# Refined Groundwater Availability Model for the Seymour Aquifer in Haskell, Knox and Baylor Counties

## Stakeholder Advisory Forum #2

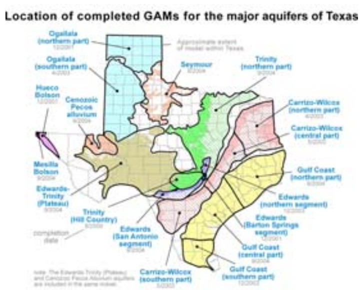
## Development of the Conceptual Model

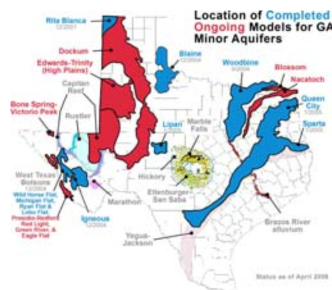
## April 27, 2009

# Outline of Presentation

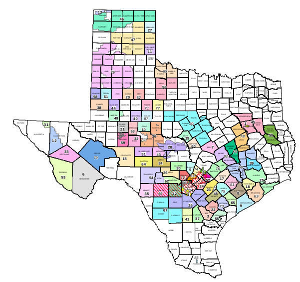
- GAM Program Summary
- Conceptual Model
- Key Data Sources
- Model Area Setting
- Previous Modeling Study
- Structure
- Water Levels
- Hydraulic Properties
- Recharge
- Natural Discharge
- Pumping
- Groundwater Quality
- Conceptual Model of Groundwater Flow
- GAM schedule

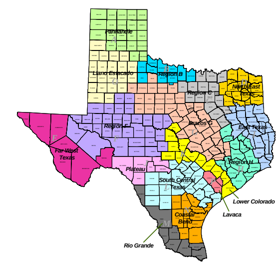
# Groundwater Availability Modeling







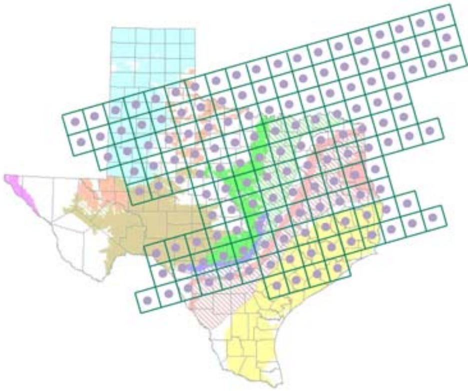


Shirley Wade

Contract Manager

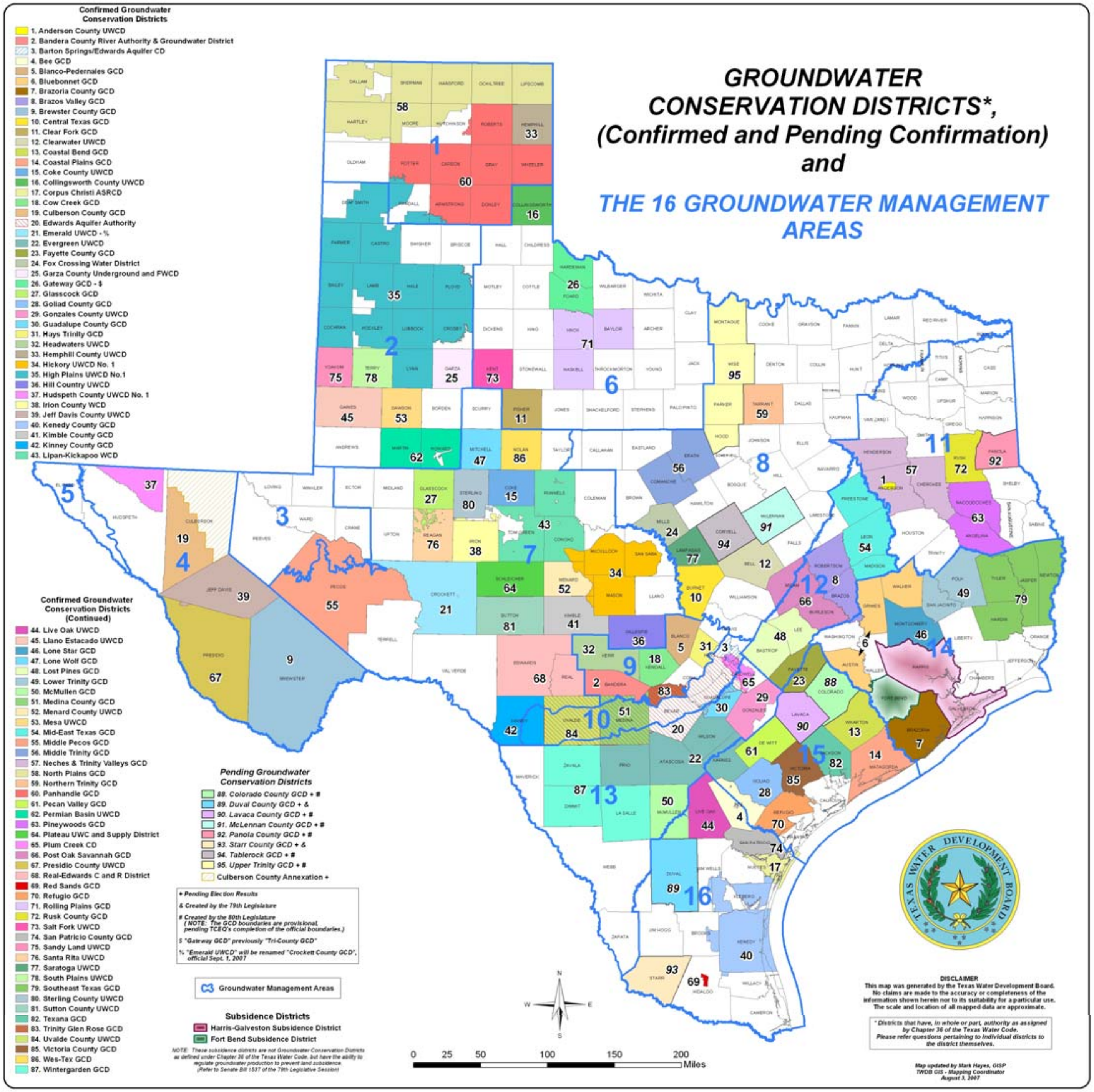
Refined Seymour Aquifer “GAM”

**Texas Water Development Board**



# what is the gam program?

- **<u>Purpose:</u> to develop tools that can be used to help Groundwater Conservation Districts, Regional Water Planning Groups, and others understand and manage their groundwater resources.**
- **<u>Public process:</u> you get to see how the model is put together.**
- **<u>Freely available:</u> models are standardized, thoroughly documented. Reports available over the internet.**
- **<u>Living tools:</u> periodically updated.**



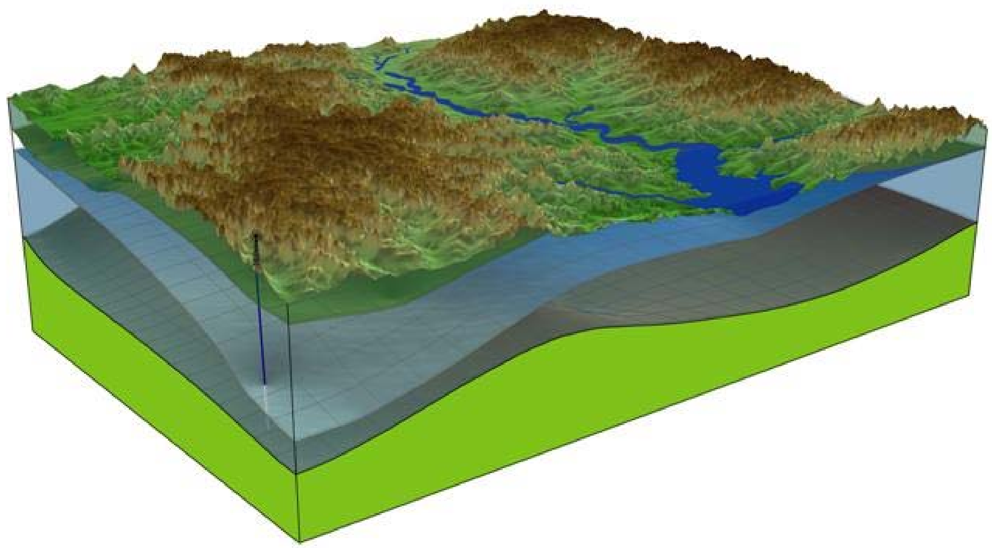
GROUNDWATER CONSERVATION DISTRICTS*, (Confirmed and Pending Confirmation) and
THE 16 GROUNDWATER MANAGEMENT AREAS
Confirmed Groundwater Conservation Districts
1. Anderson County UWCD
2. Bandera County River Authority & Groundwater District
3. Barton Springs/Edwards Aquifer CD
4. Bee GCD
5. Blanco-Pedernales GCD
6. Bluebonnet GCD
7. Brazoria County GCD
8. Brazos Valley GCD
9. Brewster County GCD
10. Central Texas GCD
11. Clear Fork GCD
12. Clearwater UWCD
13. Coastal Bend GCD
14. Coastal Plains GCD
15. Coke County UWCD
16. Collingsworth County UWCD
17. Corpus Christi ASRCD
18. Cow Creek GCD
19. Culberson County GCD
20. Edwards Aquifer Authority
21. Emerald UWCD - %
22. Evergreen UWCD
23. Fayette County GCD
24. Fox Crossing Water District
25. Garza County Underground and FWCD
26. Gateway GCD - $
27. Glasscock GCD
28. Goliad County GCD
29. Gonzales County UWCD
30. Guadalupe County GCD
31. Hays Trinity GCD
32. Headwaters UWCD
33. Hemphill County UWCD
34. Hickory UWCD No. 1
35. High Plains UWCD No.1
36. Hill Country UWCD
37. Hudspeth County UWCD No. 1
38. Irion County WCD
39. Jeff Davis County UWCD
40. Kenedy County GCD
41. Kimble County GCD
42. Kinney County GCD
43. Lipan-Kickapoo WCD
Confirmed Groundwater Conservation Districts (Continued)
44. Live Oak UWCD
45. Llano Estacado UWCD
46. Lone Star GCD
47. Lone Wolf GCD
48. Lost Pines GCD
49. Lower Trinity GCD
50. McMullen GCD
51. Medina County GCD
52. Menard County UWCD
53. Mesa UWCD
54. Mid-East Texas GCD
55. Middle Pecos GCD
56. Middle Trinity GCD
57. Neches & Trinity Valleys GCD
58. North Plains GCD
59. Northern Trinity GCD
60. Panhandle GCD
61. Pecan Valley GCD
62. Permian Basin UWCD
63. Pineywoods GCD
64. Plateau UWC and Supply District
65. Plum Creek CD
66. Post Oak Savannah GCD
67. Presidio County UWCD
68. Real-Edwards C and R District
69. Red Sands GCD
70. Refugio GCD
71. Rolling Plains GCD
72. Rusk County GCD
73. Salt Fork UWCD
74. San Patricio County GCD
75. Sandy Land UWCD
76. Santa Rita UWCD
77. Saratoga UWCD
78. South Plains UWCD
79. Southeast Texas GCD
80. Sterling County UWCD
81. Sutton County UWCD
82. Texana GCD
83. Trinity Glen Rose GCD
84. Uvalde County UWCD
85. Victoria County GCD
86. Wes-Tex GCD
87. Wintergarden GCD
Pending Groundwater Conservation Districts
88. Colorado County GCD + #
89. Duval County GCD + &
90. Lavaca County GCD + #
91. McLennan County GCD + #
92. Panola County GCD + #
93. Starr County GCD + &
94. Tablerock GCD + #
95. Upper Trinity GCD + #
Culberson County Annexation +
+ Pending Election Results
& Created by the 79th Legislature
# Created by the 80th Legislature (NOTE: The GCD boundaries are provisional, pending TCEQ's completion of the official boundaries.)
$ "Gateway GCD" previously "Tri-County GCD"
% "Emerald UWCD" will be renamed "Crockett County GCD", official Sept. 1, 2007
Groundwater Management Areas
Subsidence Districts
Harris-Galveston Subsidence District
Fort Bend Subsidence District
NOTE: These subsidence districts are not Groundwater Conservation Districts as defined under Chapter 36 of the Texas Water Code, but have the ability to regulate groundwater production to prevent land subsidence. (Refer to Senate Bill 1537 of the 79th Legislative Session)
0 25 50 100 150 200 Miles
TEXAS WATER DEVELOPMENT BOARD
DISCLAIMER
This map was generated by the Texas Water Development Board. No claims are made to the accuracy or completeness of the information shown herein nor to its suitability for a particular use. The scale and location of all mapped data are approximate.
* Districts that have, in whole or part, authority as assigned by Chapter 36 of the Texas Water Code. Please refer questions pertaining to individual districts to the district themselves.
Map updated by Mark Hayes, GISP
TWDB GIS - Mapping Coordinator
August 3, 2007

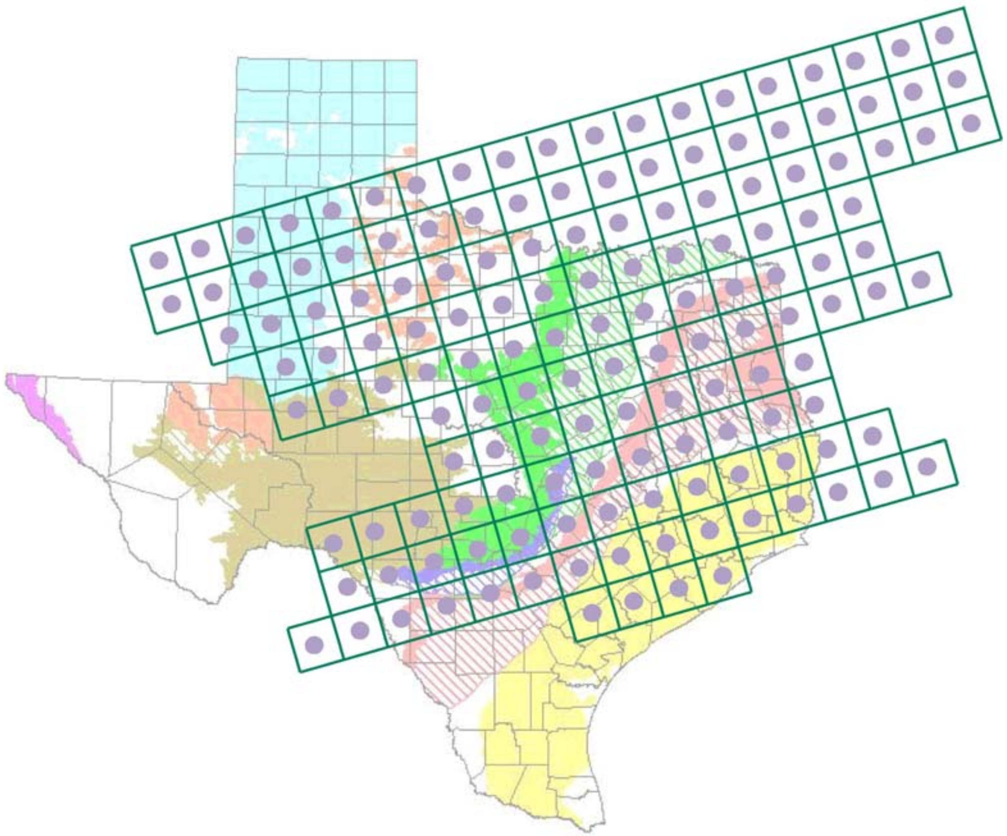
# what is a groundwater model?

- **“A model is any device that represents an approximation of a field situation” Anderson and Woessner (1992)**
- **“a representation of reality that attempts to explain some aspect of it and is always less complex than the system it represents” Domenico (1972)**
- **<u>simplified</u> numerical representation of a <u>complex</u> groundwater flow system**

# process to develop a model

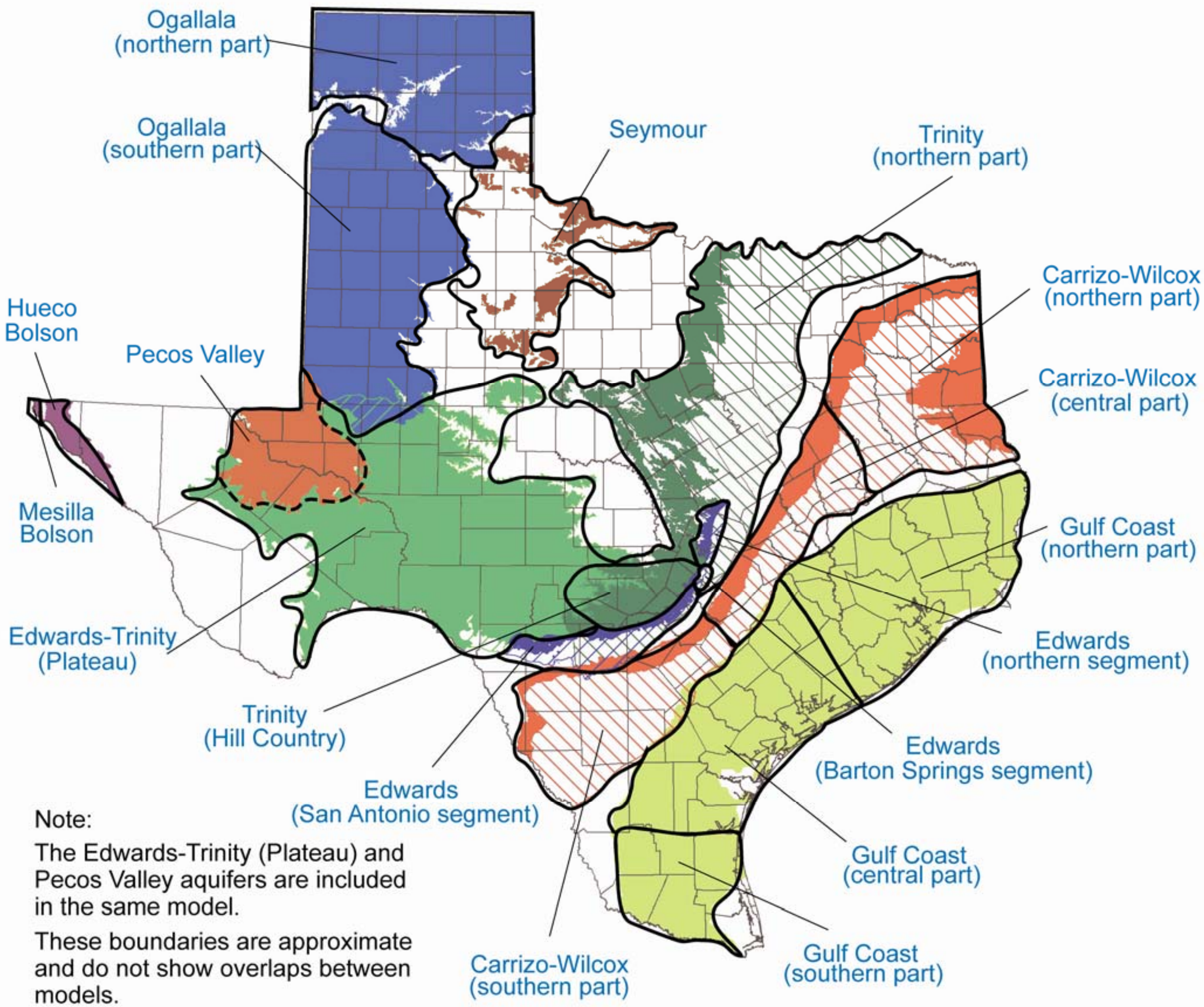
- **Gather data**
- **Create conceptual model**
- **Develop model**
- **Calibrate to measured data**
- **Make predictions**
- **Bonus: develop graphics to help understand resource**





what is the status of the models?

# 17 models completed for the major aquifers

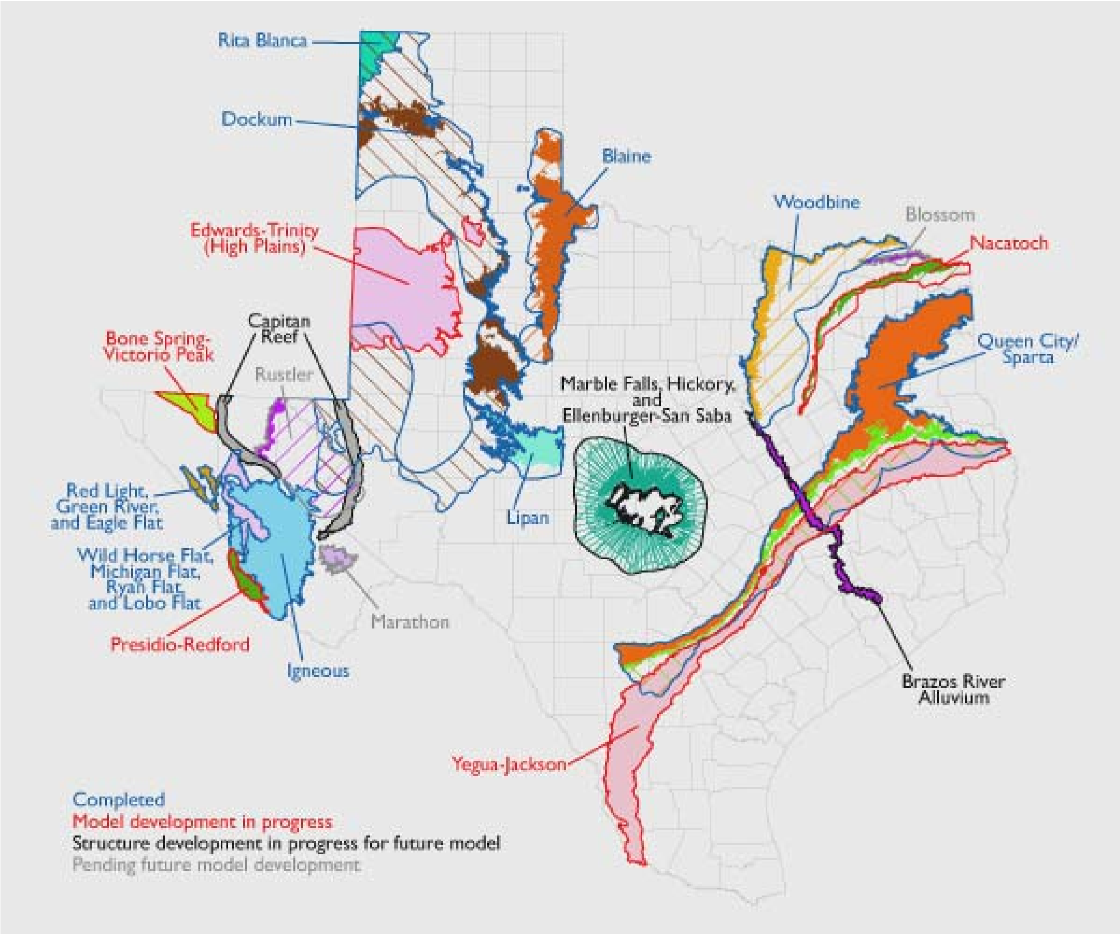



Note:

The Edwards-Trinity (Plateau) and Pecos Valley aquifers are included in the same model.

