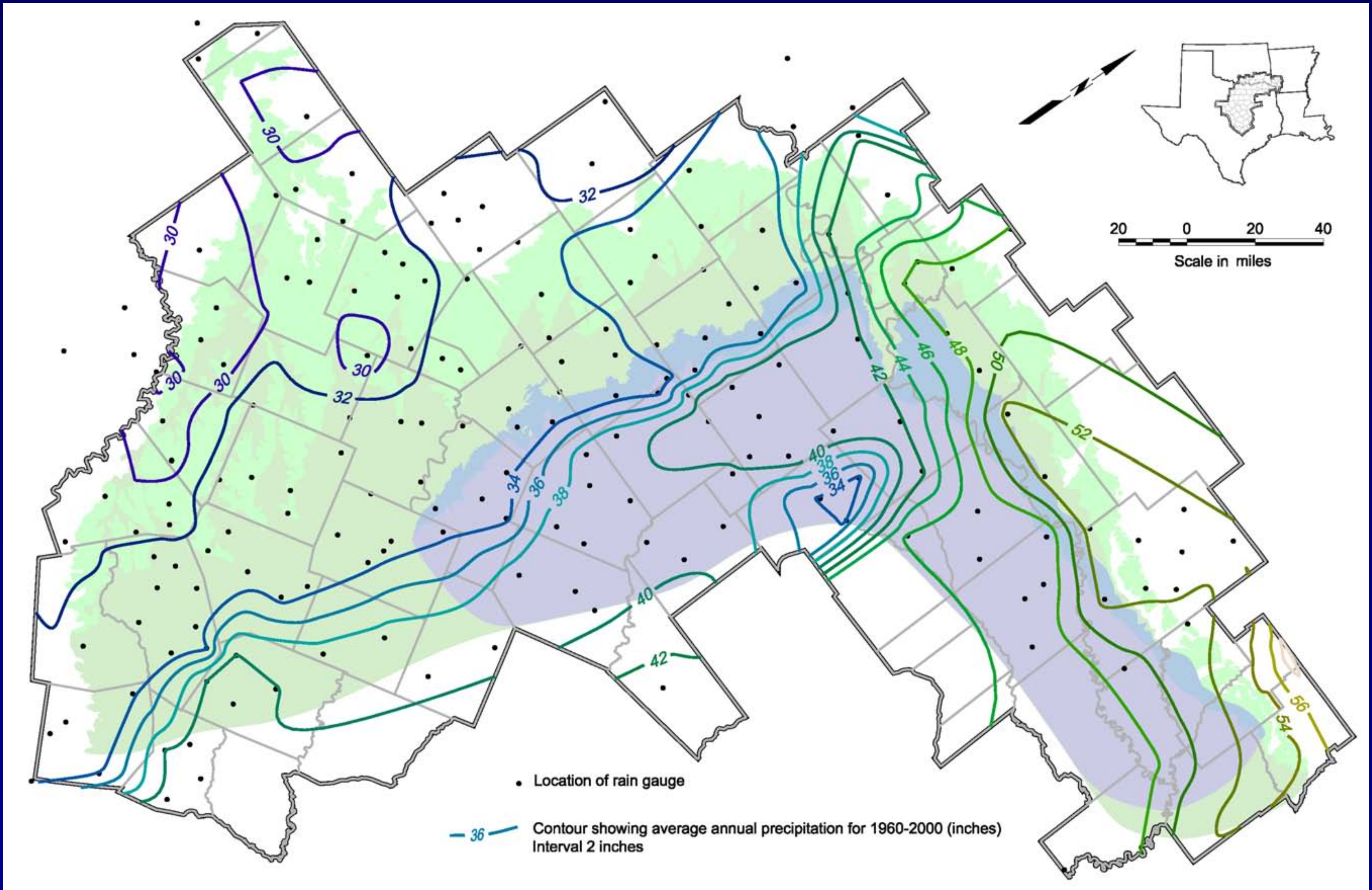
ET – Average Root Depth



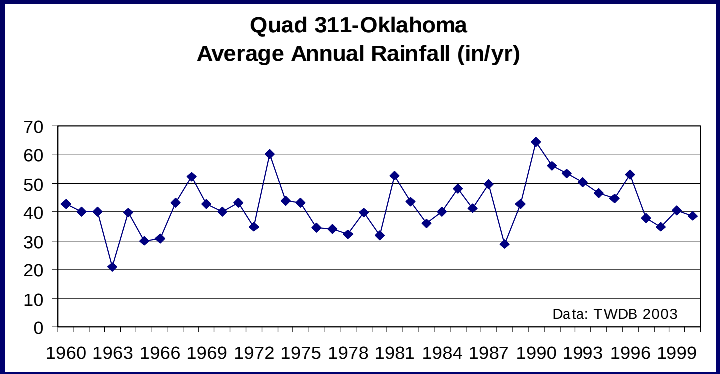
Rainfall Data Analysis

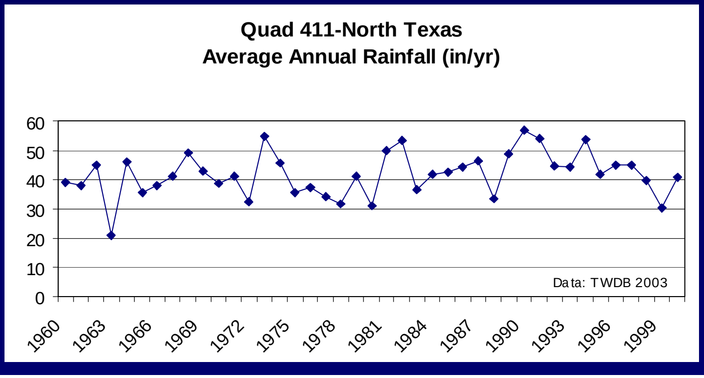
- 193 Precipitation Stations Used to establish 1960-2000 Rainfall Averages
- Average Annual Rainfall
- Historical Hydrographs and Drought of Record

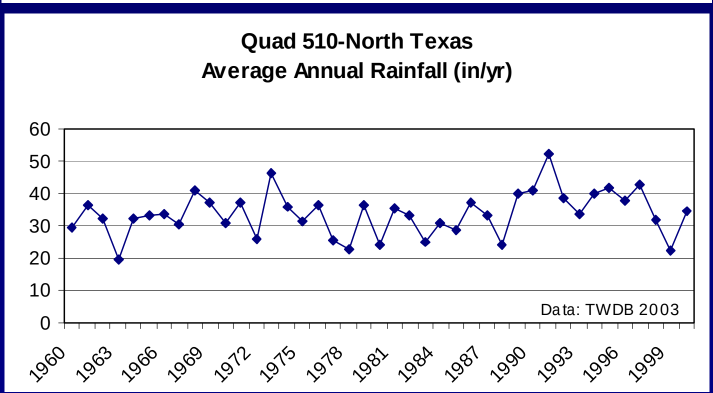
Average Annual Precipitation

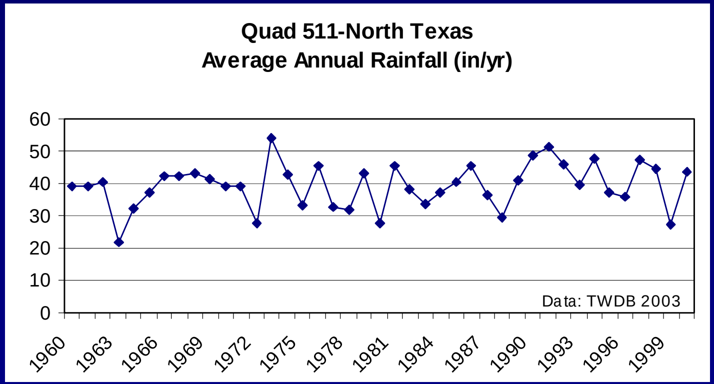


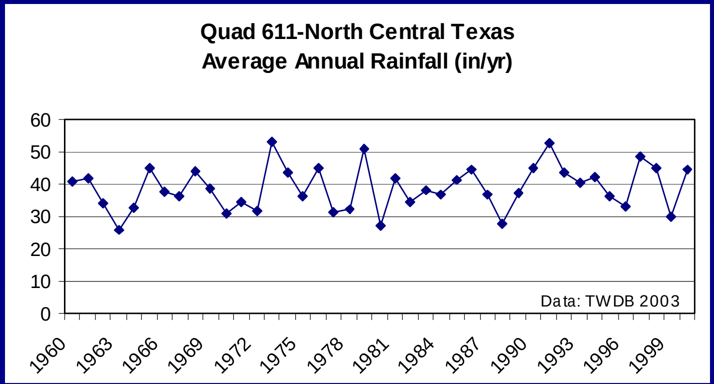
Representative Rainfall Hydrographs

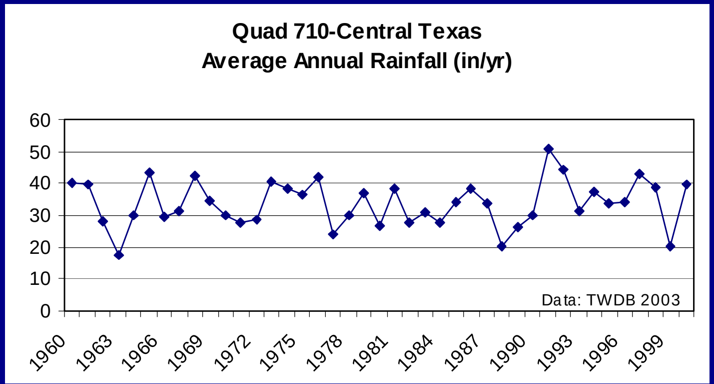












Regional Geology

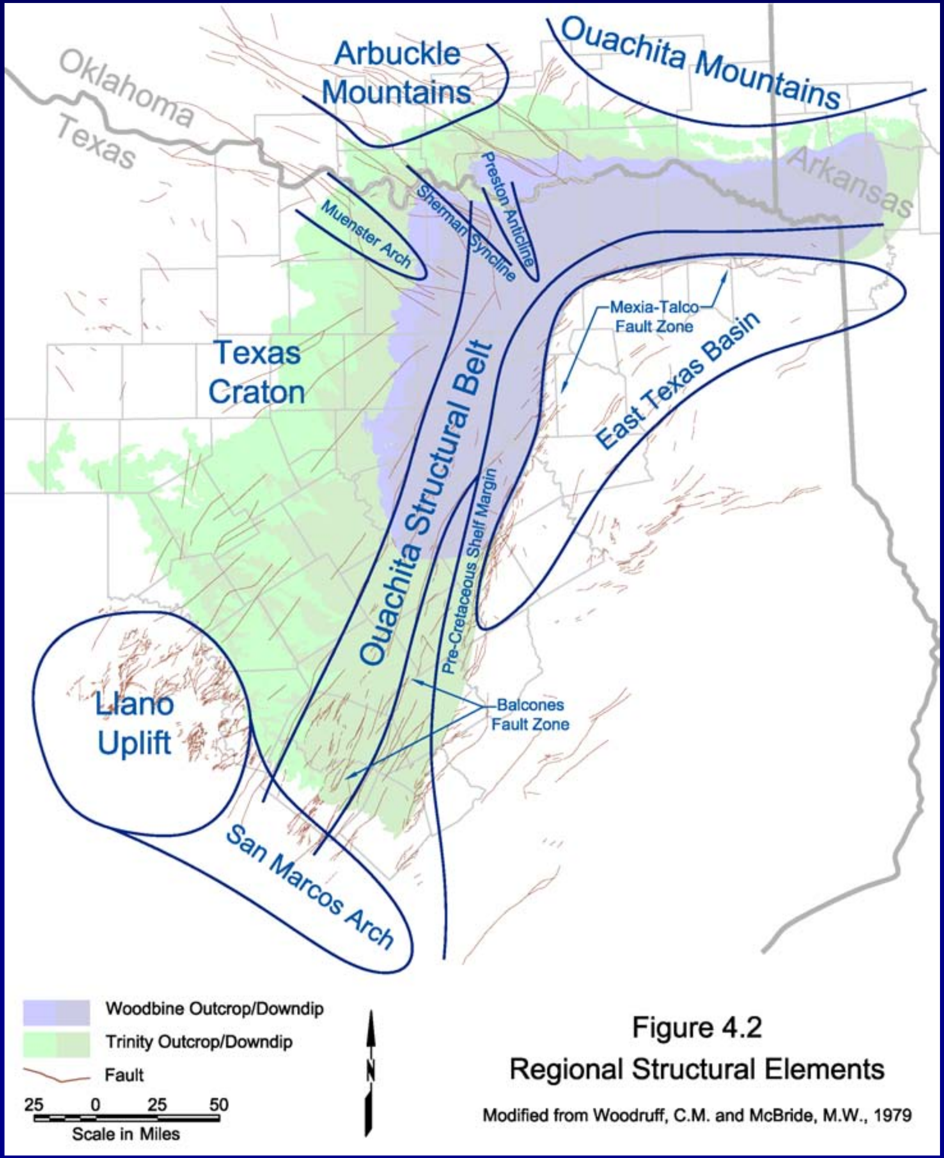
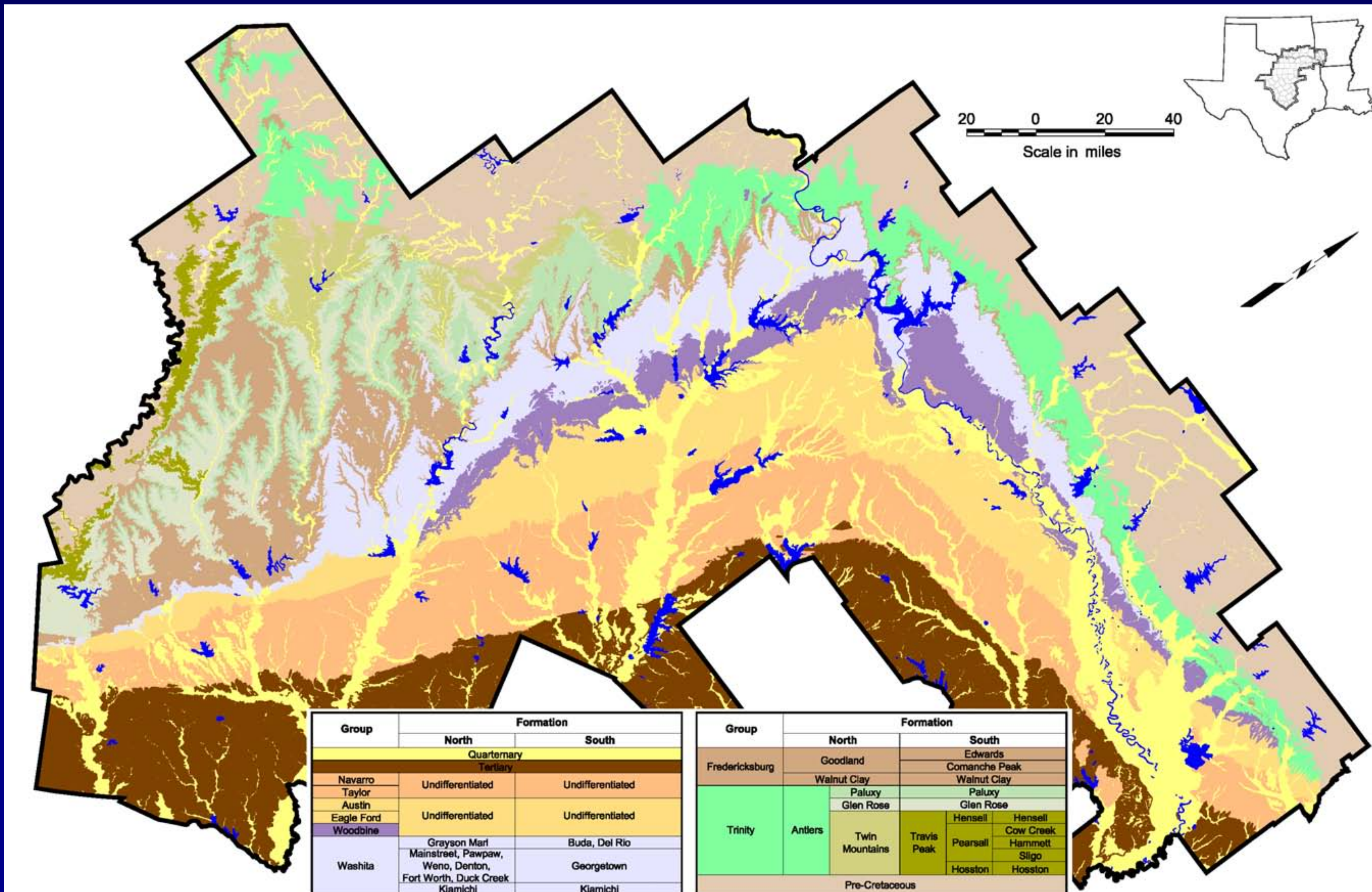


Figure 4.2
Regional Structural Elements

Modified from Woodruff, C.M. and McBride, M.W., 1979

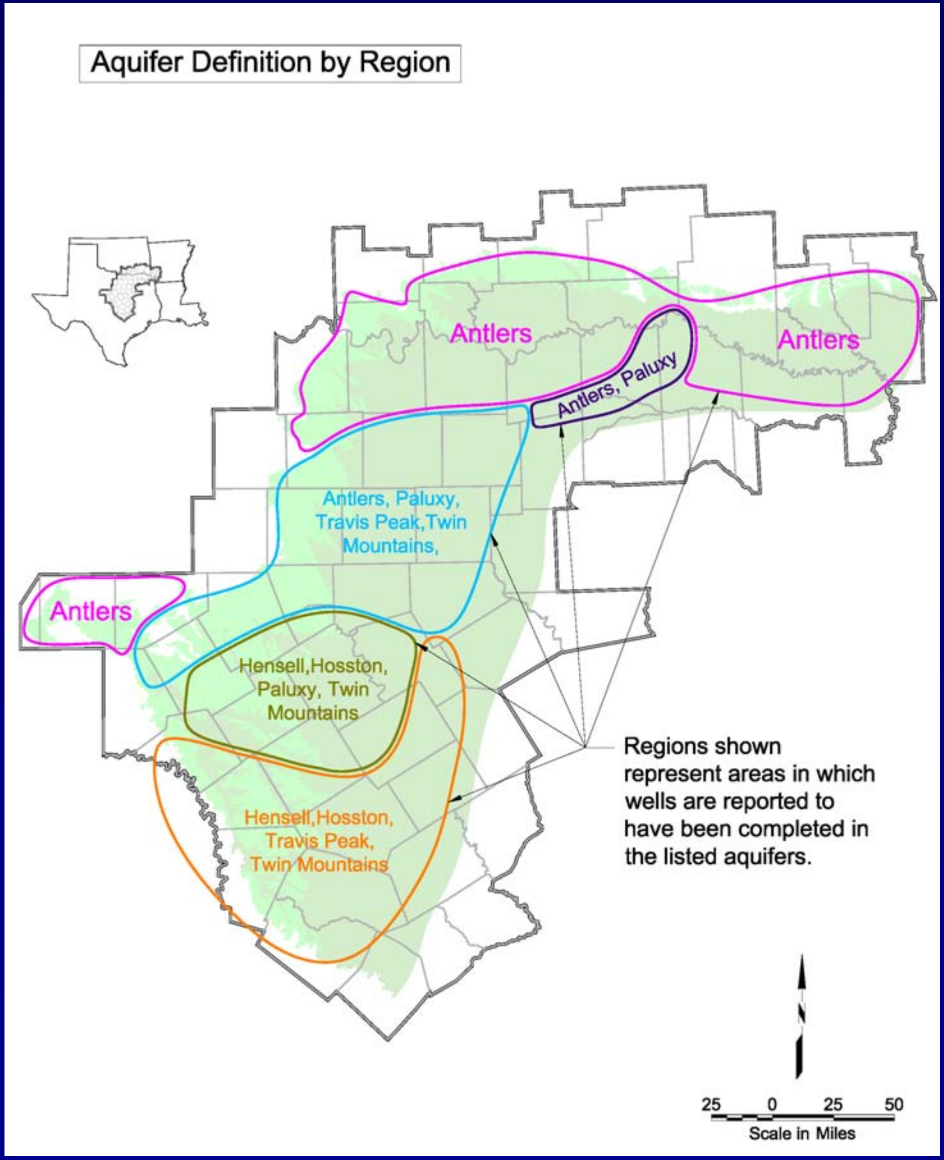
Surface Geology



Group	Formation	
	North	South
Quarternary		
Tertiary		
Navarro	Undifferentiated	Undifferentiated
Taylor		
Austin	Undifferentiated	Undifferentiated
Eagle Ford		
Woodbine		
Washita	Grayson Marl	Buda, Del Rio
	Mainstreet, Pawpaw, Weno, Denton, Fort Worth, Duck Creek	Georgetown
	Kiamichi	Kiamichi

Group	Formation				
	North		South		
Fredericksburg	Goodland		Edwards		
			Comanche Peak		
	Walnut Clay		Walnut Clay		
Trinity	Antlers	Paluxy	Paluxy		
		Glen Rose	Glen Rose		
		Twin Mountains	Travis Peak	Hensell	Hensell
				Pearsall	Cow Creek
					Hammett
					Sligo
				Hosston	Hosston
Pre-Cretaceous					

Generalized Aquifer Regions



Geologic Cross Section A- A'

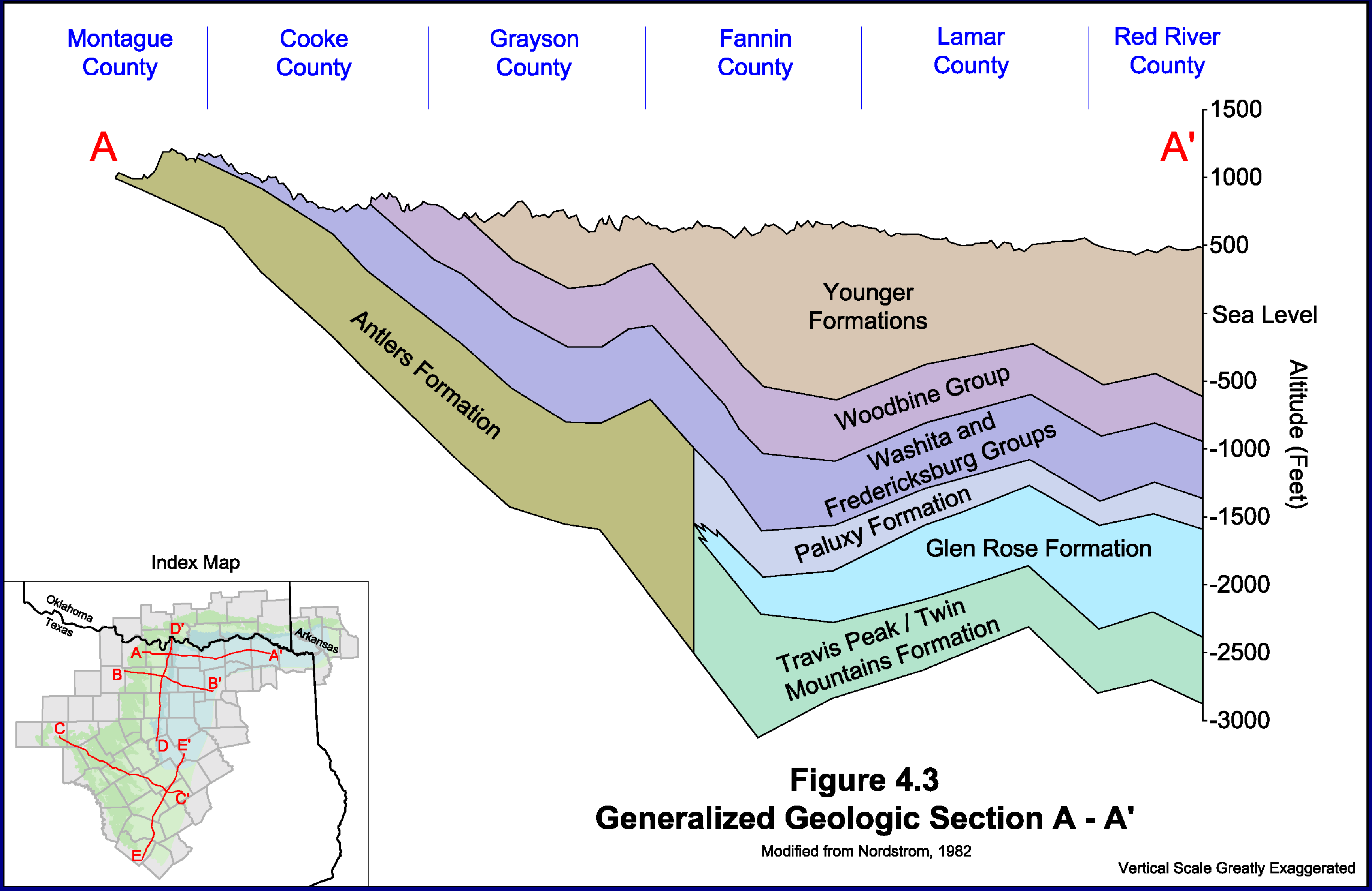
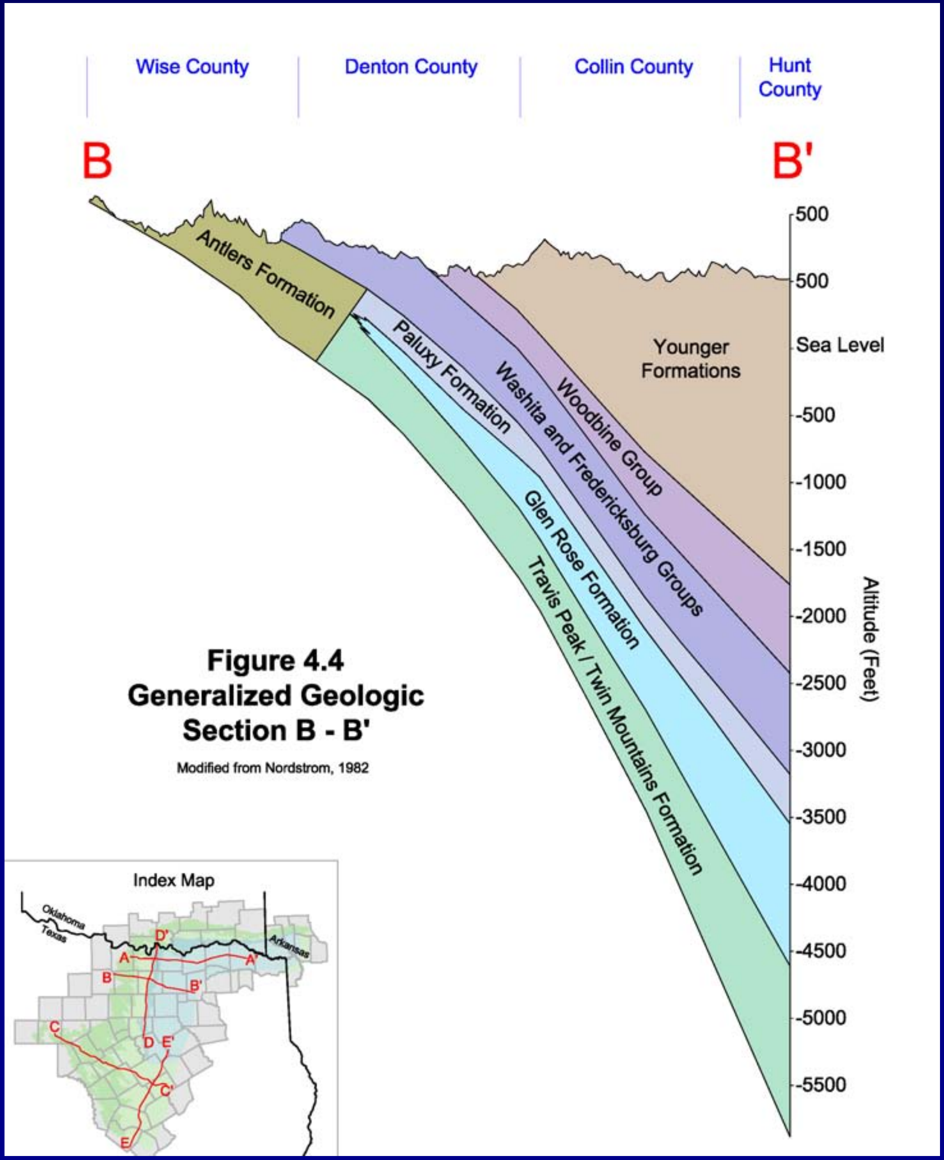


Figure 4.3
Generalized Geologic Section A - A'
Modified from Nordstrom, 1982

Geologic Cross Section B-B’



Geologic Cross Section C-C’

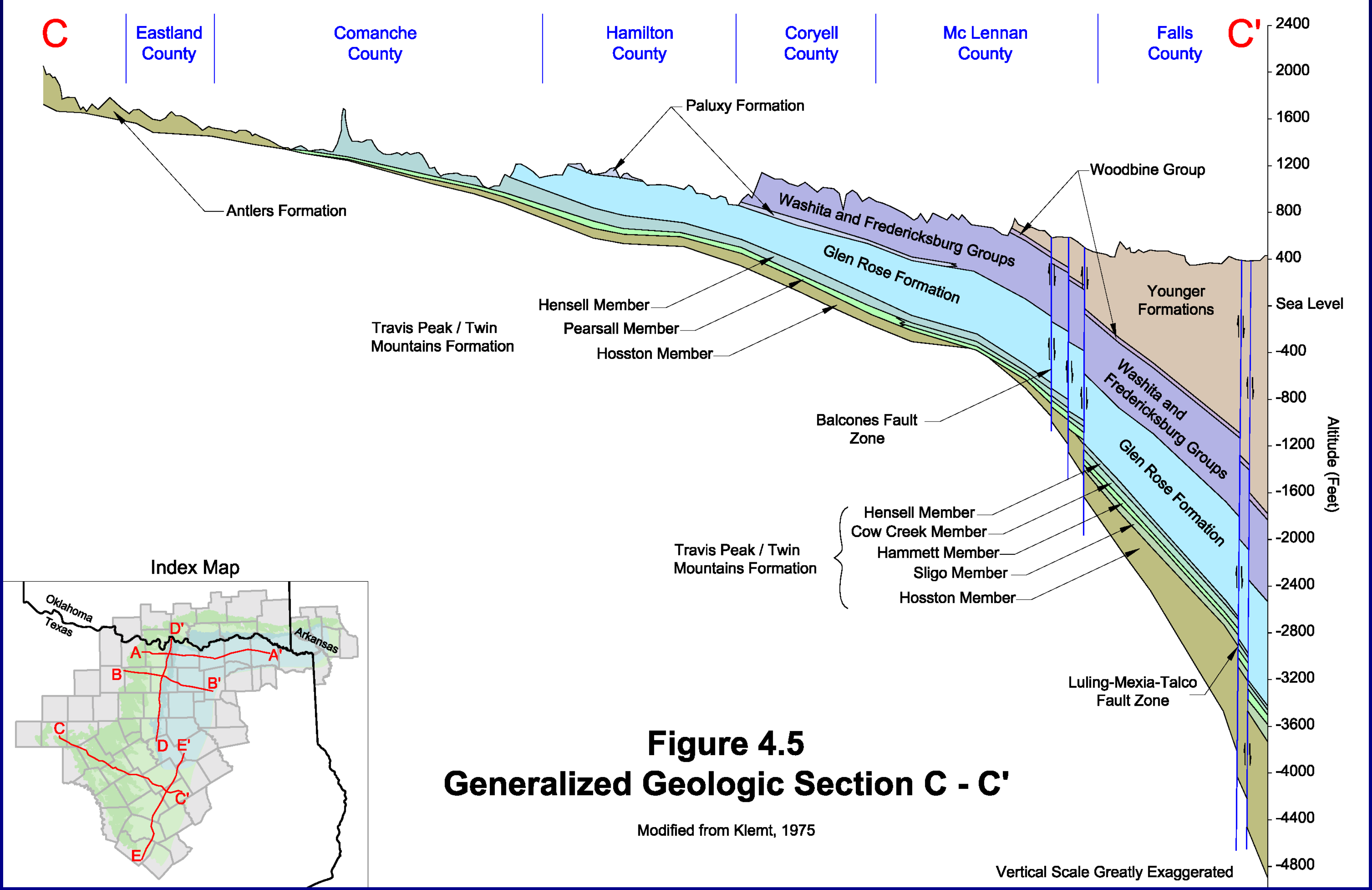


Figure 4.5
Generalized Geologic Section C - C'

Modified from Klemt, 1975

Geologic Cross Section D-D'