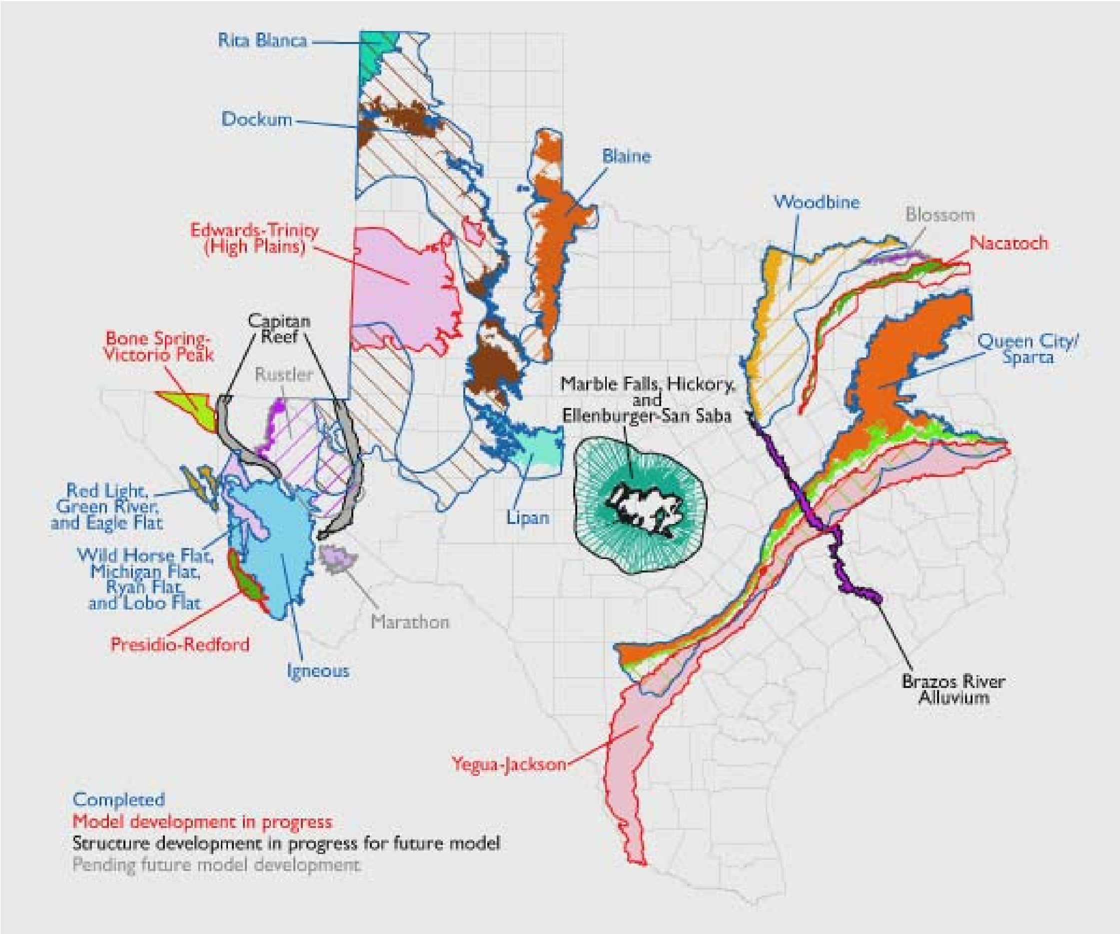
These boundaries are approximate and do not show overlaps between models.

# models completed for the minor aquifers



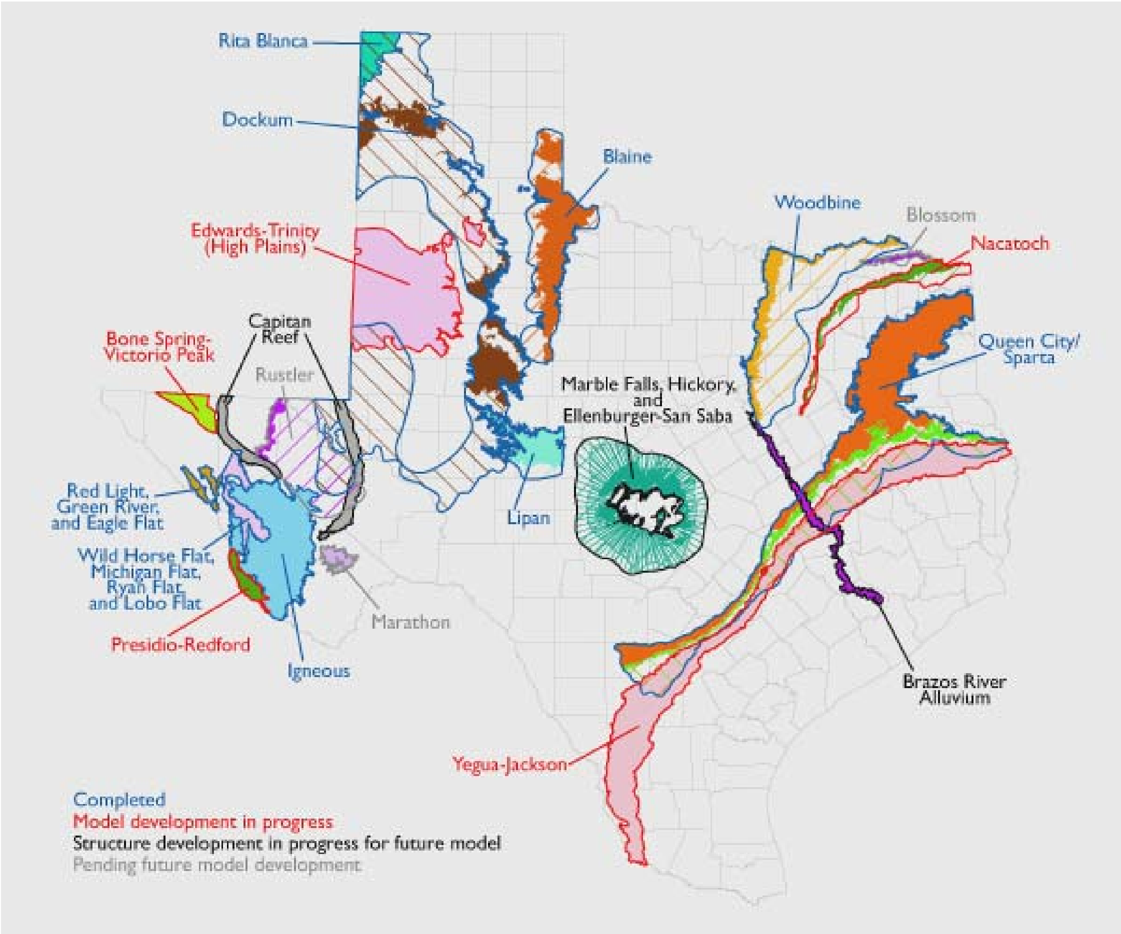

1. Rita Blanca
2. Blaine
3. Woodbine
4. Nacatoch
5. Queen City
6. Sparta
7. Lipan
8. Igneous
9. Parts of West Texas Bolsons
10. Dockum
11. Edwards-Trinity (High Plains)

# models under development for the minor aquifers

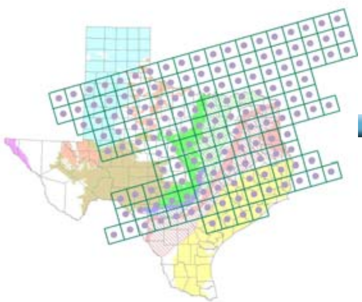



1. Yegua-Jackson
2. Presidio portion of West Texas Bolsons
3. Independent model of Bone Spring-Victorio Peak

# models to be completed for the minor aquifers

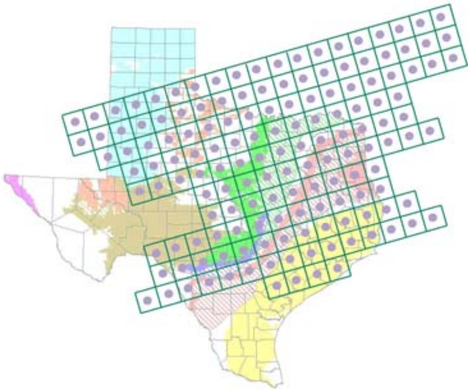



1. Brazos River Alluvium
2. Llano Uplift—Marble Falls, Ellenburger-San Saba, & Hickory
3. Capitan Reef Complex
4. Blossom
5. Marathon
6. Rustler (next to be modeled)



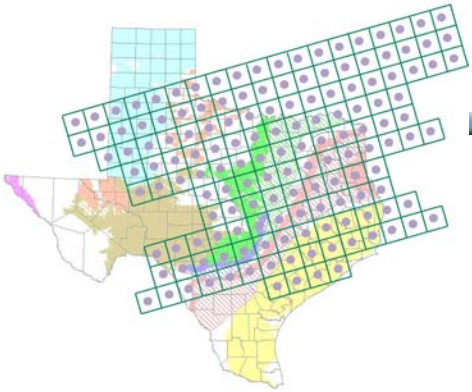
# how do we use GAM?

- **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
- **Groundwater Management Areas, Groundwater Conservation Districts and Regional Water Planning Groups can request runs**



# do we have to use GAM?

- **Water Code & Texas Water Development Board rules require that Groundwater Conservation Districts use GAM information, if available, for their management plans.**
- **TWDB rules require that Regional Water Planning Groups use managed available groundwater estimates, if developed in time for the planning cycle**

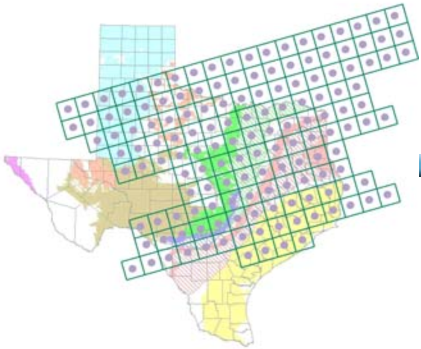


# what is groundwater availability or a MAG?

- <u>Managed available groundwater</u> (MAG)…the amount of groundwater available for use.
- The State does not directly decide how much groundwater is available for use: Groundwater Conservation Districts will through Groundwater Management Area process.
- A GAM is a <u>tool</u> that can be used to assess groundwater availability once Groundwater Conservation Districts within Groundwater Management Areas decide on the desired future condition of the aquifer.

# GAM are living tools…

- **Groundwater Conservation Districts, Regional Water Planning Groups, Texas Water Development Board, and others collect new information on aquifer.**
- **Texas Water Development Board plans to update GAMs every five years with new information.**
- **Please share information and ideas with TWDB on aquifers and GAMs.**



# participating in the GAM process

- **Stakeholder Advisory Forums (SAF)**
  - hear about progress on the model
  - comment on model assumptions
  - offer information (timing is important!)
  - http://www.twdb.state.tx.us/gam/GamSH.asp
- **Report review**
  - Conceptual model http://www.twdb.state.tx.us/gam/symr/symr.htm
  - at end of project
- **Contact Texas Water Development Board**
  - contract manager

# comments:

Shirley Wade
shirley.wade@twdb.state.tx.us
(512)936-0883

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

Web information:
www.twdb.state.tx.us/gam

# Conceptual Model

# Conceptual Model

- “The conceptual model dictates how you have translated the “real world” to a mathematical model.
- Relevant processes and physical elements controlling groundwater flow in the aquifer are identified and quantified (geology, hydraulic properties, water levels, and sources & sinks)

# Key Data Sources

# Key Data Sources

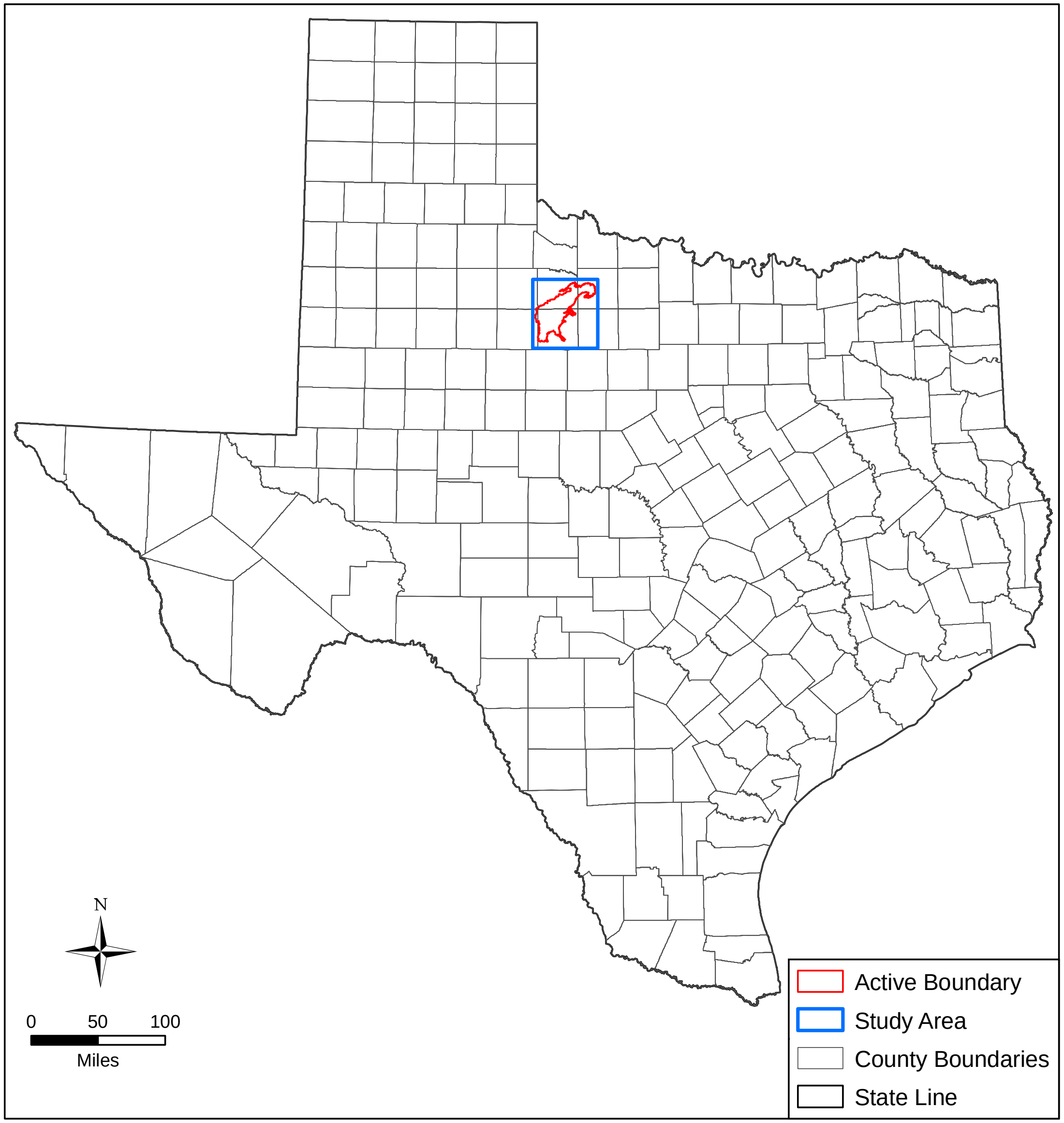
- County reports by the TWDB and predecessors
- Drillers’ logs from TWDB WIID and provided by the Rolling Plains GCD
- Brune (1975) spring locations and flows
- USGS spring database
- TWDB website
  - Water-level data
  - Spring data
  - Surface geology (TNRIS)
  - Evaporation

# Key Data Sources (cont'd)

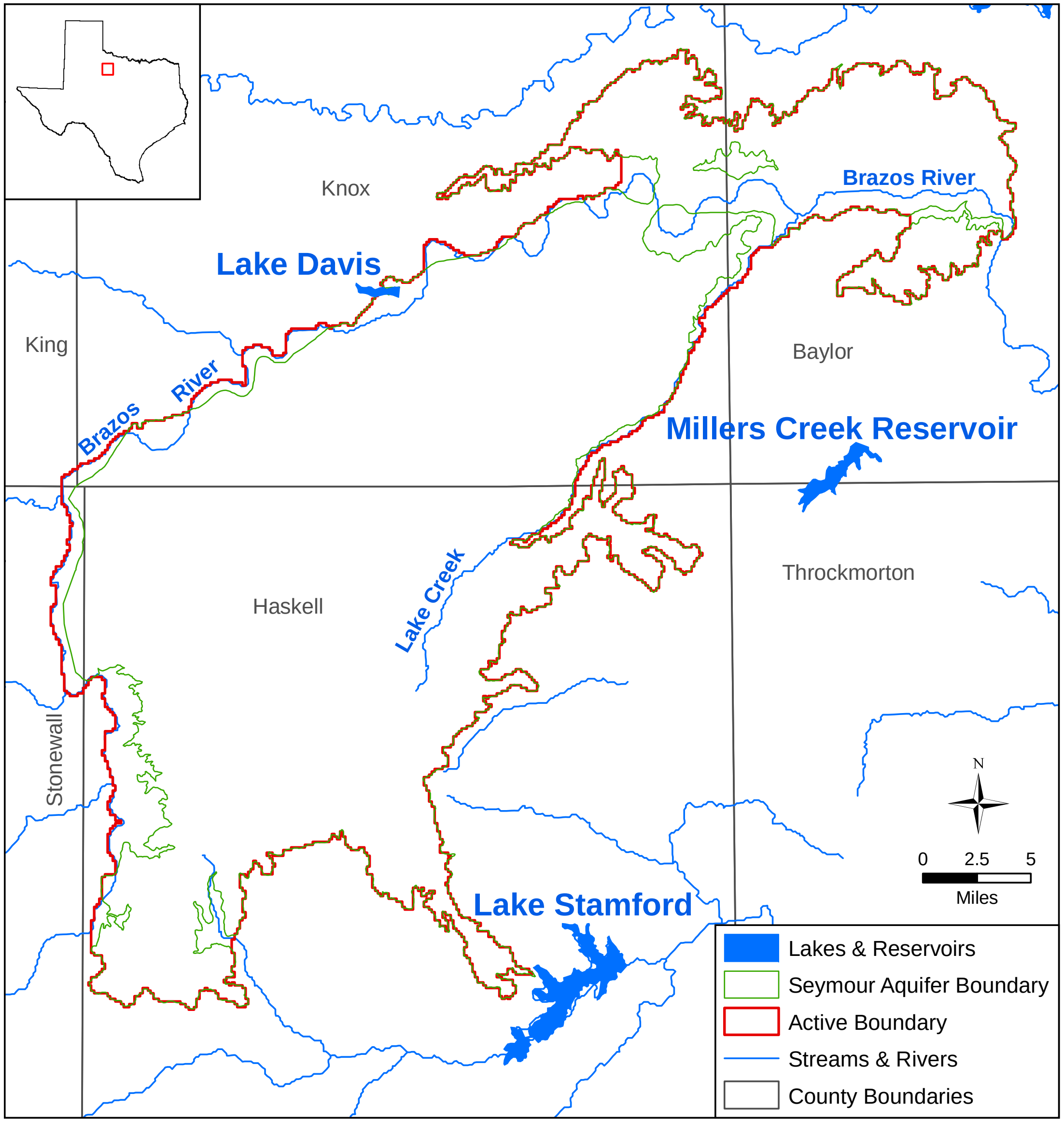
- U.S. Geological Survey website
  - topography
  - groundwater data
- U.S. EPA
  - stream characteristics
  - land use / land cover
  - soil type
- Oregon State University & National Climatic Data Center
  - Precipitation
  - Temperature