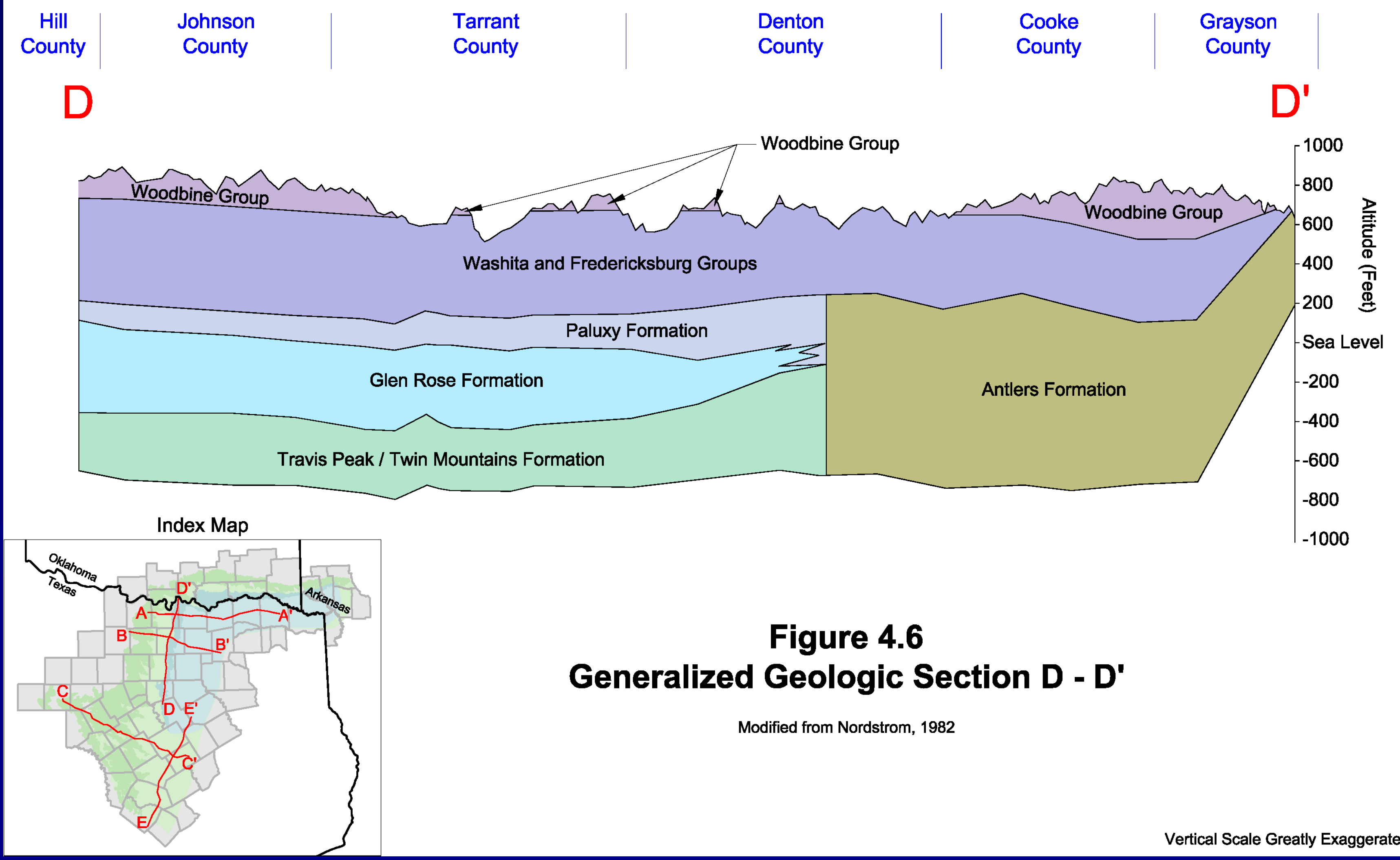


Figure 4.6
Generalized Geologic Section D - D'

Modified from Nordstrom, 1982

Vertical Scale Greatly Exaggerated

Geologic Cross Section E-E'

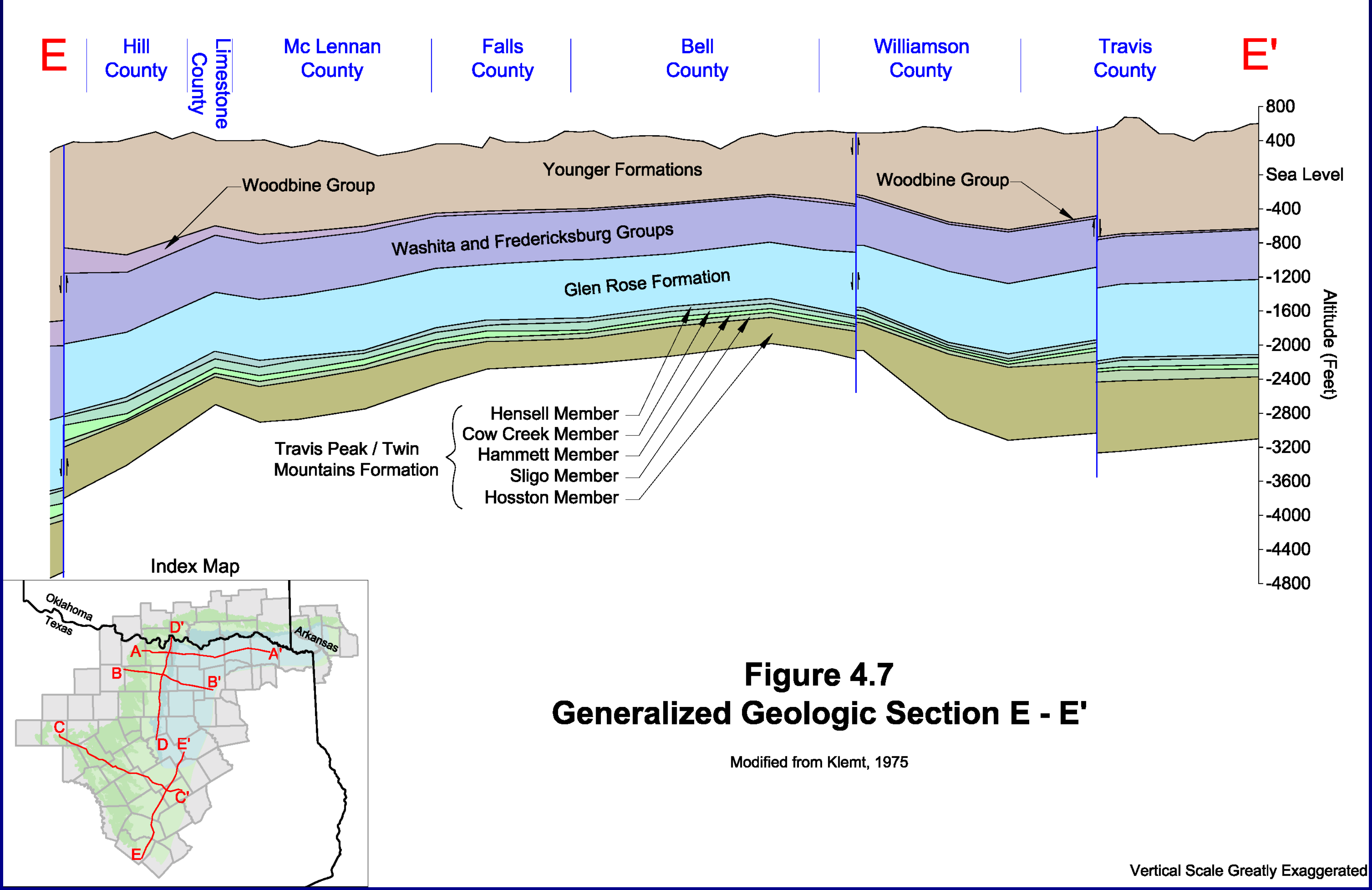


Figure 4.7
Generalized Geologic Section E - E'

Modified from Klemt, 1975

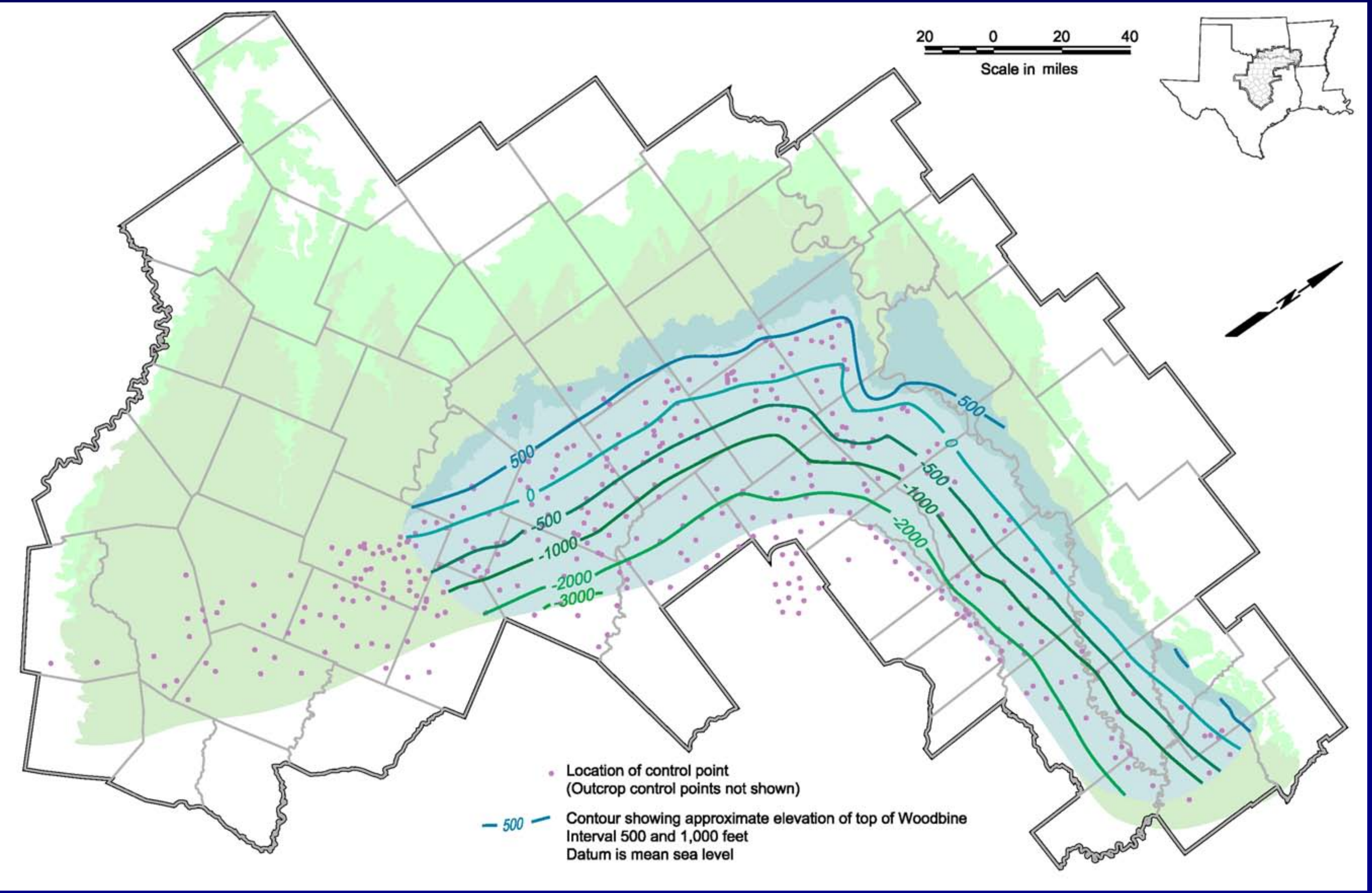
Geology / Hydrostratigraphy

<table>
<tr><th>System</th><th>Series</th><th>Groups</th><th colspan="5">Formation</th><th colspan="2">Approximate Maximum Thickness</th><th>Model Layers</th></tr>
<tr><td colspan="3"></td><td colspan="2">North</td><td colspan="3">South</td><td>North</td><td>South</td><td rowspan="2"></td></tr>
<tr><td>Tertiary</td><td colspan="9">Undifferentiated</td></tr>
<tr><td rowspan="19">Cretaceous</td><td rowspan="5">Gulfian</td><td>Navarro</td><td colspan="2" rowspan="5">Undifferentiated</td><td colspan="3" rowspan="5">Undifferentiated</td><td>800</td><td>550</td><td rowspan="4">GHB</td></tr>
<tr><td>Taylor</td><td>1500</td><td>1,100</td></tr>
<tr><td>Austin</td><td>700</td><td>600</td></tr>
<tr><td>Eagle Ford</td><td>650</td><td>300</td></tr>
<tr><td>Woodbine</td><td>700</td><td>200</td><td>1</td></tr>
<tr><td rowspan="14">Comachian</td><td rowspan="4">Washita</td><td colspan="2">Grayson Marl</td><td colspan="3">Buda, Del Rio</td><td rowspan="4">1,000</td><td>150</td><td rowspan="7">2</td></tr>
<tr><td colspan="2">Mainstreet, Pawpaw, Weno, Denton</td><td colspan="3" rowspan="2">Georgetown</td><td rowspan="2">150</td></tr>
<tr><td colspan="2">Fort Worth, Duck Creek</td></tr>
<tr><td colspan="2">Kiamichi</td><td colspan="3">Kiamichi</td><td>50</td></tr>
<tr><td rowspan="3">Fredricksburg</td><td colspan="2" rowspan="2">Goodland</td><td colspan="3">Edwards</td><td rowspan="3">250</td><td>175</td></tr>
<tr><td colspan="3">Comanche Peak</td><td>150</td></tr>
<tr><td colspan="2">Walnut Clay</td><td colspan="3">Walnut Clay</td><td>200</td></tr>
<tr><td rowspan="7">Trinity</td><td rowspan="7">Antlers</td><td>Paluxy</td><td colspan="3">Paluxy</td><td>400</td><td>200</td><td>3</td></tr>
<tr><td>Glen Rose</td><td colspan="3">Glen Rose</td><td>1,500</td><td>1,500</td><td>4</td></tr>
<tr><td rowspan="5">Twin Mountains</td><td rowspan="5">Travis Peak</td><td>Hensell</td><td>Hensell</td><td rowspan="5">1,000</td><td rowspan="5">1,800</td><td>5</td></tr>
<tr><td rowspan="3">Pearsall</td><td>Cow Creek</td><td rowspan="3">6</td></tr>
<tr><td>Hammett</td></tr>
<tr><td>Sligo</td></tr>
<tr><td>Hosston</td><td>Hosston</td><td>7</td></tr>
<tr><td>Paleozoic</td><td colspan="9">Undifferentiated</td><td></td></tr>
</table>

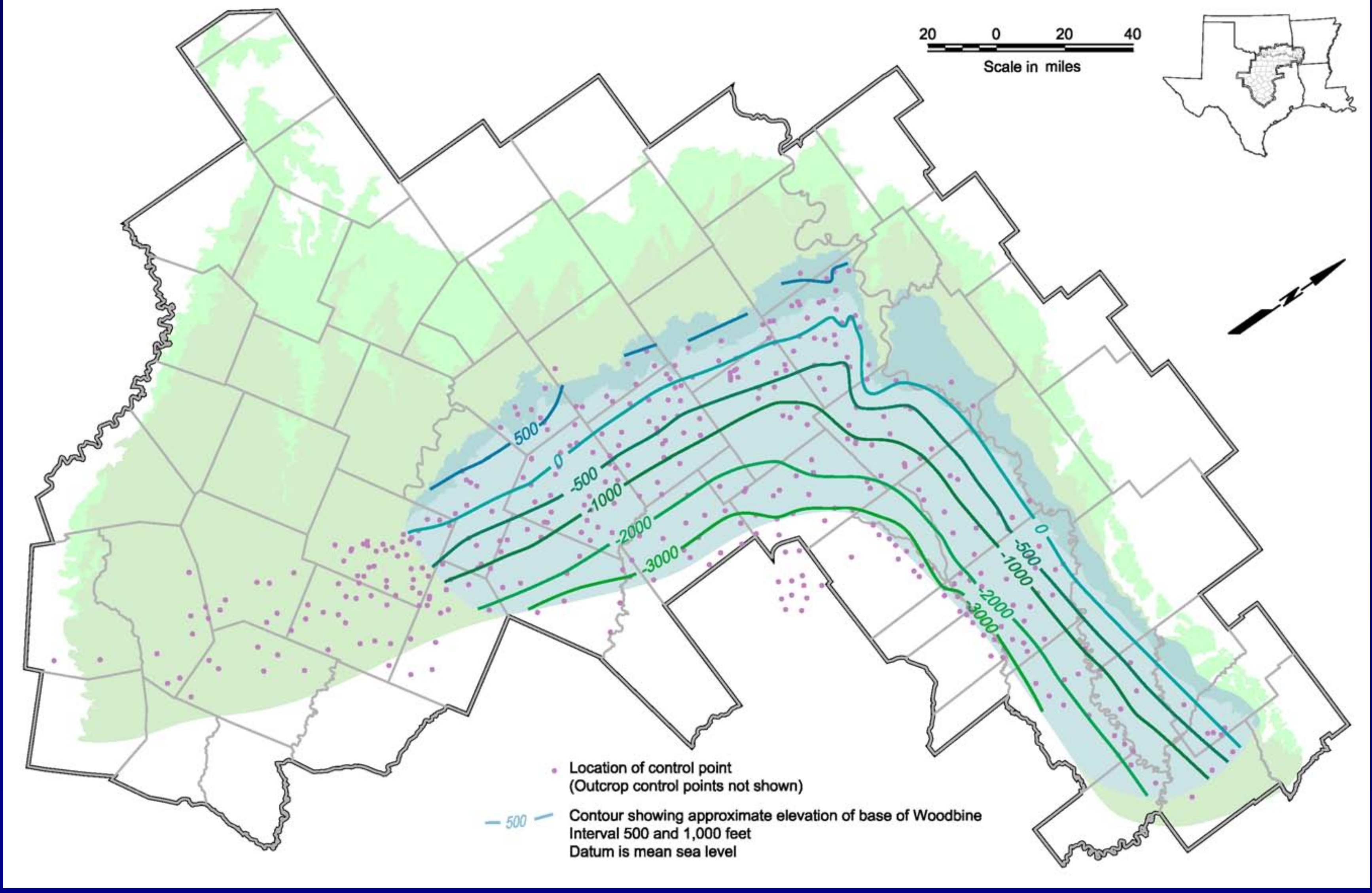
Structure Mappings

- Stratigraphic determinations made on about 800 geophysical logs
- Geophyisical log sources
  - TCEQ Surface Casing Division
  - TWDB Well Records
  - USGS Library