# Model Area Setting

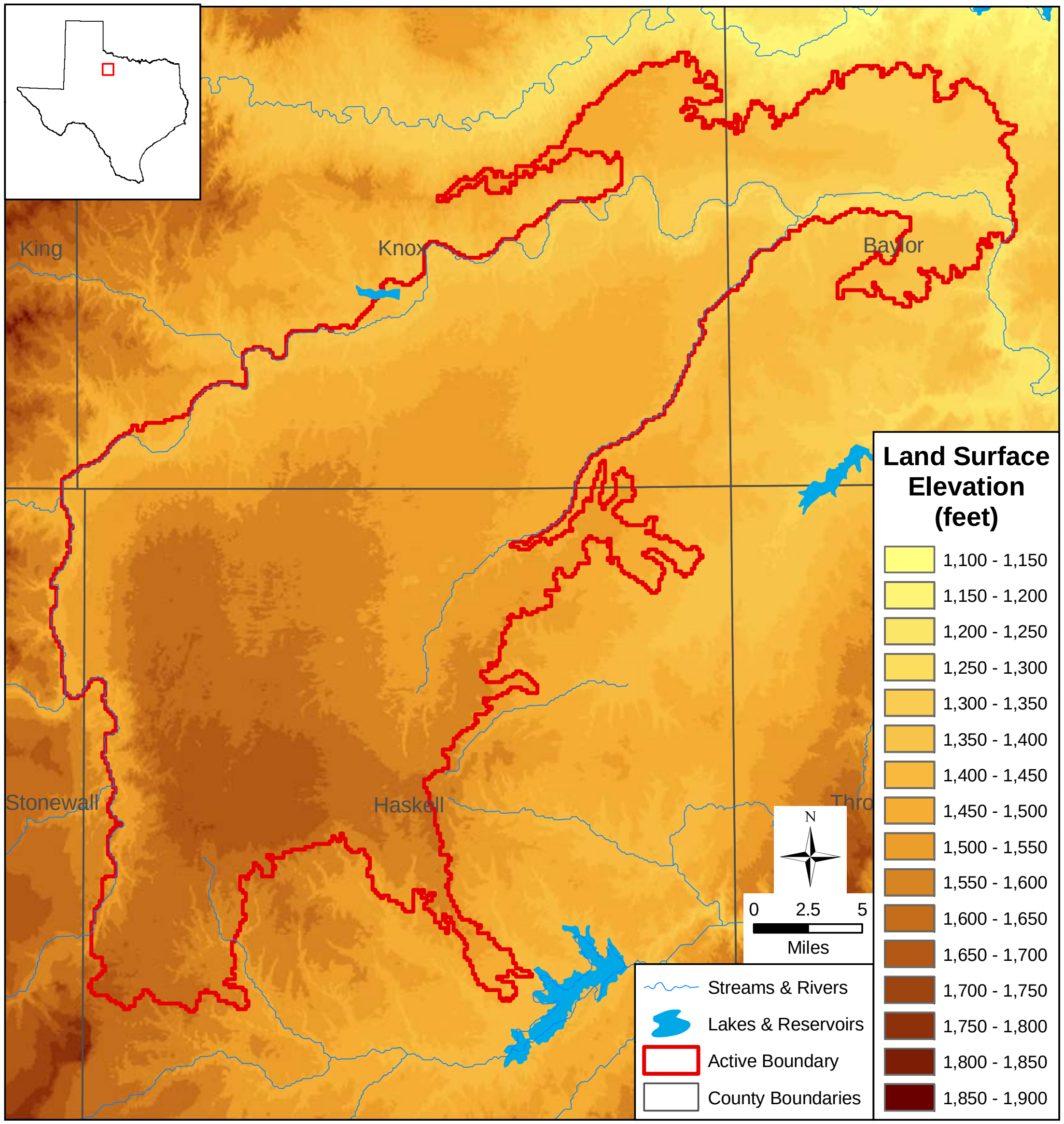
# Model Extent



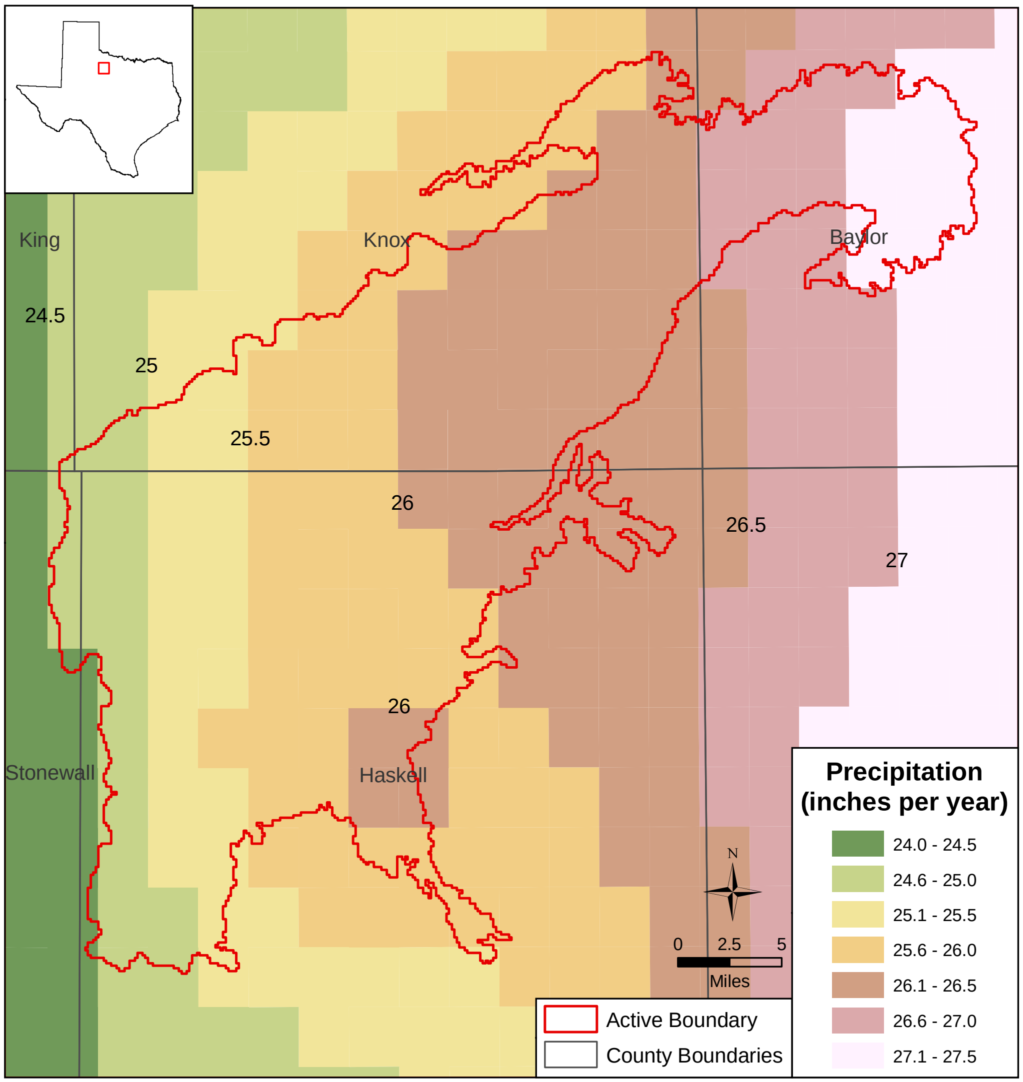
# Surface Water

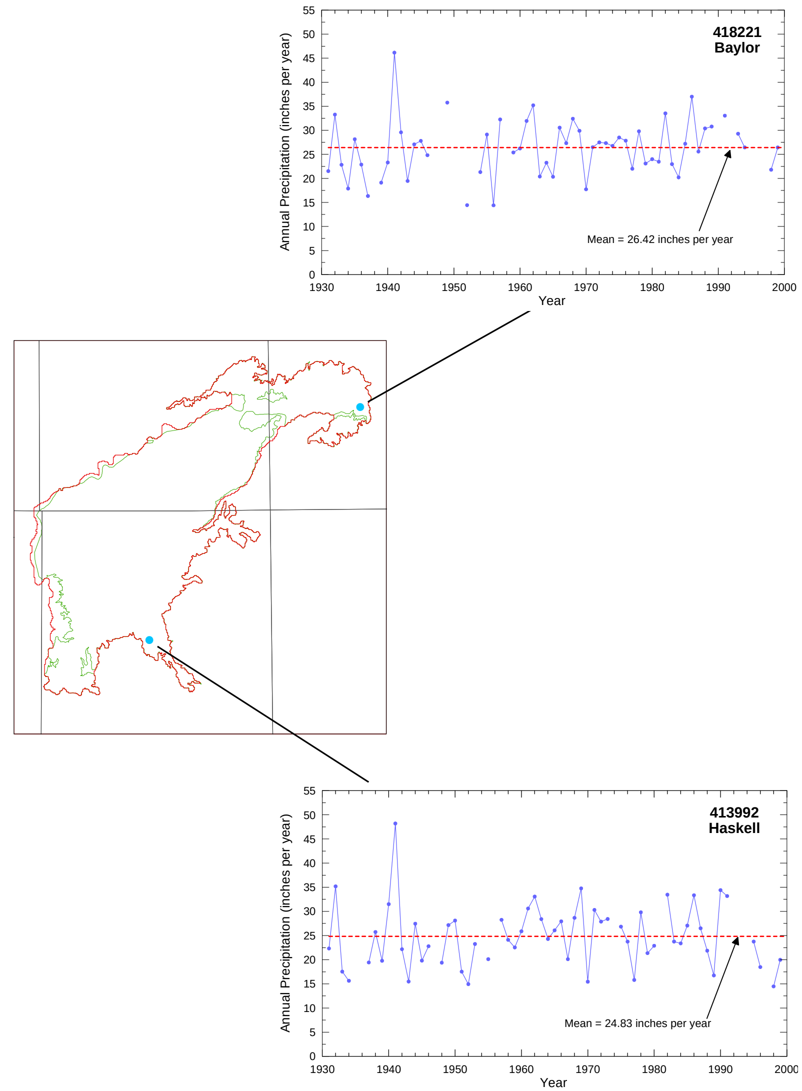


# Land Surface Elevation

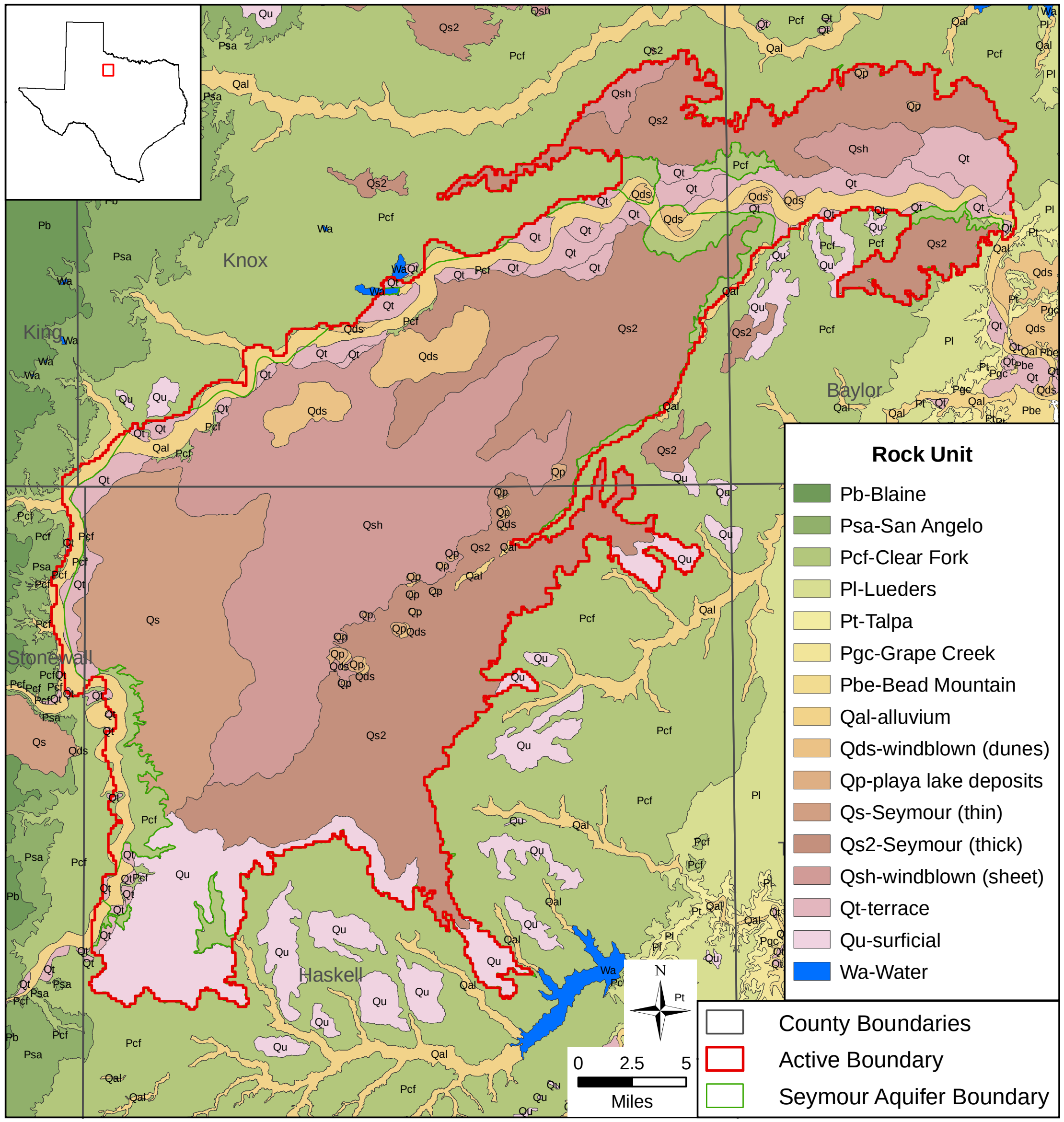


# Average Annual Precipitation



# Surface Geology

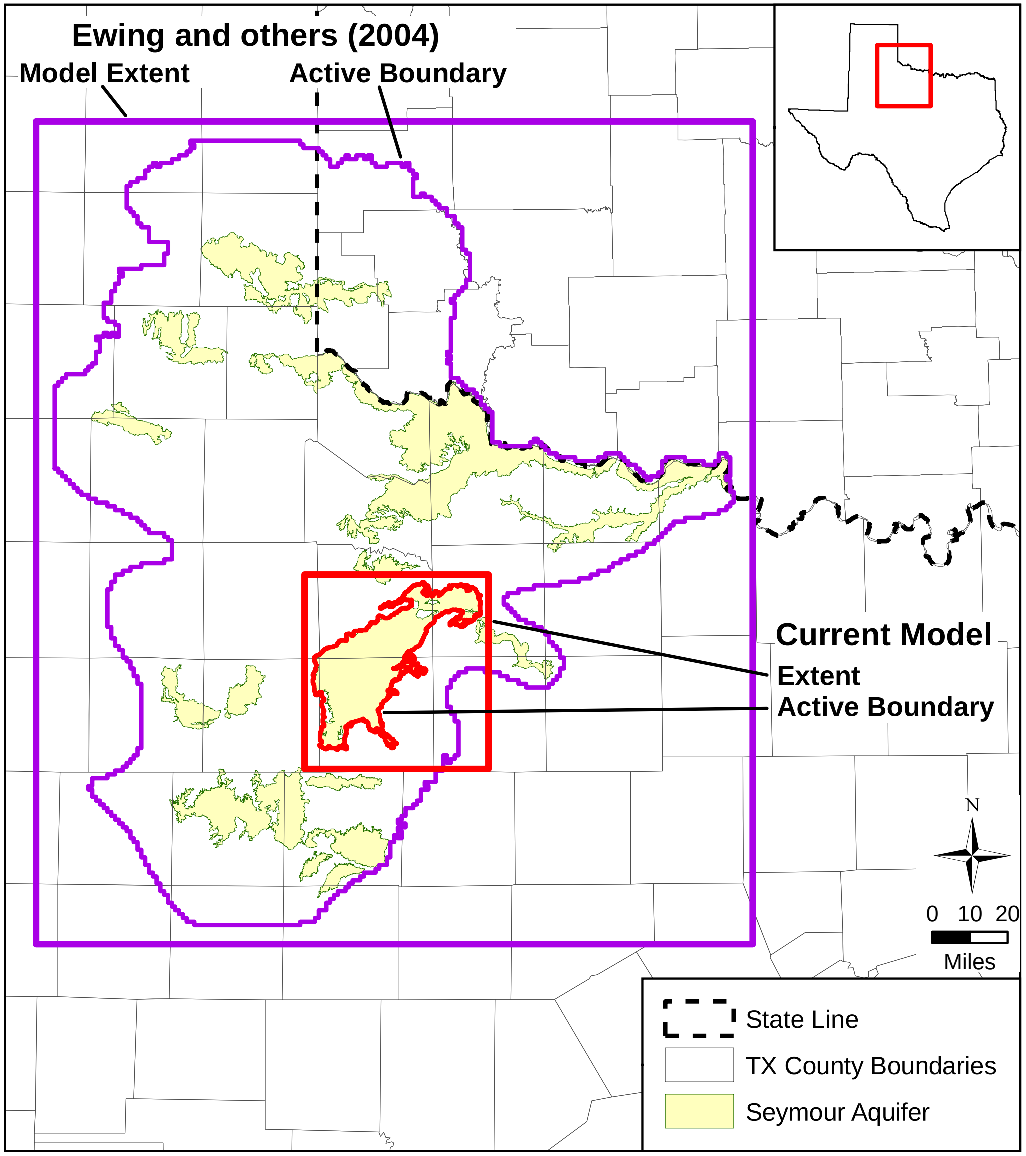


# Brief Land Use and Land Cover History

- **Nomadic Indians and buffalo, prior to 1880**
  - Grassland and savannah with some mesquite in river valleys and sheltered areas
- **Overgrazing by domestic livestock, about 1880 to about 1910**
  - Damaged surface soil
  - Replacement of grassland and savannahs with brushland and woodland (widespread mesquite)
- **Development of land for agricultural purposes, about 1910 through 1940s**
  - Repaired surface soil through tilling and plowing
  - Some terracing of the land
  - Removal of mesquite