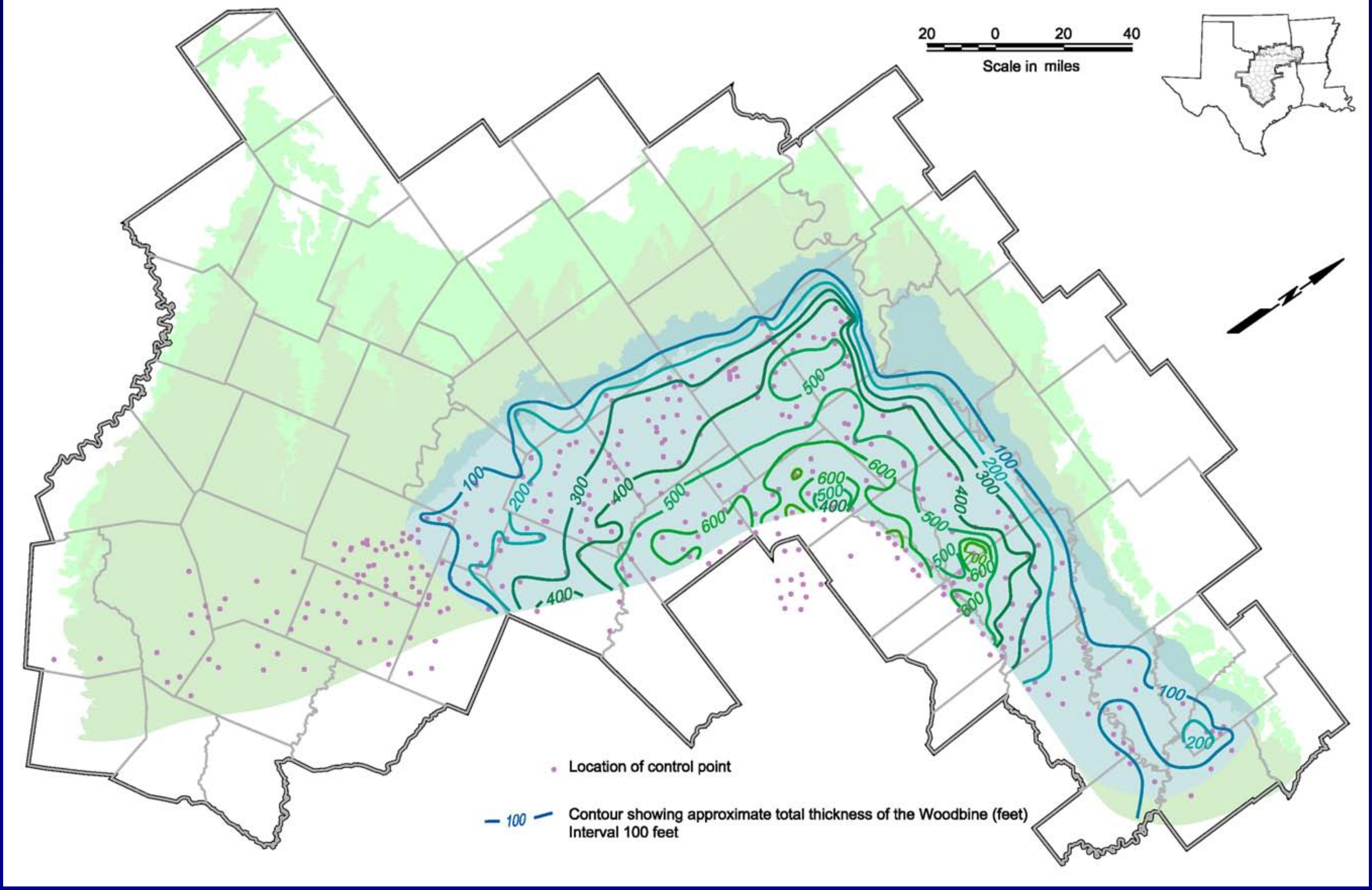
Elevation of Top of Woodbine



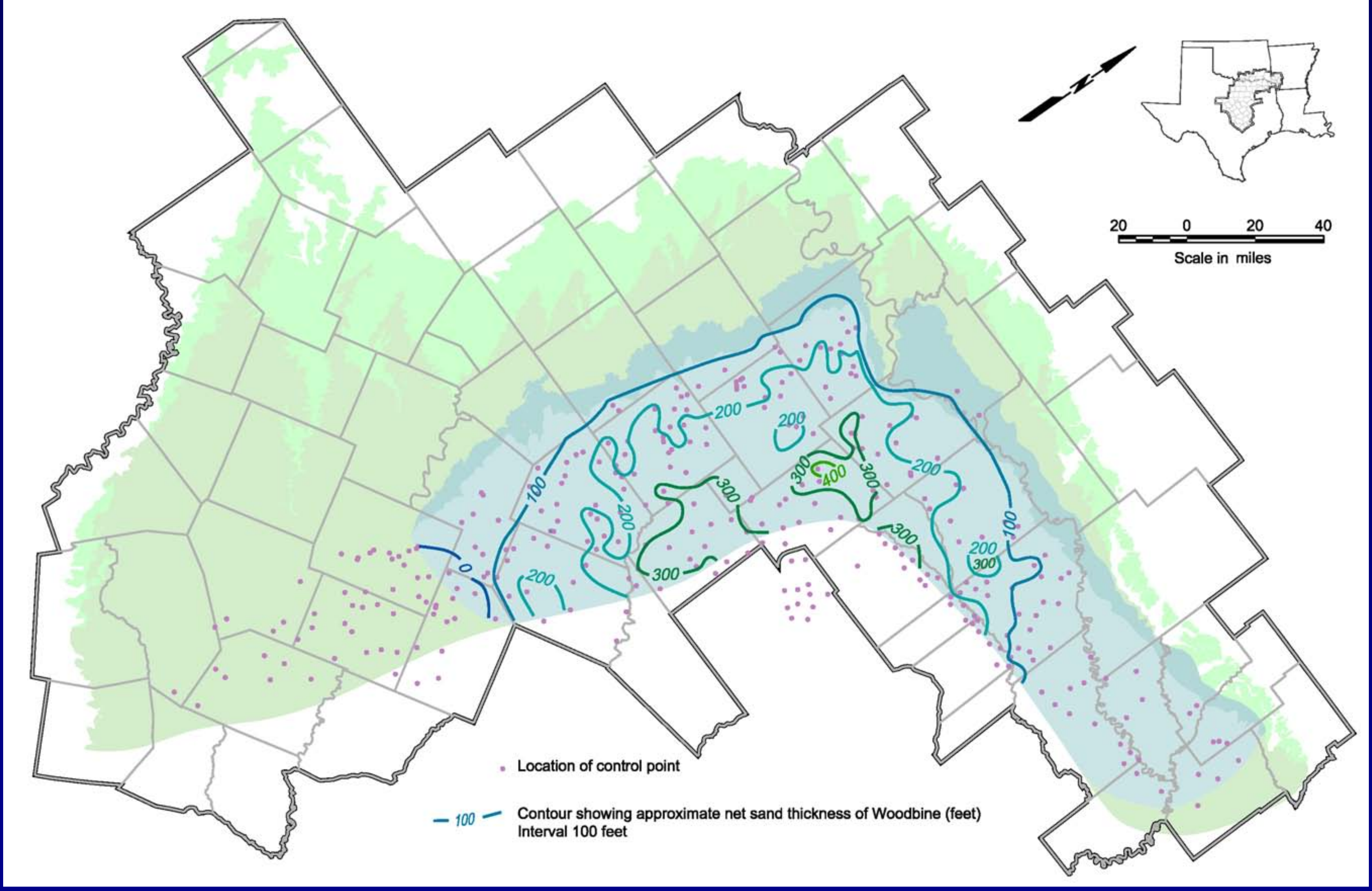
Elevation of Base of Woodbine



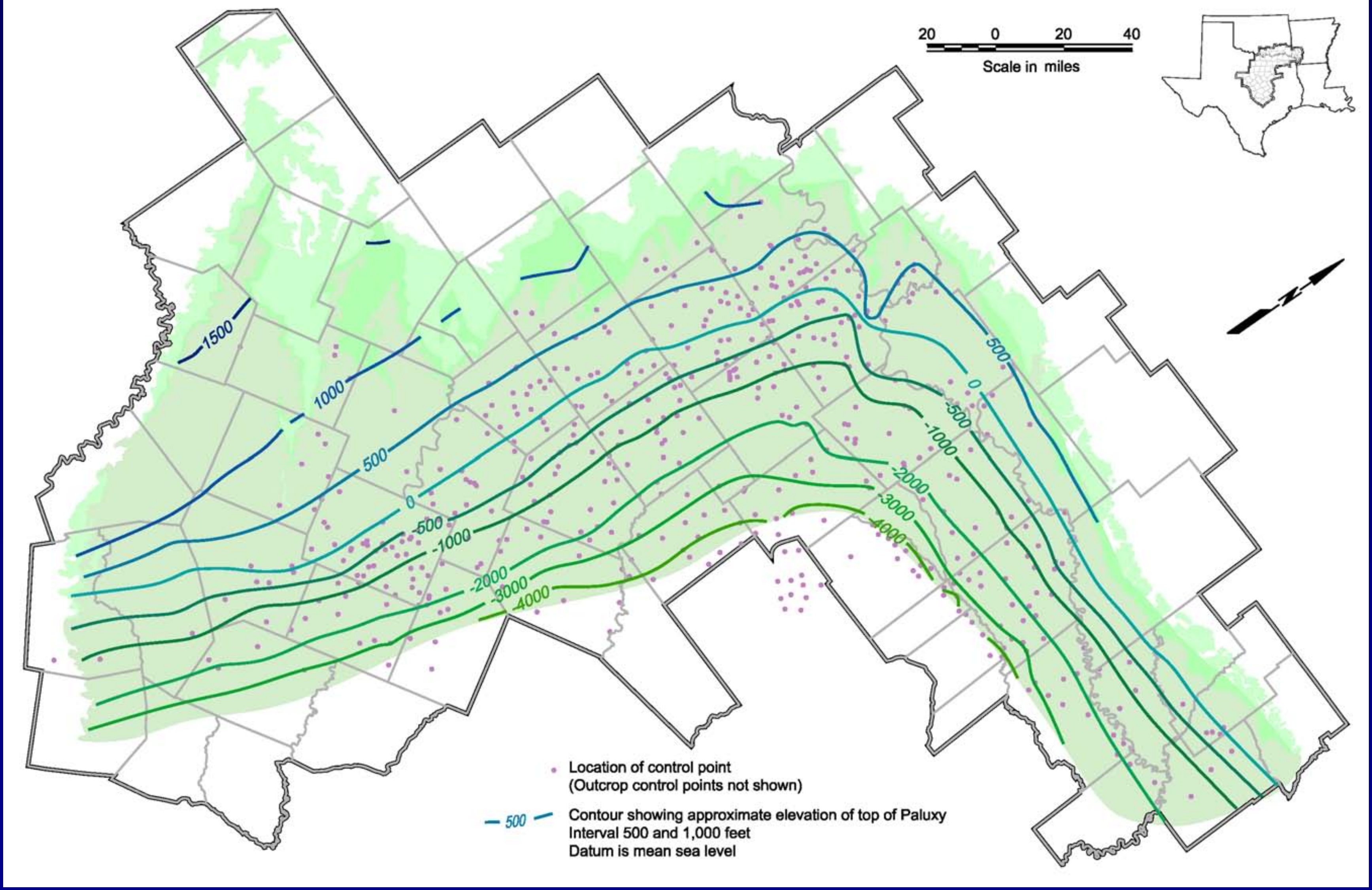
Net Thickness of Woodbine



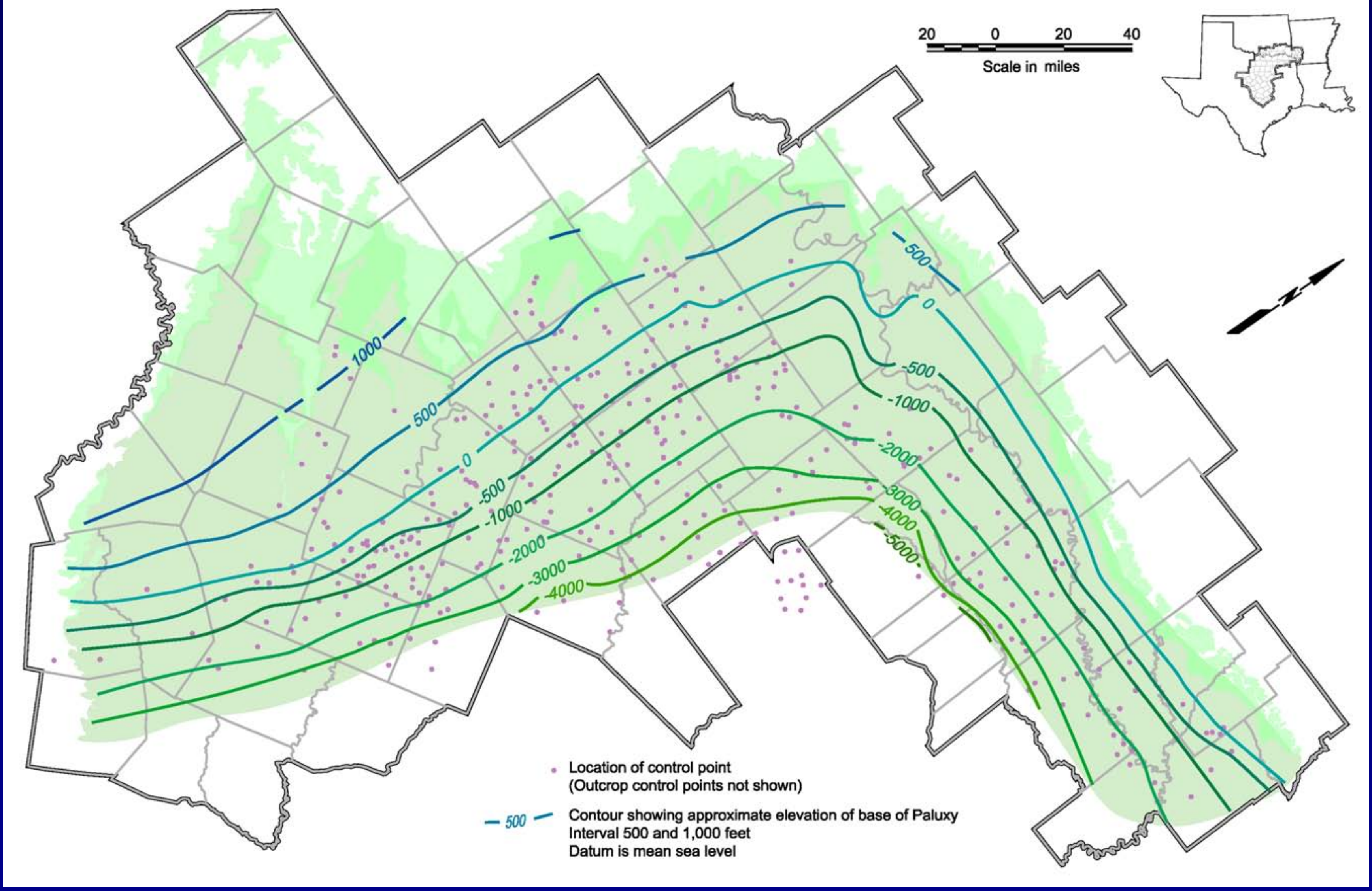
Net Sand Thickness of Woodbine



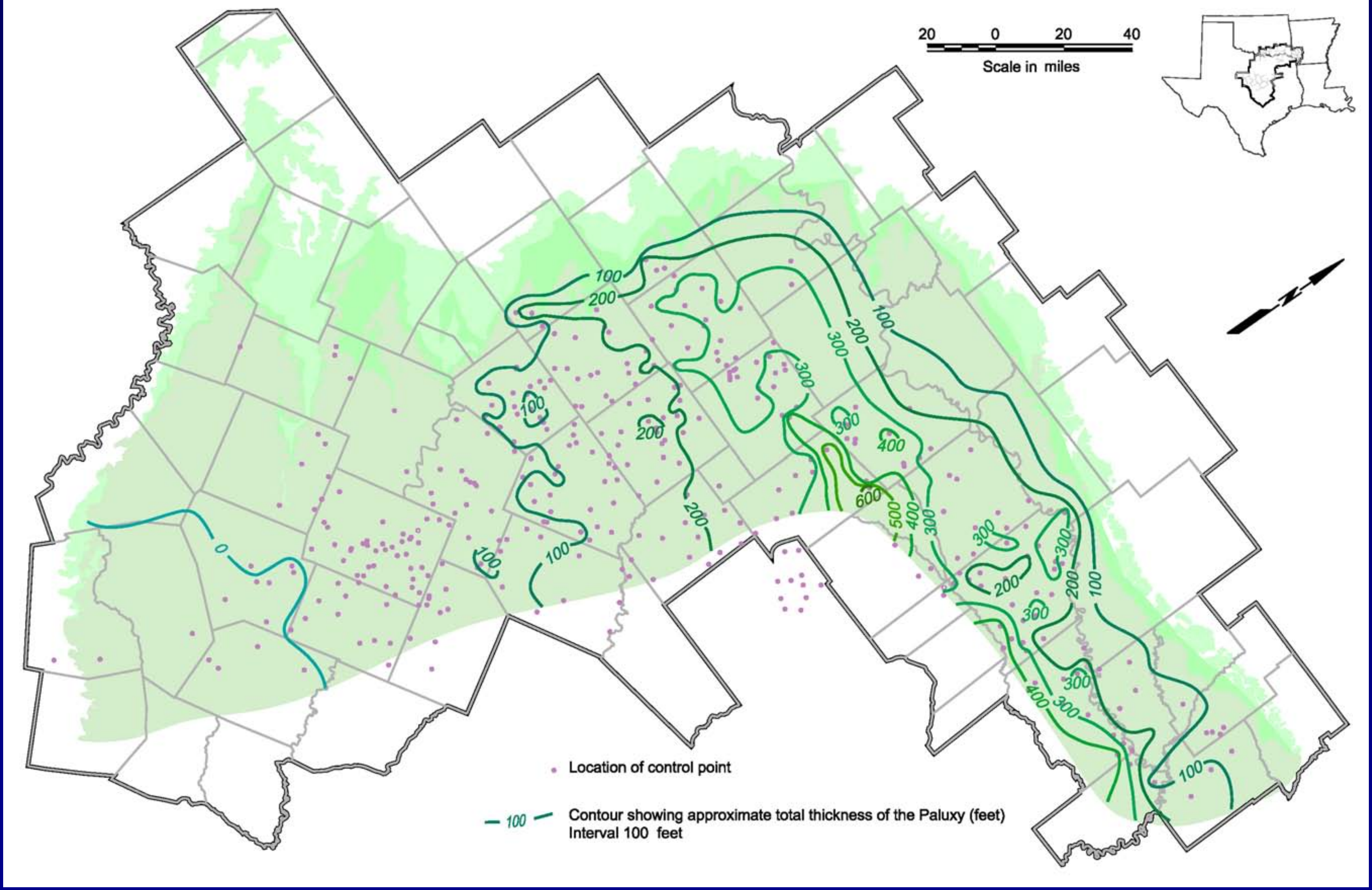
Elevation of Top of Paluxy



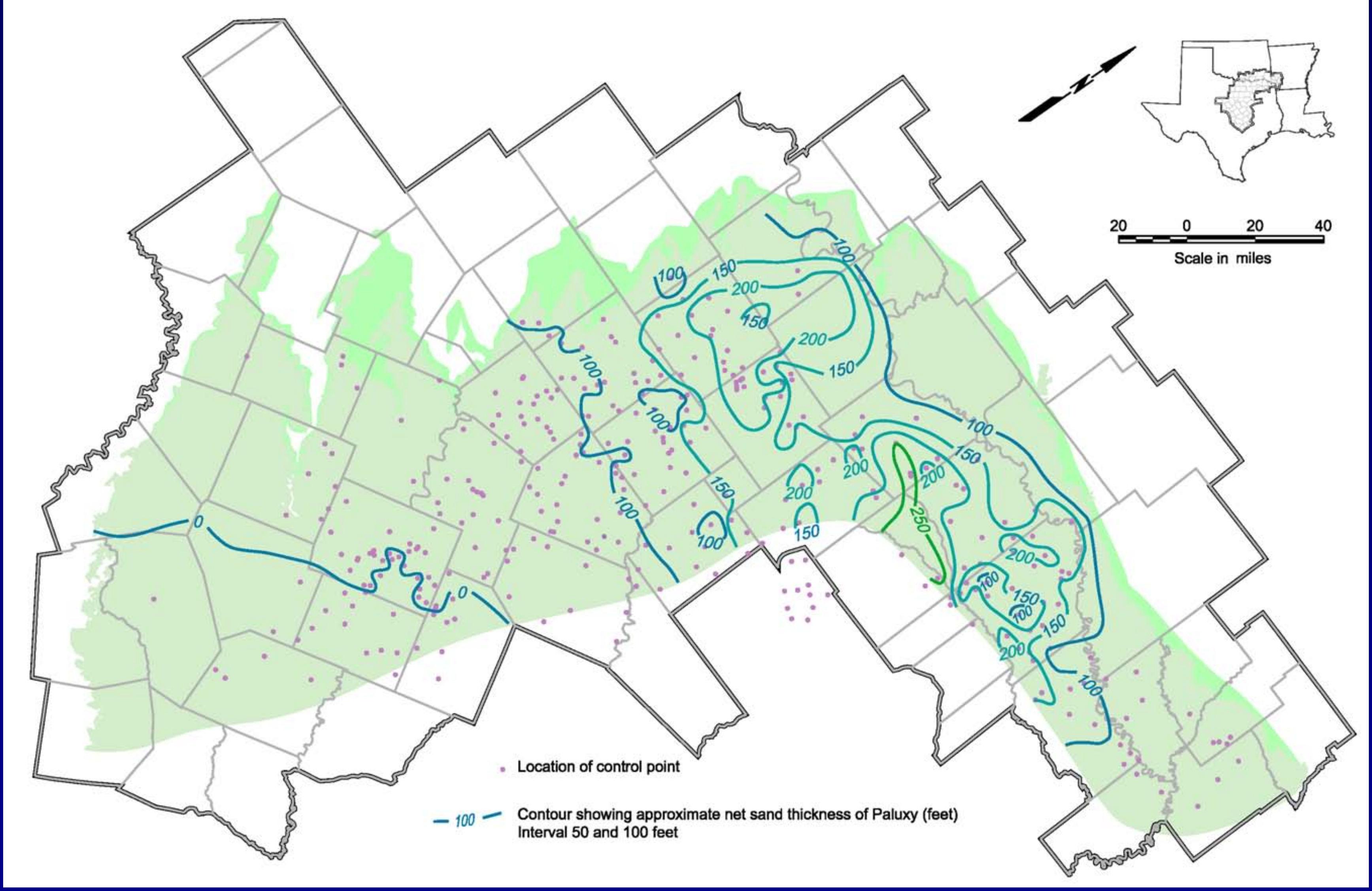
Elevation of Base of Paluxy



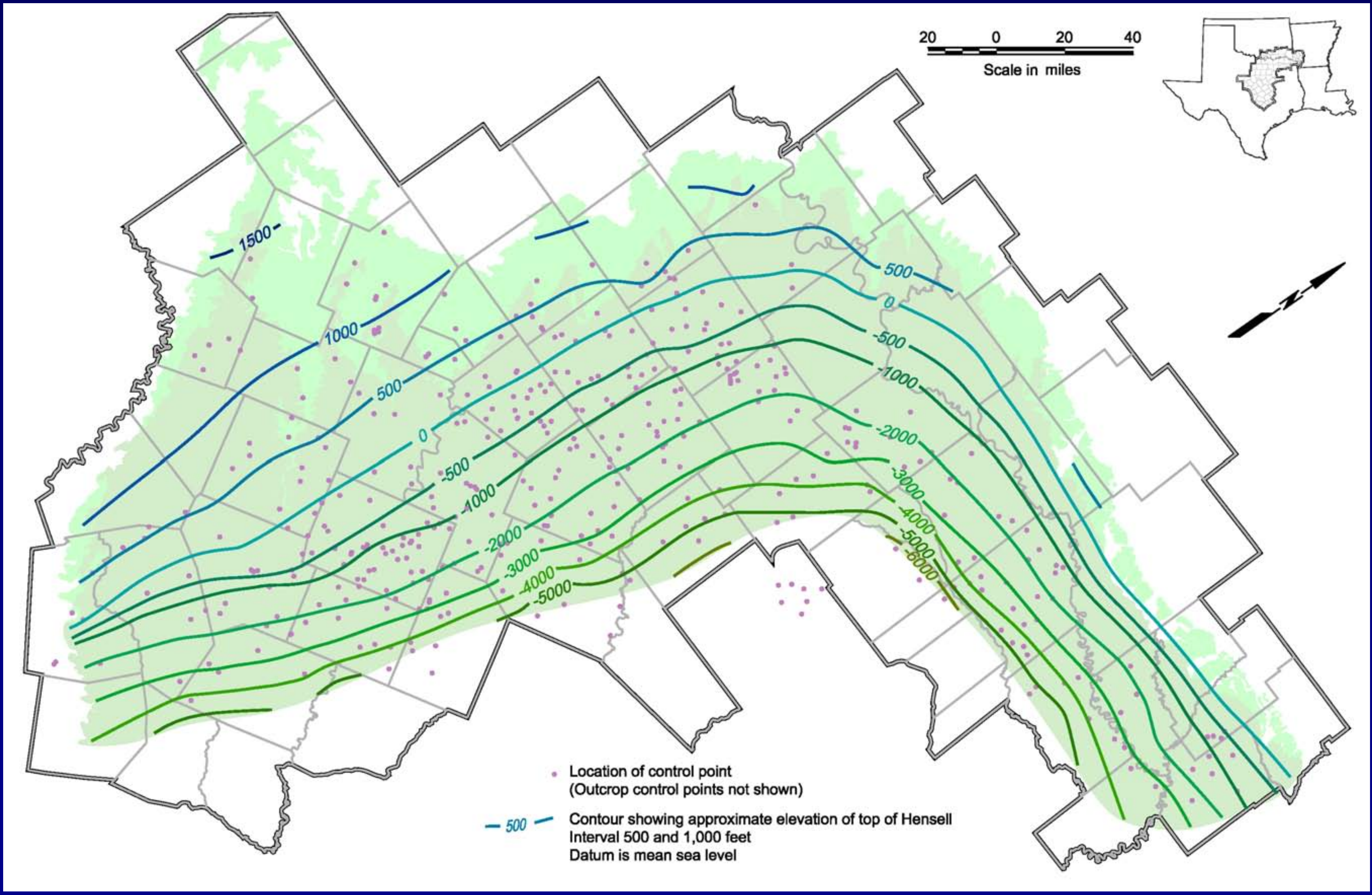
Net Thickness of Paluxy



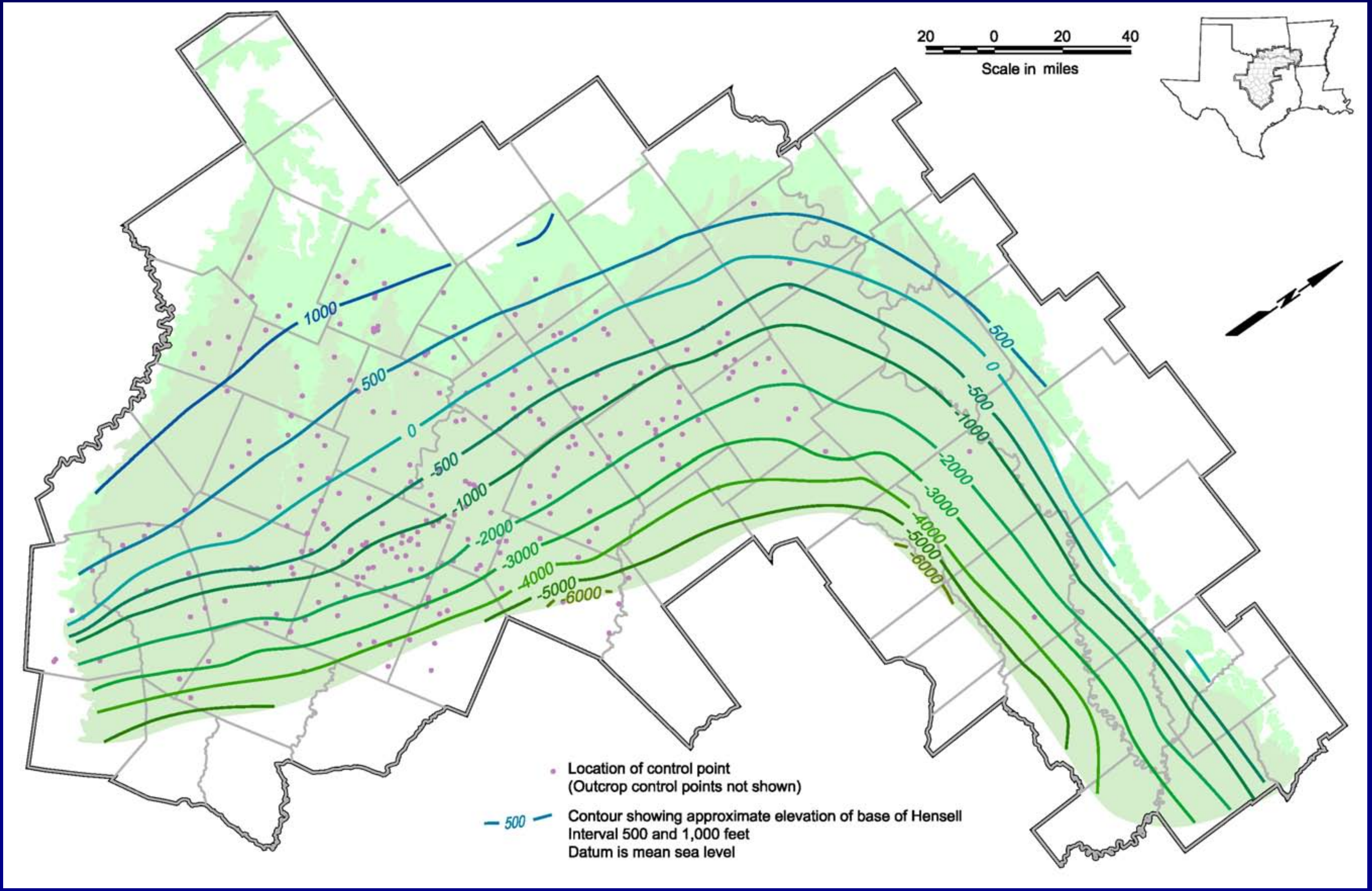
Net Sand Thickness of Paluxy



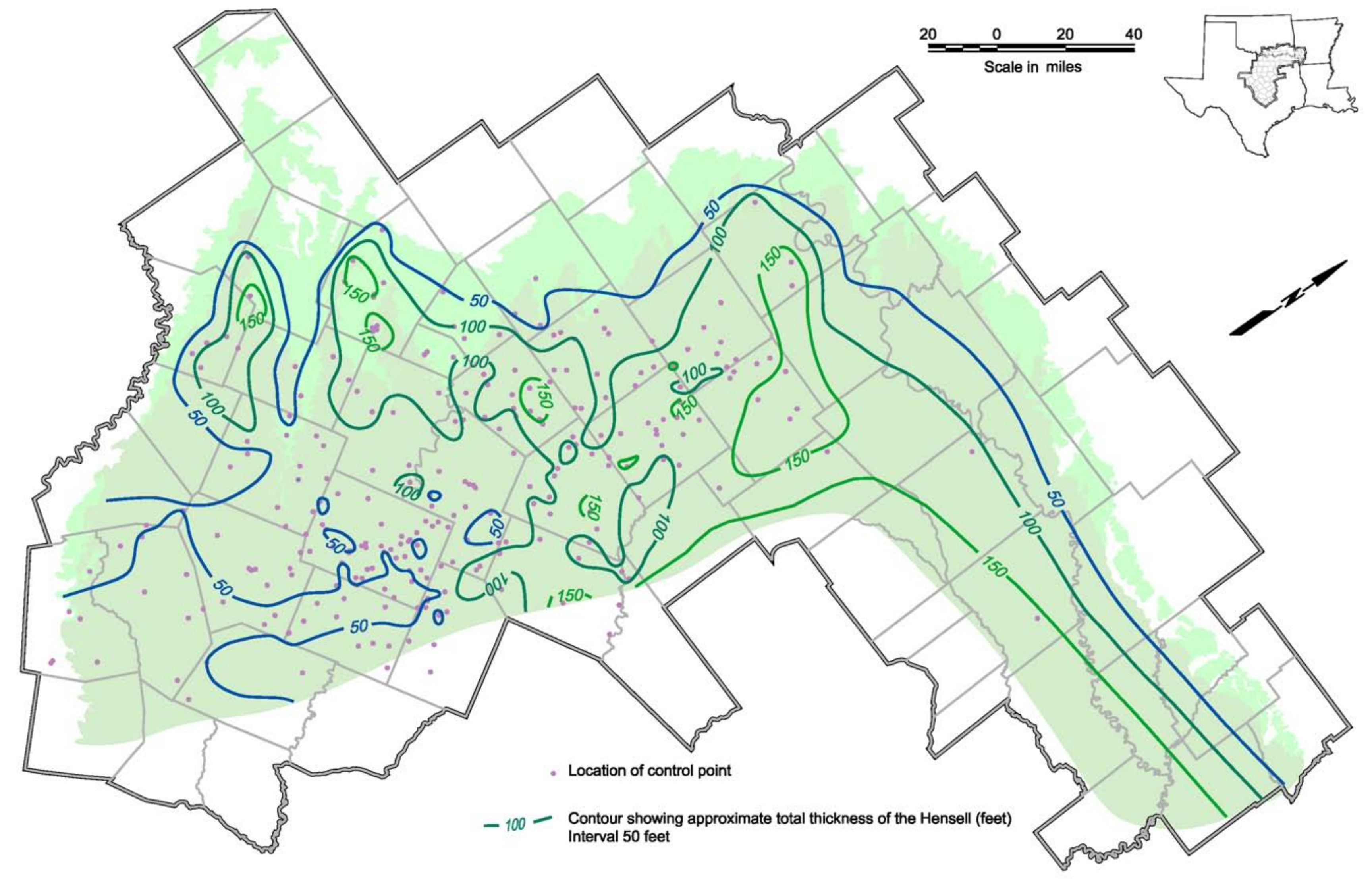
Elevation of Top of Hensell



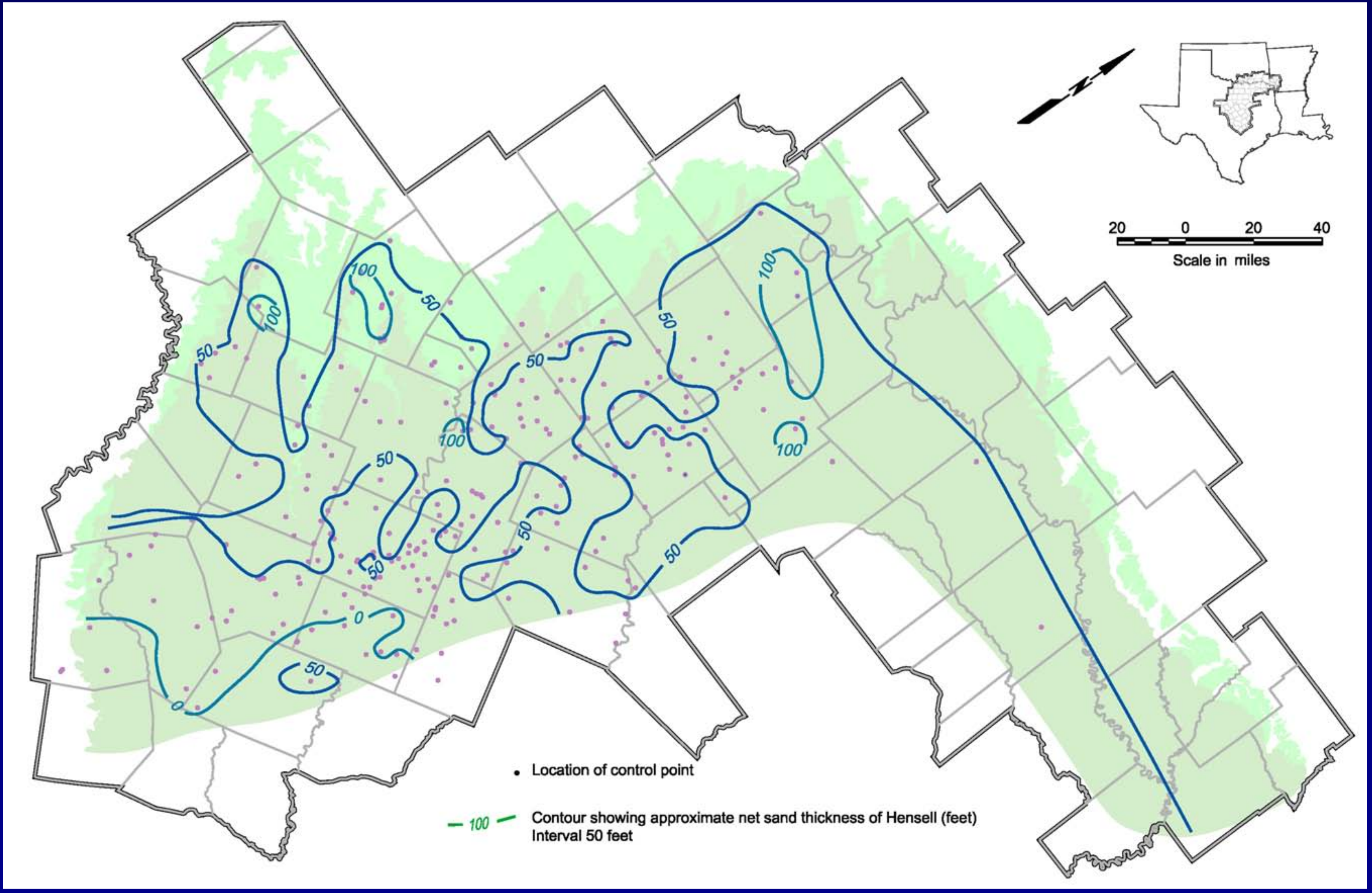
Elevation of Base of Hensell



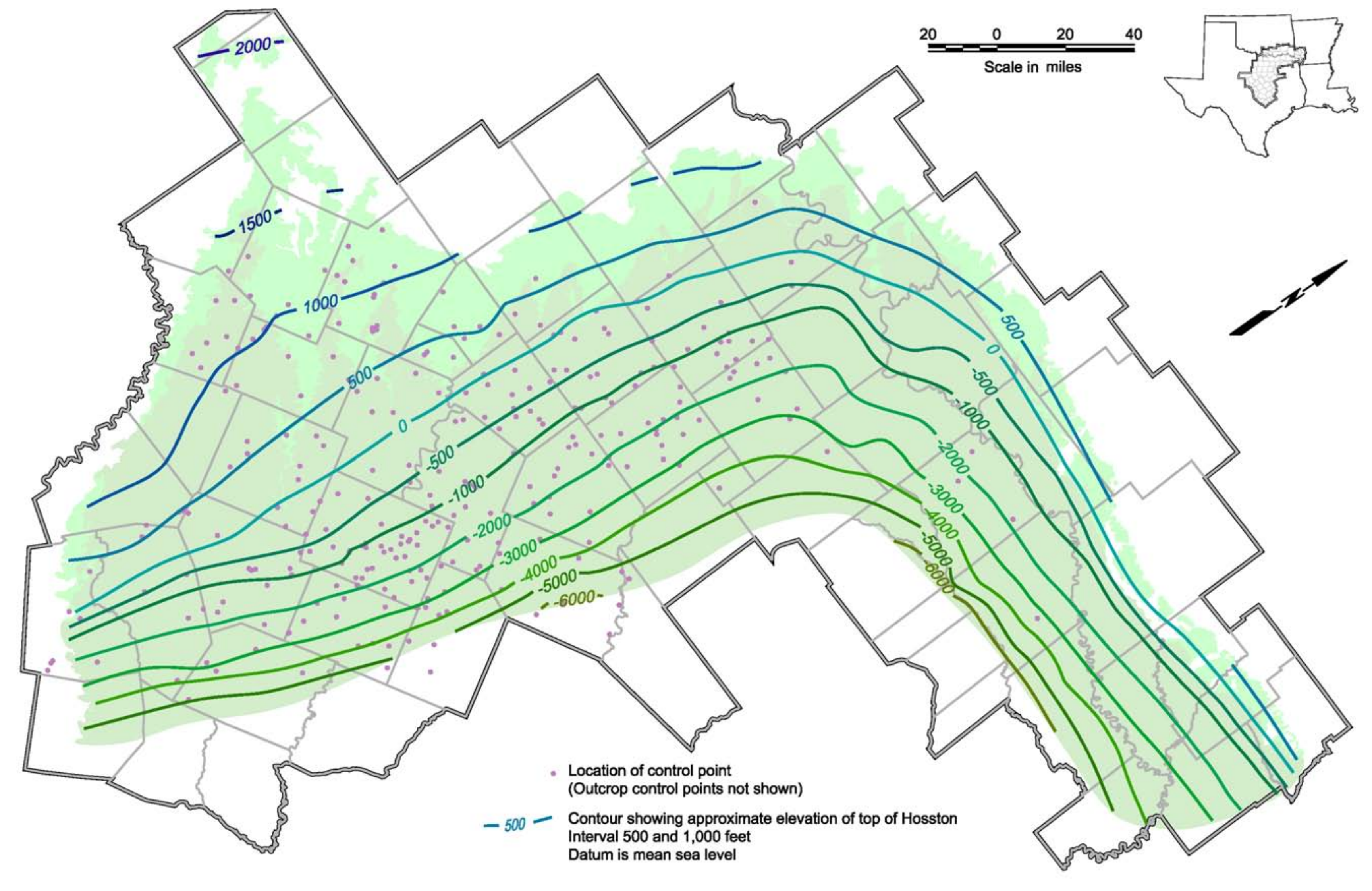
Net Thickness of Hensell



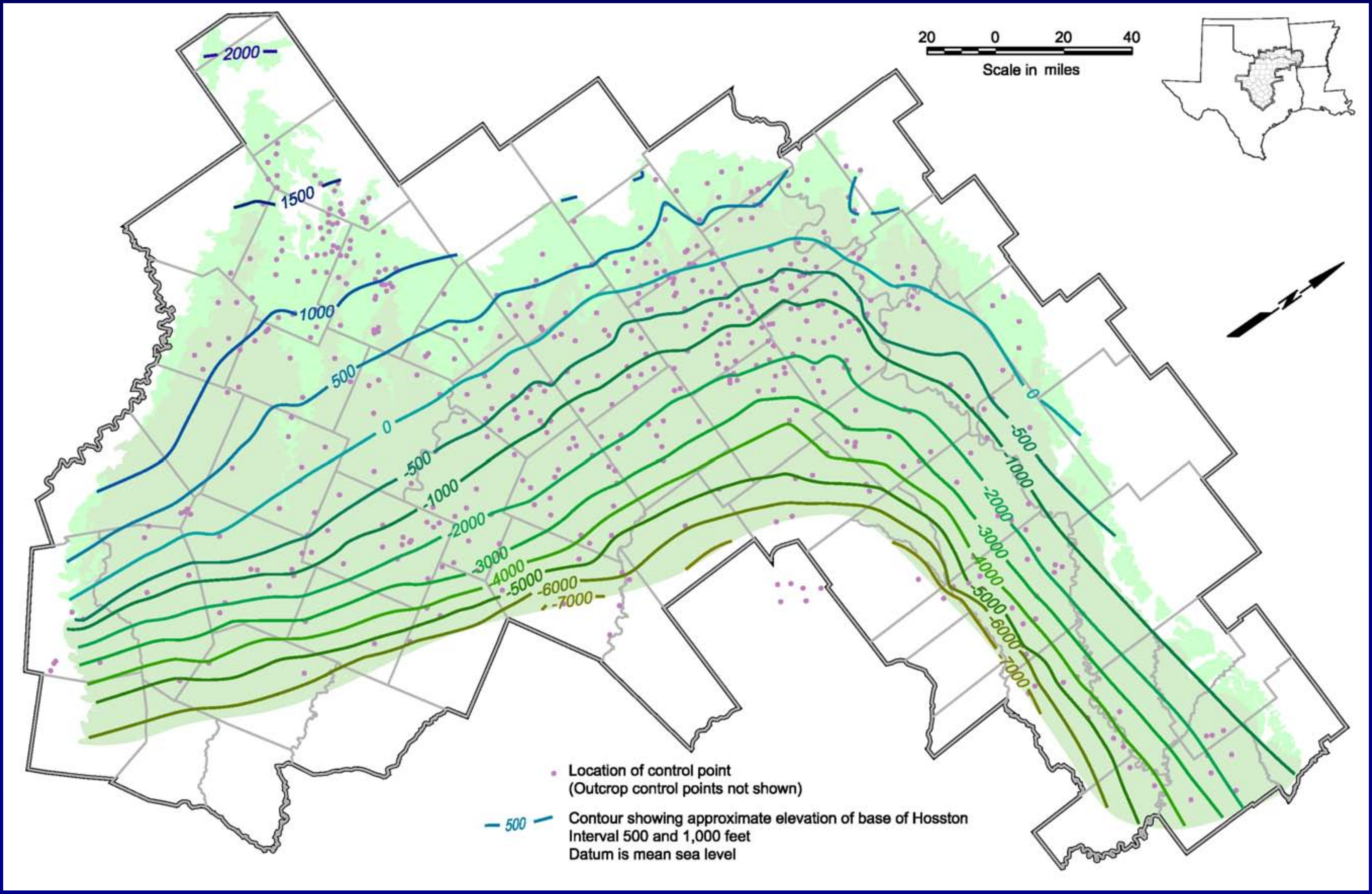
Net Sand Thickness of Hensell



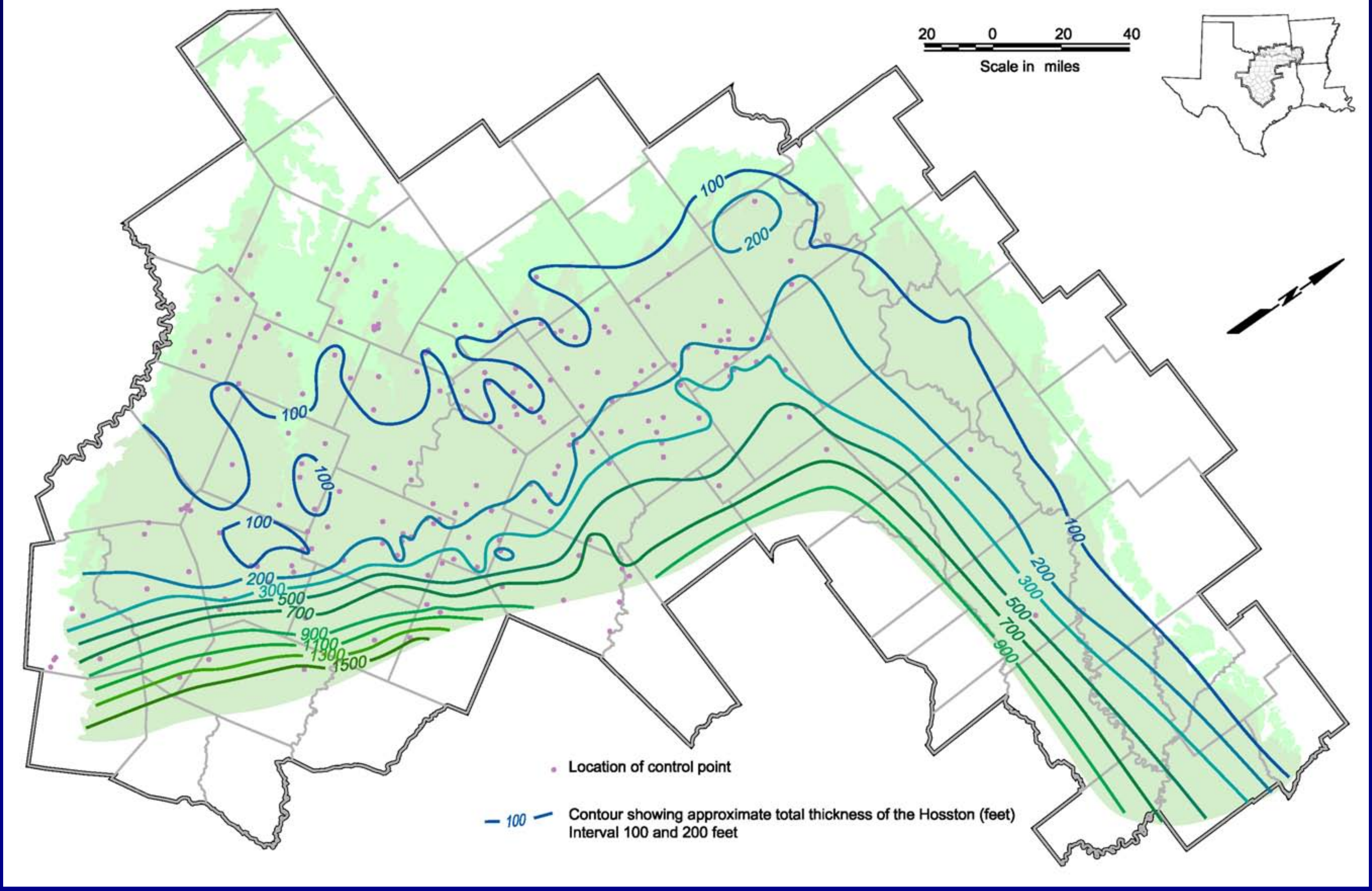
Elevation of Top of Hosston



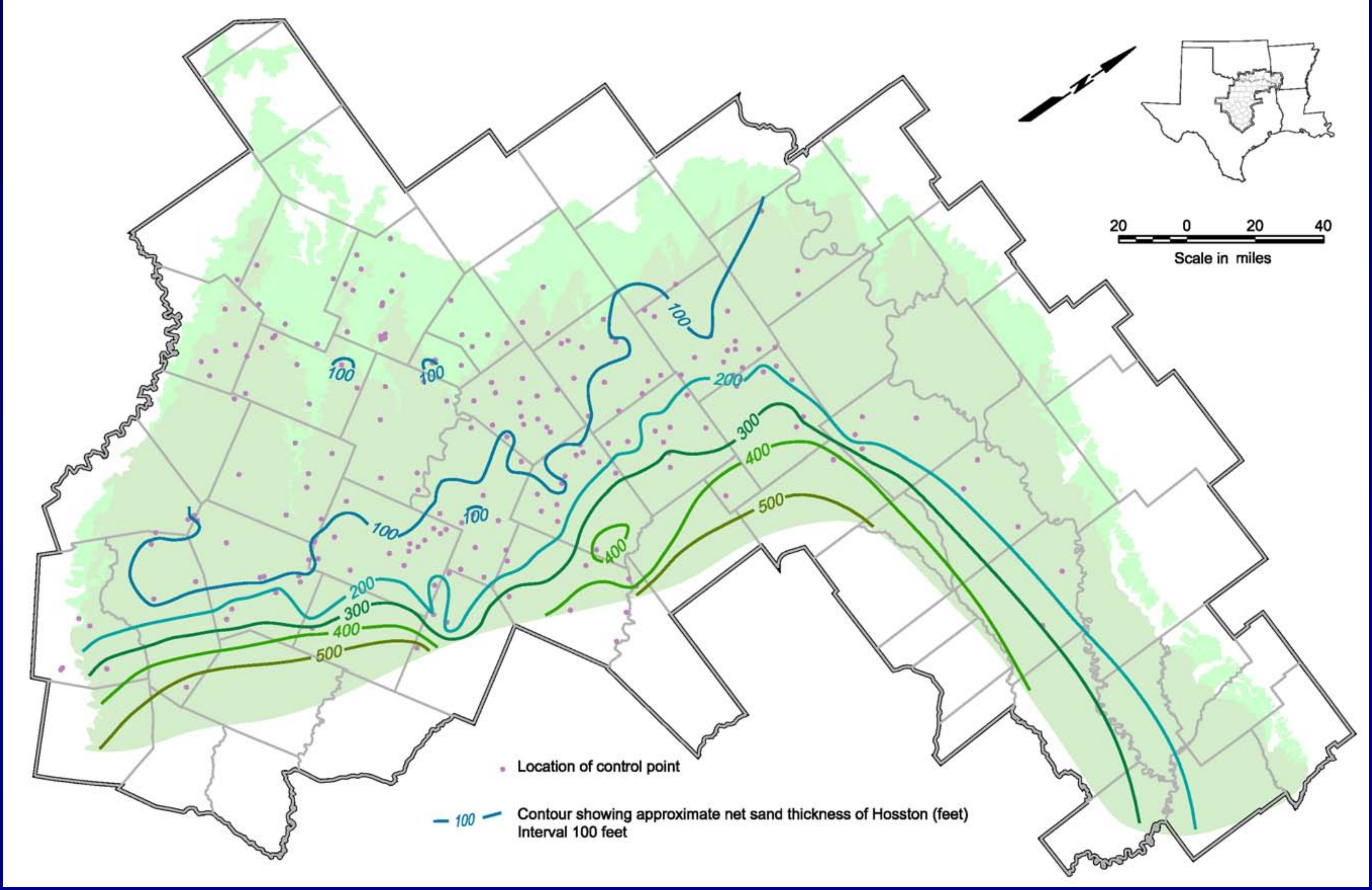
Elevation of Base of Hosston



Net Thickness of Hosston



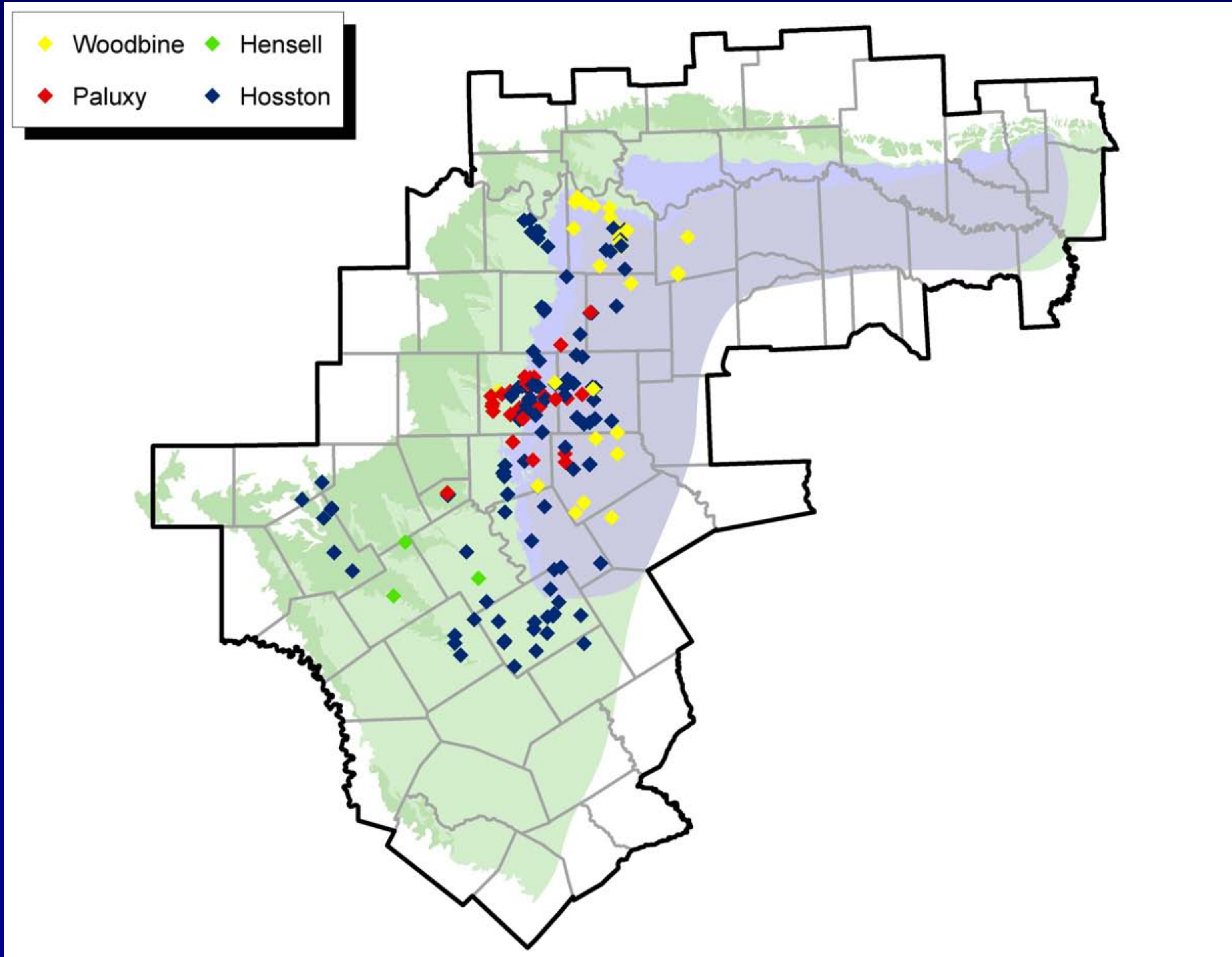
Net Sand Thickness of Hosston



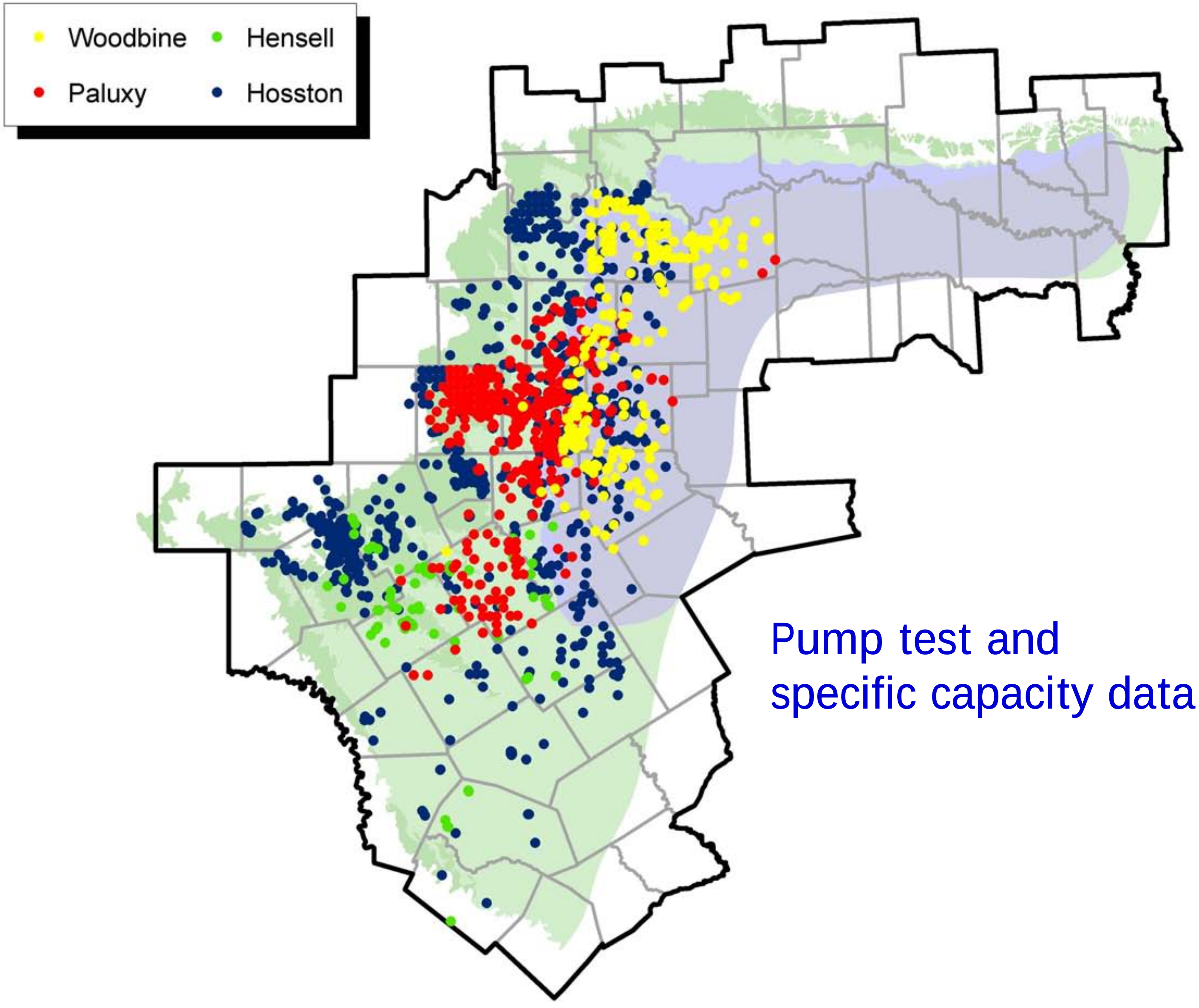
Hydraulic Properties

- Data collected from numerous sources published during the last century
- Much of this data was compiled by R. Mace in 1994
- Pump test data was used where available and supplemented with transmissivities derived from specific capacity data