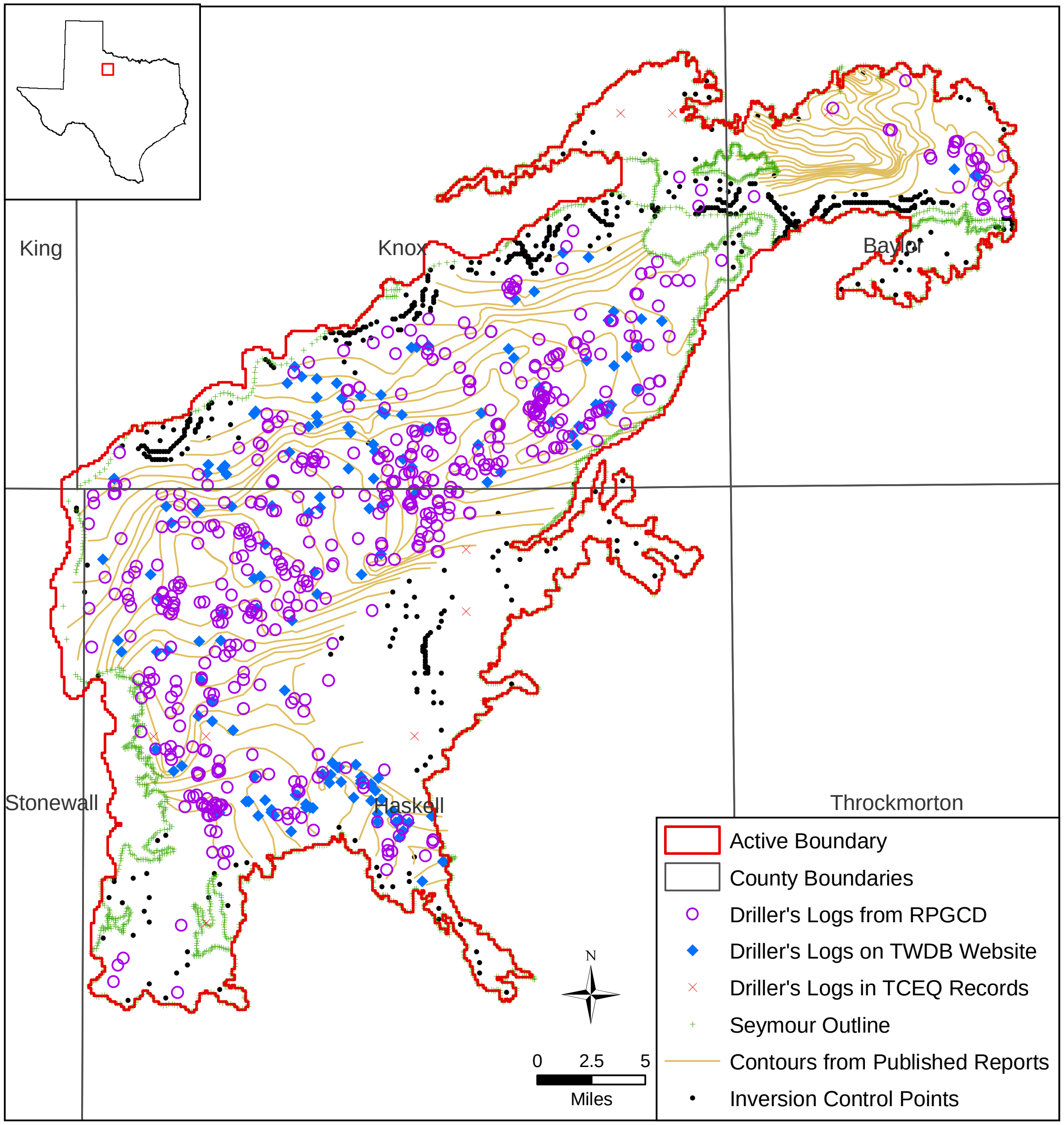
# Previous Modeling Study

# Previous Seymour Aquifer GAM

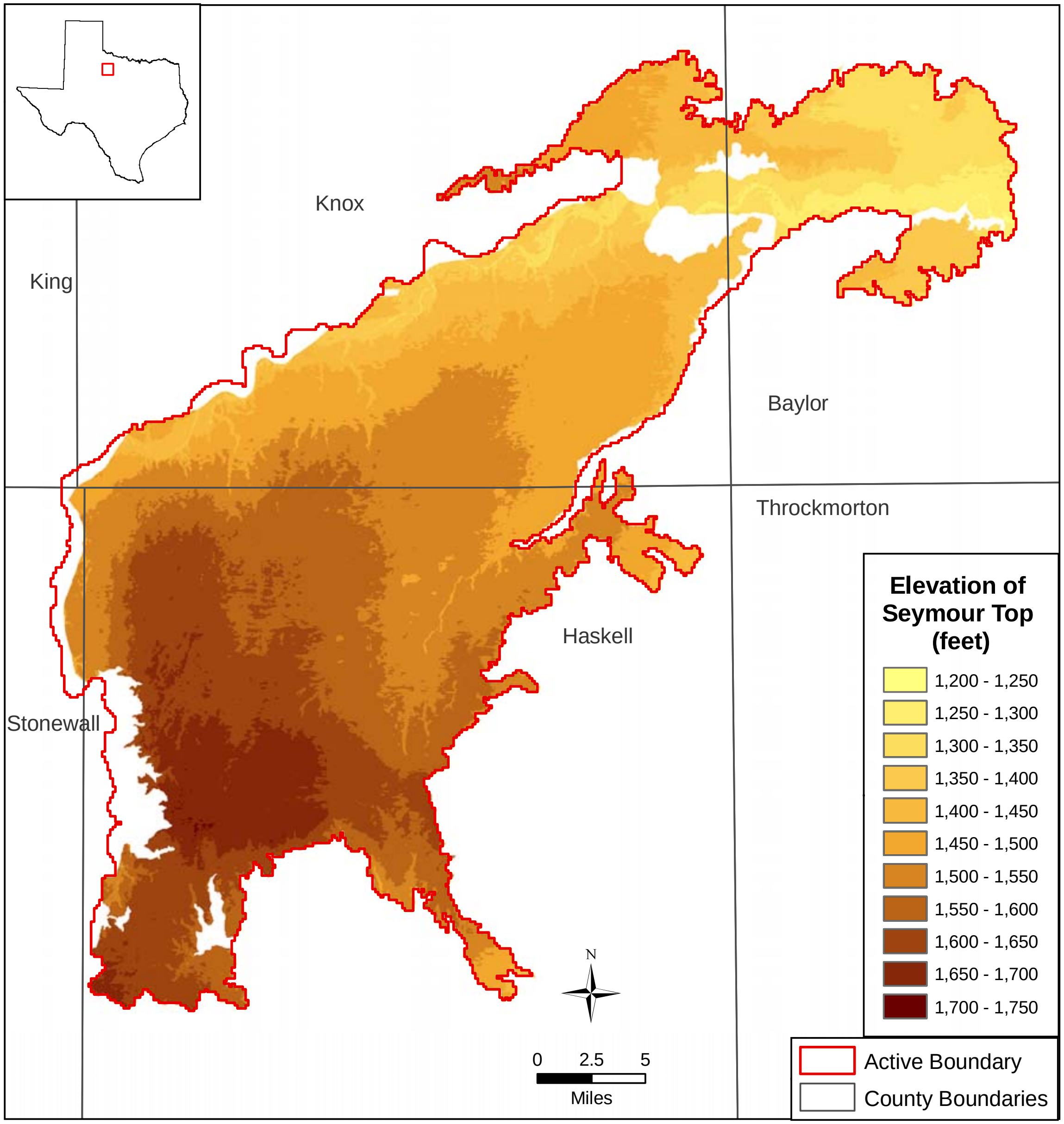


# Structure

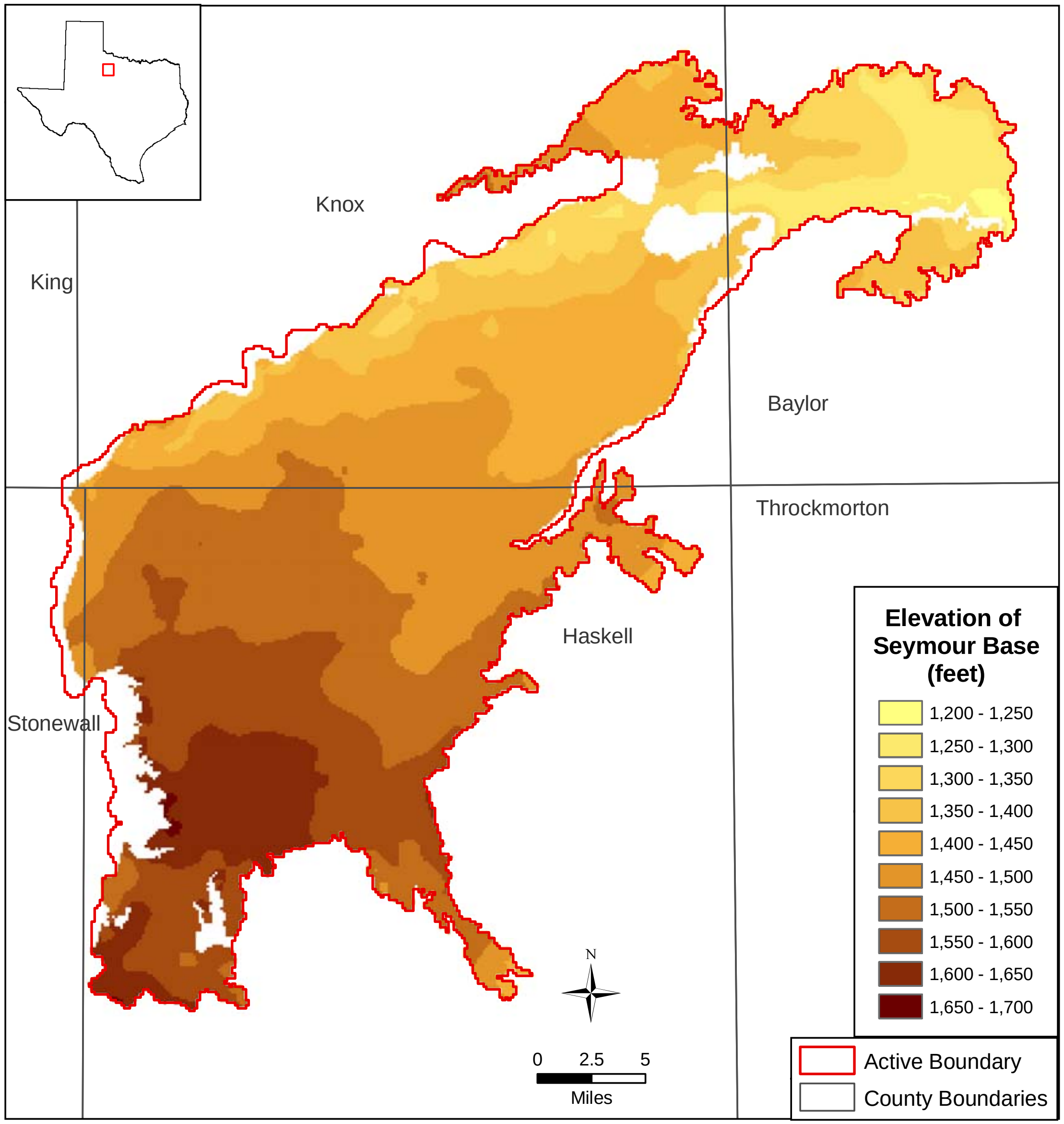
# Seymour Structure Data Sources



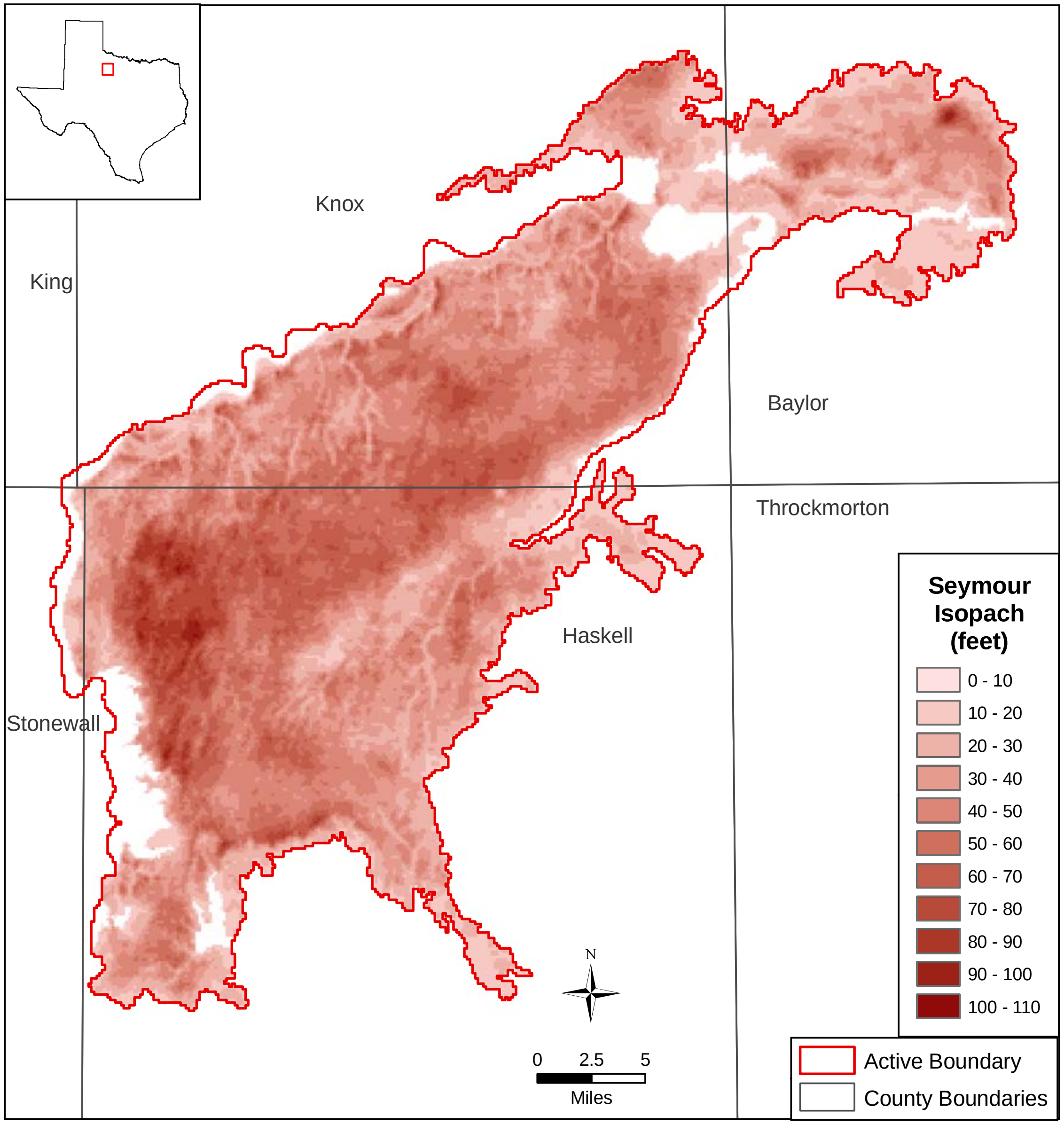
# Seymour Top Elevation



# Seymour Basal Elevation

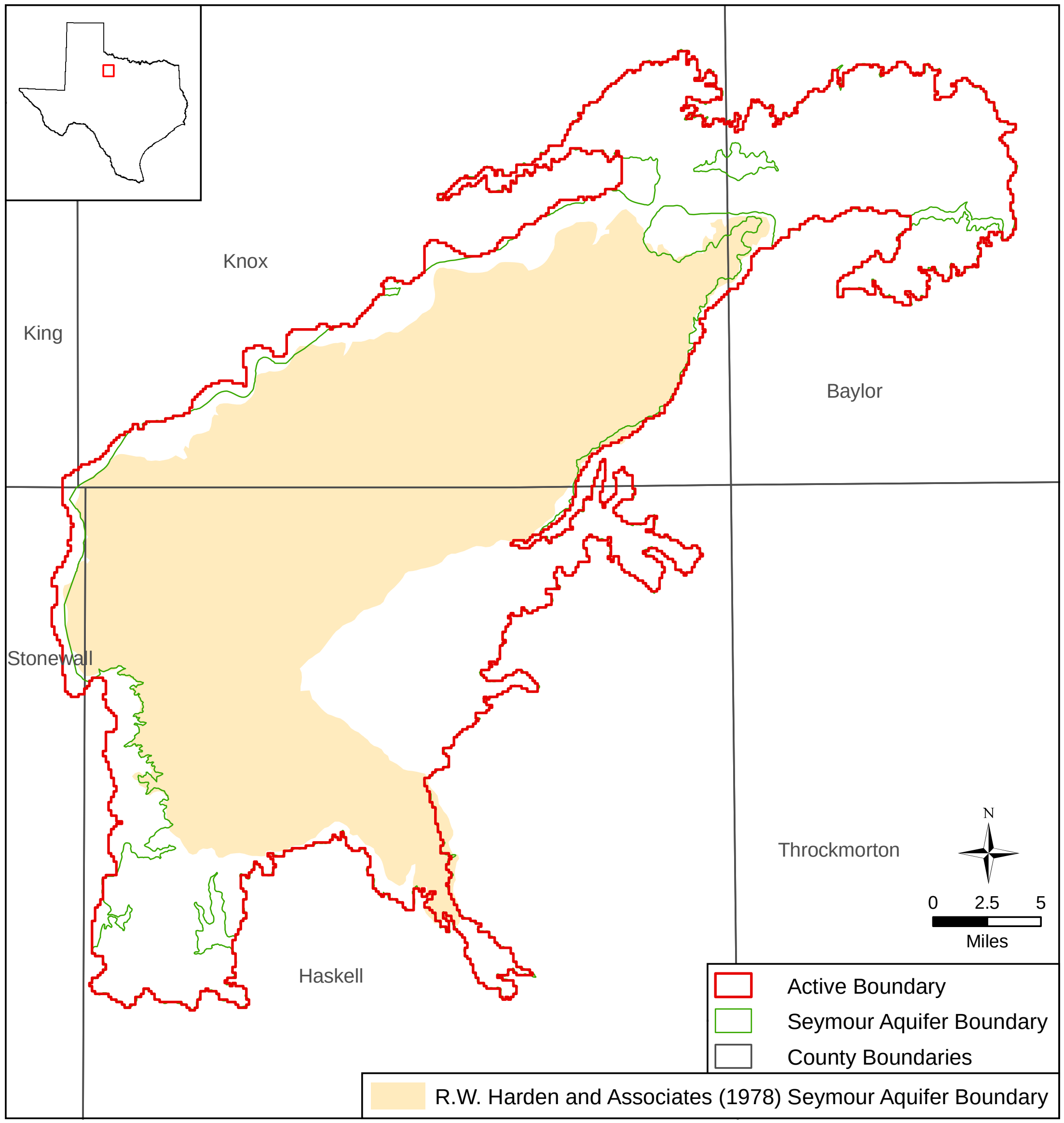


# Seymour Isopach

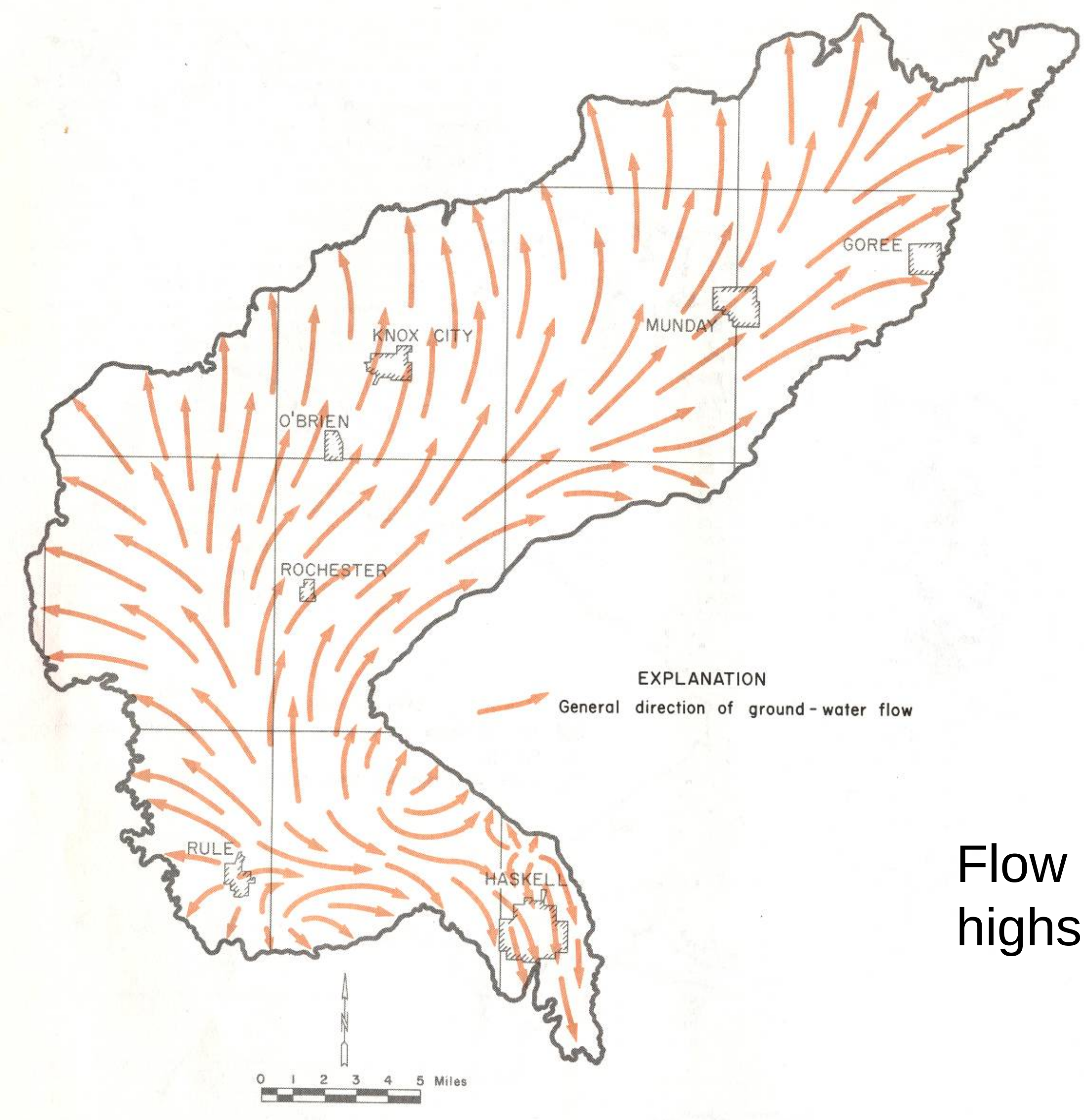


# Water Levels

# Water Producing Portion of Seymour Formation



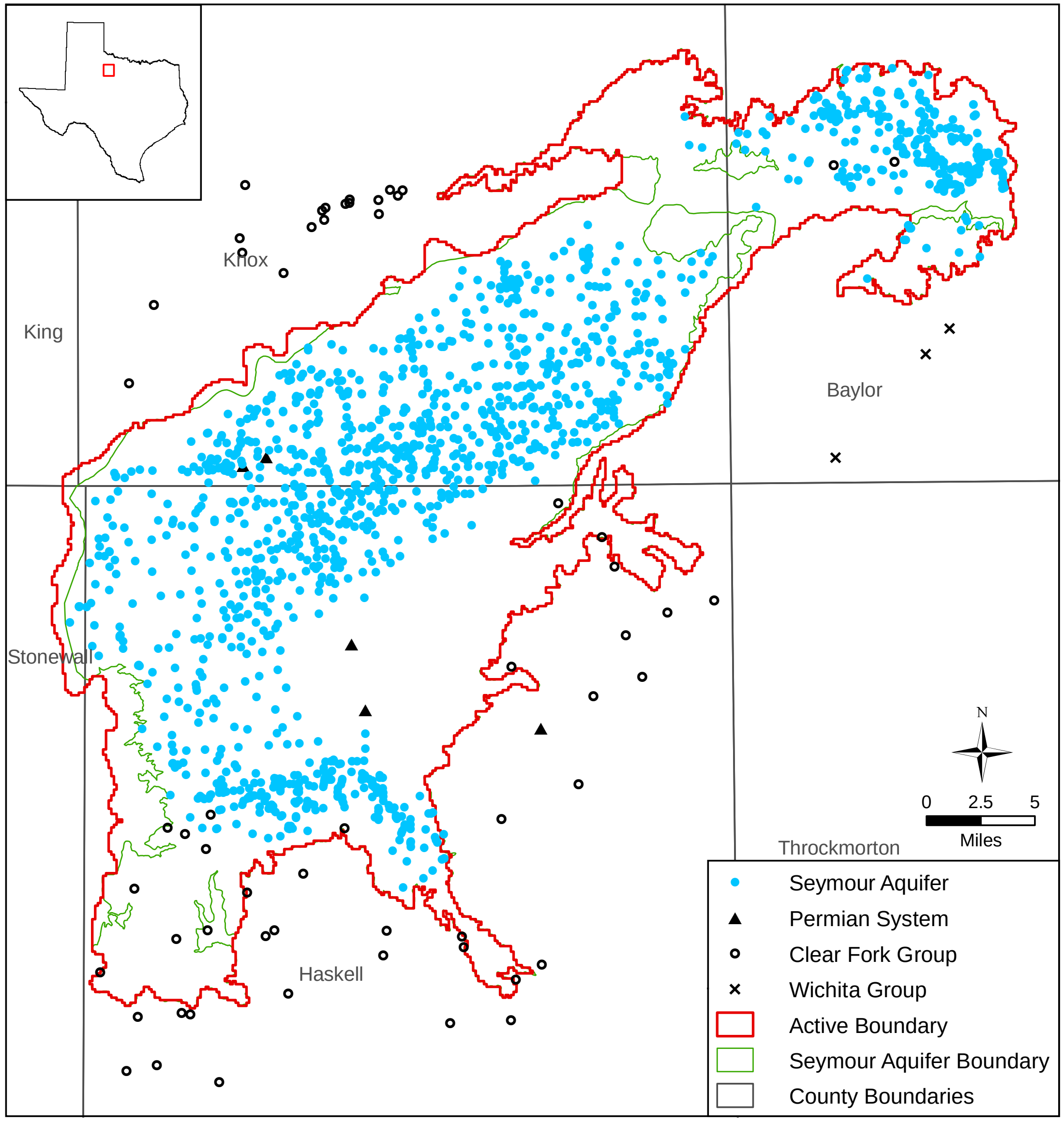
# Regional Groundwater Flow




(from R.W. Harden and Associates, 1978)

Flow is generally from topographic highs to topographic lows.

# Locations with Water-Level Data



# Historical Water-Level Fluctuations

- Some unknown saturated thickness during steady-state conditions prior to the advent of land use changes in 1880
  - No data for development of steady-state water-level elevations
  - Brune (2002) reports evidence of Indian camps near several springs flowing from the Seymour Aquifer indicating water in the aquifer
- Gordon (1913) indicates groundwater was not found throughout the Seymour Aquifer in Haskell and Knox counties in 1905-1906

# Historical Water-Level Fluctuations (cont'd)

- Bandy (1934) indicates significant rises in the groundwater in the Seymour Aquifer between about 1910 and 1934.
  - Interviewed residents of northwestern Haskell County
  - Inventoried wells in northwestern Haskell County
  - Provides specific information on water-level rises
- Preston (1978) states "oldtimers" in Baylor County report that "where the Seymour Formation is well developed…there were only small amounts of water available form the Seymour 40 or 50 years ago".

# Historical Water-Level Fluctuations (cont'd)

- Very little information on water-level changes between 1934 and the 1950s
- Water-level declines in the 1950s due to severe drought and significant increase in pumping for irrigation purposes
- Since 1950s
  - Water levels in aquifer have fluctuated due to changes in precipitation and pumping
  - In general, no significant, permanent drawdowns or gains in storage in the aquifer

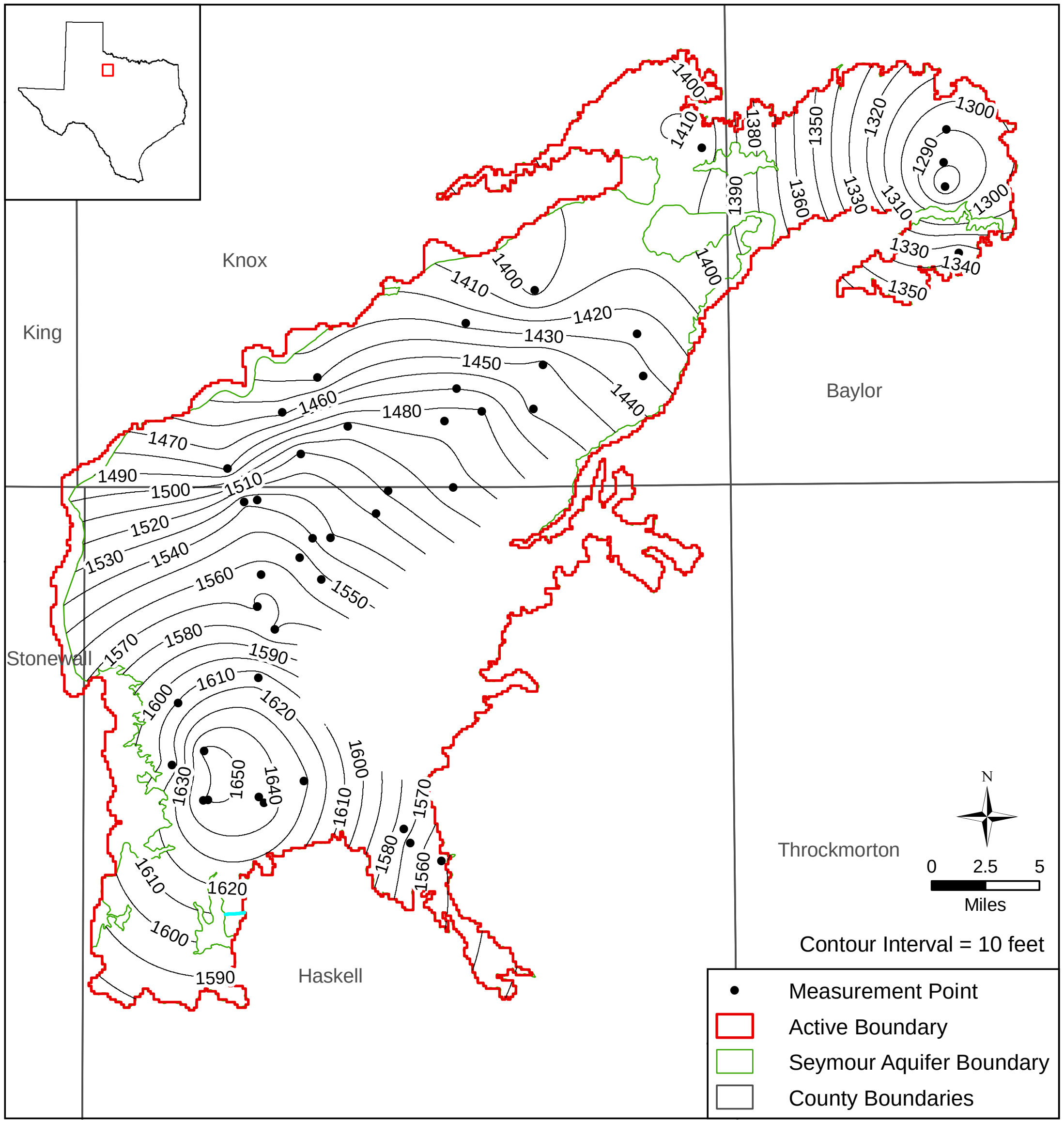
# Steady-State Conditions – Seymour Aquifer

- Defined as a balance between aquifer recharge and natural aquifer discharge
- For typical aquifers, steady-state conditions are present prior to significant development of the aquifer (i.e., pumpage)
- For the Seymour Aquifer, steady-state conditions were disrupted in the late 1880s due to significant land use changes, which appear to have decreased recharge and increased natural discharge
- Water-level data for steady-state conditions are not available

# Steady-State Conditions – Seymour Aquifer (cont'd)

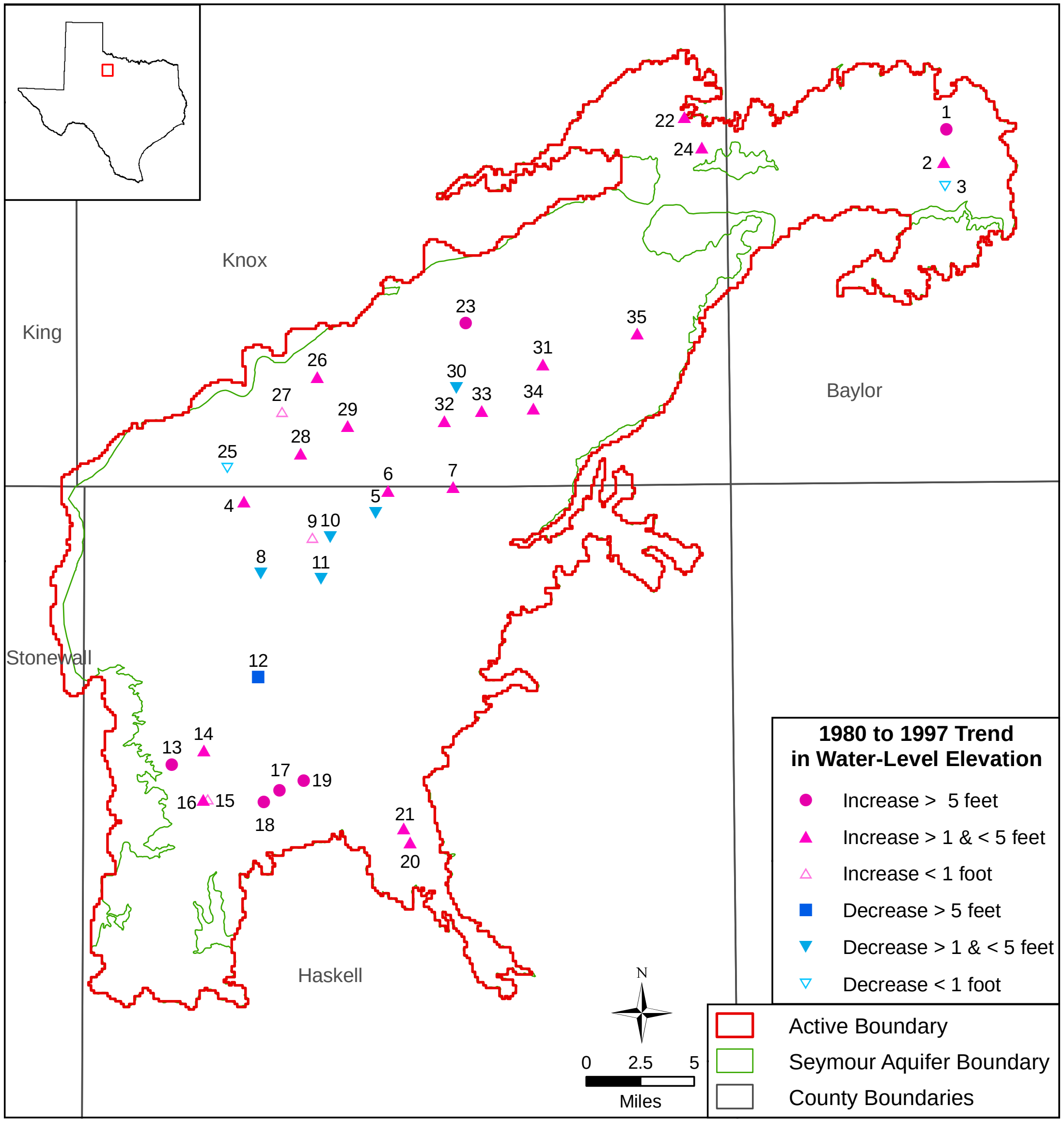
- Assume the aquifer had some saturated thickness under steady-state conditions
  - This is supported by the fact that Brune (2002) found buffalo bones and evidence of Indian encampments near several springs that flow from the Seymour Aquifer
- Limitation of developing steady-state water-level elevations from spring elevations
  - Elevations and exact locations are not available for most of the springs in Brune (2002)
  - Can match some springs in Brune (2002) to springs in the TWDB database to get location and elevation
  - Unable to accurately represent water levels in the topographically high areas where springs are absent