Transmissivity Data Control From Pump Test

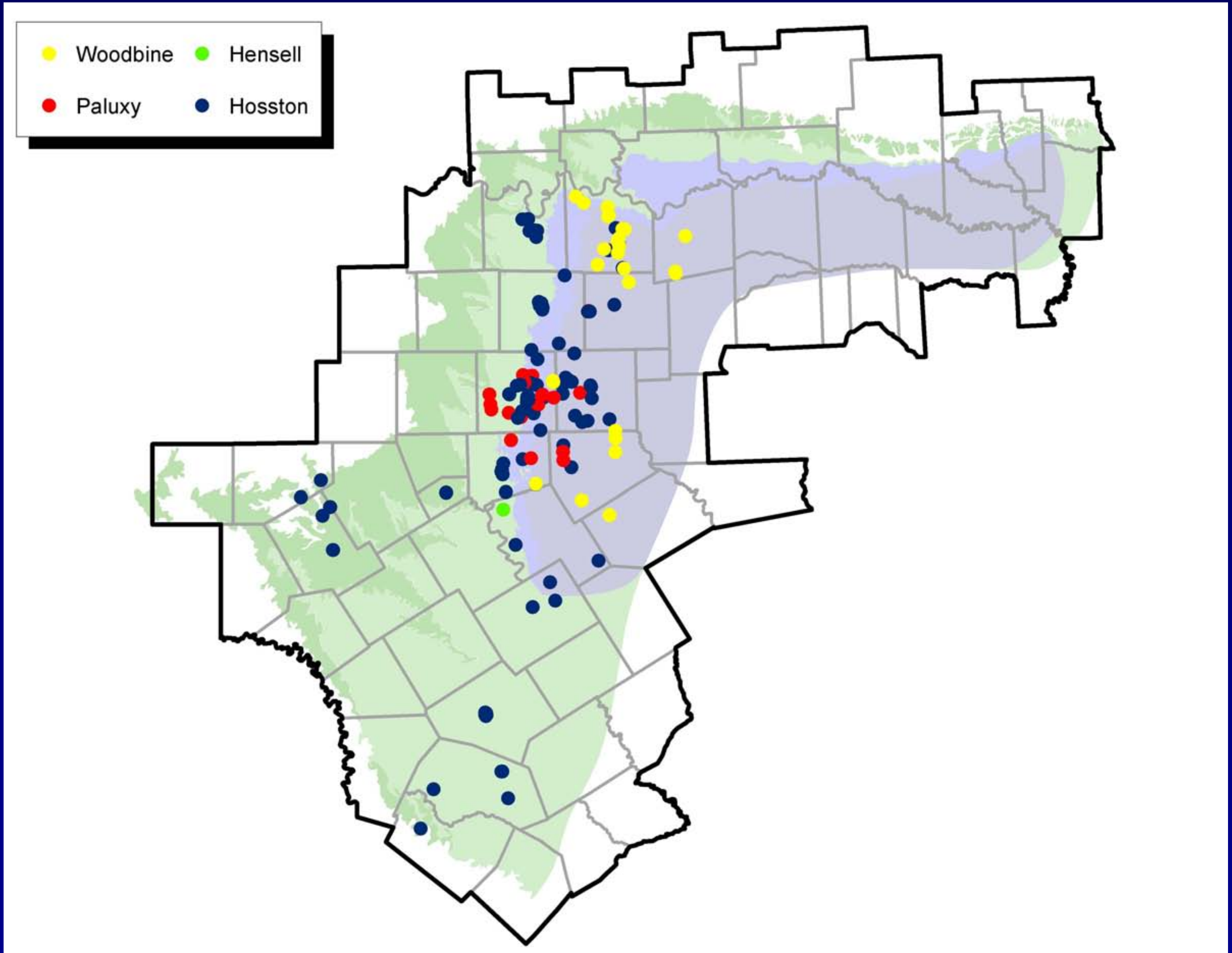


Transmissivity Data Control

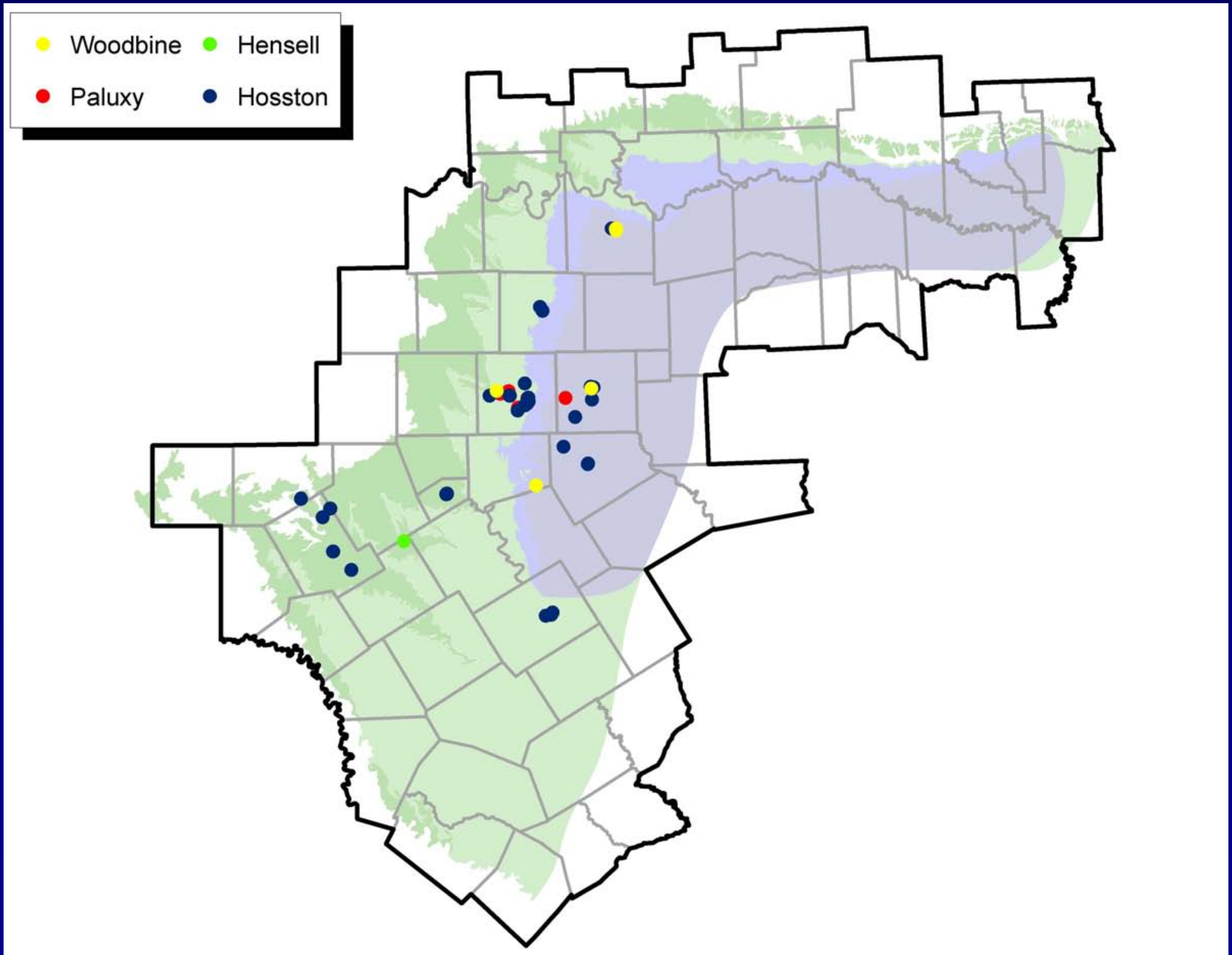


Pump test and
specific capacity data

Hydraulic Conductivity Data Control

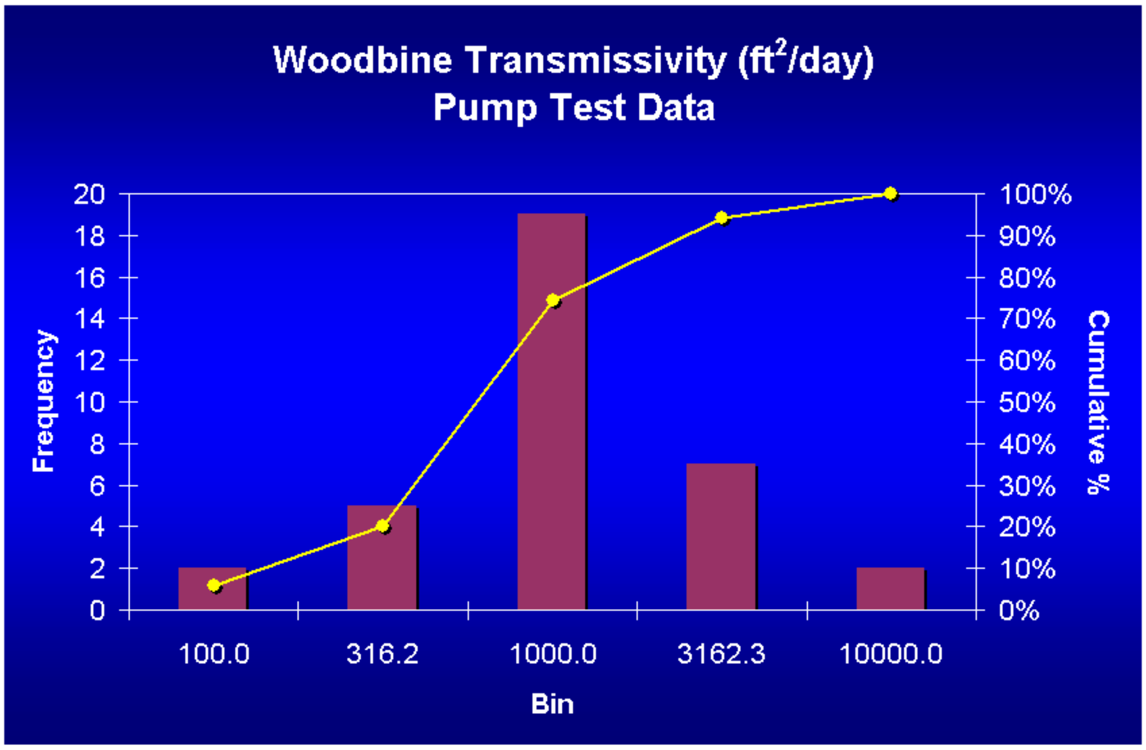


Storativity Data Control



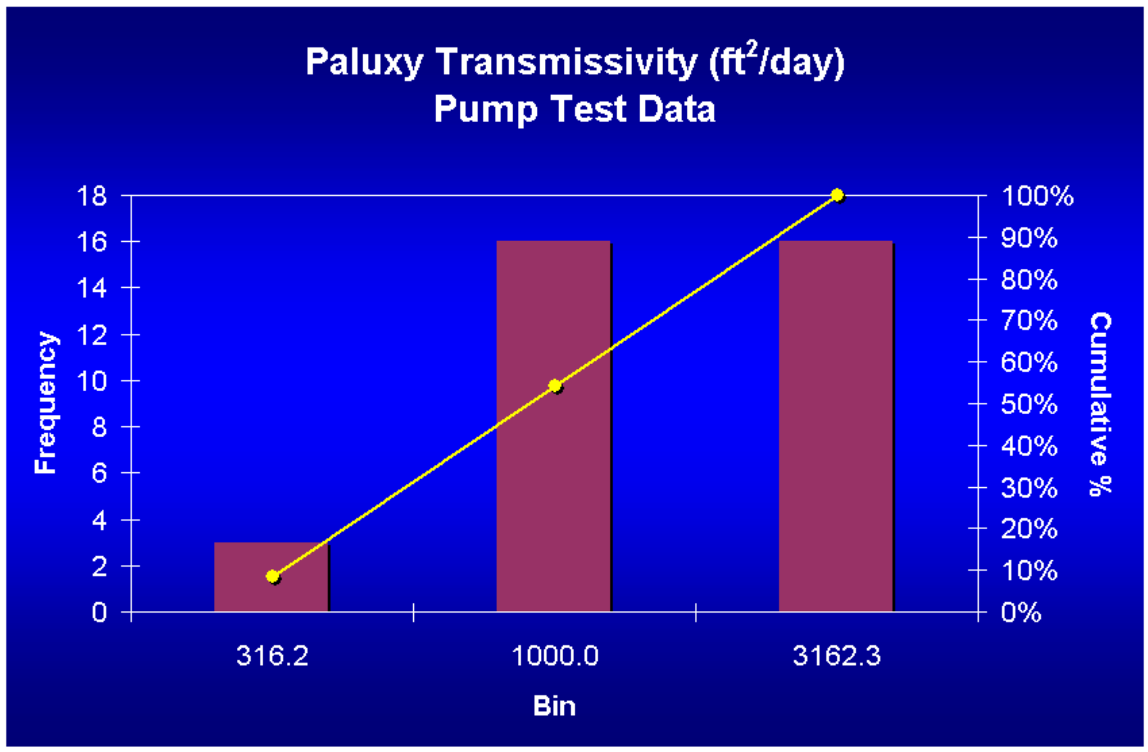
Woodbine Transmissivity From Pump Test

Statistical Summary of T (ft^2/day)	
Number of Samples	35
Average T	985.90
Standard Deviation T	1078.72
Average of Log T	2.79
Standard Deviation of Log T	0.43
Geometric Mean T	618.28



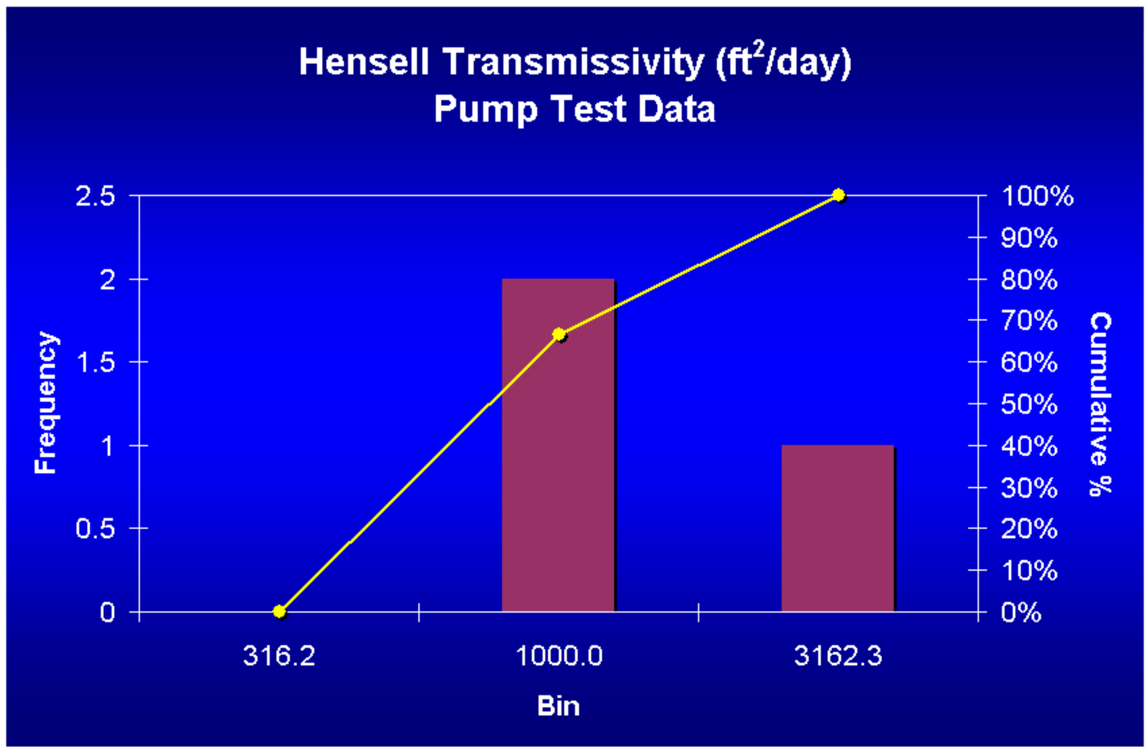
Paluxy Transmissivity From Pump Test

Statistical Summary of T (ft^2/day)	
Number of Samples	35
Average T	1046.19
Standard Deviation T	629.28
Average of Log T	2.94
Standard Deviation of Log T	0.27
Geometric Mean T	876.54



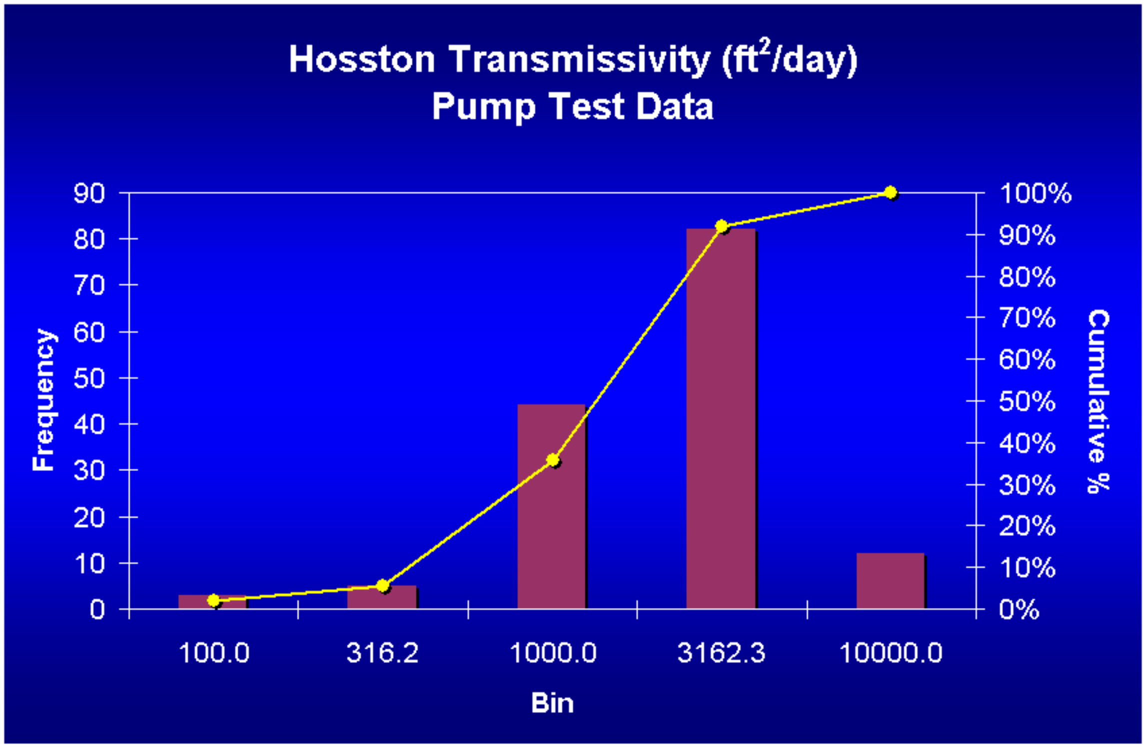
Hensell Transmissivity From Pump Test

Statistical Summary of T (ft^2/day)	
Number of Samples	3
Average T	1334.17
Standard Deviation T	768.20
Average of Log T	3.08
Standard Deviation of Log T	0.23
Geometric Mean T	1205.38



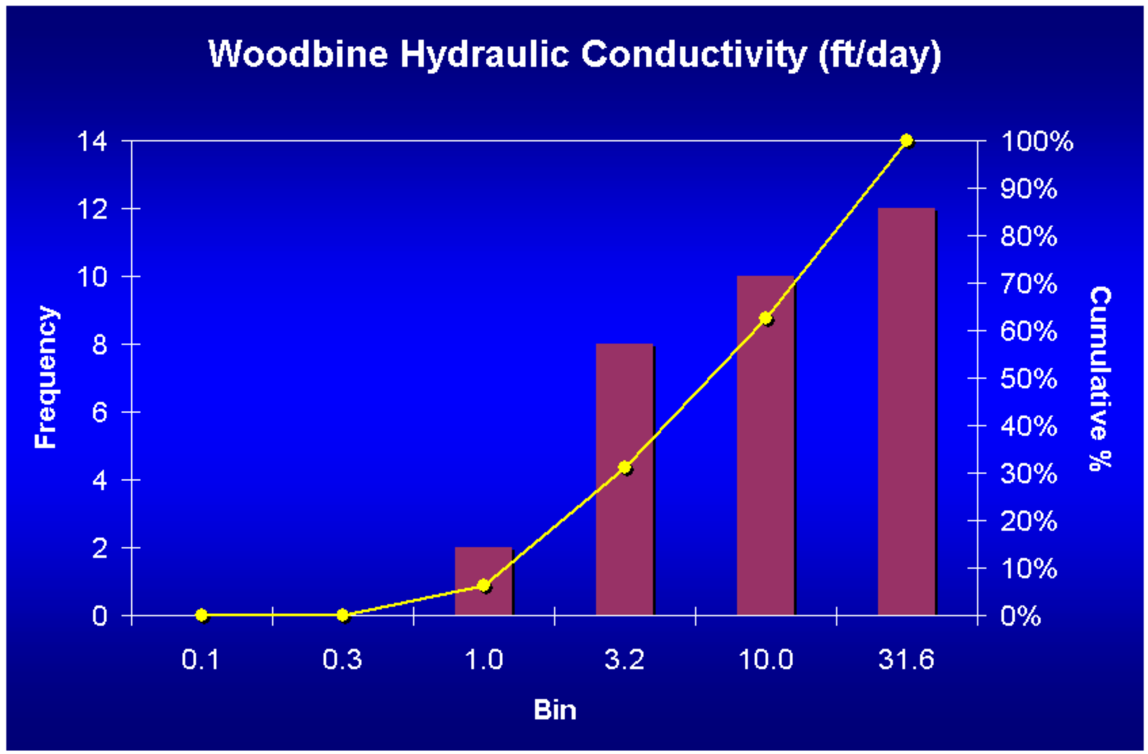
Hosston Transmissivity From Pump Test

Statistical Summary of T (ft^2/day)	
Number of Samples	146
Average T	1572.57
Standard Deviation T	980.82
Average of Log T	3.09
Standard Deviation of Log T	0.35
Geometric Mean T	1235.07