# Water-Level Elevations for Model Calibration




## Seymour Aquifer 1997

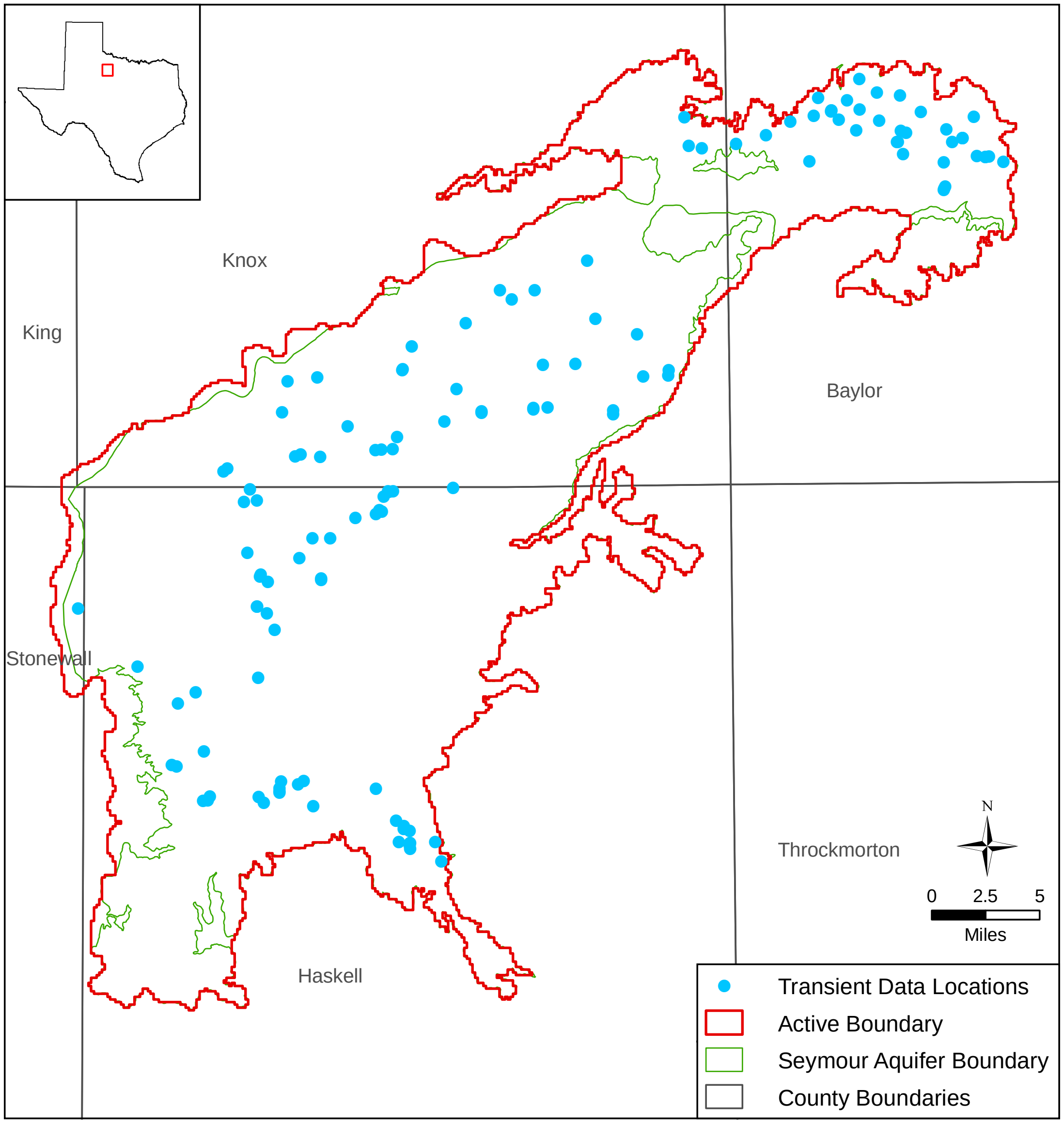
# Water-Level Elevations for Model Calibration



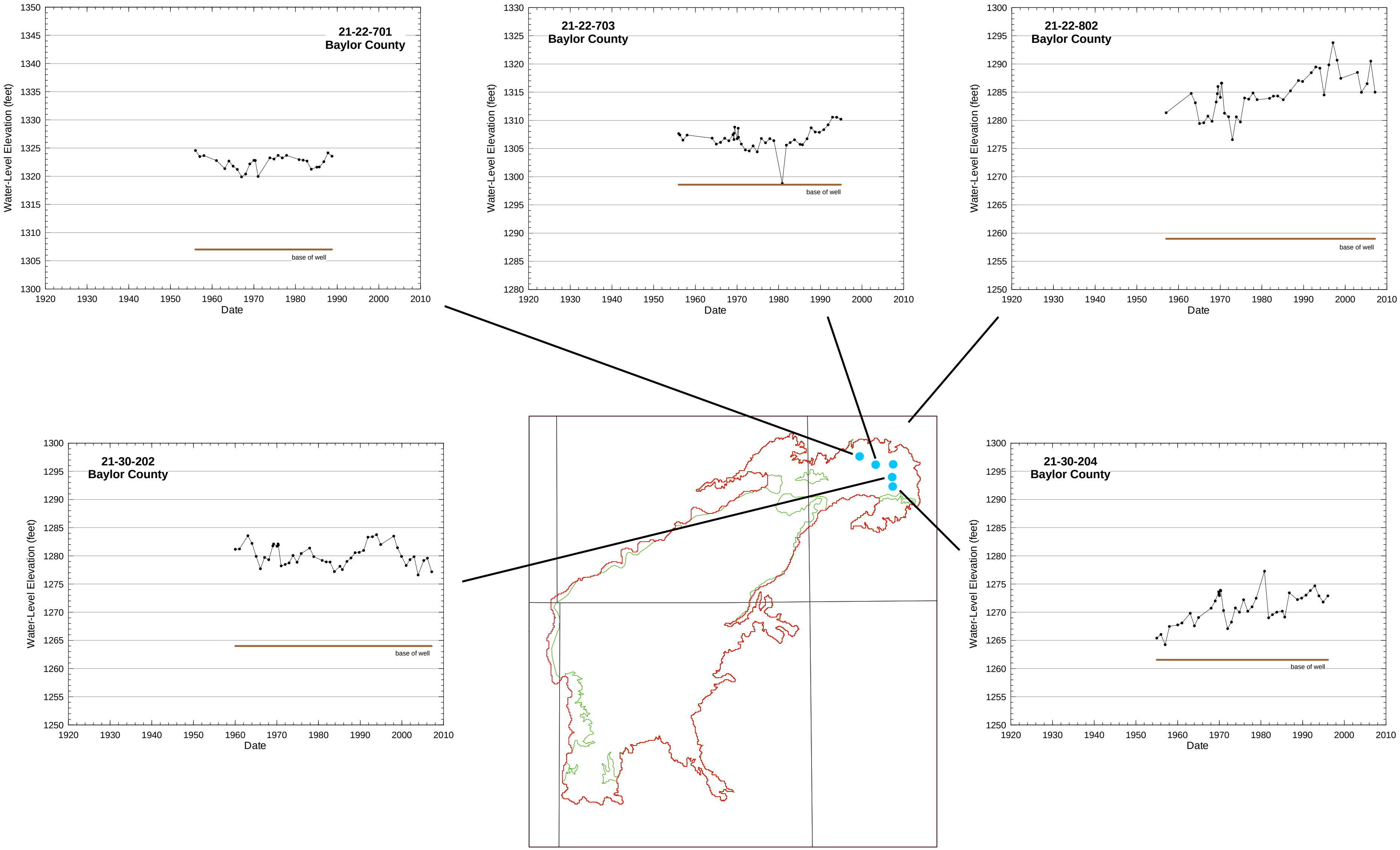
# Cross-Formational Flow

- No clear indication of gradient between Seymour Aquifer and underlying Clear Fork Group in Baylor County
- Water-level data indicate a potential for downward flow from the Seymour Aquifer to the Clear Fork Group in southern Haskell County
- No available data for comparison of water levels in the Seymour Aquifer and Clear Fork Group in Knox County