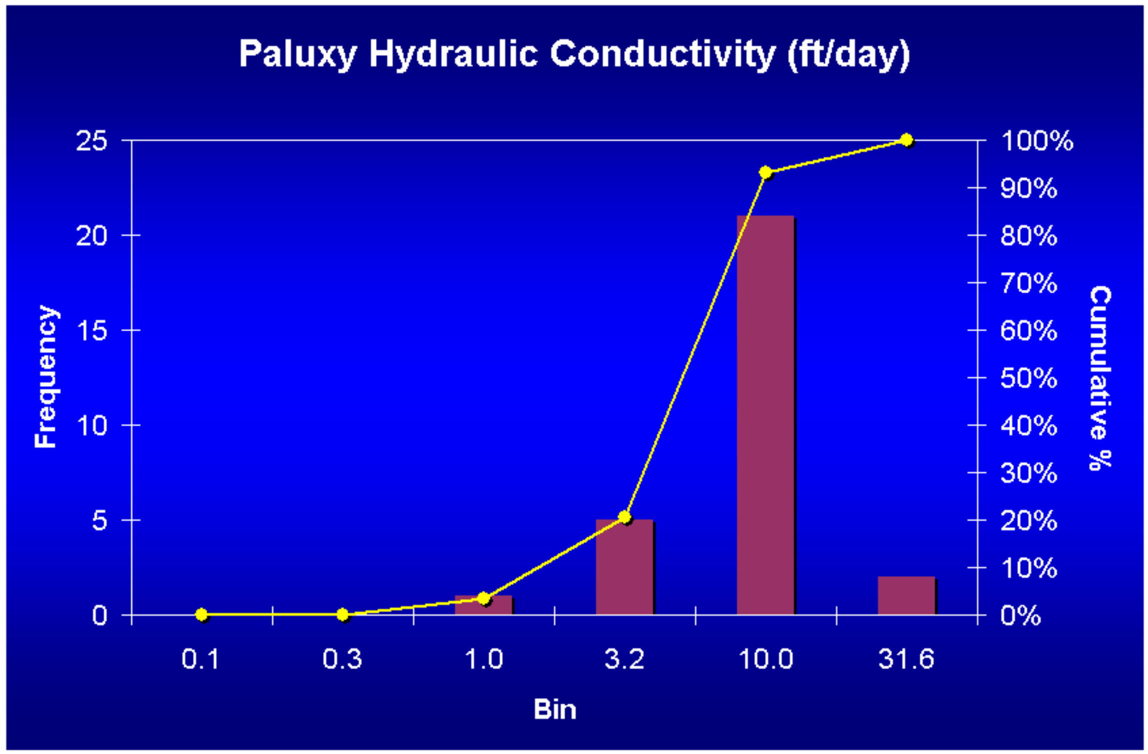
Woodbine Hydraulic Conductivity

Statistical Summary of K (ft/day)	
Number of Samples	32
Average K	8.72
Standard Deviation K	7.21
Average of Log K	0.76
Standard Deviation of Log K	0.44
Geometric Mean K	5.81



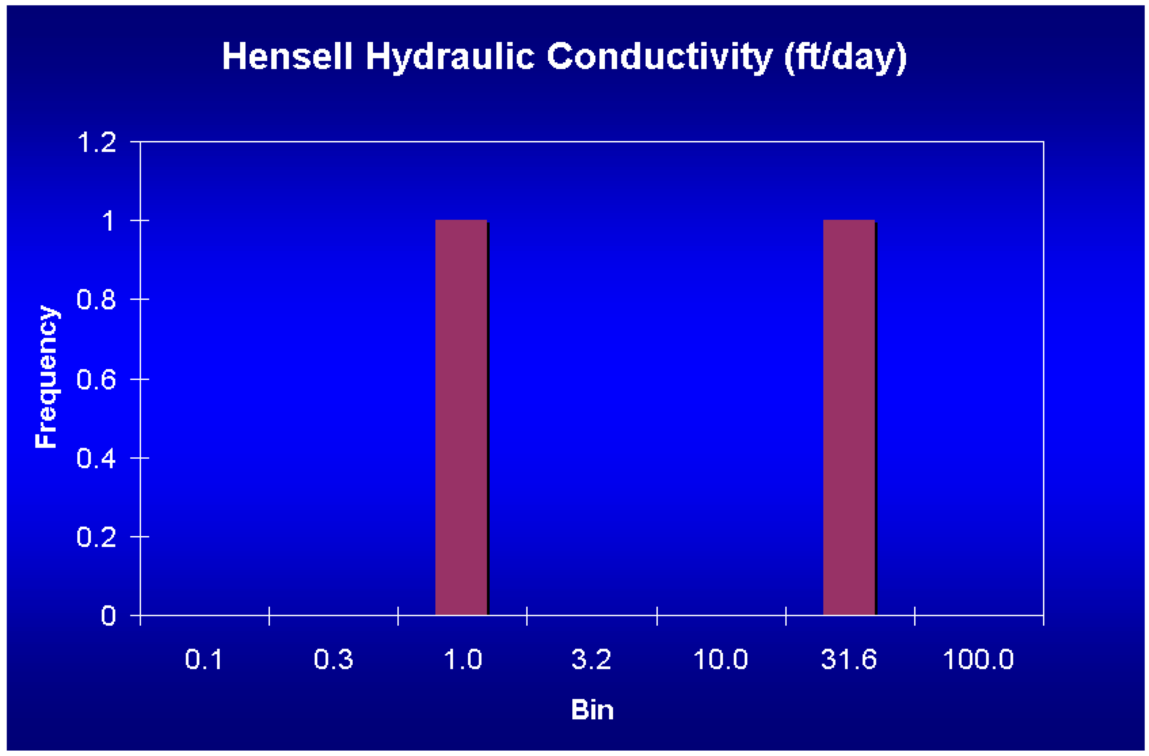
Paluxy Hydraulic Conductivity

Statistical Summary of K (ft/day)	
Number of Samples	29
Average K	5.77
Standard Deviation K	3.50
Average of Log K	0.69
Standard Deviation of Log K	0.27
Geometric Mean K	4.87



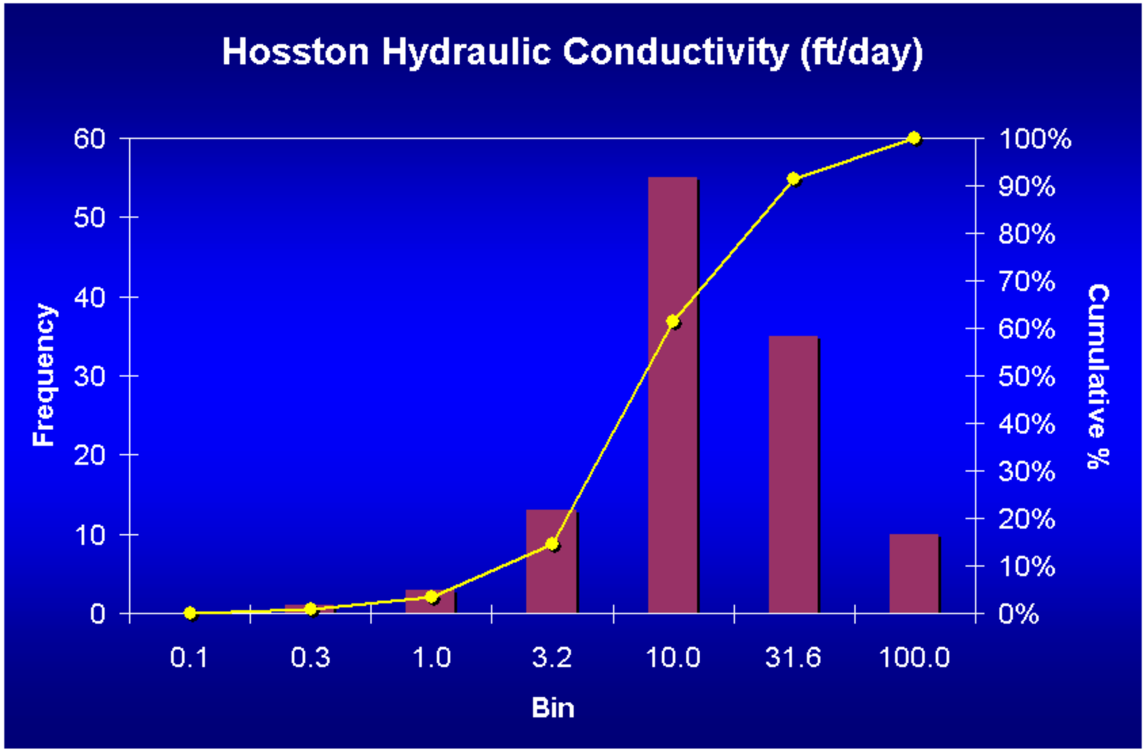
Hensell Hydraulic Conductivity

Statistical Summary of K (ft/day)	
Number of Samples	2
Average K	7.14
Standard Deviation K	9.04
Average of Log K	0.50
Standard Deviation of Log K	0.89
Geometric Mean K	3.19



Hosston Hydraulic Conductivity

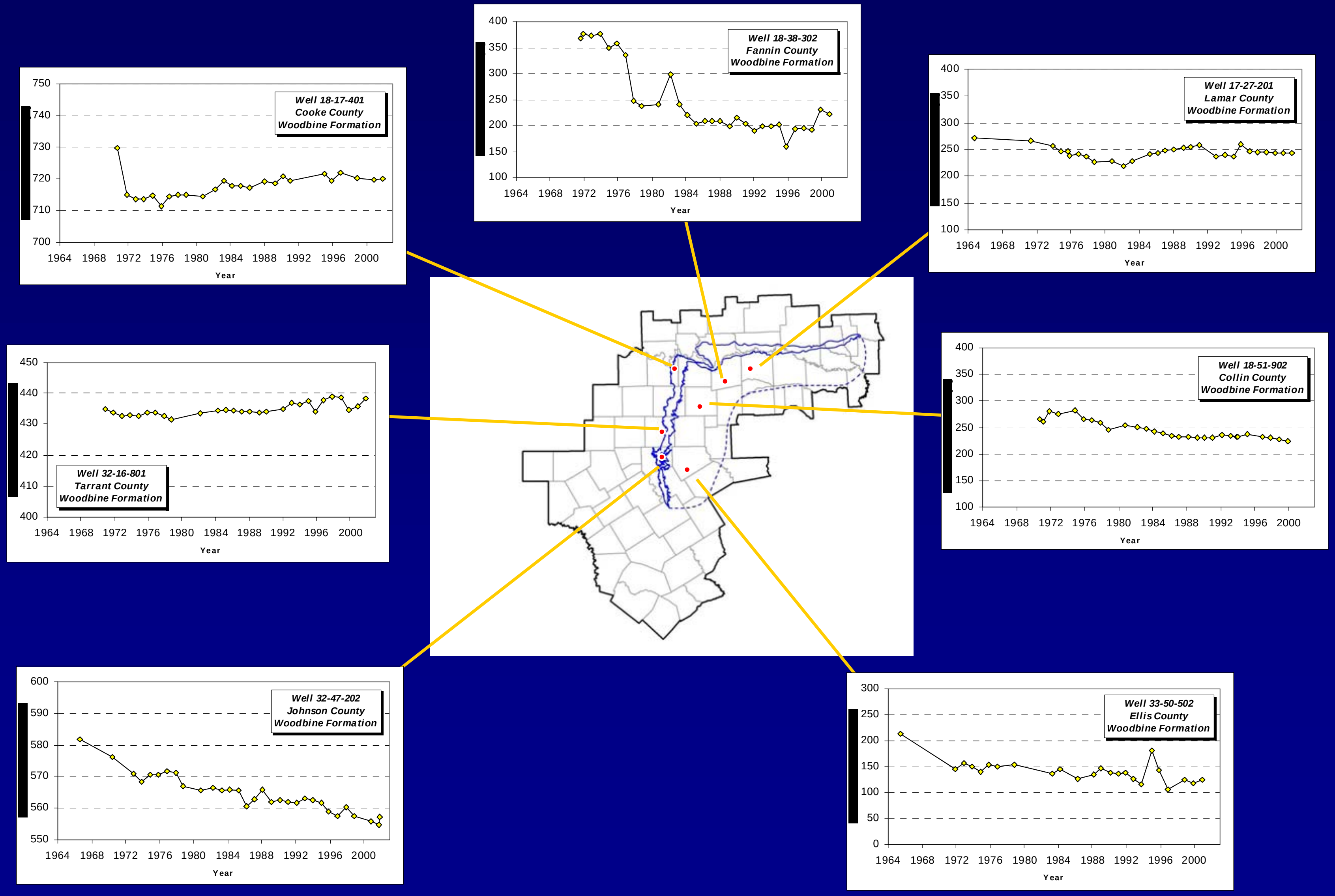
Statistical Summary of K (ft/day)	
Number of Samples	117
Average K	12.05
Standard Deviation K	10.67
Average of Log K	0.90
Standard Deviation of Log K	0.44
Geometric Mean K	7.92



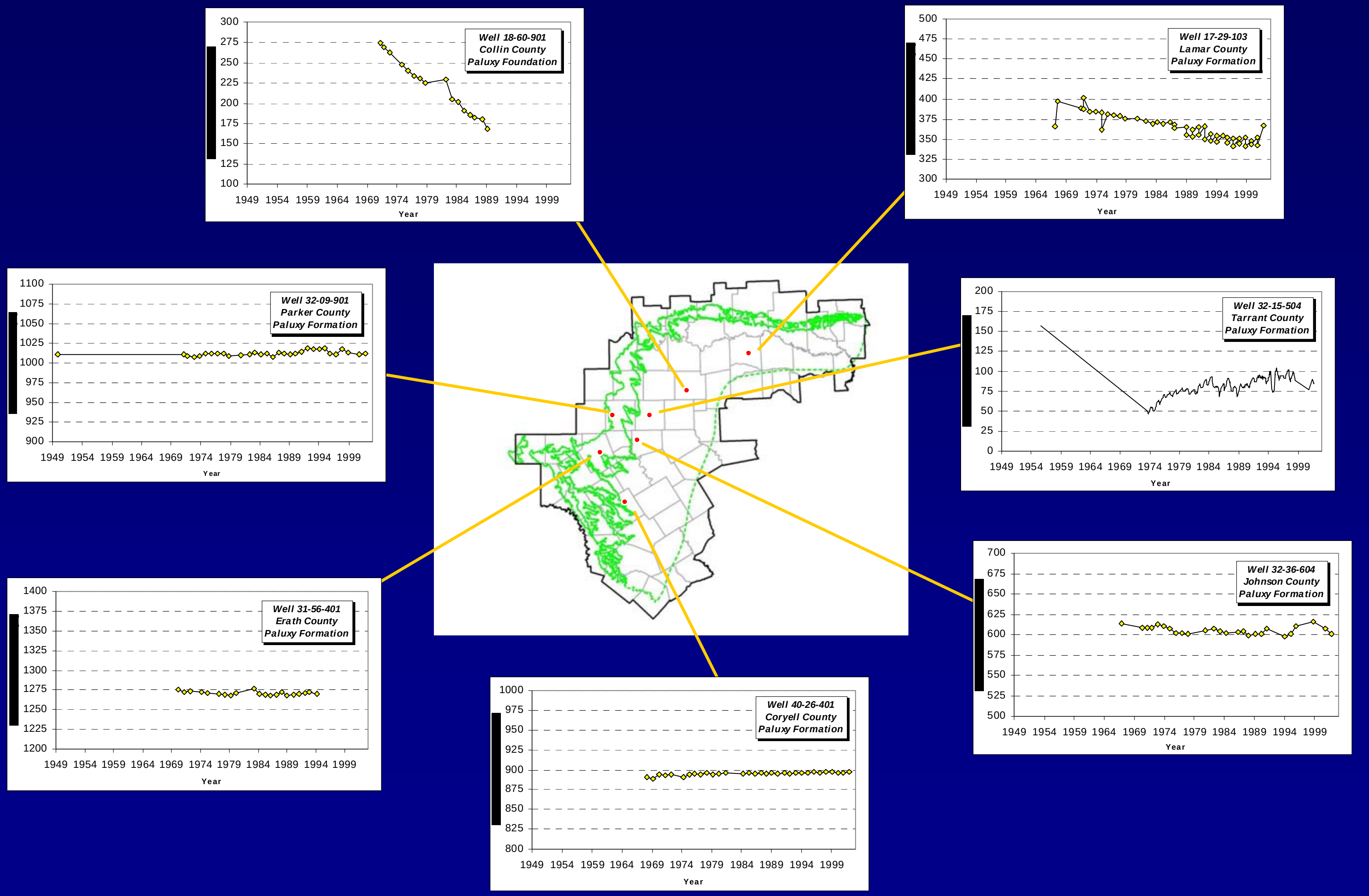
Water Levels

- Data from TWDB database
- 750+ hydrographs assembled for the four aquifers in the study area

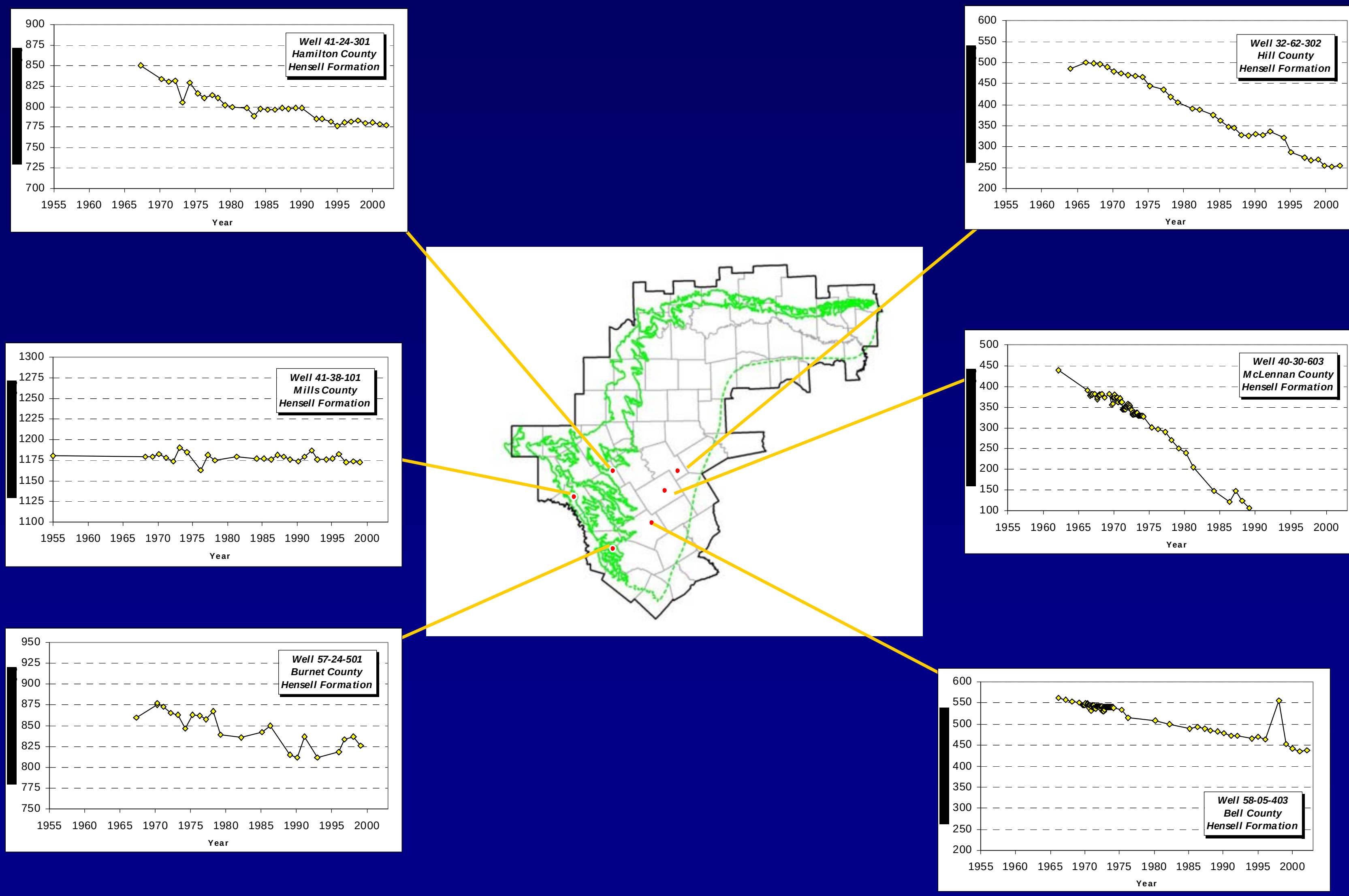
Representative Woodbine Hydrographs



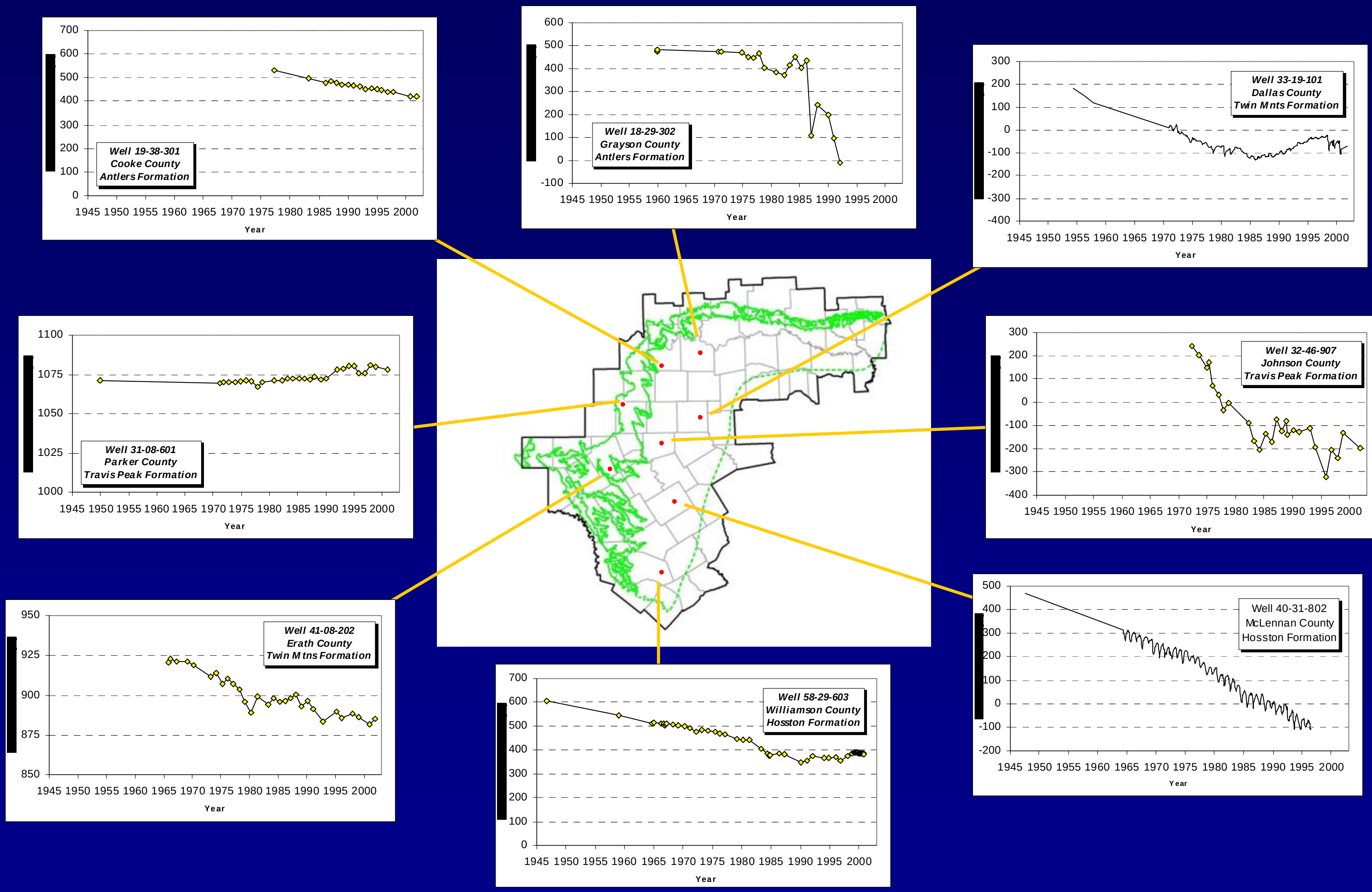
Representative Paluxy Hydrographs



Representative Hensell Hydrographs



Representative Hosston Hydrographs



Predevelopment Water Levels

- Problems:

1. Significant number of wells producing from the aquifers before 1900, including large numbers of flowing artesian wells
2. Little to no water level data to base water level maps on

Pre-1900 Woodbine Wells

County	Number of Wells
Dallas	43
Denton	8
Ellis	33+
Grayson	25
Hill	12
Johnson	7
Lamar	1
Tarrant	23

Data from Hill, 1901

Pre-1900 Paluxy Wells

County	Number of Wells
Bell	10
Cooke	37
Dallas	1
Denton	45
Hill	3
Johnson	16
McLennan	5
Tarrant	46

Data from Hill, 1901

Pre-1900 Trinity Wells

County	Number of Wells
Bell	36
Bosque	67
Burnet	1
Comanche	numerous
Cooke	6
Coryell	41
Denton	2
Eastland	1
Erath	27+
Grayson	1
Hamilton	24

Data from Hill, 1901

Pre-1900 Trinity Wells (cont.)

County	Number of Wells
Hill	4
Hood	25
Johnson	8
McLennan	27
Mills	3
Parker	21+
Somervell	283
Tarrant	7
Travis	10
Williamson	20
Wise	13

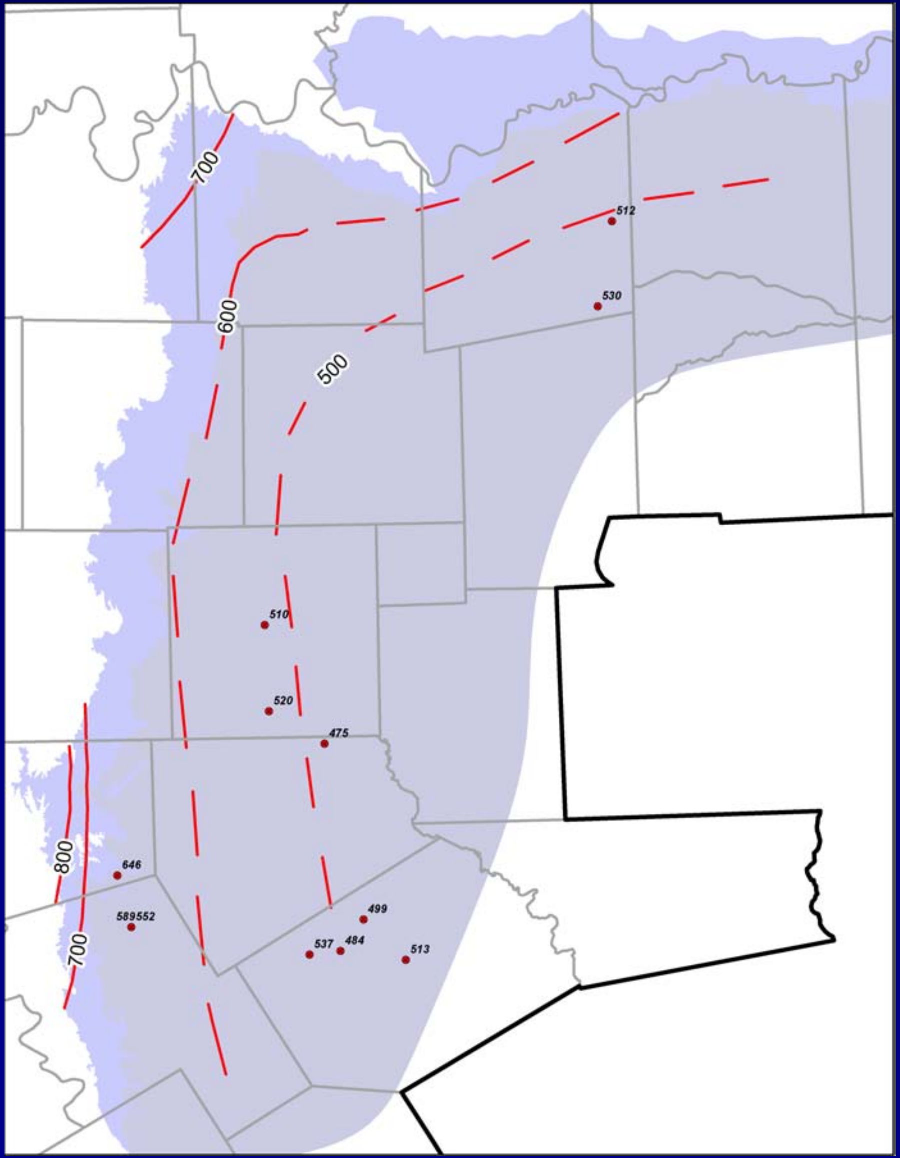
Data from Hill, 1901

Predevelopment Water Levels

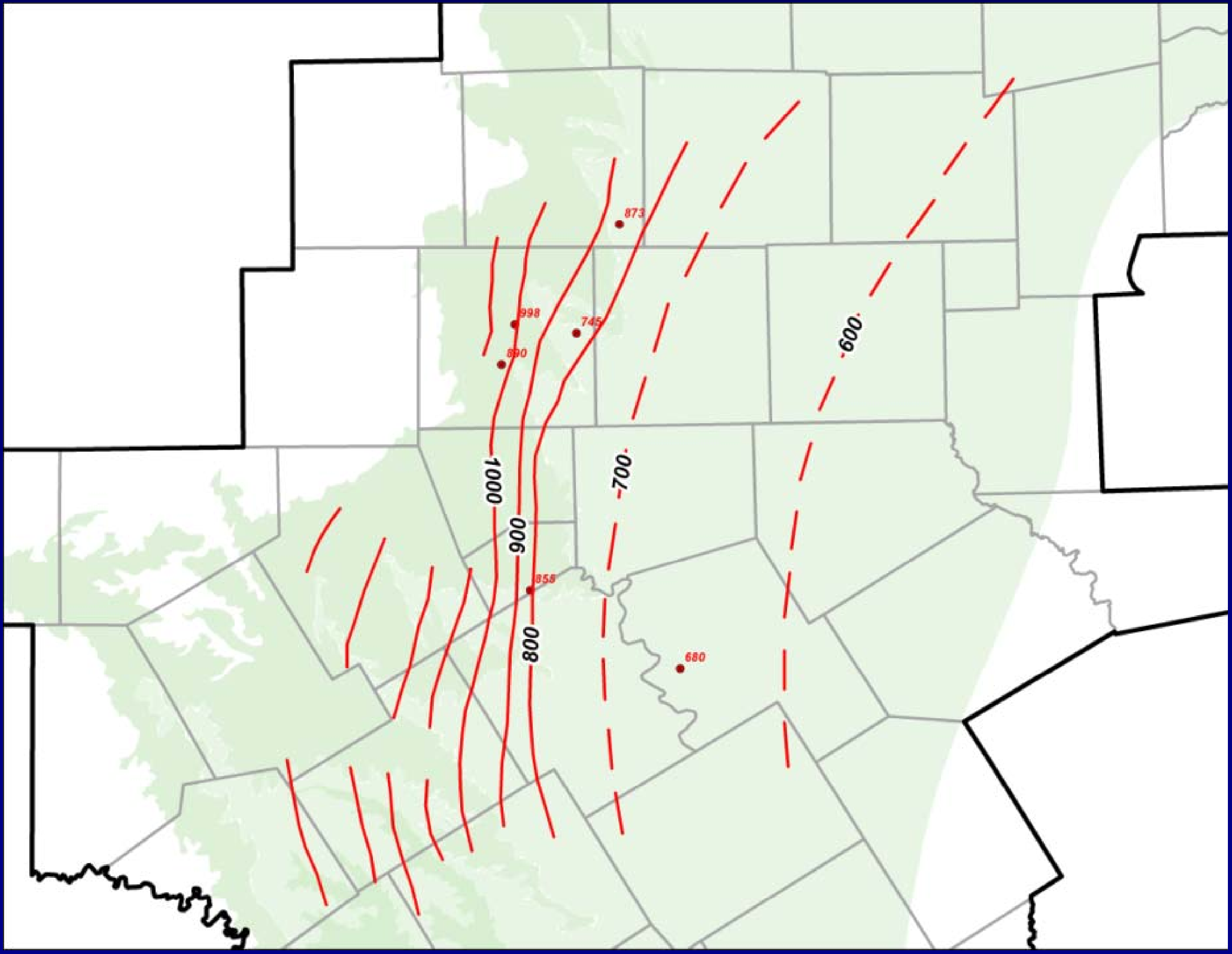
- Maps based on:

1. Hill (1901) maps for Trinity, Paluxy, and Woodbine aquifers
2. Data from Hill (1901) and Fiedler (1934)
3. Hydrographs and estimated pre-development water levels
4. Conceptual idea of groundwater flow before development of the aquifers