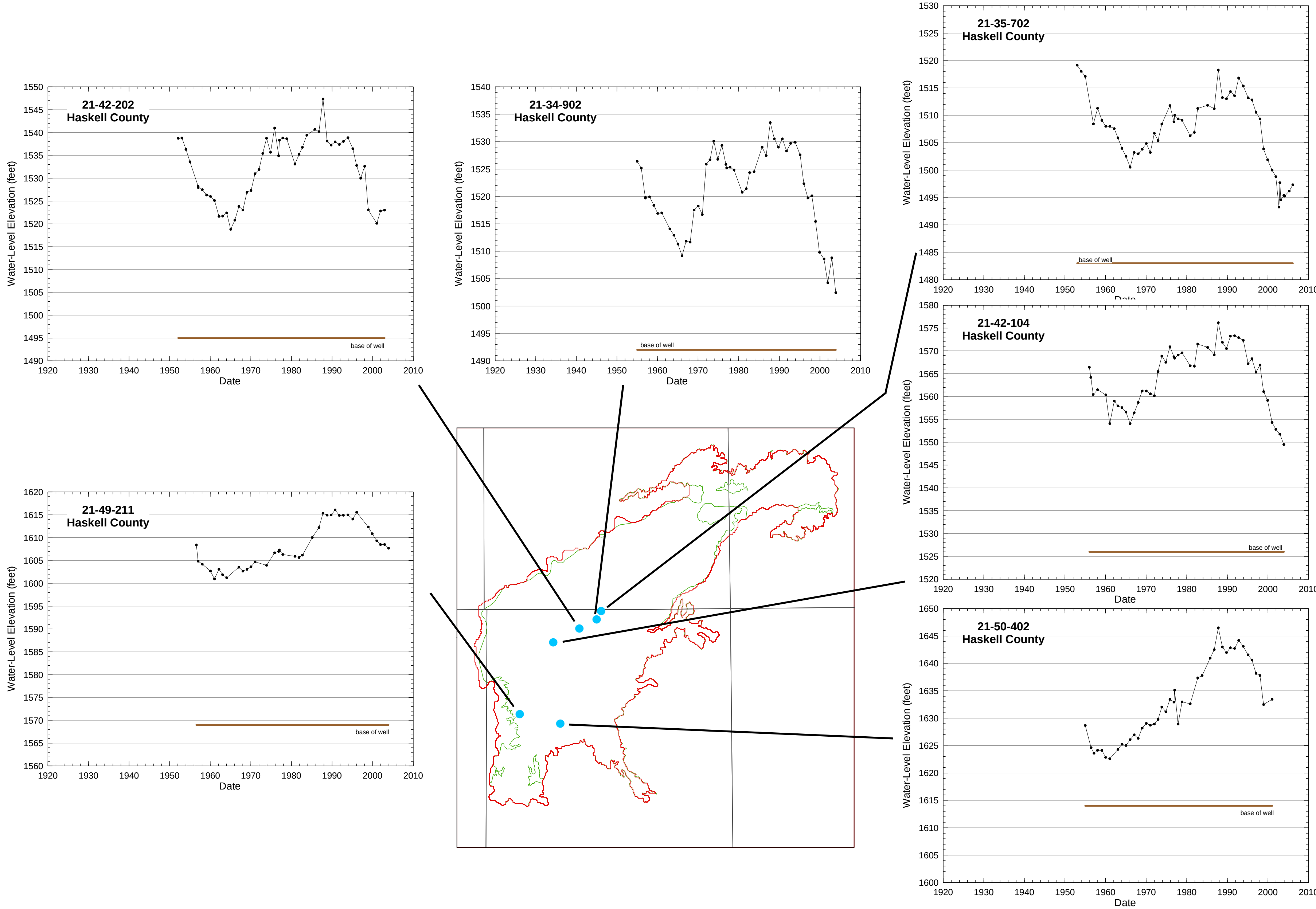
# Transient Water-Level Data



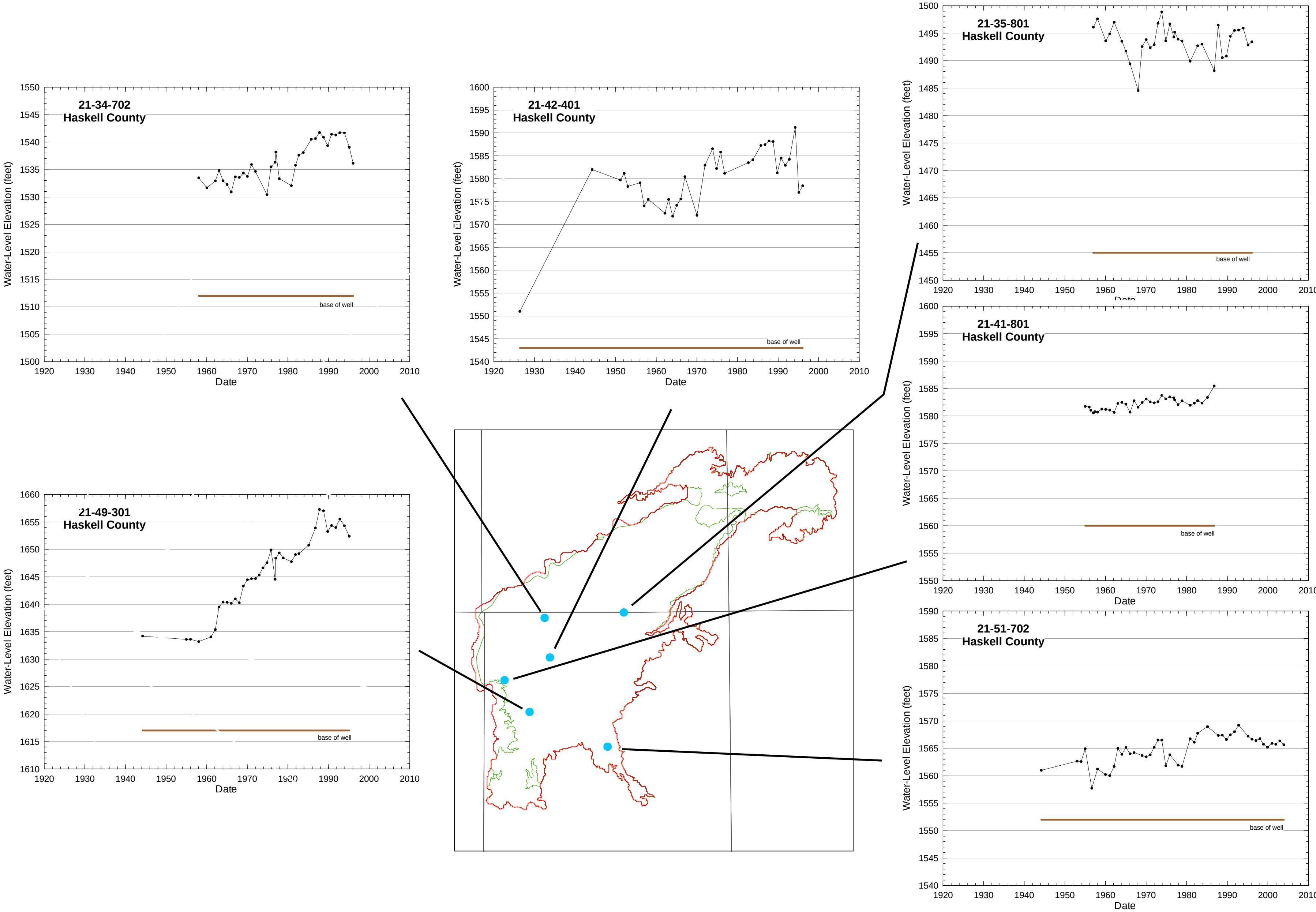
# Transient Water-Level Data



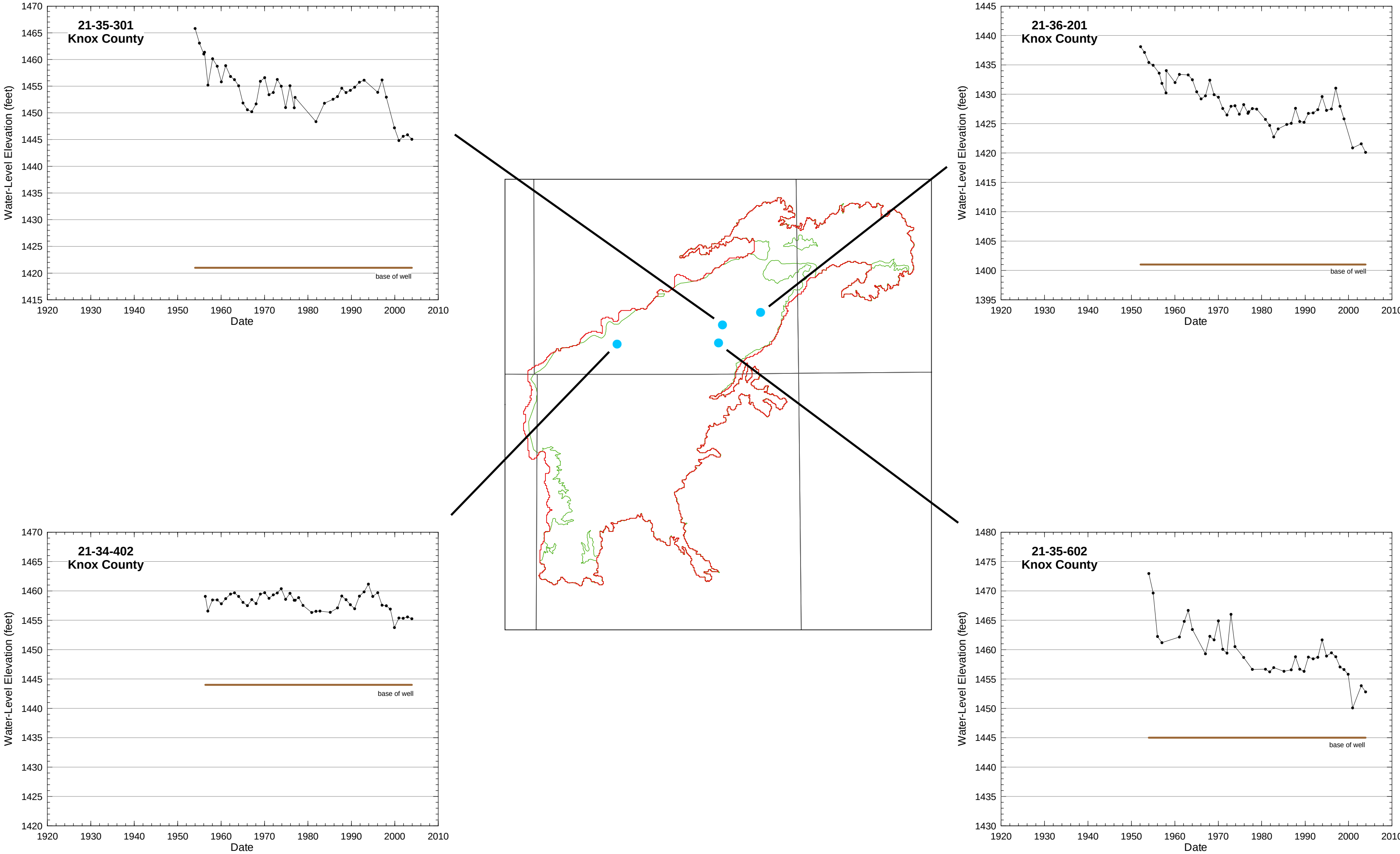
# Transient Water-Level Data



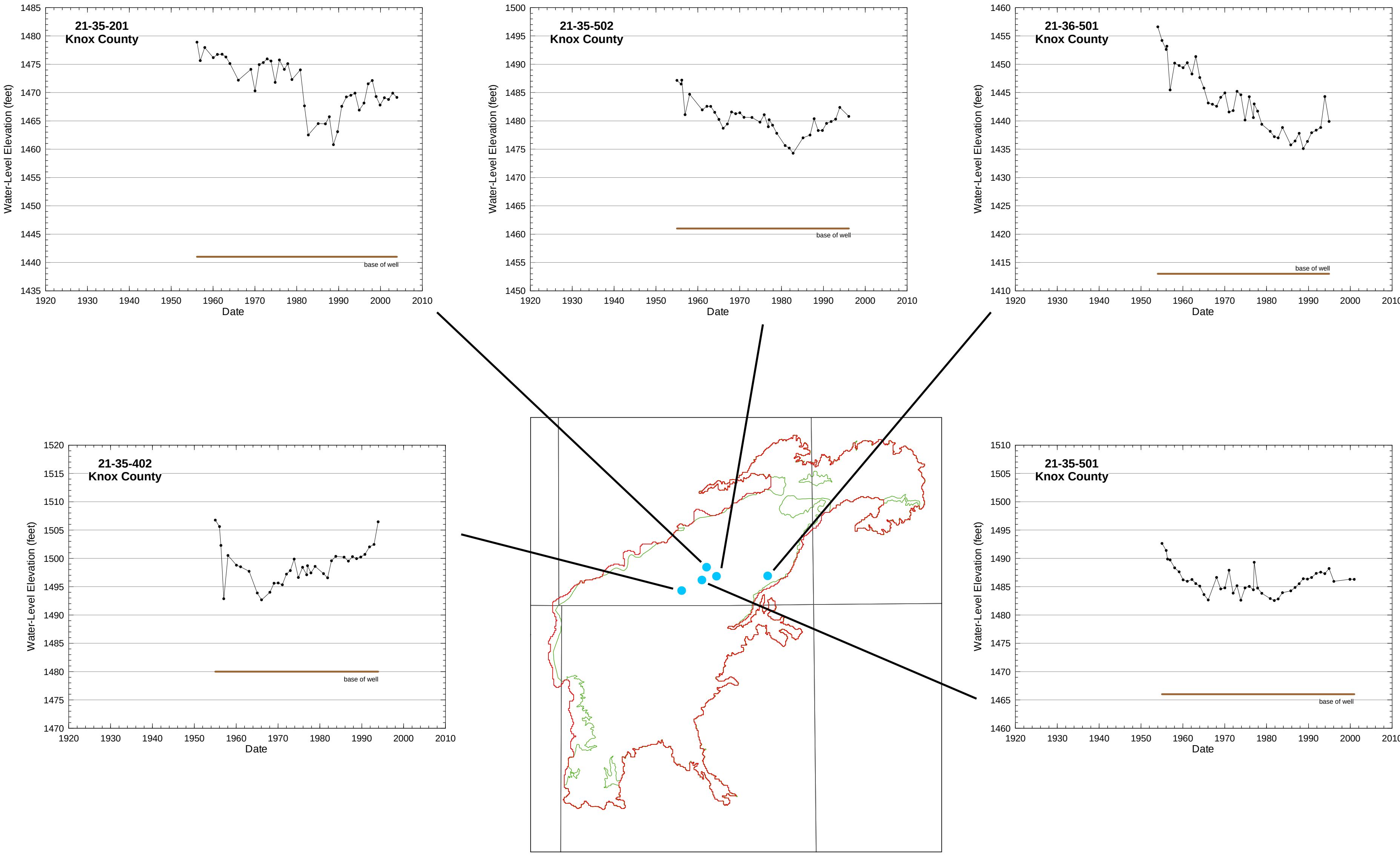
# Transient Water-Level Data



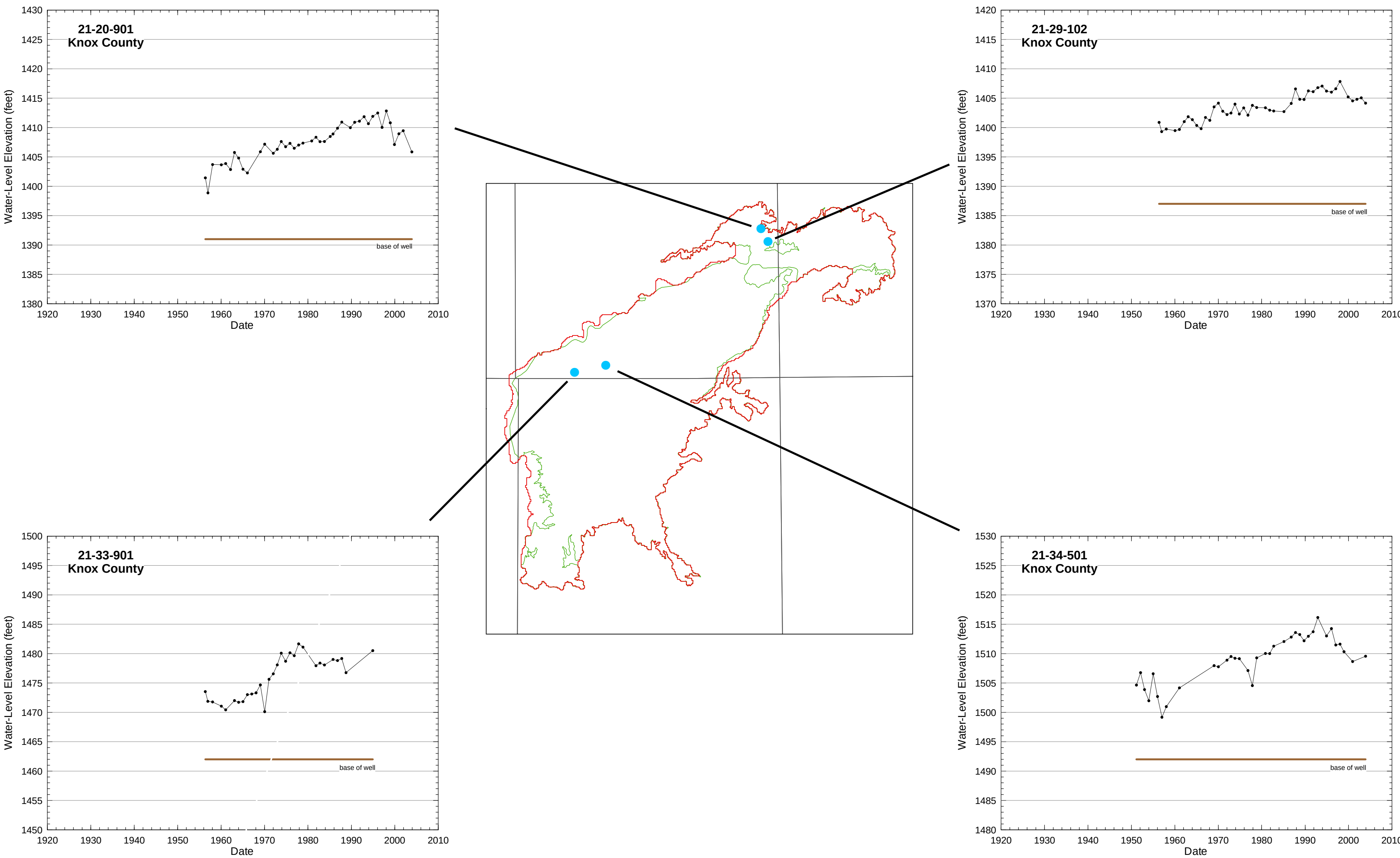
# Transient Water-Level Data



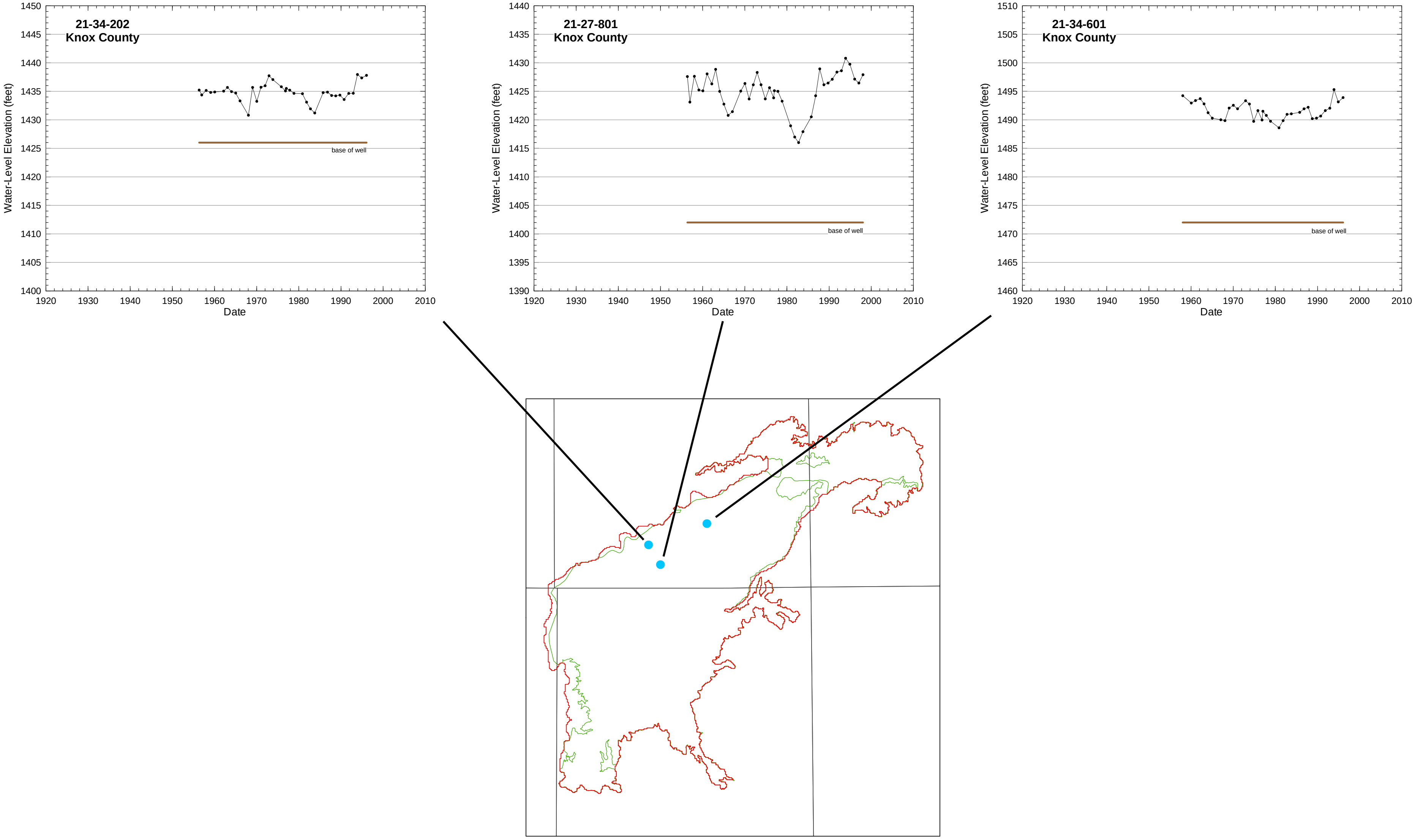
# Transient Water-Level Data



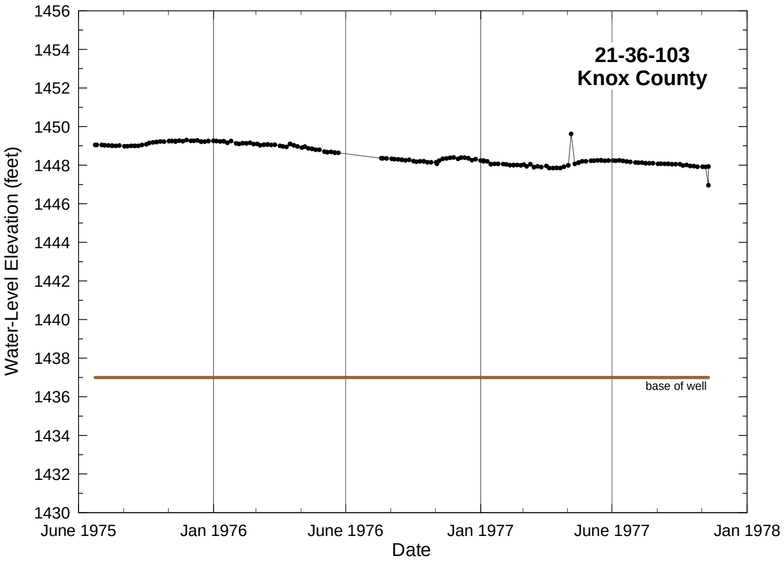
# Transient Water-Level Data

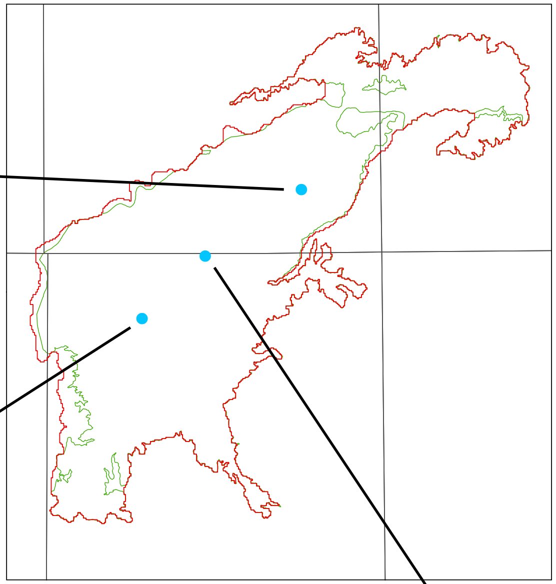


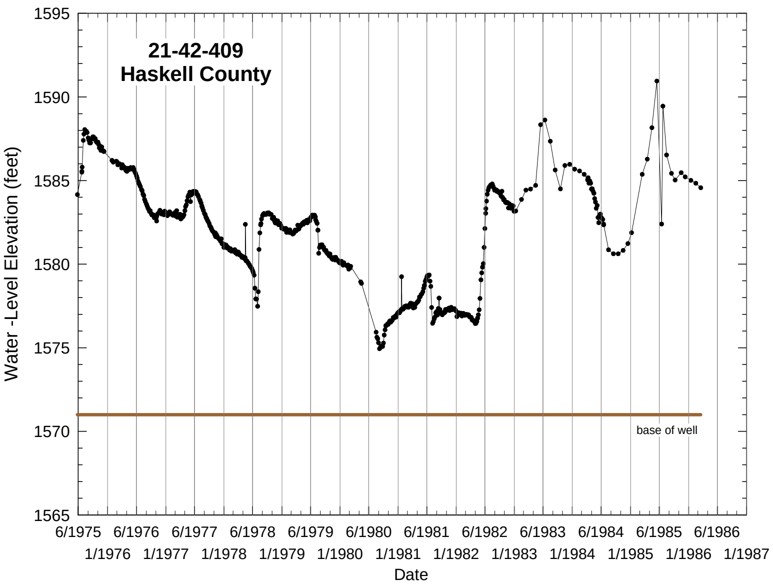
# Transient Water-Level Data

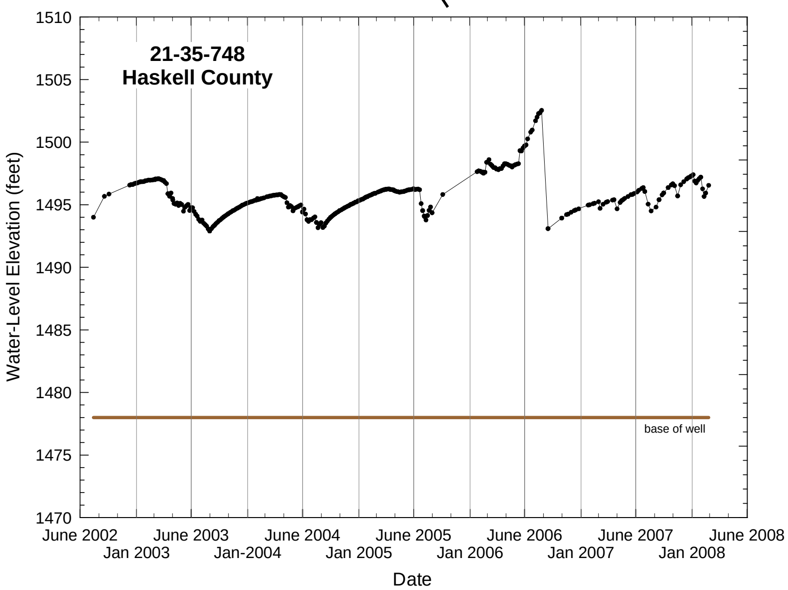


# Transient Water-Level Data

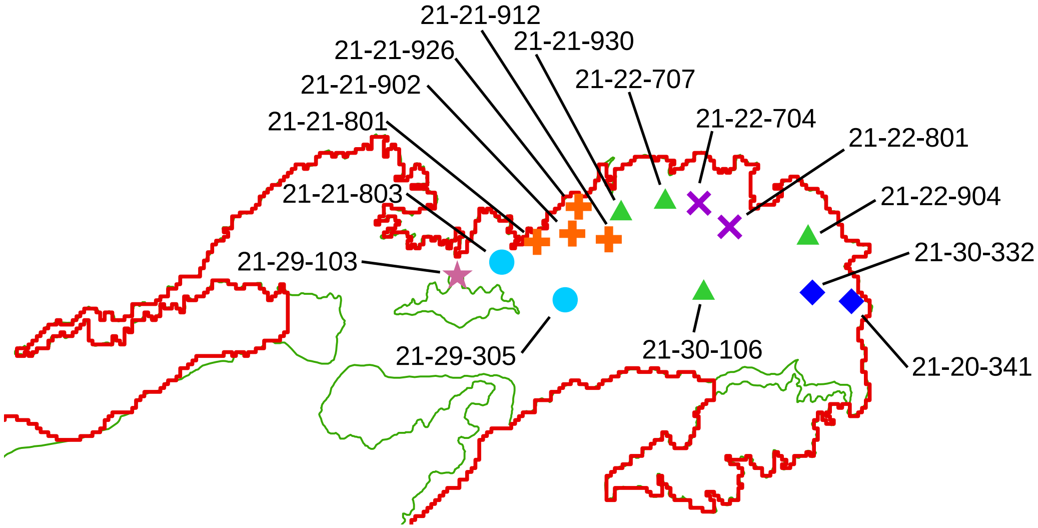


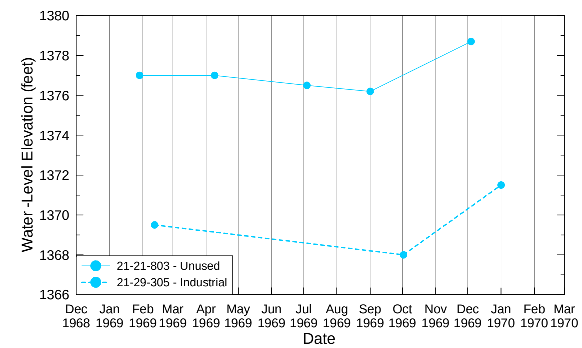



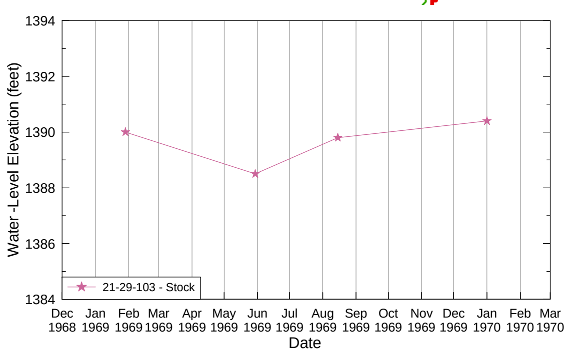


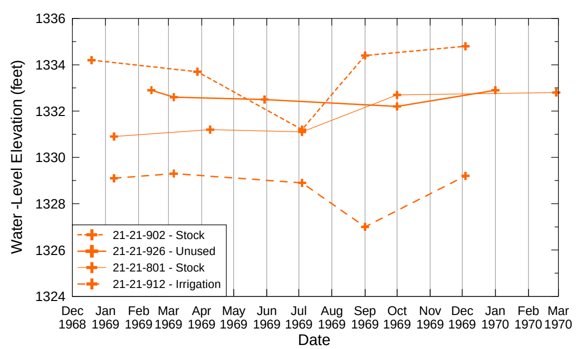



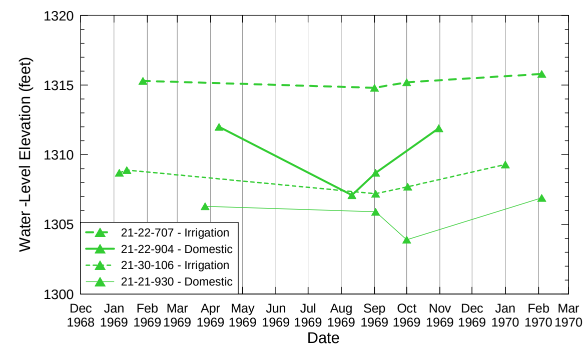
# Transient Water-Level Data

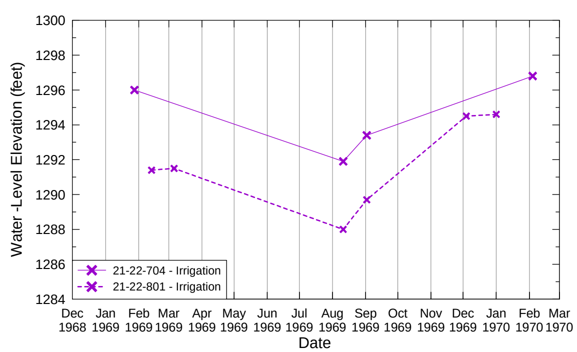


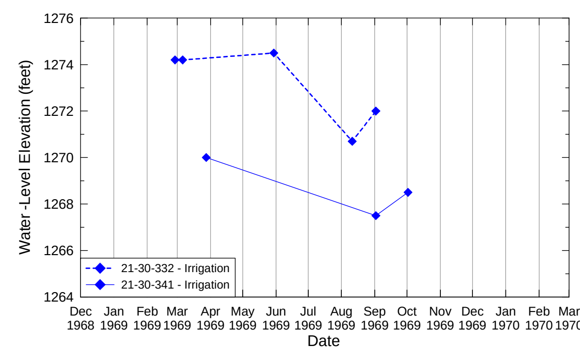



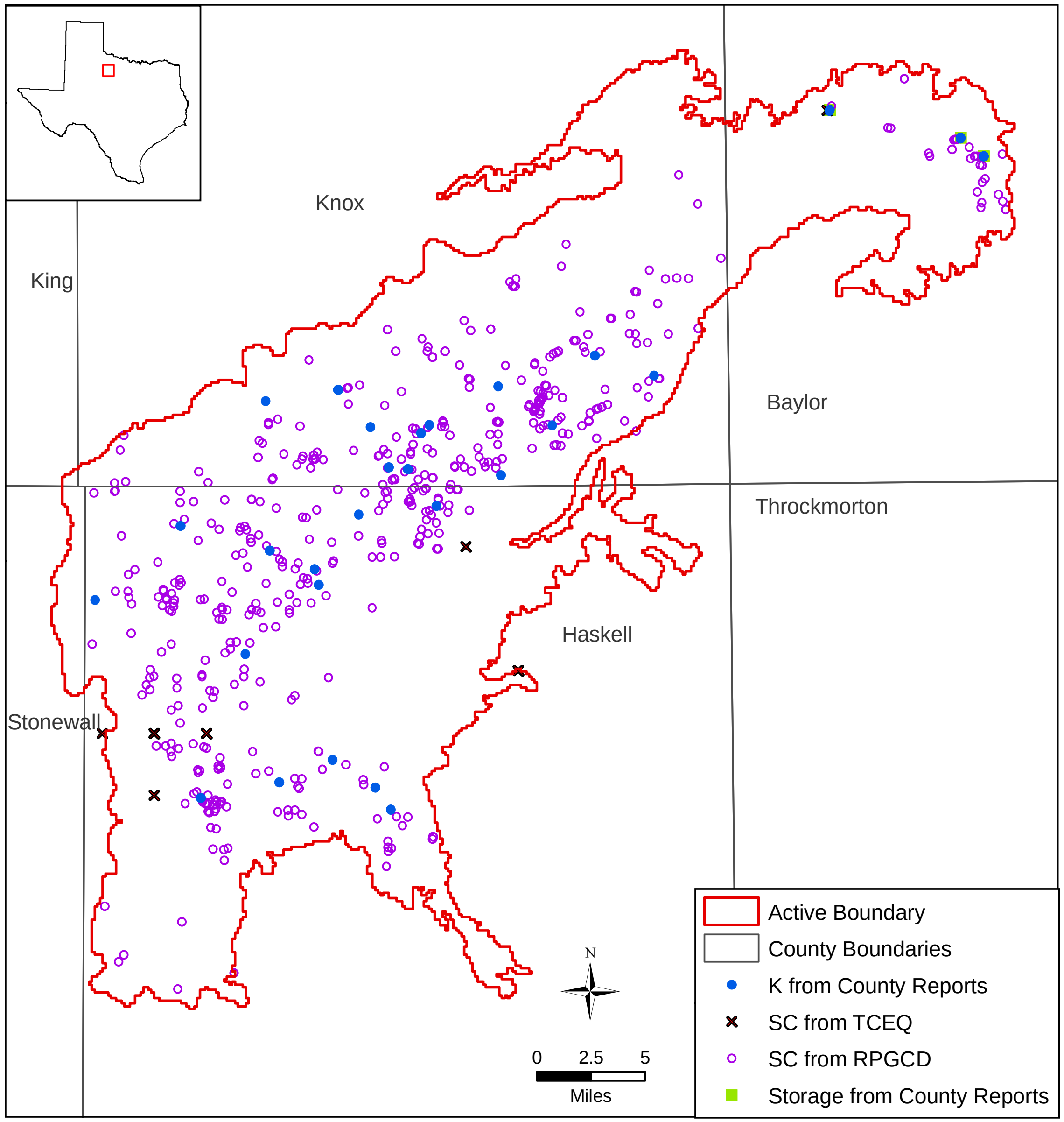



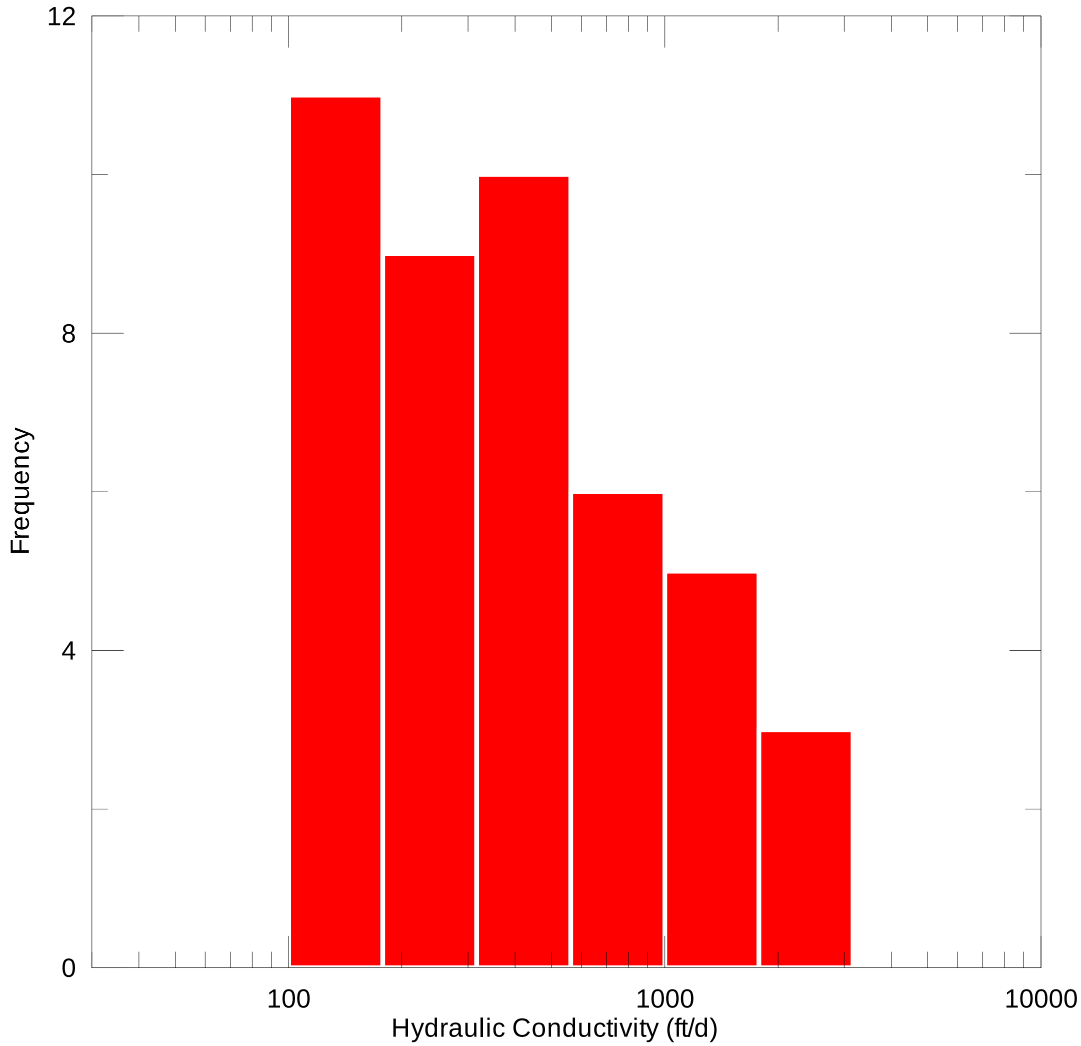



# Hydraulic Properties

# Seymour Aquifer Hydraulic Properties



# Histogram – Hydraulic Conductivity

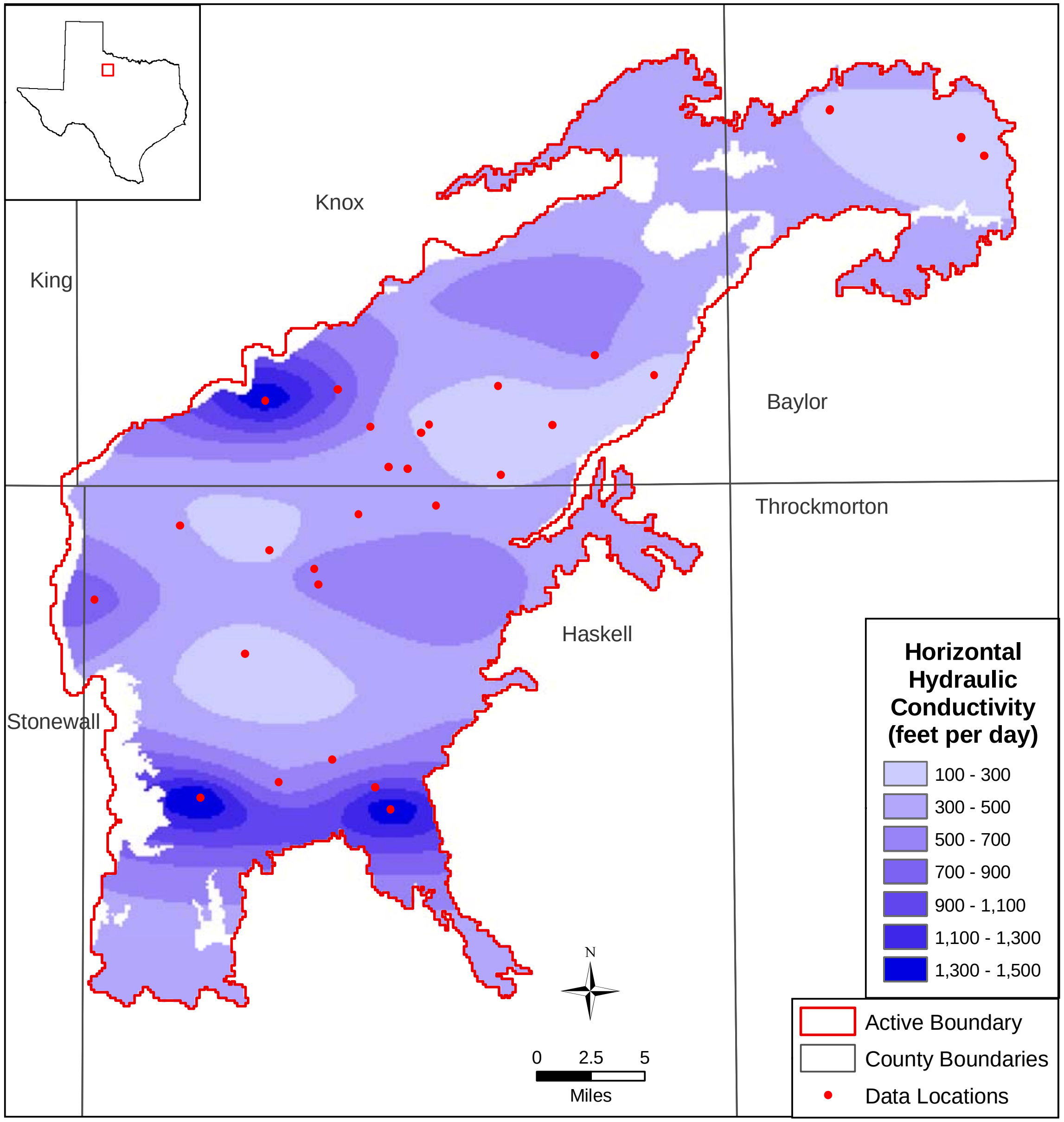



| Statistic | Seymour Aquifer |
|---|---|
| Number of Samples | 44 |
| Arithmetic Mean | 564.8 |
| Median | 342.6 |
| Geometric Mean | 386.0 |
| Standard Deviation K | 549.8 |
| Standard Deviation $Log_{10}(K)$ | 0.37 |

High standard deviation indicates high variability in Seymour hydraulic conductivity

Indicates hydraulic conductivity of Seymour Aquifer is high

# Hydraulic Conductivity Map



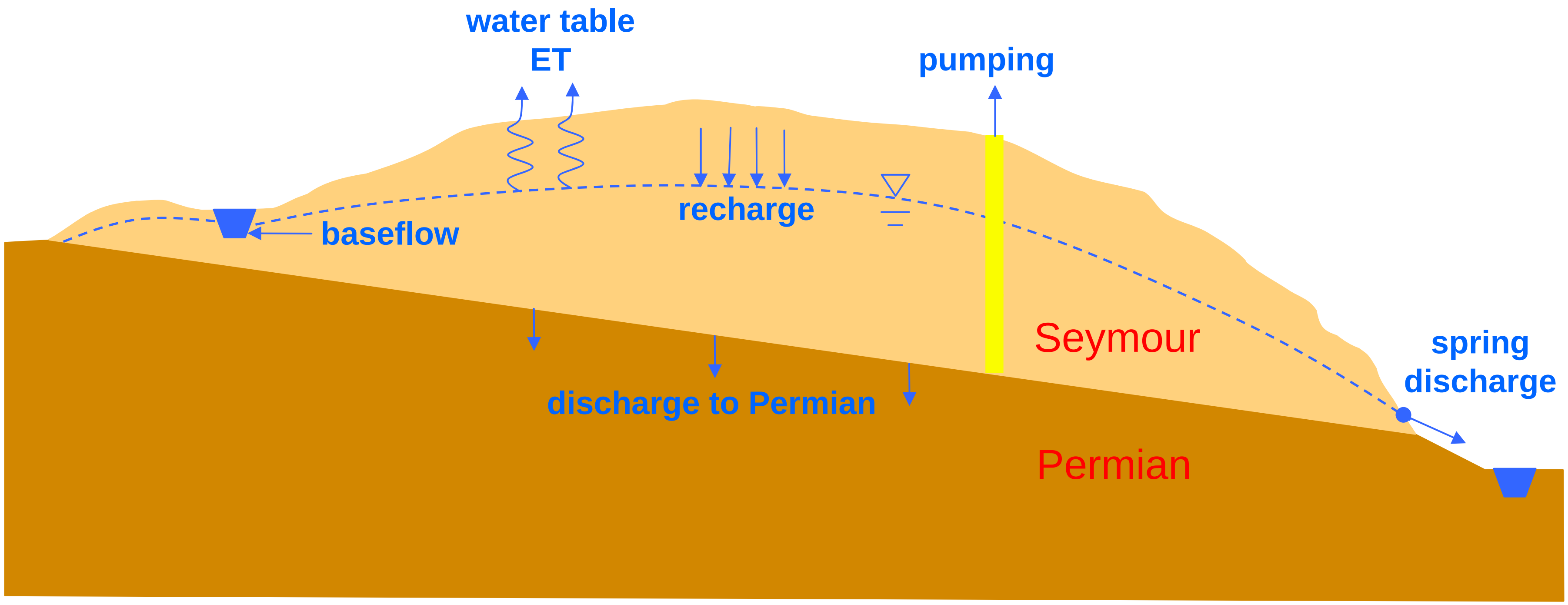
# Vertical Conductivity

- Vertical Conductivity
  - No vertical conductivity data available
  - No vertical variation in conductivity in Seymour Aquifer
  - Clear Fork conductivity will dictate leakance between layers
- Specific Yield
  - Seymour specific yield estimates from published reports (falls within literature values)

| County | Well Number | Storage | | Reference |
|---|---|---|---|---|
| | | Point | Average | |
| Baylor | 2130387 | 0.03 | 0.11 | Preston, 1978 |
| Baylor | 2130385 | 0.04 | | |
| Baylor | 2122911 | 0.04 | | |
| Baylor | 2122912 | 0.06 | | |
| Baylor | 2122913 | 0.08 | | |
| Baylor | 2121941 | 0.16 | | |
| Baylor | 2121940 | 0.18 | | |
| Baylor | 2130386 | 0.30 | | |
| Haskell-Knox | - | - | 0.15 | R.W. Harden & Associates, 1978 |

# Recharge

# Summary of Aquifer Recharge and Discharge



# Recharge

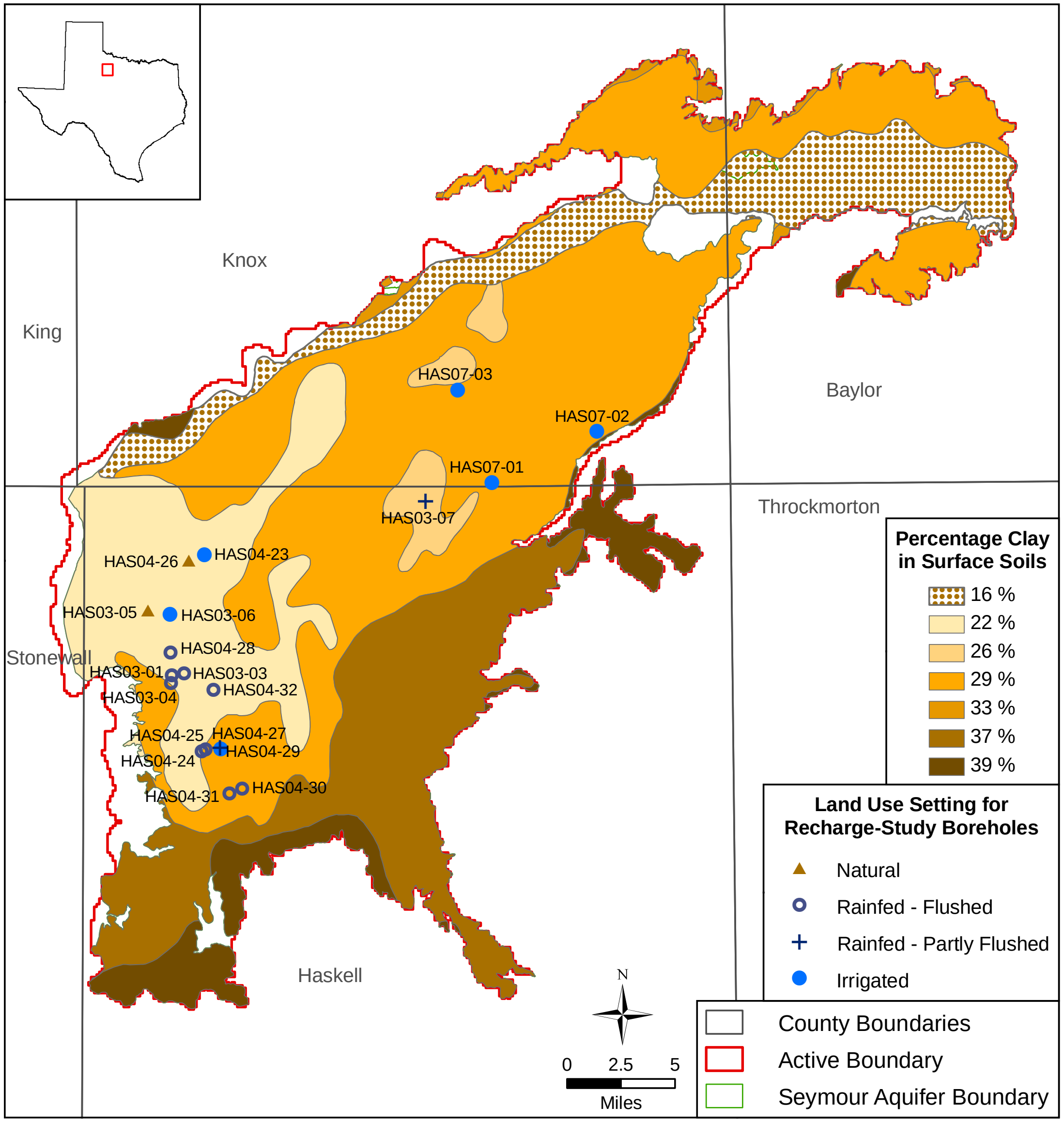
- Recharge – The addition of water to the water table. Recharge equals water inputs at ground surface (precipitation + irrigation + stream loss) minus water losses (runoff + evapotranspiration)
- Recharge is a complex function of
  - Precipitation (rate, volume, distribution),
  - Evapotranspiration (ET)
  - Runoff
  - Soil moisture, soil type
  - Depth to water
- Recharge is not directly measurable at the model scale
- Recharge varies as a function of time and location

# Recharge Estimates

- Literature values:

| County | Recharge (in/yr) | Reference | Technique |
|---|---|---|---|
| Haskell, Knox | 2.2 | Harden & Assoc., 1978 | water budget |
| Baylor | 2.6 | Preston, 1978 | baseflow discharge |

# Surface Soil Clay Content

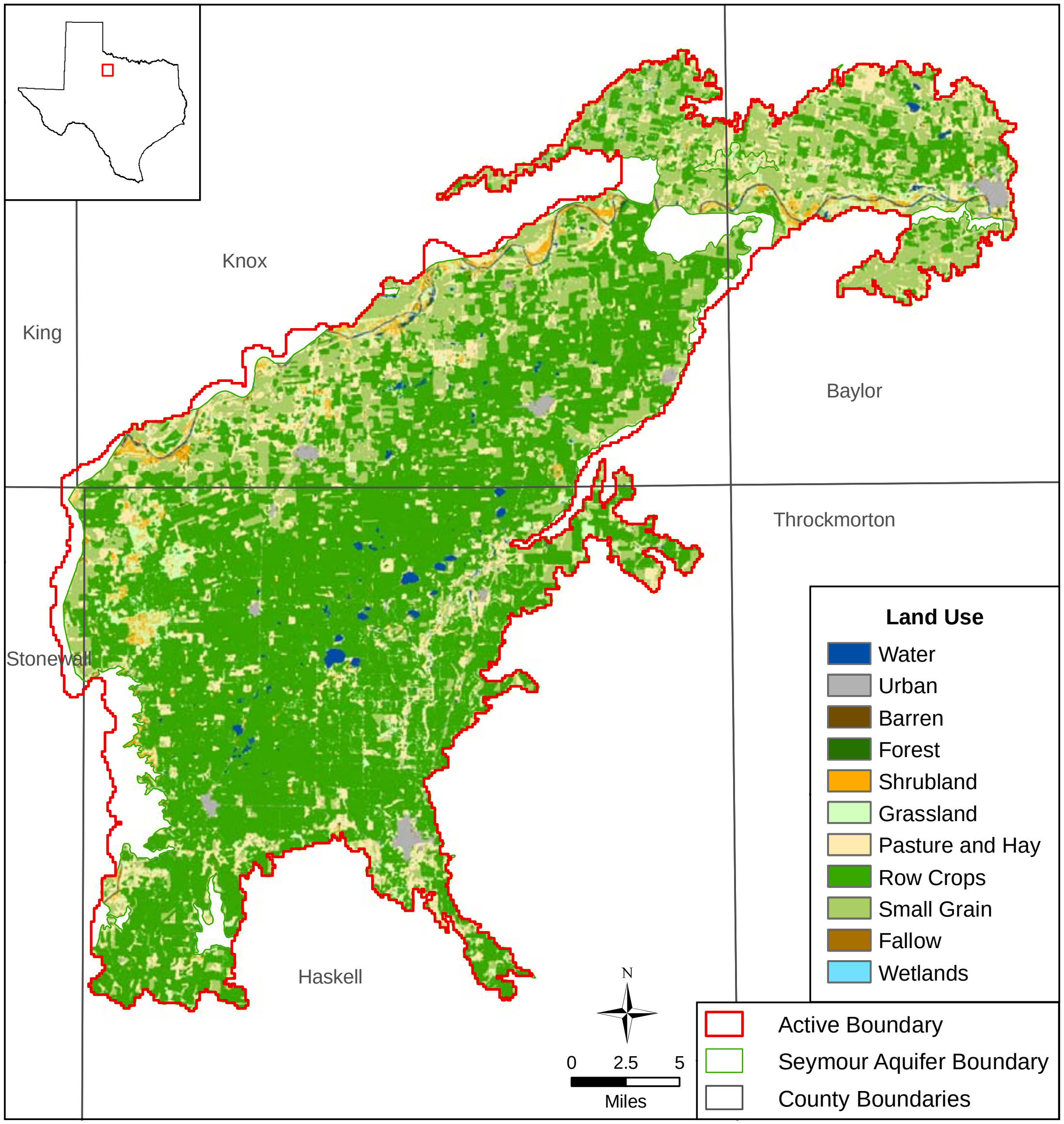


# Recharge Estimates

- BEG (Bridget Scanlon and Jeff Olyphant) analysis:

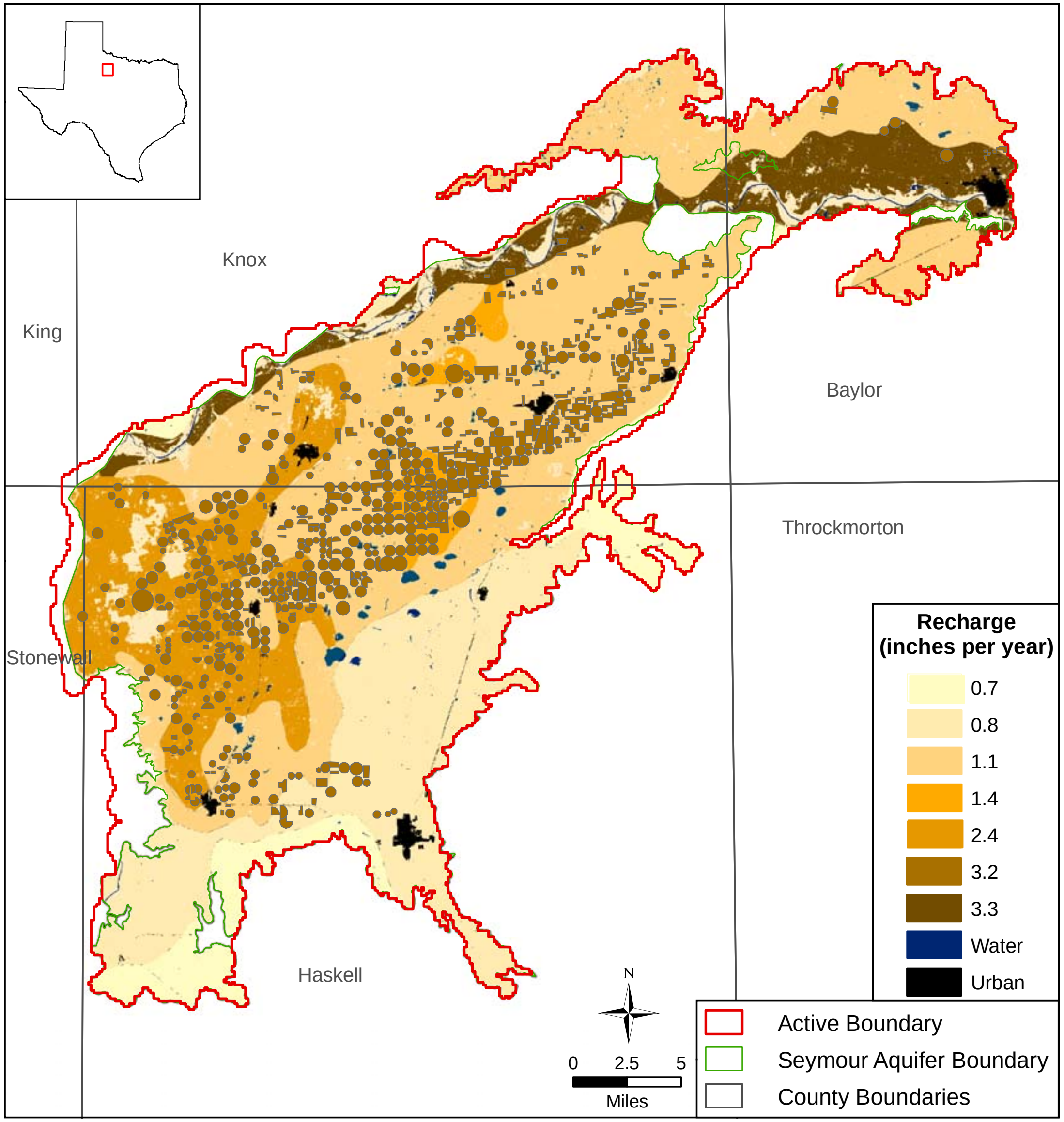
| Method | Type | Recharge | | | |
|---|---|---|---|---|---|
| | | Min (in/yr) | Max (in/yr) | Mean (in/yr) | Median (in/yr) |
| CMB | Natural Boreholes | 0.3 | 1.1 | 0.7 | 0.7 |
| CMB | Rainfed Boreholes | 0.4 | 1.7 | 1.1 | 0.9 |
| CMB | Irrigated Boreholes | 1.5 | 5.8 | 3.2 | 2.6 |
| WTF | Observation Wells | 2 | 5.5 | 3.5 | 2.7 |
| WTF | Bandy Wells | 0.8 | 5.0 | 2.5 | 2.0 |

# Land Use



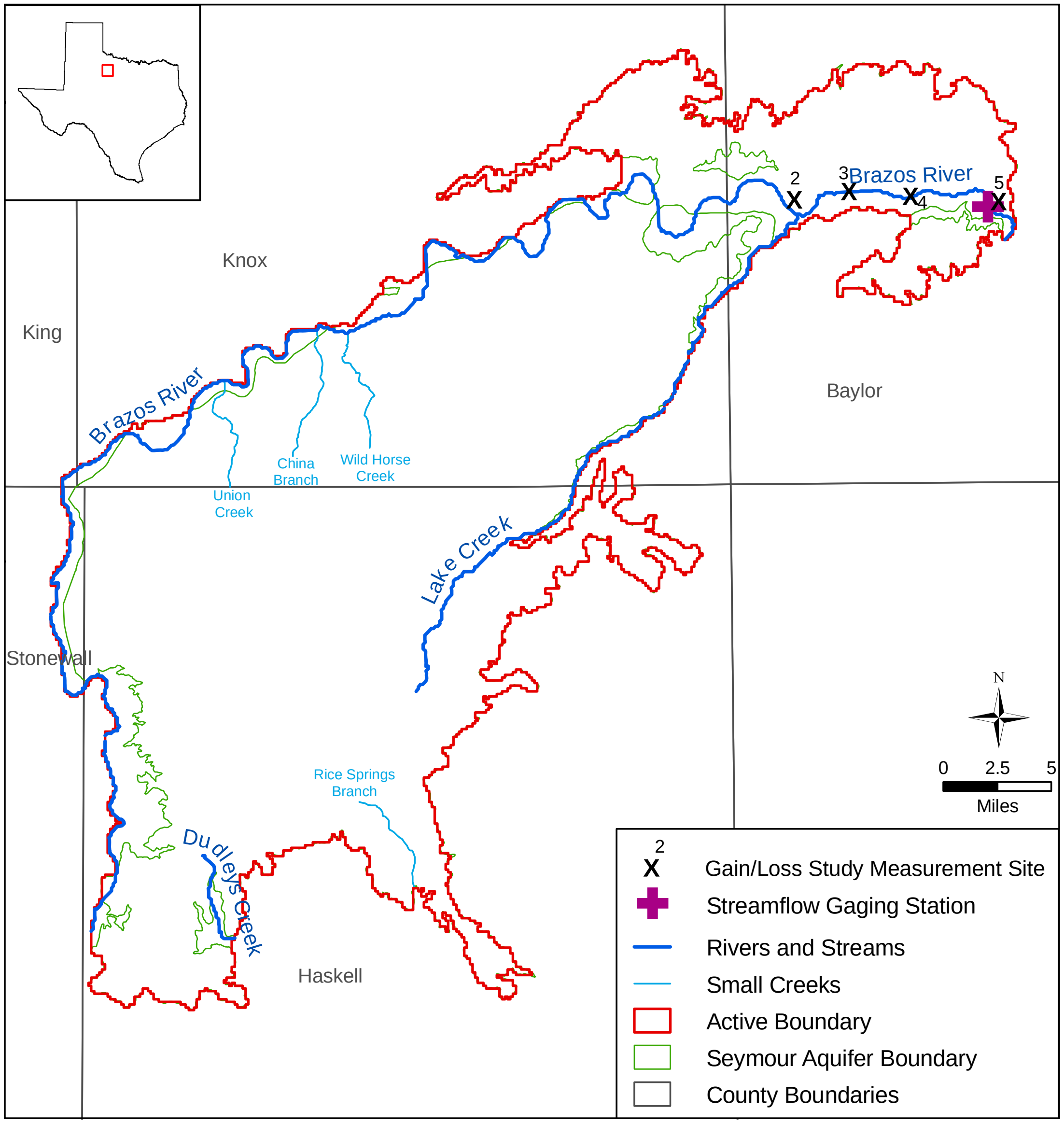
Knox
King
Baylor
Throckmorton
Stonewall
Haskell
Land Use
Water
Urban
Barren
Forest
Shrubland
Grassland
Pasture and Hay
Row Crops
Small Grain
Fallow
Wetlands
N
0
2.5
5
Miles
Active Boundary
Seymour Aquifer Boundary
County Boundaries