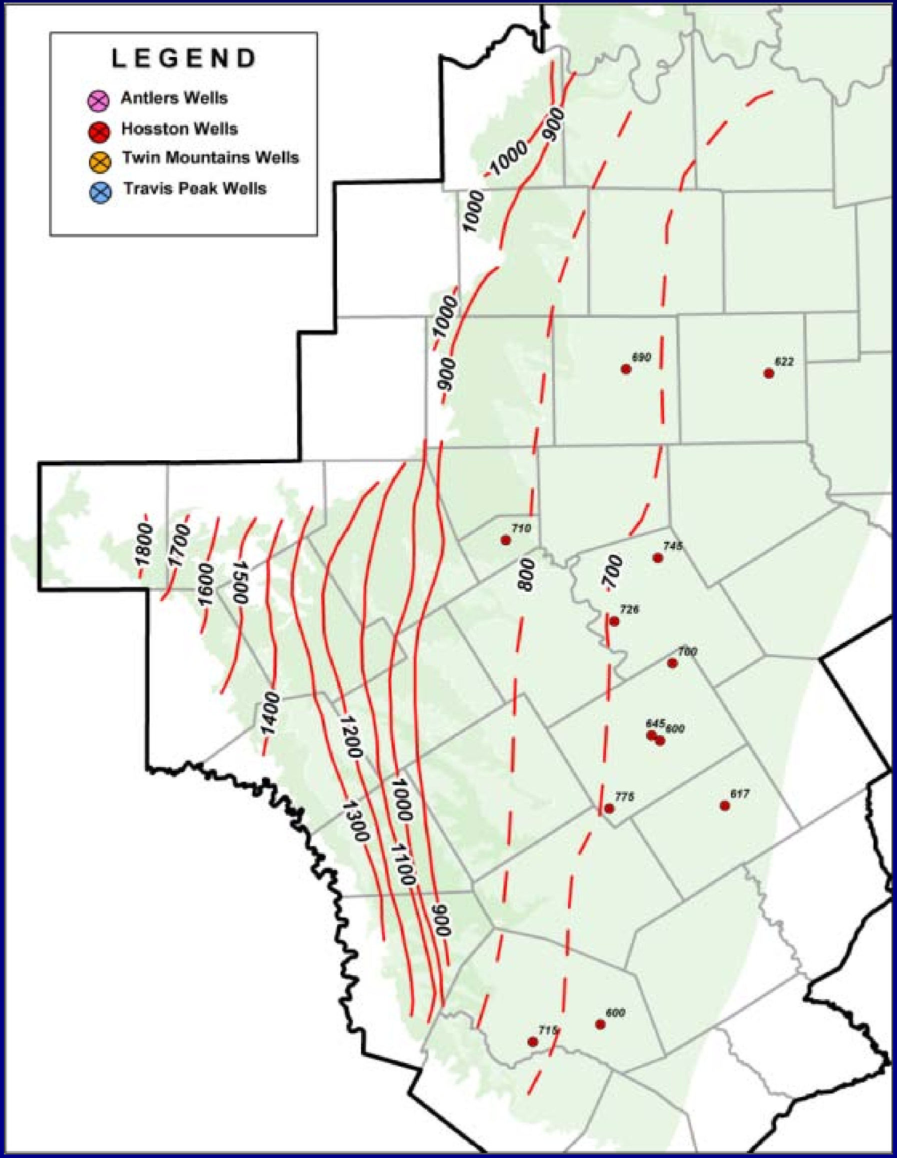
Woodbine Water Level - Predevelopment



Paluxy Water Level - Predevelopment



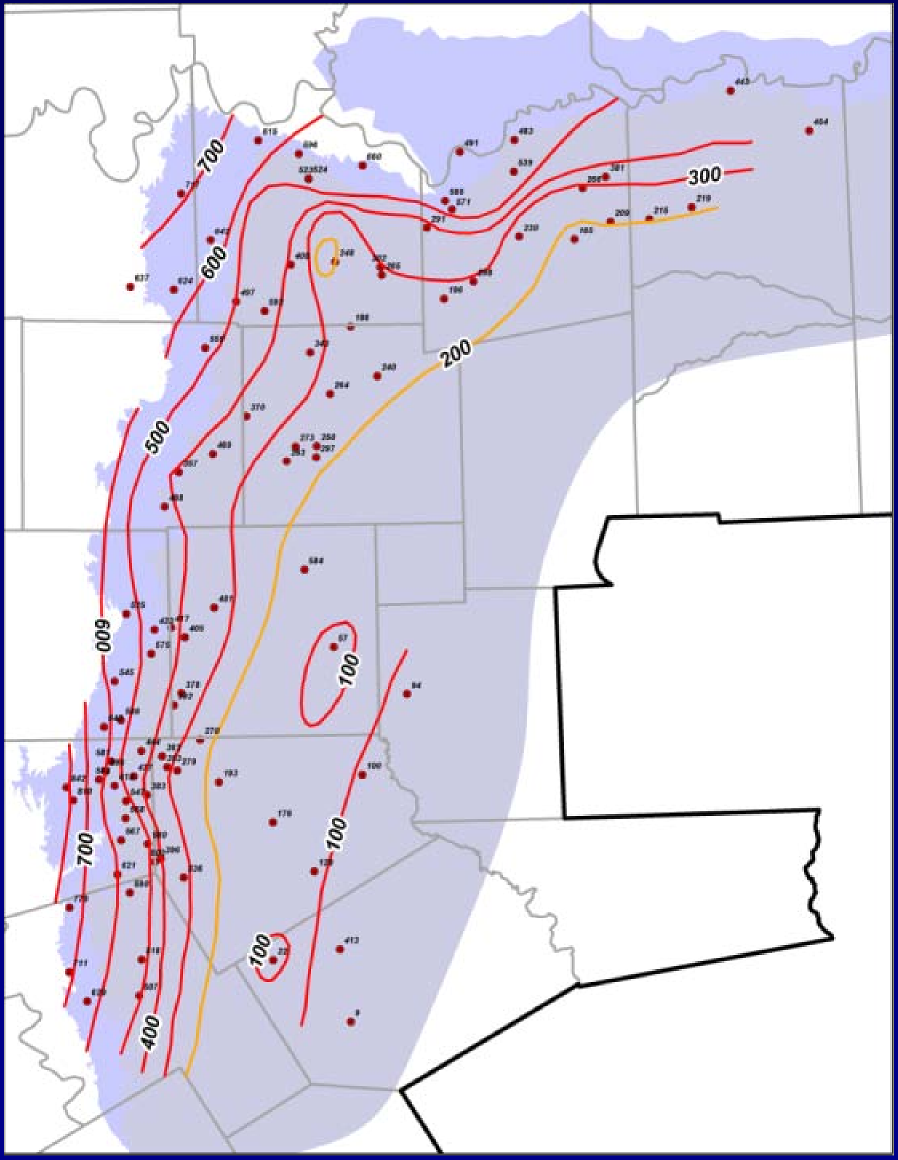
Hosston Water Level - Predevelopment



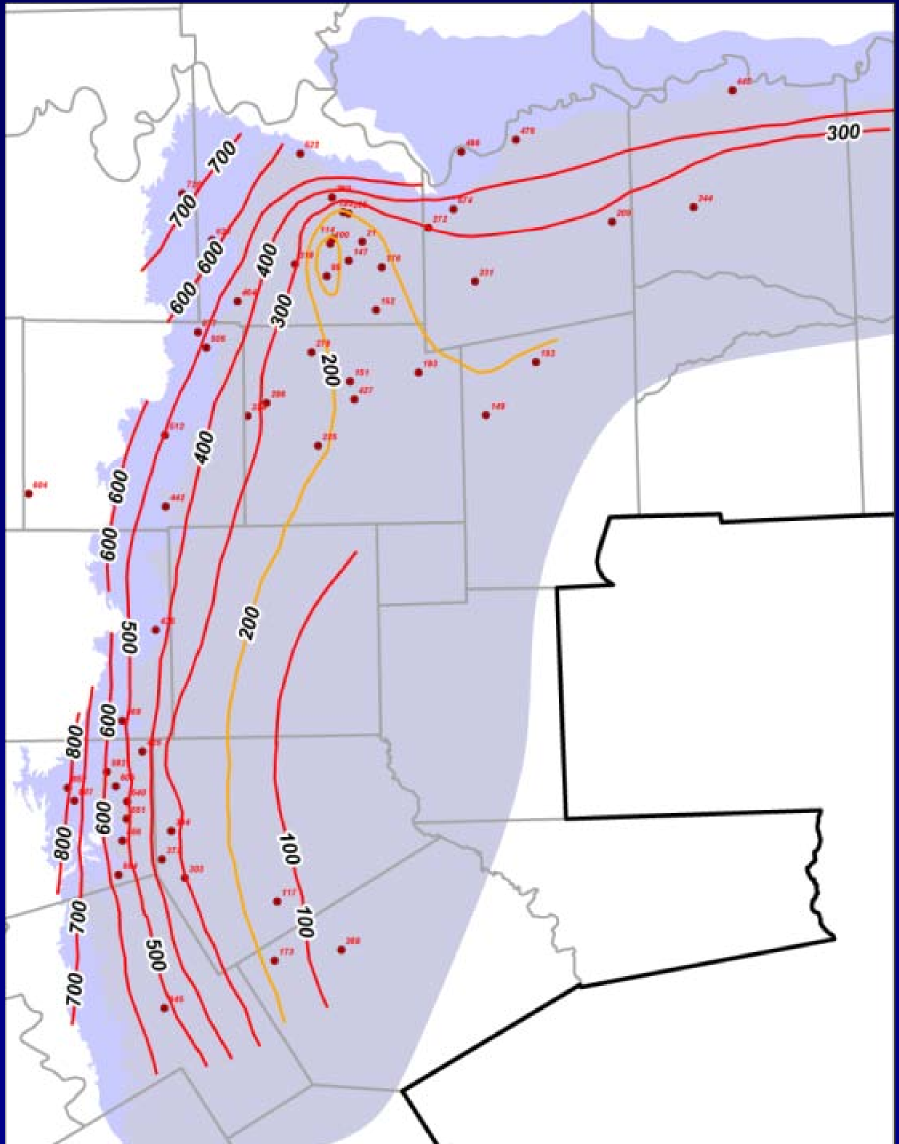
Development of Aquifers

- Significant development occurred prior to calibration/verification periods (before 1980)
- Large areas of artesian pressure decline over long periods of time

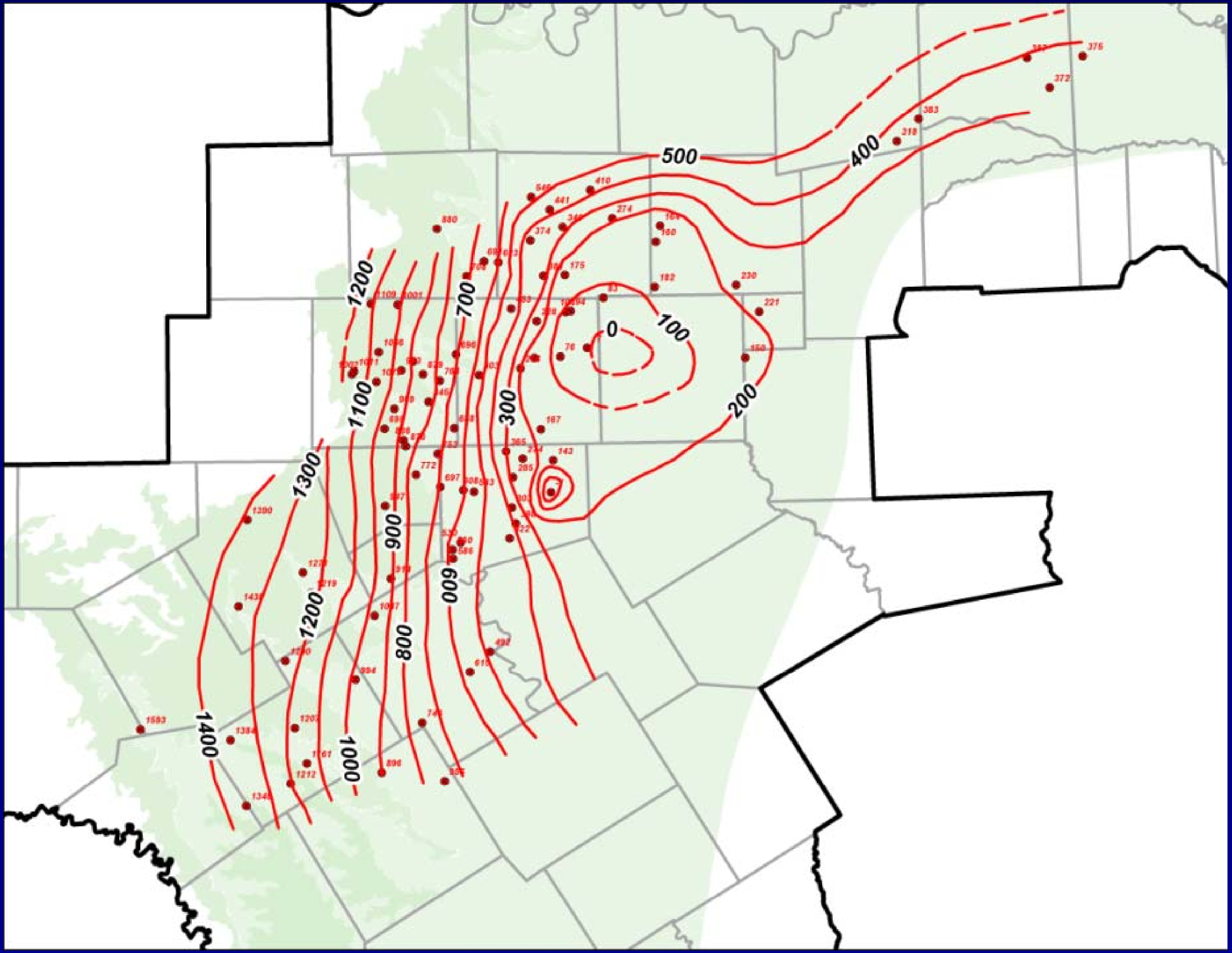
Woodbine Water Level - 1980



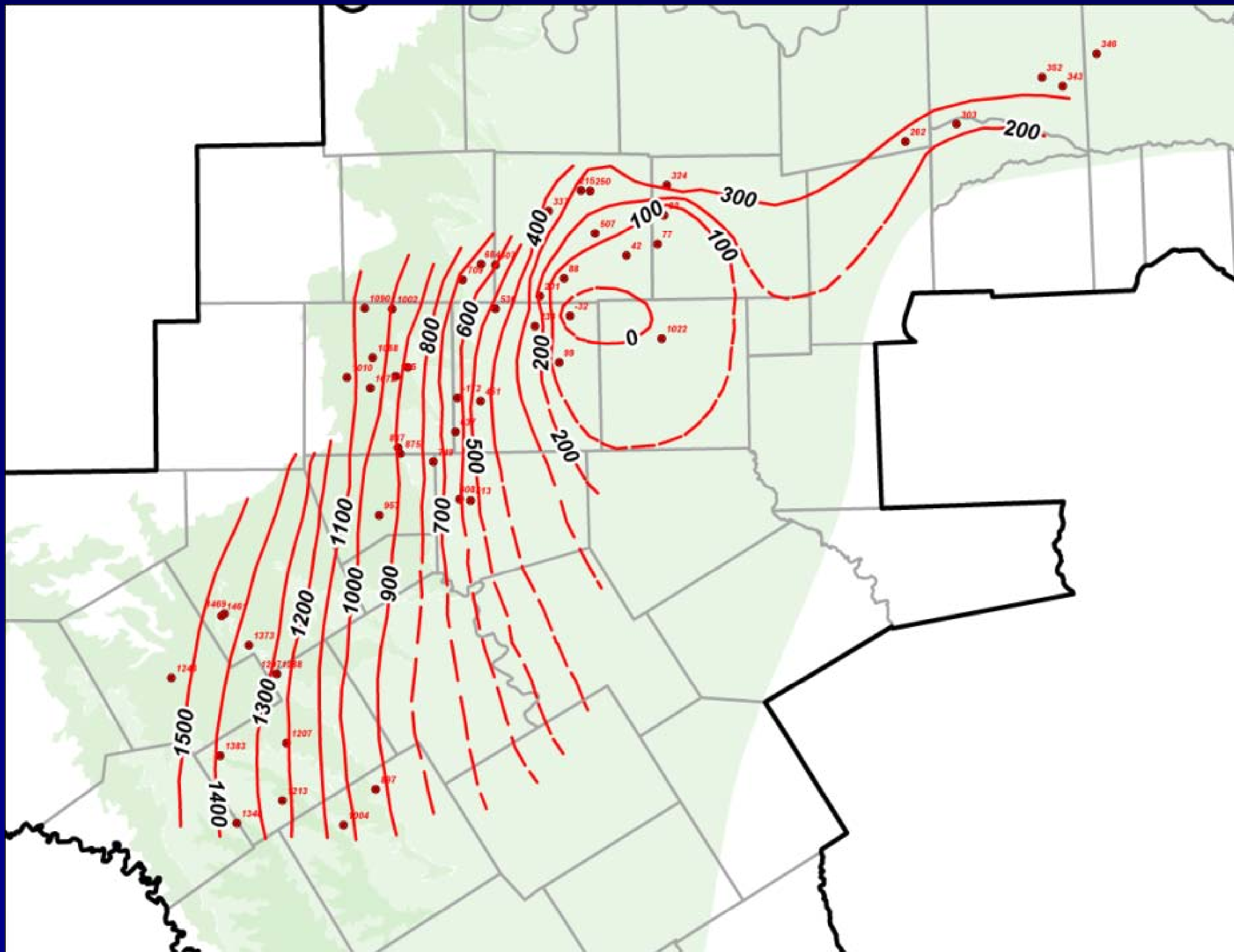
Woodbine Water Level – 2000



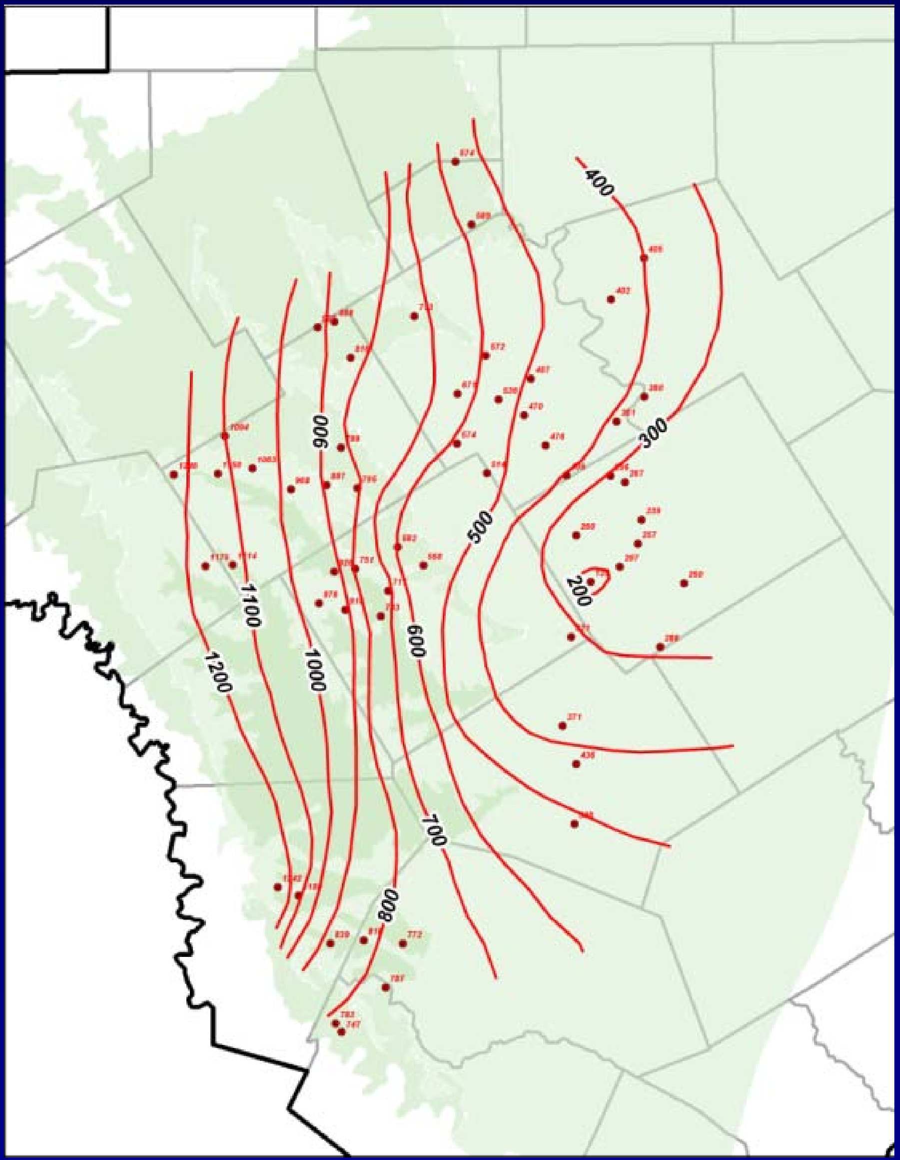
Paluxy Water Level - 1980



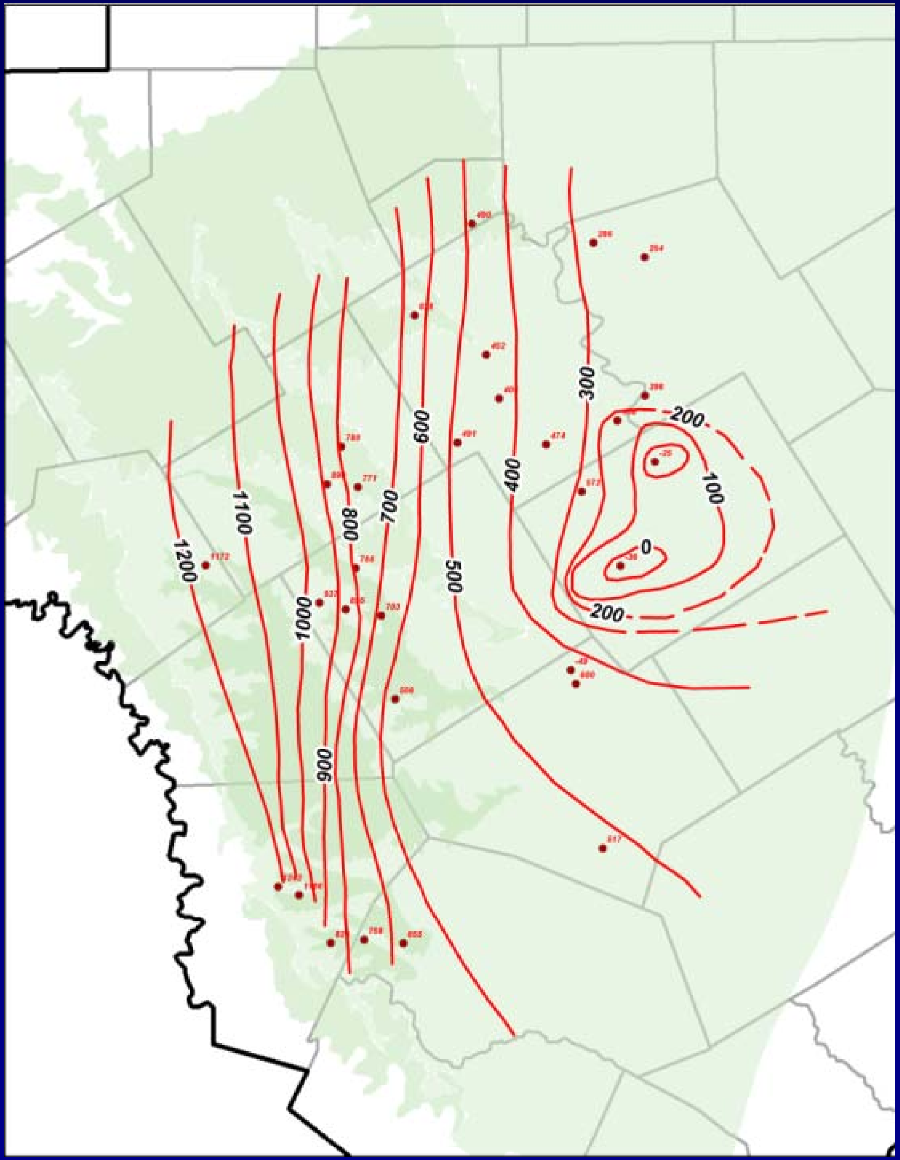
Paluxy Water Level - 2000



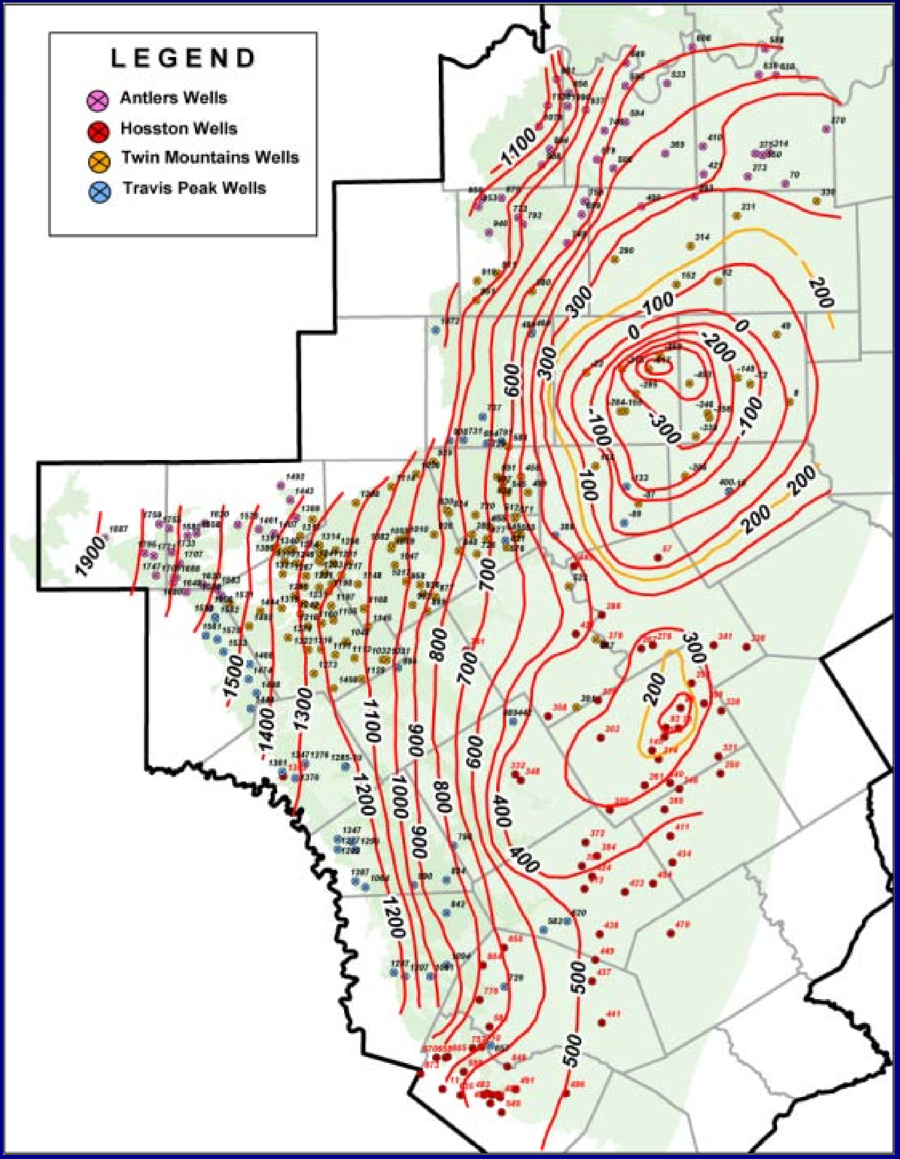
Hensell Water Level - 1980



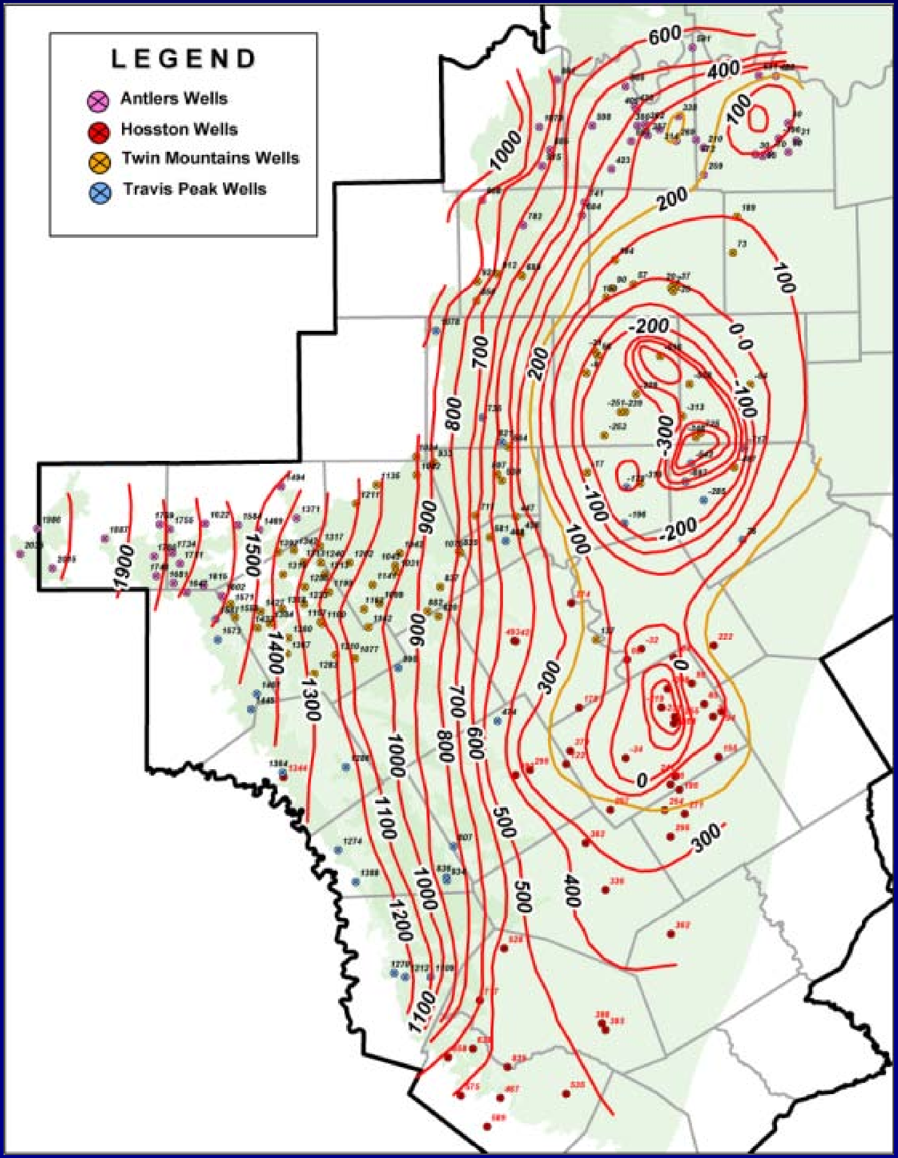
Hensell Water Level - 2000



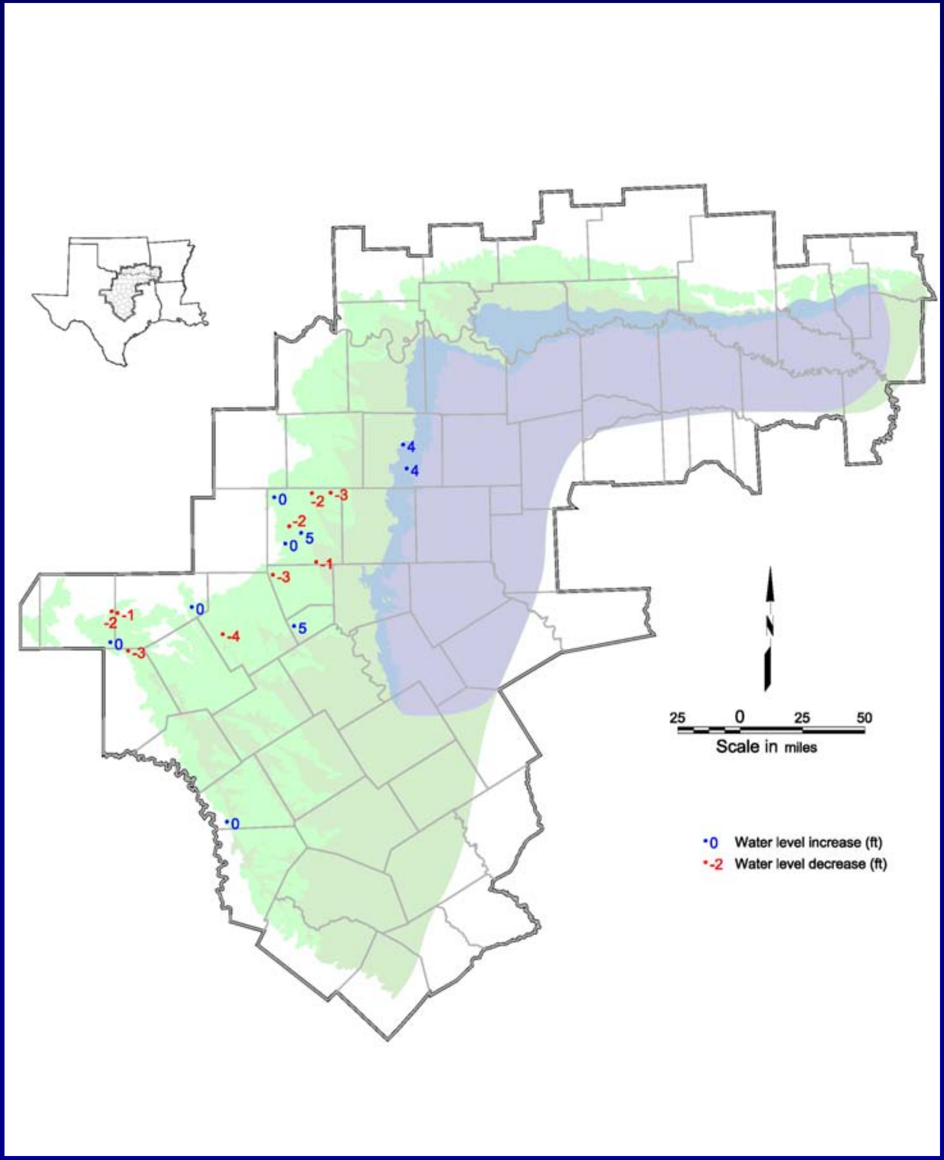
Hosston Water Level - 1980



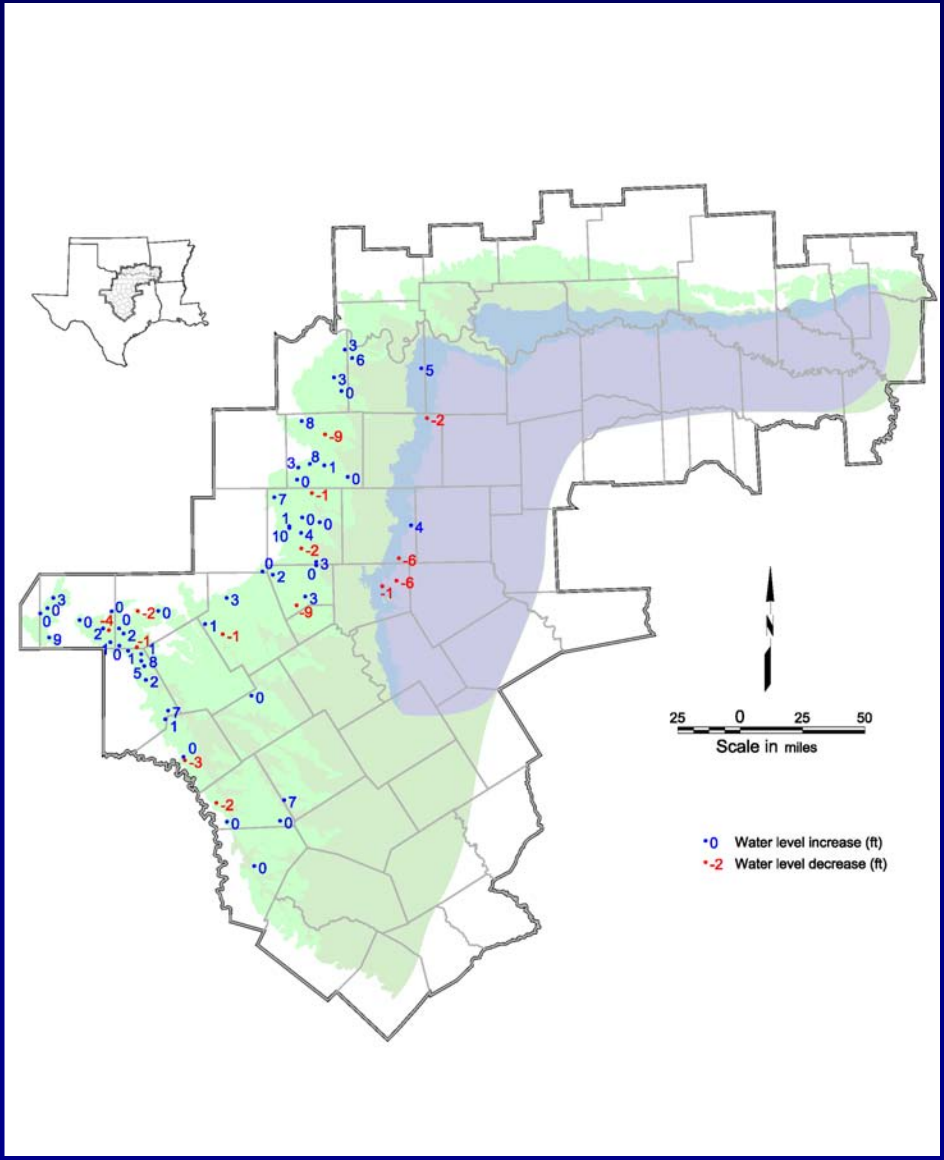
Hosston Water Level – 2000



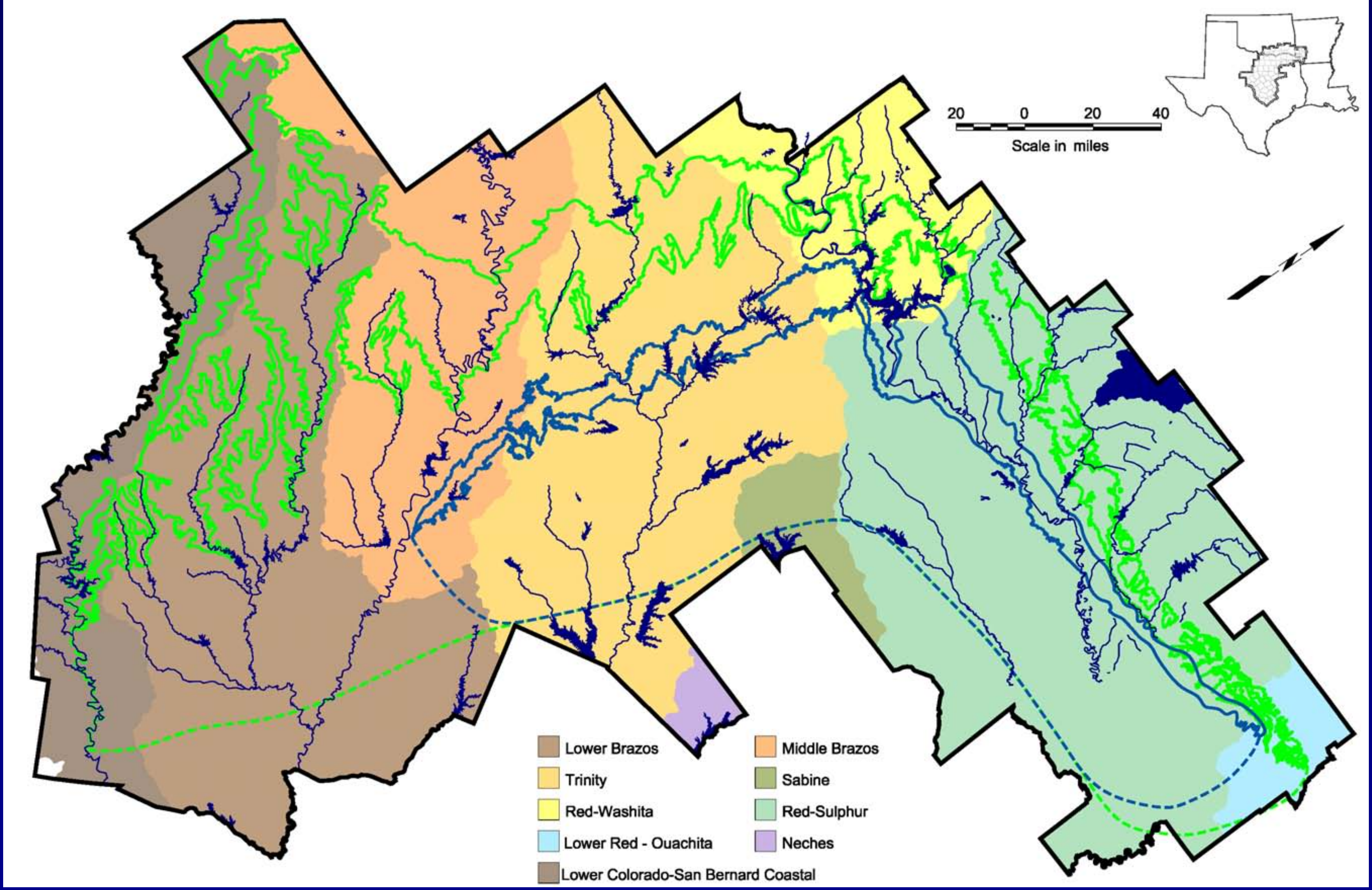
Water Table Change 1950-1980



Water Table Change 1980-2000



Major River Basins



List of Reservoirs

Trinity Outcrop

- Lake Travis
- Proctor Lake
- Squaw Creek Lake
- Lake Granbury
- Lake Weatherford
- Eagle Mountain Lake

Woodbine Outcrop

- Lake Ray Roberts
- Lewisville Lake
- Grapevine Lake
- Aquilla Lake

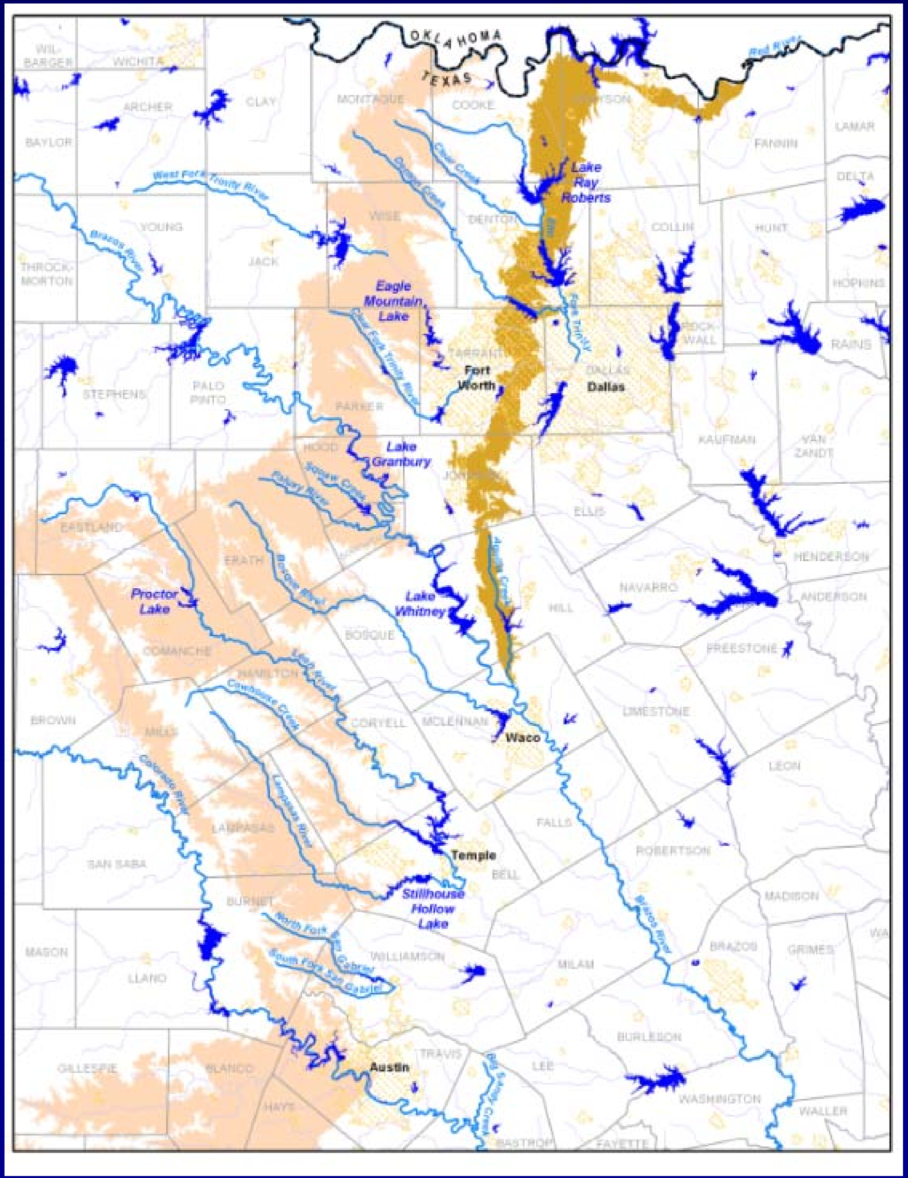
Trinity Confined

- Lake Georgetown
- Stillhouse Hollow Lake
- Belton Lake
- Lake Waco
- Lake Whitney
- Lake Pat Cleburne
- Benbrook Lake
- Lake Worth
- Lake Arlington

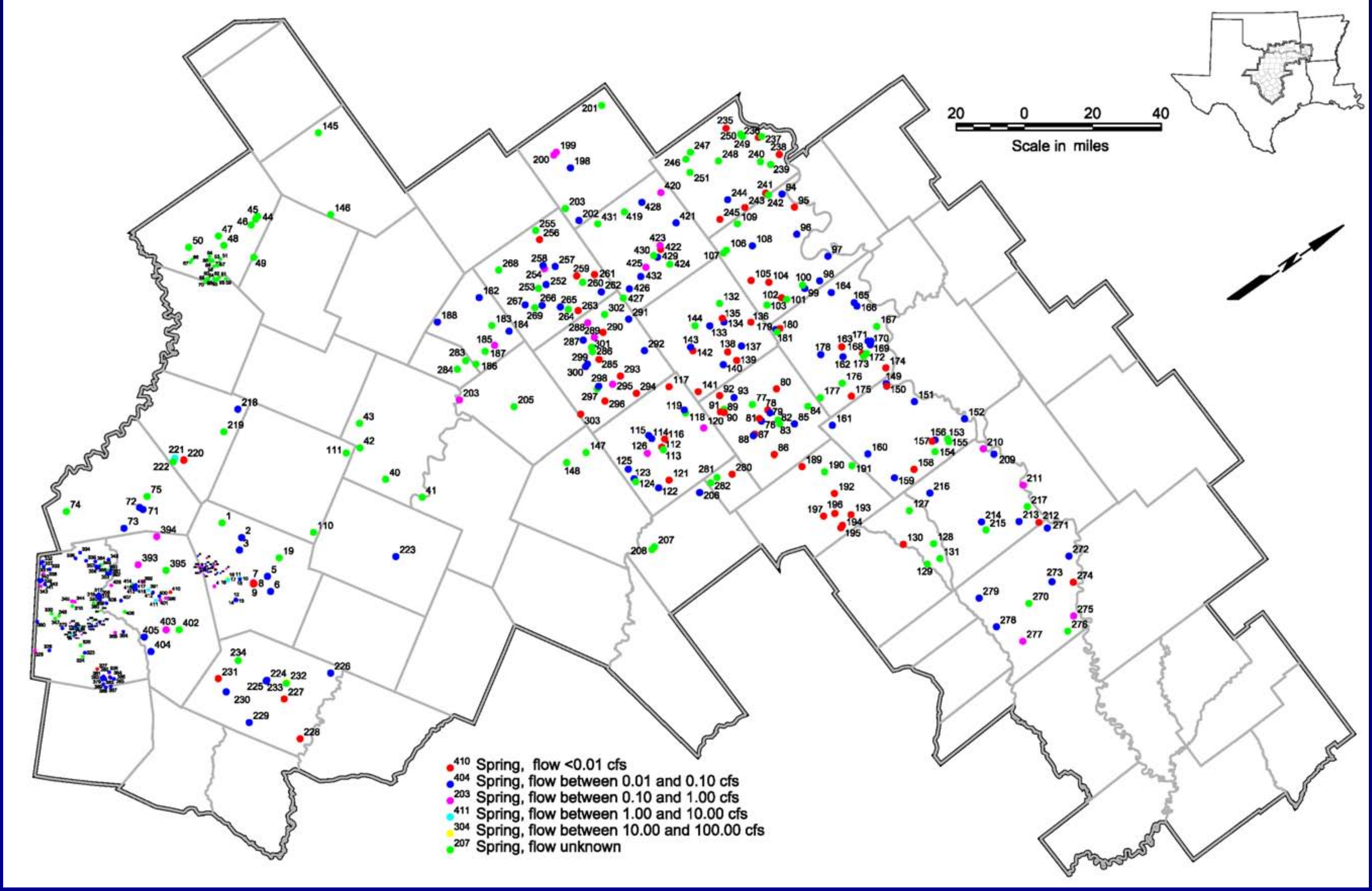
List of Major Rivers/Streams

- Red River
- Elm Fork Trinity
- Clear Creek
- Denton Creek
- Big Sandy Creek
- West Fork Trinity
- Clear Fork Trinity
- Brazos River
- Squaw Creek
- Paluxy River
- Bosque River
- Leon River
- Cowhouse Creek
- Lampasas River
- North/South San Gabriel
- Colorado River
- Aquilla Creek

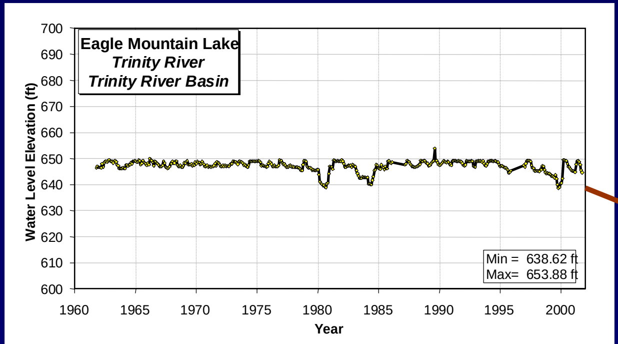
Surface Water Feature Map

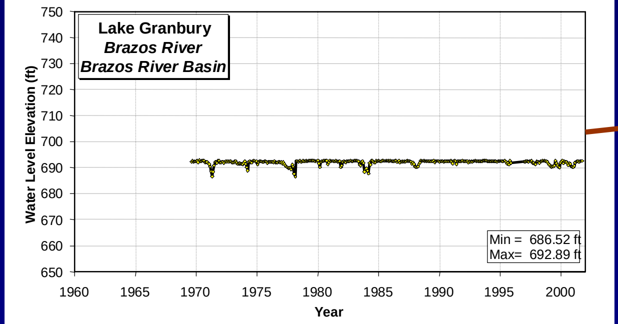


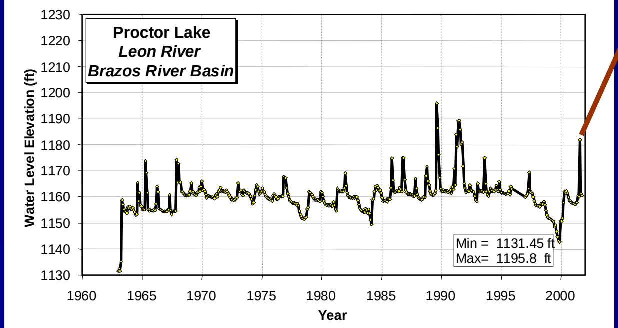
Spring Inventory

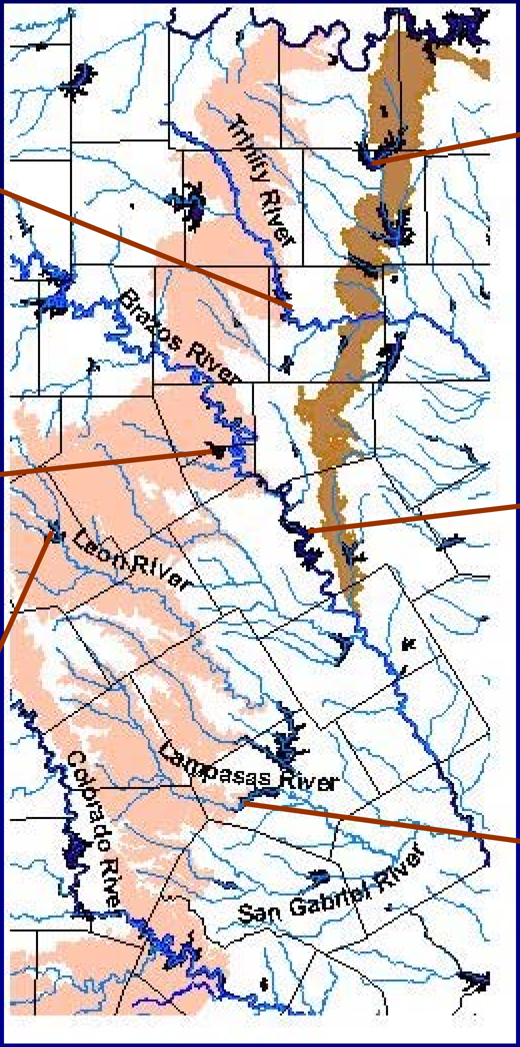


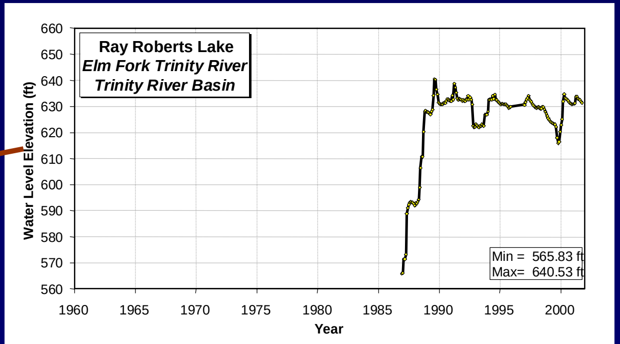
Selected Reservoir Hydrographs

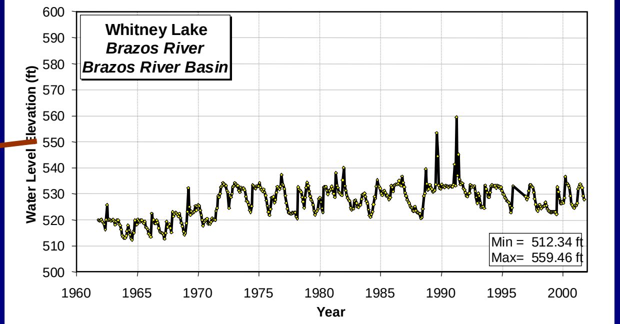


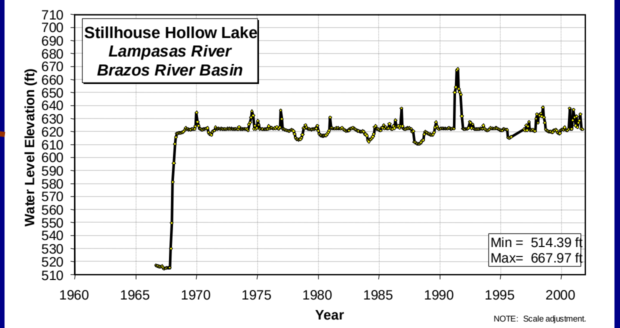




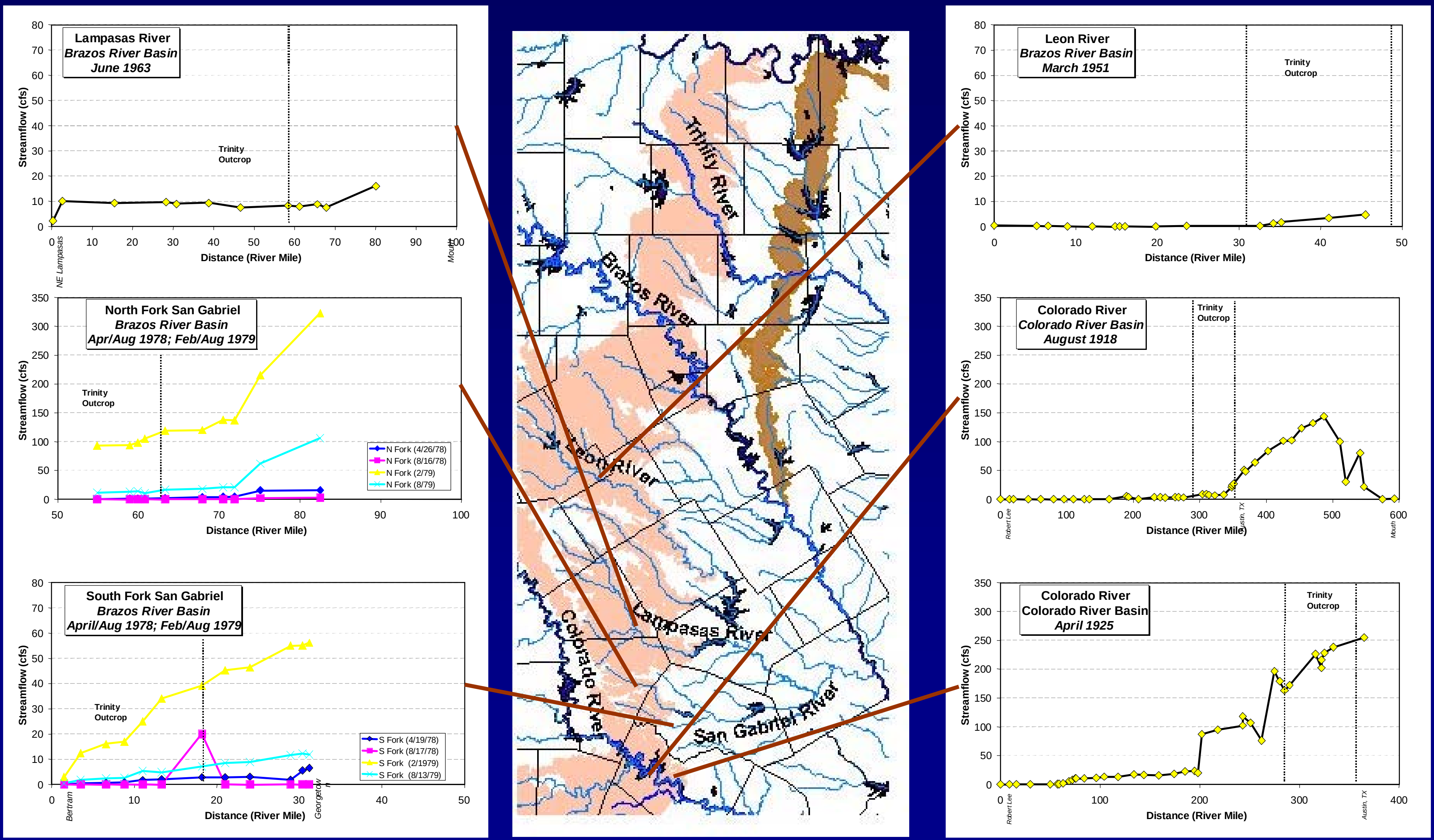






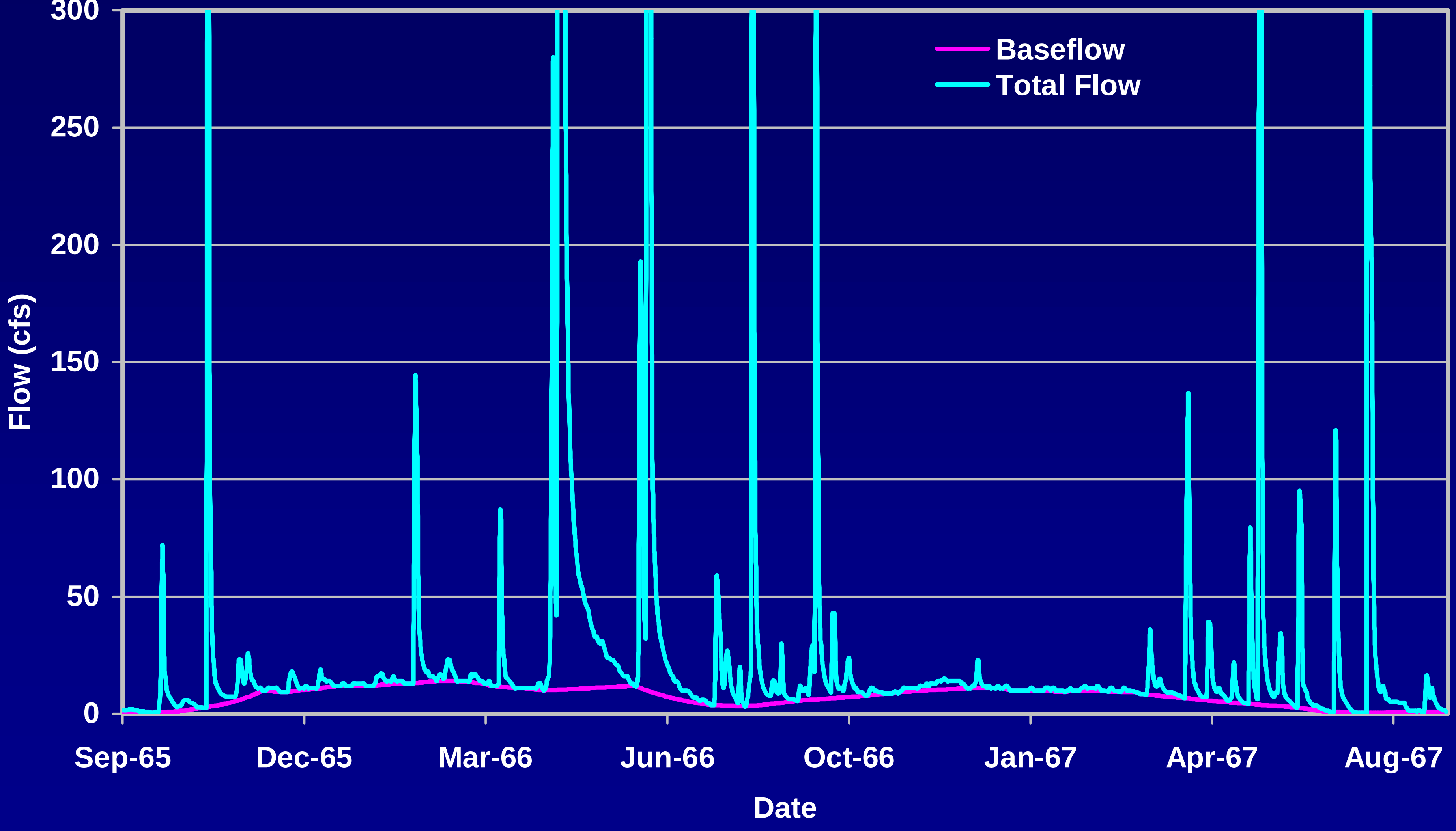


Selected Segments with Gains/Losses



Example Streamflow Separation —

Paluxy River near Glen Rose, Texas



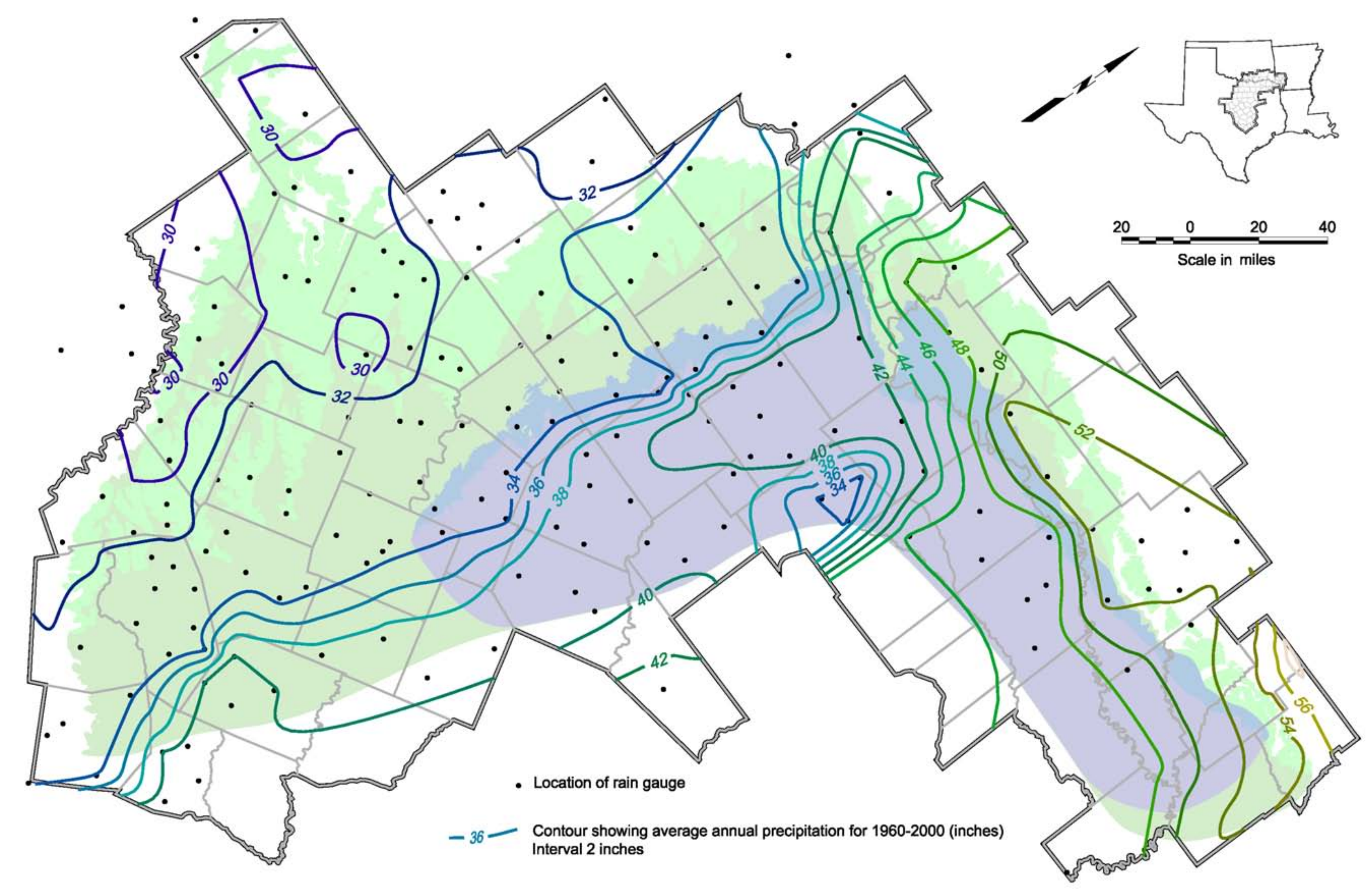
Recharge

- Controlled by many factors
- Many methods to estimate recharge have been used
- Large range of previous estimates of recharge
- Many datasets of controlling factors are inconclusive to data effect on recharge
- How do we really estimate recharge?????

Factors Controlling Recharge

- Climate/Precipitation
- Topography
- Geology & subsurface stratification
- Soils
- Land Use
- Vegetation
- Hydrology

Average Annual Precipitation



Summary of Previous Recharge Estimates

Location	Recharge rate (in/yr)	Reference	Technique
Kendall	1.3	Ashworth, 1983	baseflow discharge
Hill Country	1.5 (0.07 - 4.6)	Bluntzer, 1992	baseflow discharge
DFW Area	4.4	Dutton et al., 1996	Cross section groundwater model
Northern Trinity	0.04 - 0.3	Dutton et al., 1996	groundwater modeling
Northern Trinity	1.2	Klemt et al., 1975	assumed
Hill Country	2.2	Kuniansky and Holligan, 1994	groundwater modeling
Hill Country	2.1 - 6.0	Kuniansky, 1989	baseflow
Kendall	2.2	Mace et al., 2000	baseflow
Hill Country	1.4	Mace et al., 2000	groundwater modeling
Kendall	1.5	Reeves, 1967	baseflow
Kerr	1	Reeves, 1969	baseflow

From Scanlon et al., 2002

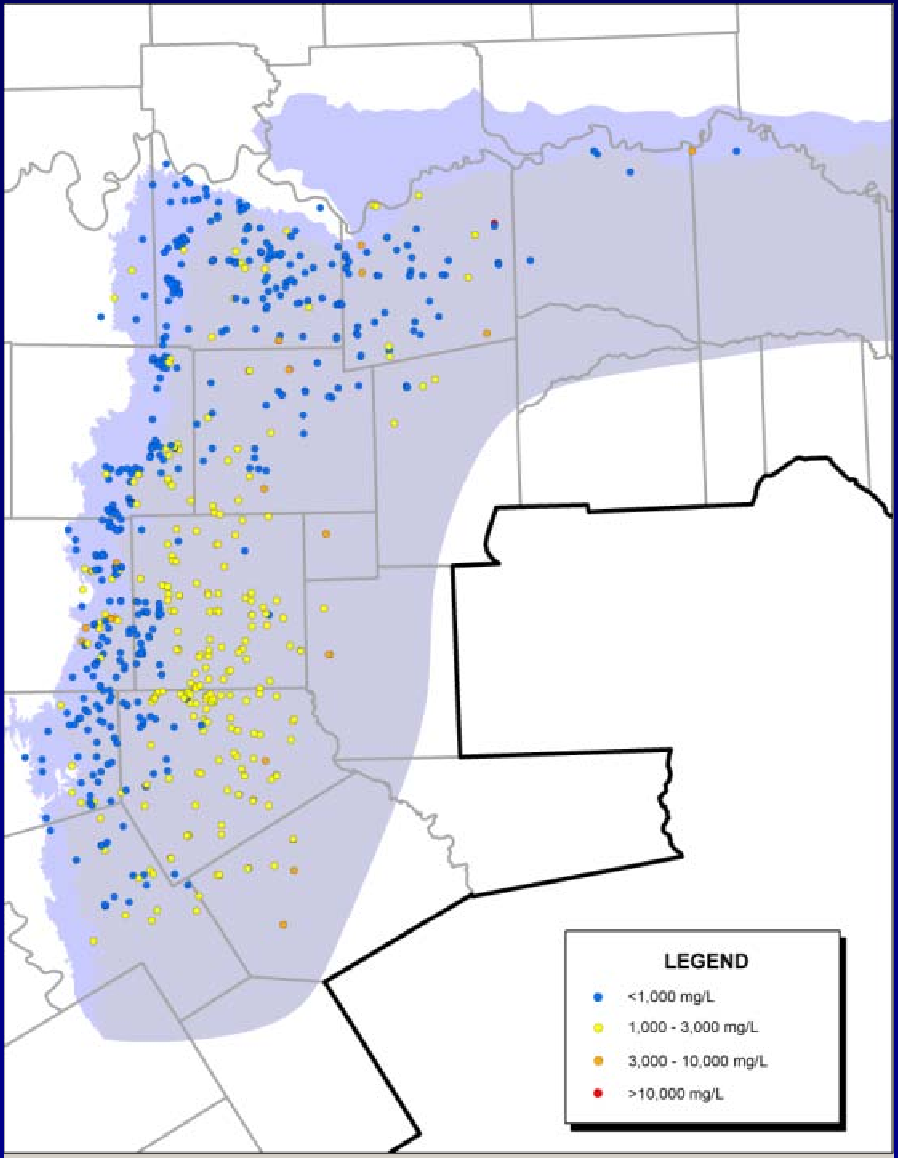
Approach to Estimating Recharge

- Initial estimate of 3% of mean annual rainfall
- Modeling will provide guidance on variation of the 3% estimate and spatial distribution
- Will ratio 3% estimate by outcrop area within each model cell (thin outcrop belts)
- Rate to be constrained by
  - Water level gradients away from outcrop
  - Long term water table trend

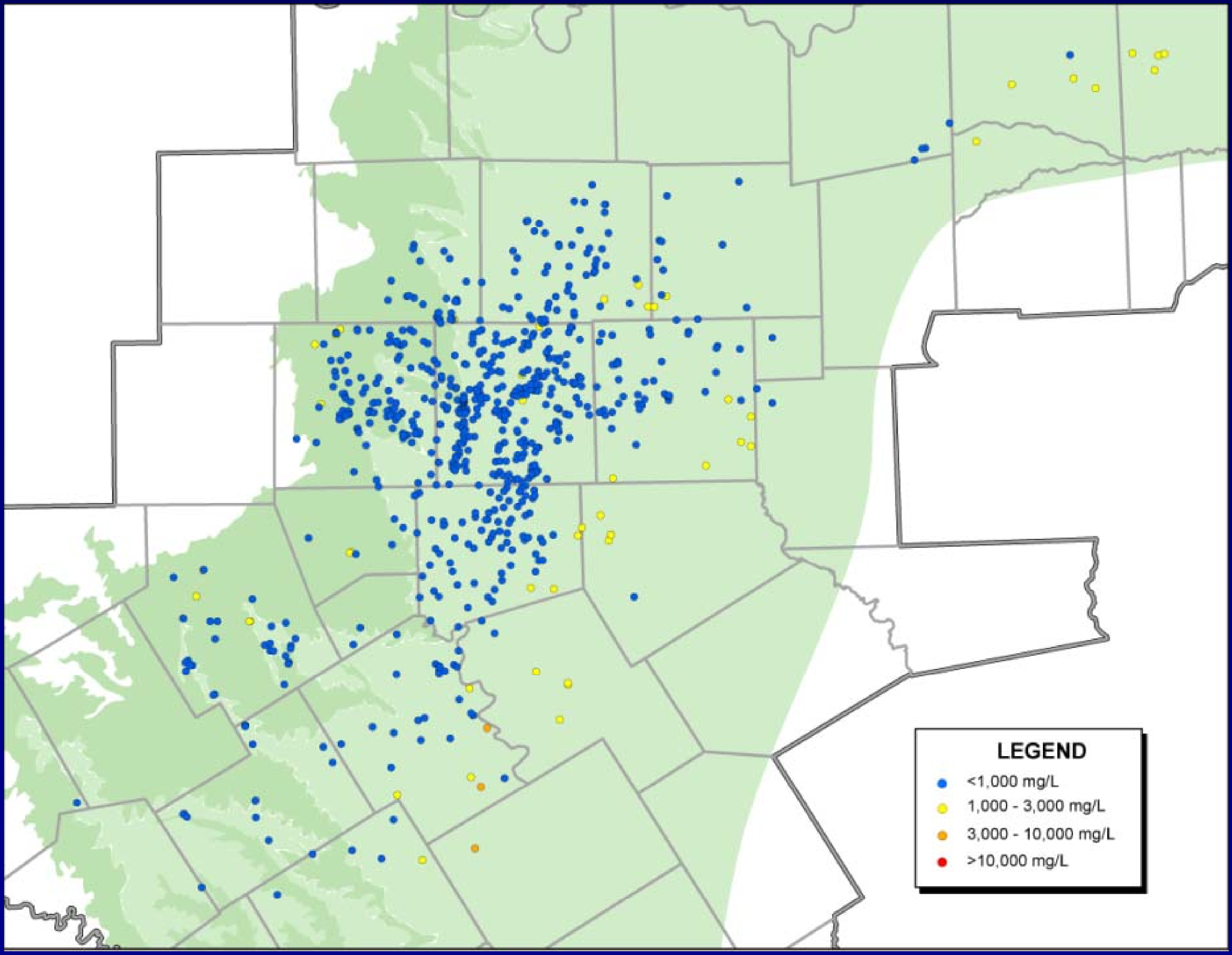
Water Quality

- Based on data from TWDB database
- For conceptual model, an evaluation of total dissolved solids was done

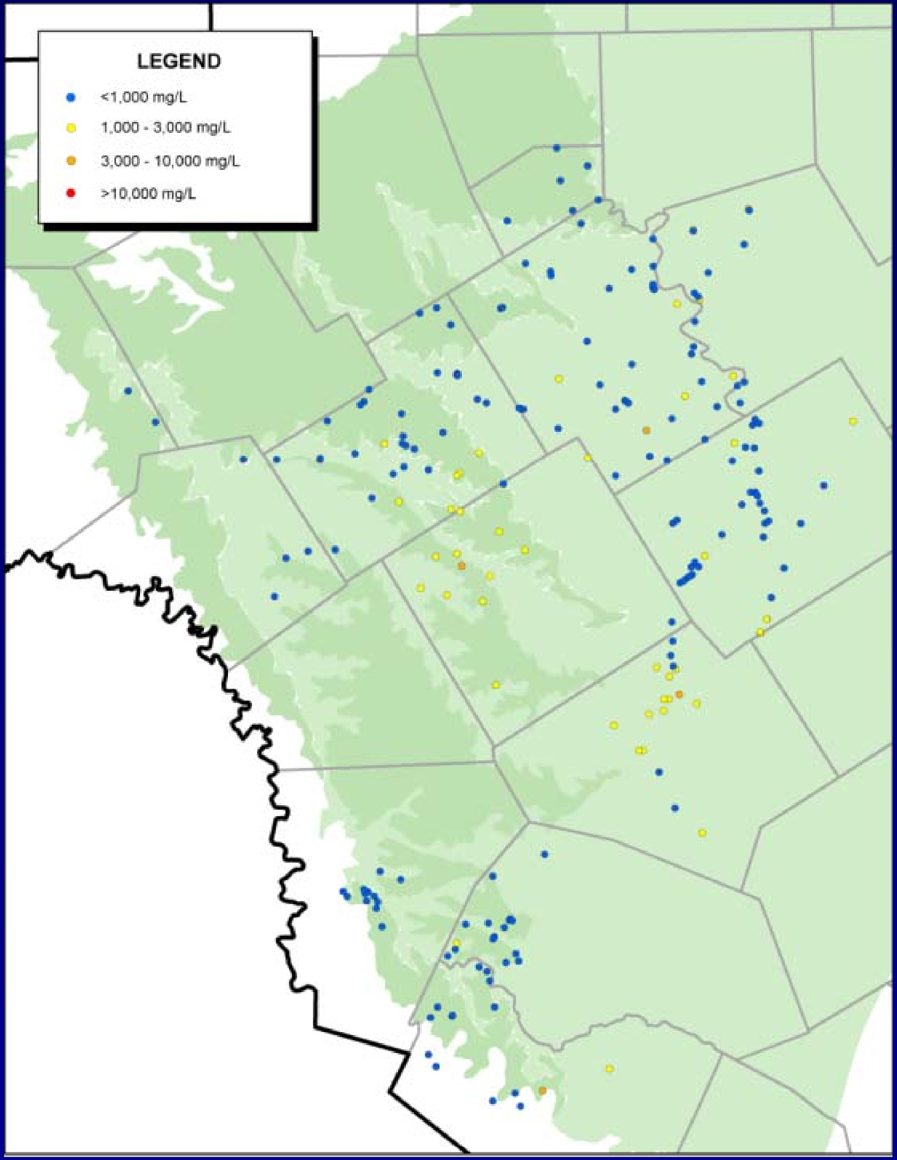
Woodbine Water Quality



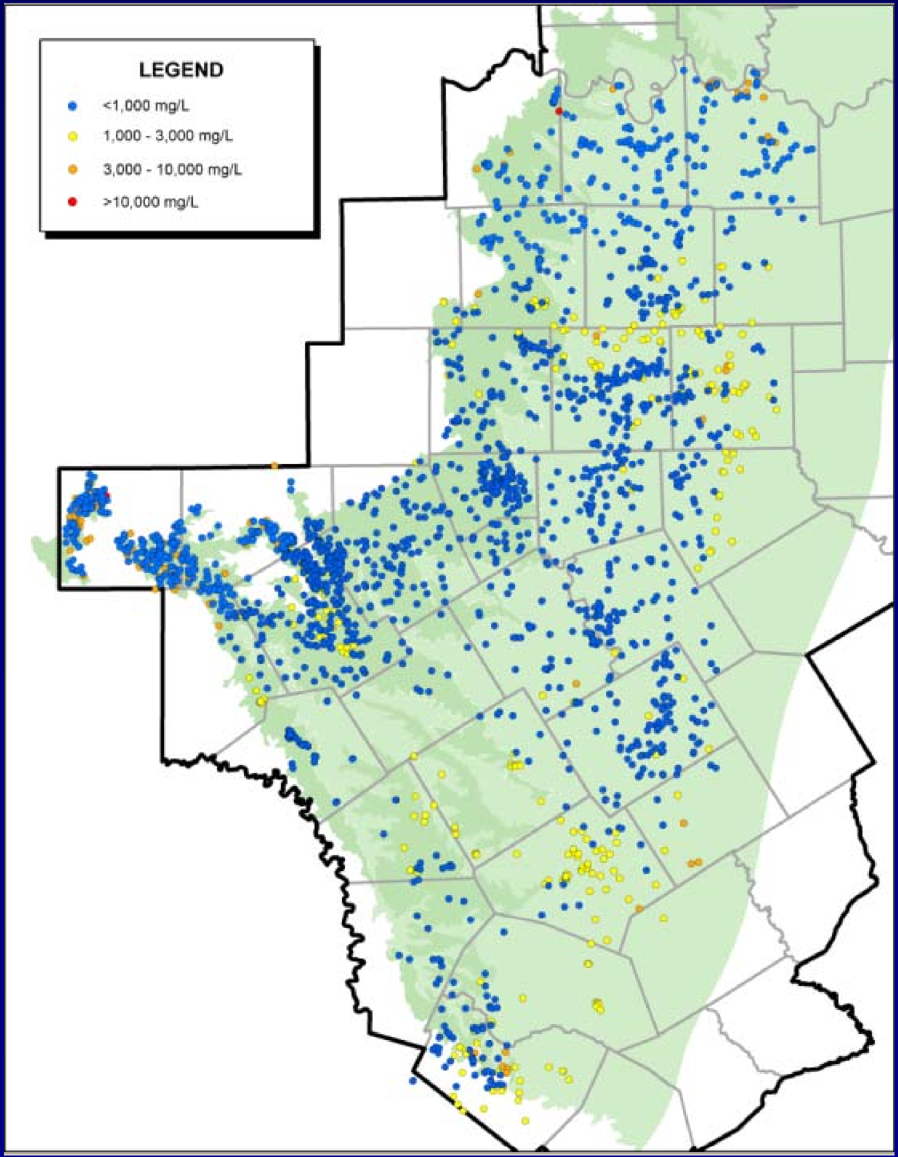
Paluxy Water Quality



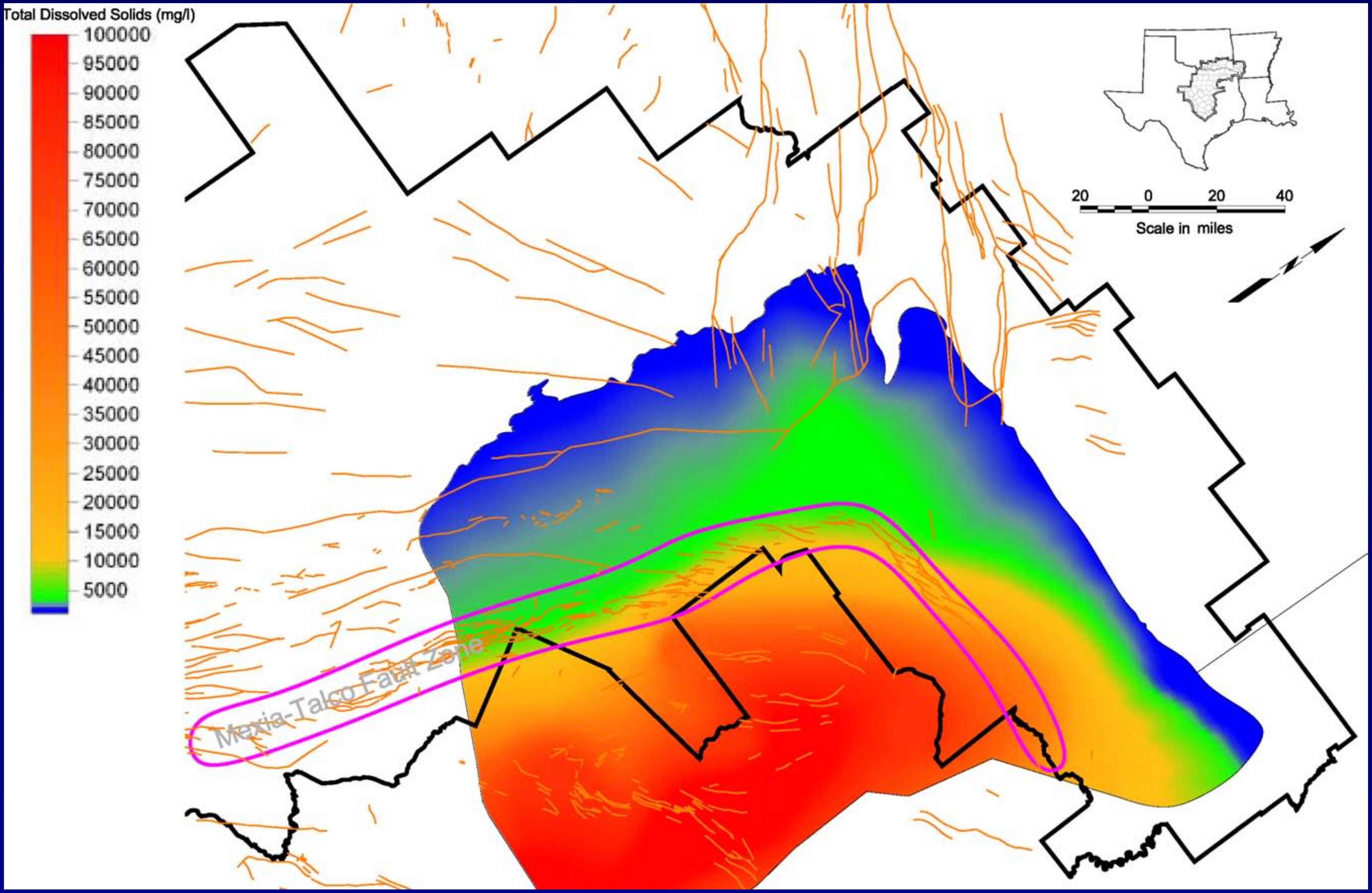
Hensell Water Quality



Hosston Water Quality



Woodbine Downdip Water Quality



Pumpage Distribution

- Approach outlined in GAM technical memo 02-02
- Point Source Locations
  - Municipal , water utilities, manufacturing, industrial, mining, and steam electric power
  - Irrigation according to TWDB well database and historical records
- Non – point
  - Livestock and rural domestic
    - Rural domestic approach will use CCN boundaries unioned with urban GIS coverage
  - Irrigation point source distribution to be checked with land use

Pumpage by County

	County	1980	1990	2000	2010	2020	2030	2040	2050
Texas Counties	***Bastrop***	0	0	0	0	0	0	0	0
	Bell	2,299	2,222	947	957	1,065	1,198	1,236	1,286
	Bosque	2,521	3,272	1,596	1,407	1,450	1,496	1,553	1,692
	Brown	1,465	1,907	1,823	1,769	1,786	1,805	1,802	1,787
	Burleson	795	1,036	0	0	0	0	0	0
	Burnet	1,470	2,017	676	742	833	882	898	889
	Callahan	1,604	1,442	1,858	1,809	1,704	1,632	1,556	1,528
	Collin	3,721	5,347	981	1,779	2,462	2,499	2,691	2,640
	Comanche	11,269	26,665	21,053	21,033	21,018	21,014	21,010	21,018
	Cooke	5,846	6,027	6,995	3,961	3,936	3,402	3,454	3,517
	Coryell	4,181	1,877	1,551	1,564	1,582	1,581	1,562	1,540
	Dallas	17,918	9,959	6,242	6,418	4,163	4,666	4,717	4,579
	Delta	293	350	863	729	668	614	574	550
	Denton	8,574	9,435	6,203	4,406	5,115	4,647	4,801	4,624
	Eastland	10,153	9,101	6,664	6,663	6,726	6,709	6,698	6,680
	Ellis	4,772	10,023	4,798	2,937	3,048	2,728	2,824	2,881
	Erath	13,760	14,225	14,440	13,640	13,721	13,799	13,817	13,857
	Falls	1,138	1,293	43	42	42	43	45	47
	Fannin	1,597	1,906	430	335	363	373	363	348
	Fayette	1,182	1,404	0	0	0	0	0	0
	Freestone	754	1,024	0	0	0	0	0	0
	Grayson	14,079	14,919	5,828	4,102	4,203	4,129	3,683	3,820
	Hamilton	2,611	2,067	1,647	1,589	1,537	1,423	1,389	1,324
	Henderson	2,638	4,529	0	0	0	0	0	0
	Hill	3,149	2,368	825	816	825	868	907	945
	Hood	2,745	4,296	4,002	3,974	4,478	4,930	5,133	5,347
	Hopkins	1,449	1,901	0	0	0	0	0	0
	Hunt	2,466	3,904	303	304	305	302	304	280
	Jack	378	444	534	508	494	475	447	421
	Johnson	5,876	7,939	1,876	1,723	1,849	1,992	1,911	1,998
	Kaufman	1,912	3,266	0	0	0	0	0	0
	Lamar	1,699	2,118	282	690	676	607	607	519
	Lampasas	1,209	1,321	743	736	736	737	739	742
	Lee	676	982	0	0	0	0	0	0
	Limestone	1,135	1,391	5	5	5	5	5	5
	McLennan	12,320	13,170	1,583	1,520	1,497	1,521	1,498	1,500
	Milam	1,153	1,392	136	139	140	140	140	139
	Mills	1,238	1,175	1,242	1,222	1,210	1,172	1,156	1,115
	Montague	922	1,053	544	504	502	487	474	454
	Navarro	1,394	1,960	32	34	35	37	38	39
	Palo Pinto	1,081	1,328	114	128	141	145	148	156
	Parker	3,444	6,134	4,486	2,343	2,863	2,199	2,601	2,580
	Rains	471	743	0	0	0	0	0	0
	Red River	1,281	1,252	48	48	45	47	47	48
	Robertson	587	808	0	0	0	0	0	0
	Rockwall	537	977	0	0	0	0	0	0
	Somervell	1,050	1,129	1,173	755	816	882	962	1,053
	Tarrant	19,749	16,910	6,091	4,199	3,891	3,902	4,270	4,118
	Taylor	1,067	1,307	627	602	586	585	585	590
	Travis	7,961	11,727	294	298	382	680	699	596
	Van Zandt	2,266	3,294	0	0	0	0	0	0

	County	1980	1990	2000	2010	2020	2030	2040	2050
Oklahoma	***Atoka***	30	136	109	163	184	203	226	245
	Bryan	1,245	877	2,130	1,602	1,675	1,711	1,784	1,842
	Carter	78	129	53	129	145	160	182	207
	Choctaw	356	392	462	523	606	688	783	897
	Johnston	54	839	939	975	1,022	1,054	1,117	1,179
	Love	3,055	2,155	1,904	2,205	2,320	2,358	2,472	2,548
	Marshall	942	523	985	818	837	874	912	959
	McCurtain	90	77	57	77	83	84	85	86
	Pushmataha	0	0	0	0	0	0	0	0
Arkansas	***Hempstead***	0	†	†	†	†	†	†	†
	Howard	392	†	†	†	†	†	†	†
	Little River	0	†	†	†	†	†	†	†
	Miller	0	†	†	†	†	†	†	†
	Pike	22	†	†	†	†	†	†	†
	Sevier	997	†	†	†	†	†	†	†

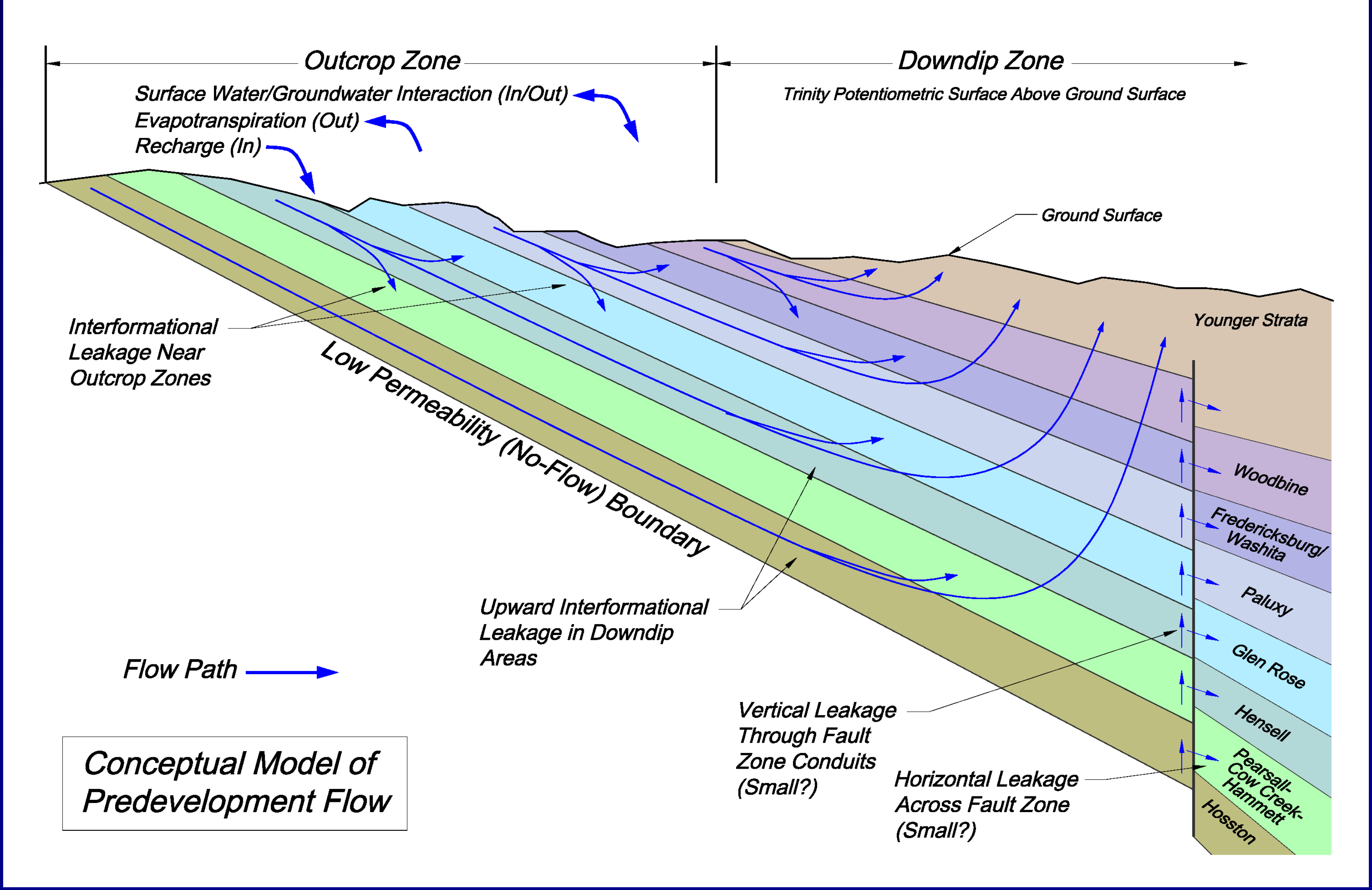
Pumpage Distribution Documentation

- Access database
- Model pumpage itemized by simulation period and model cell
  - Point source listing for each individual user/use
  - Non-point allocation listings

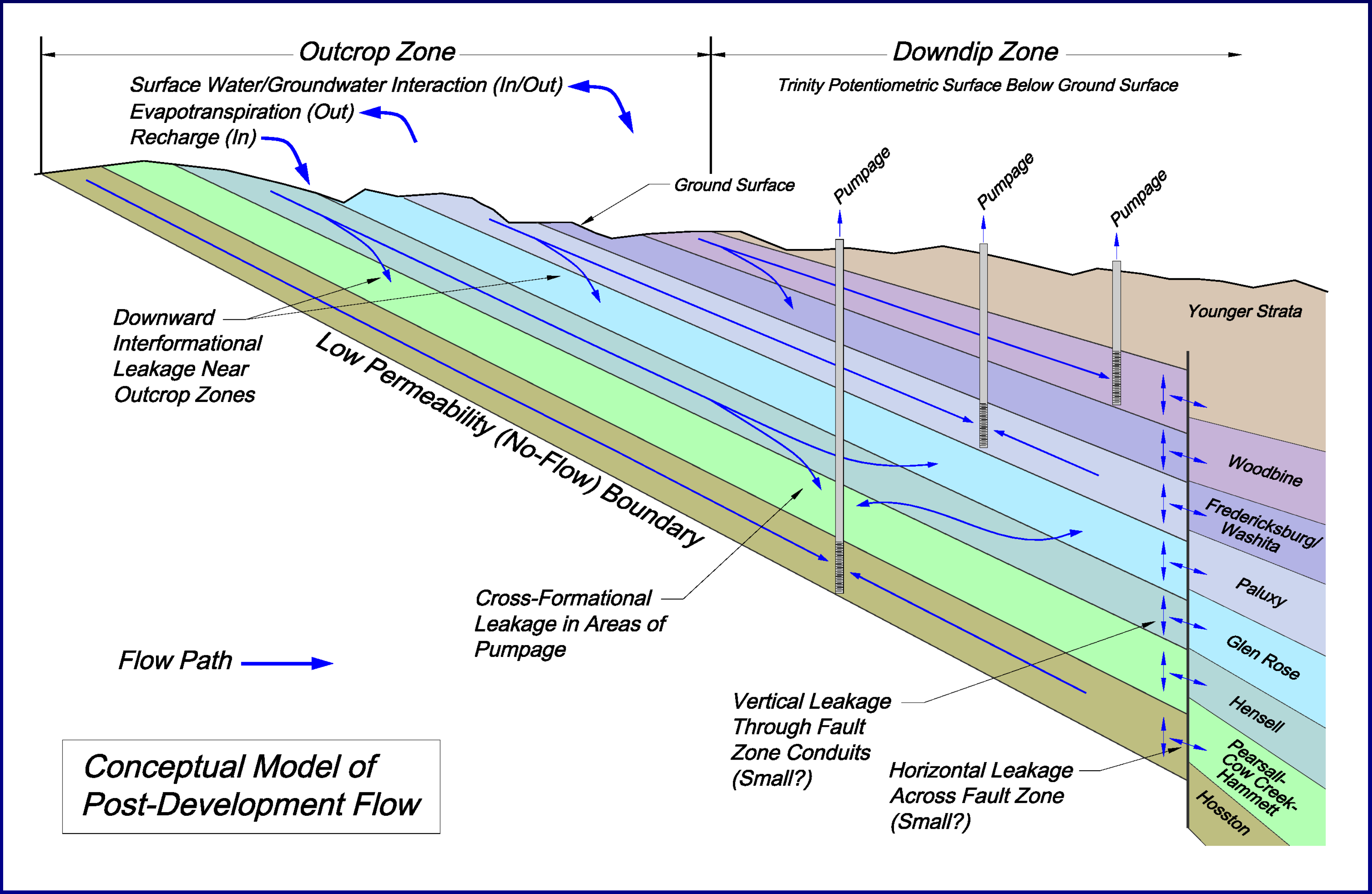
Modeling Approach

- Conceptual Model of Flow
- Historical Simulation
- Boundary Conditions

Conceptual Flow - Predevelopment



Conceptual Flow – Post-Development



Pre-Calibration Period
Model Development Strategy

- Simulate period of 1900 – 1980 using time-varying specified head package
  - Will be based on additional water level mappings for early time periods
  - Develops stable water table portion of model and capture of rejected recharge
- Transition to wells package for calibration period
  - Must provide for a stable transition
    - Matching water budget of time-varying specified head cells and pumpage targets

Model Boundary Approach

- No Flow Boundary
  - Downdip at Mexia-Talco fault zone
    - Based on water quality characteristics
  - Underlying Pre-Cretaceous
  - Southwest and Northeast boundaries
- General Head Boundary
  - Overlying Woodbine model layer

Project Schedule Milestones

- Project Initiation - January 2003
- Draft Conceptual Model Complete – August 2003
- Model Development Begins – Sept. 2003
- Study Completion Date – March 2004
- Final Report - August 2004

Northern Trinity / Woodbine Groundwater Availability Model

SAF Open Discussion

Stakeholder Advisory Forum Meeting
Northern Trinity-Woodbine Aquifer GAM
8/5/2003

Name	Representing
John Lich	T.C.E.Q.
Ricky Tow	City of Alvord
Tom Gooch	Freese & Nichols, Inc.
Dave O'Rourke	HDR
Scott Nelson	W.P.R.C.
David Wasson	Benbrook Water
Ali Chowdhury	T.W.D.B.
Paul Holroyd	City of Hewitt
Natalie Houston	U.S.G.S.
Bob Harden	R.W. Harden & Associates, Inc.
Alan Strittmatter	Strittmatter, Inc.
Tracy Relinski	R.W. Harden & Associates, Inc.
Stephanie Griffin	Freese & Nichols, Inc.
Gary Fisher	City of Alvarado (Dannenbaum)
Joe Yelderman	Dept of Geology, Baylor University
David Gattis	City of Sherman
Kraig Kahler	City of Weatherford
Sharon Hayes	City of Weatherford
Michael Cyrocki	Delta Environmental
Ron McCuller	City of Grand Prairie
Jim Poythress	City of Willow Park
Claud R. Arnold	City of Willow Park
Terry Skaggs	City of Willow Park
Paul Russell	City of Hurst

Summary of Questions/Answers
SAF No. 2
Freese & Nichols, Inc.
Fort Worth, Texas
August 5th, 2003

1. Q: What does RWPG represent?
   A: Regional Water Planning Groups

2. Q: Could you touch on the deposition environment of the Woodbine?
   A: The Woodbine sand was deposited as a fluvial-deltaic or nearshore environment that was reworked somewhat by transgressive seas.

3. Q: How did you project usage in Texas counties?
   A: Groundwater usage in Texas is compiled from historical records provided by the Texas Water Development Board and future projections and the Year 2000 demands come from RWPG demand projections. (Since the meeting, an error in the compilation of the historical data has been noted and some of the pumpage estimates are being adjusted)

4. Q: What is the source code?
   A: MODFLOW-96 is the source code for the groundwater model. It is a publicly available groundwater flow model from the United States Geological Survey.

5. Q: Will there be access to the model and research results after it has been developed?
   A: Yes, the model and all supporting data will be publicly available by request to the Texas Water Development Board. Also, the final report will also be available for download from the Board's website.

6. Q: Are the rivers lowering the water tables?
   A: In some locations rivers are sources of local groundwater discharge. In this particular setting, rivers can be thought of as lowering the water table. Where rivers are topographically higher than the underlying groundwater table, the rivers are actually trying to raise the water table.

7. Q: What about all of the oil & gas wells in the area? Could they pose a problem for use of this aquifer?
   A: Typically, construction failure of an oil or gas well can cause a localized pollution problem. But this is a very local problem and regional use is not affected.