# Recharge for Transient Model



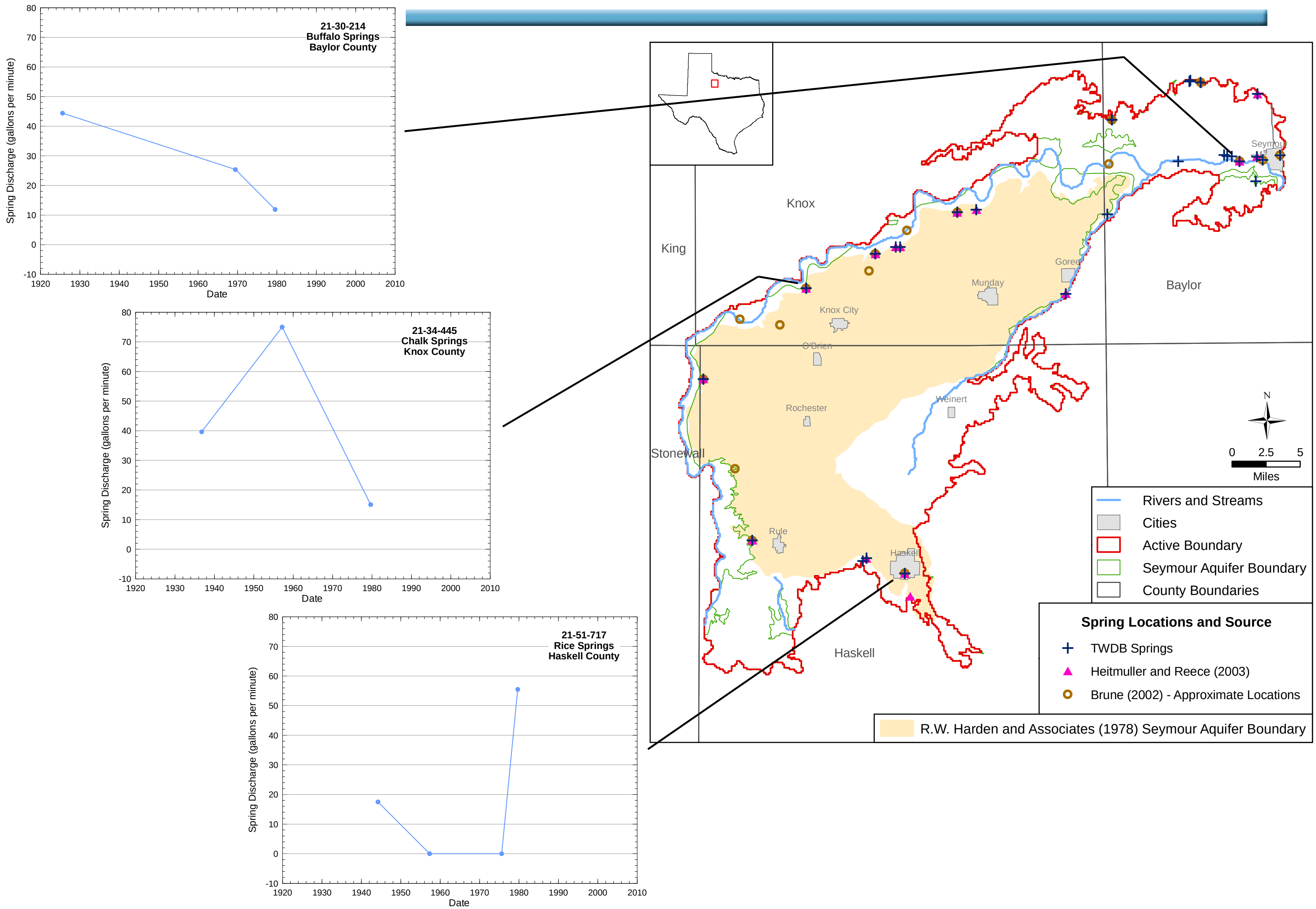
# Natural Discharge

# Rivers and Streams

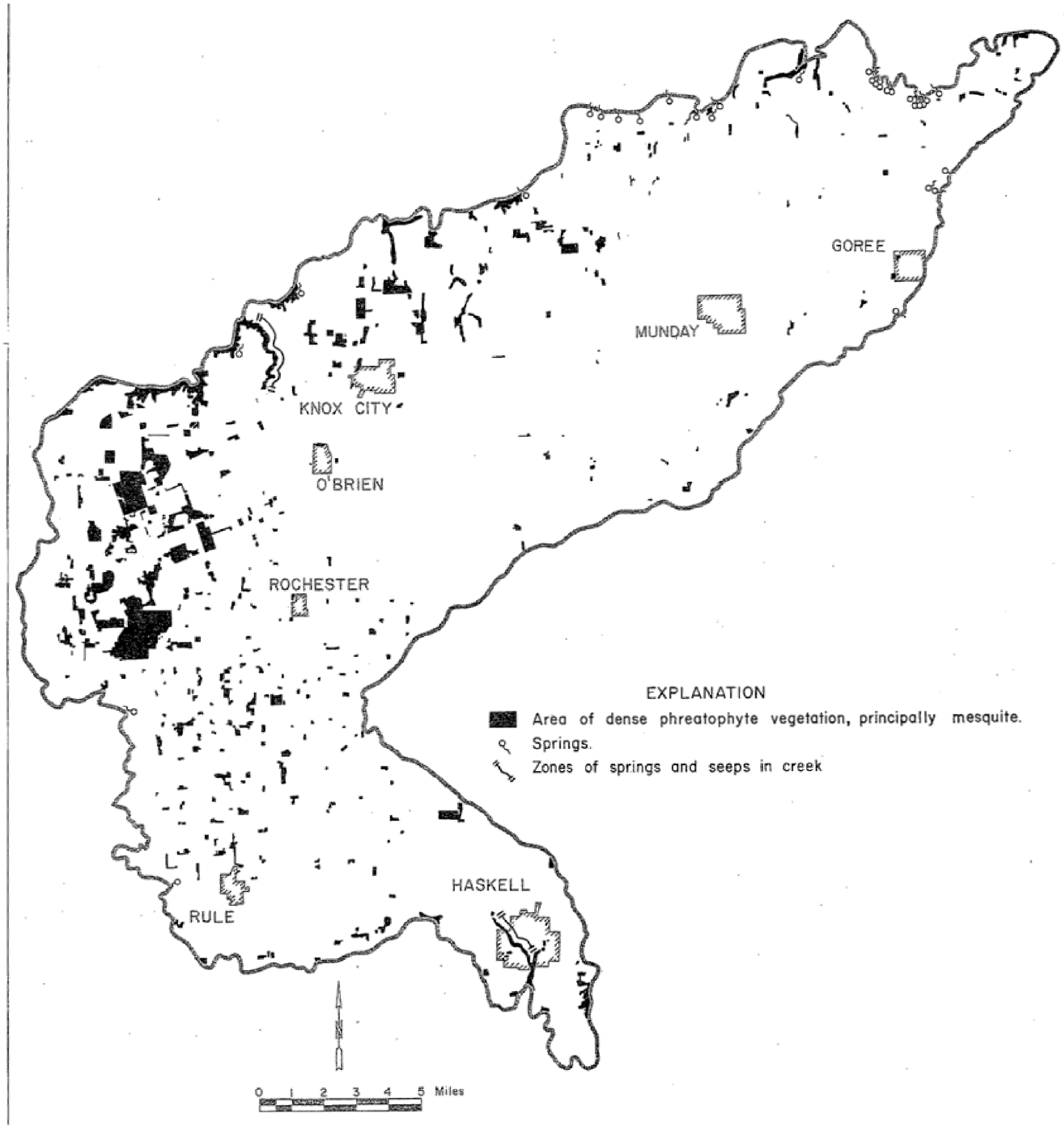



| Measurement Site | Flow (cfs) | Net Gain (cfs) | Yearly Discharge Repsented by Net Gain (AF) |
|---|---|---|---|
| 1 | 34.6 | - | - |
| 2 | 34.7 | 1 | 72.4 |
| 3 | 35.2 | 0.5 | 362.5 |
| 4 | 37.8 | 2.6 | 1882.5 |
| 5 | 38.7 | 0.9 | 651.6 |

# Springs - Locations

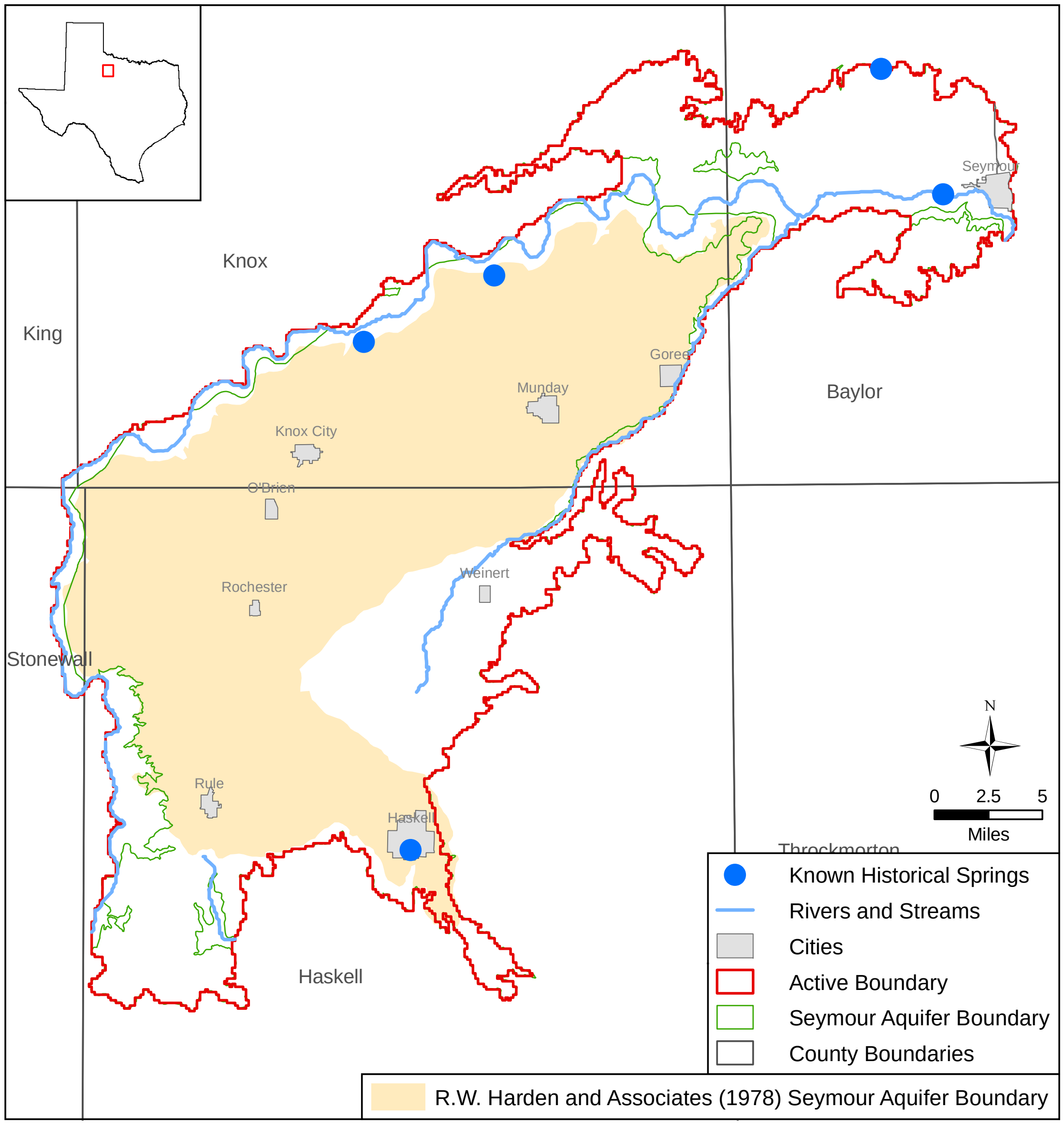


# Zones of Springs & Seeps

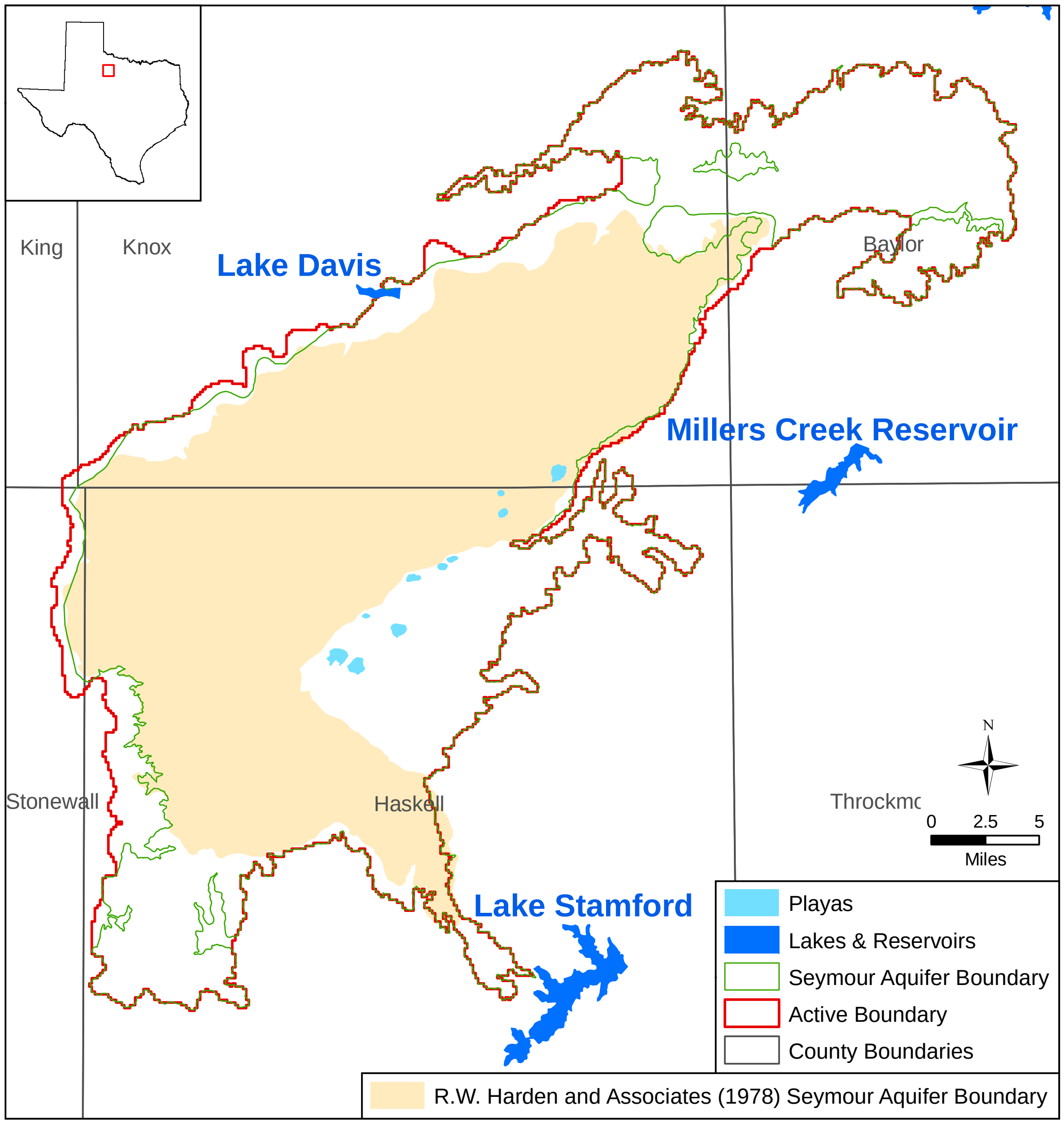



(from R.W. Harden and Associates, 1978)

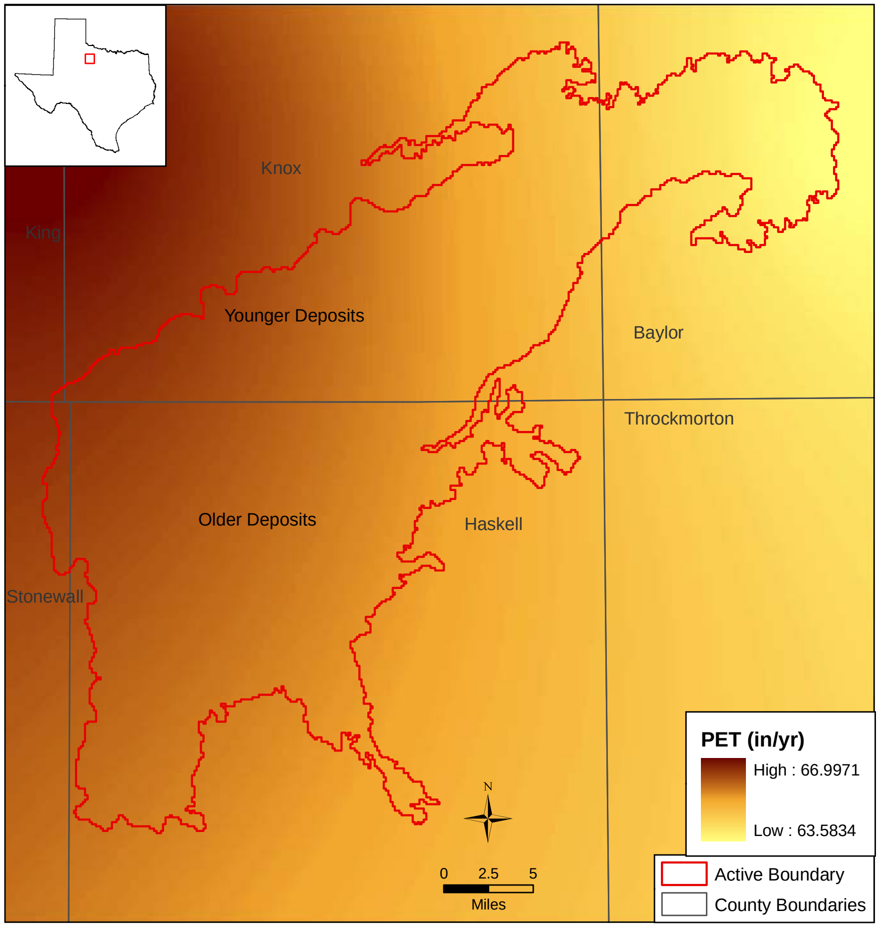
# Springs – Known Historical



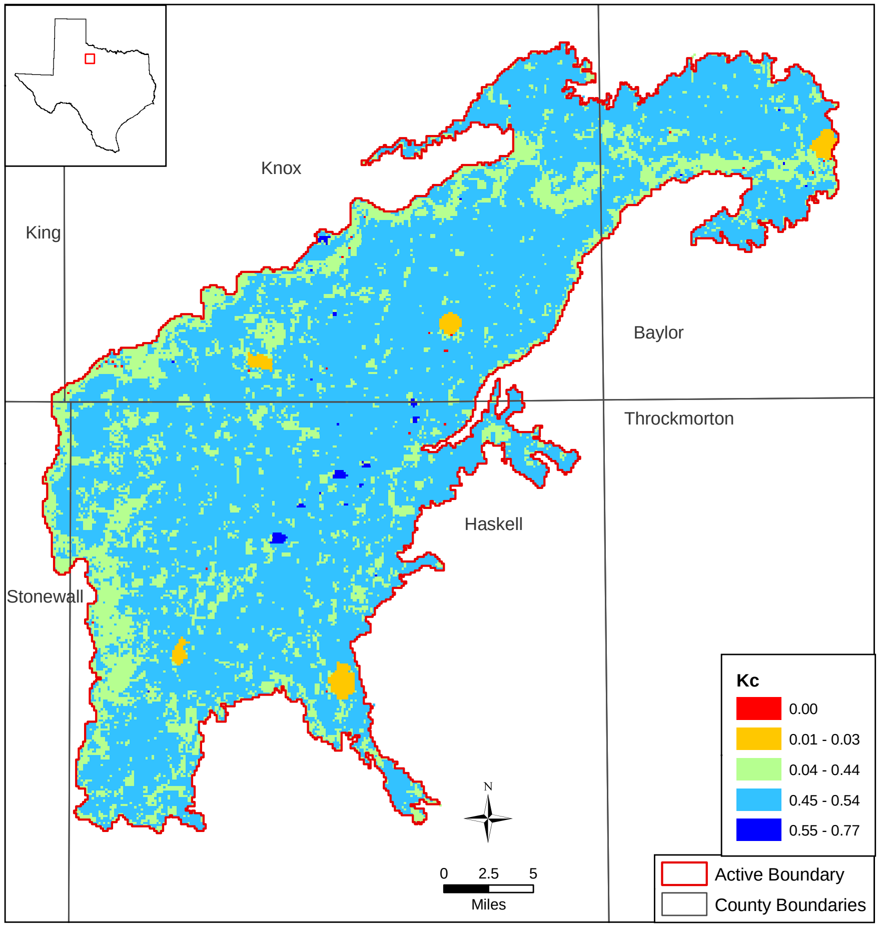
# Reservoirs and Playas



# Evapotranspiration

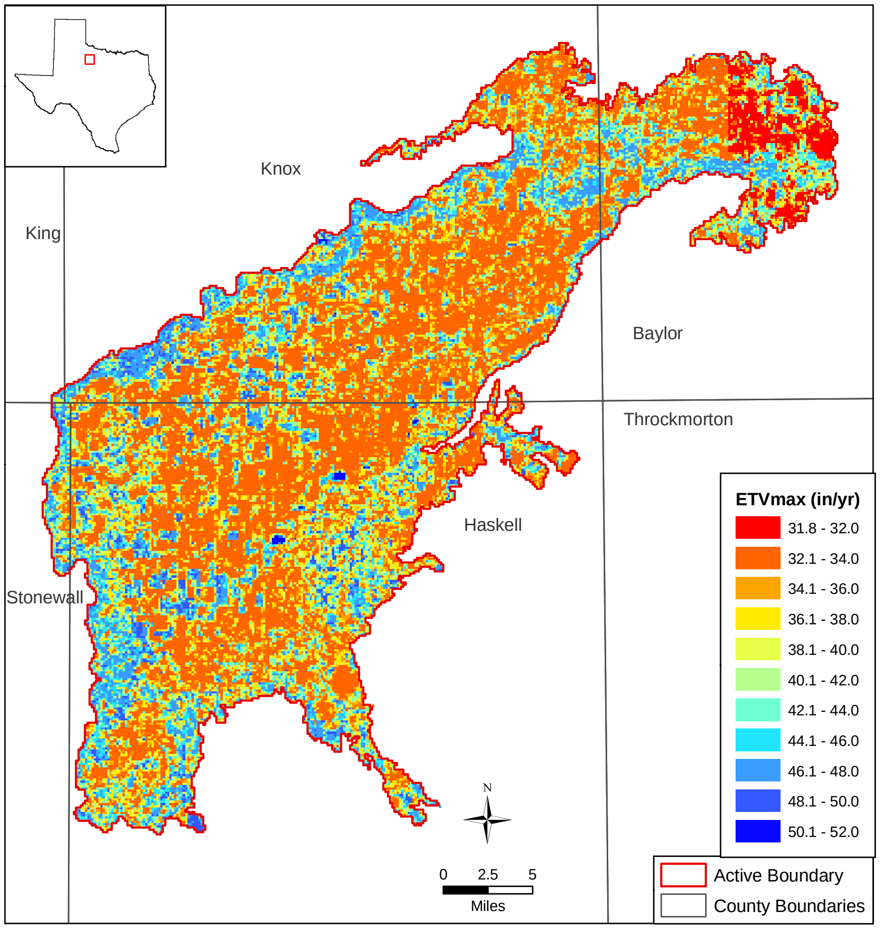



Potential Evapotranspiration (PET)

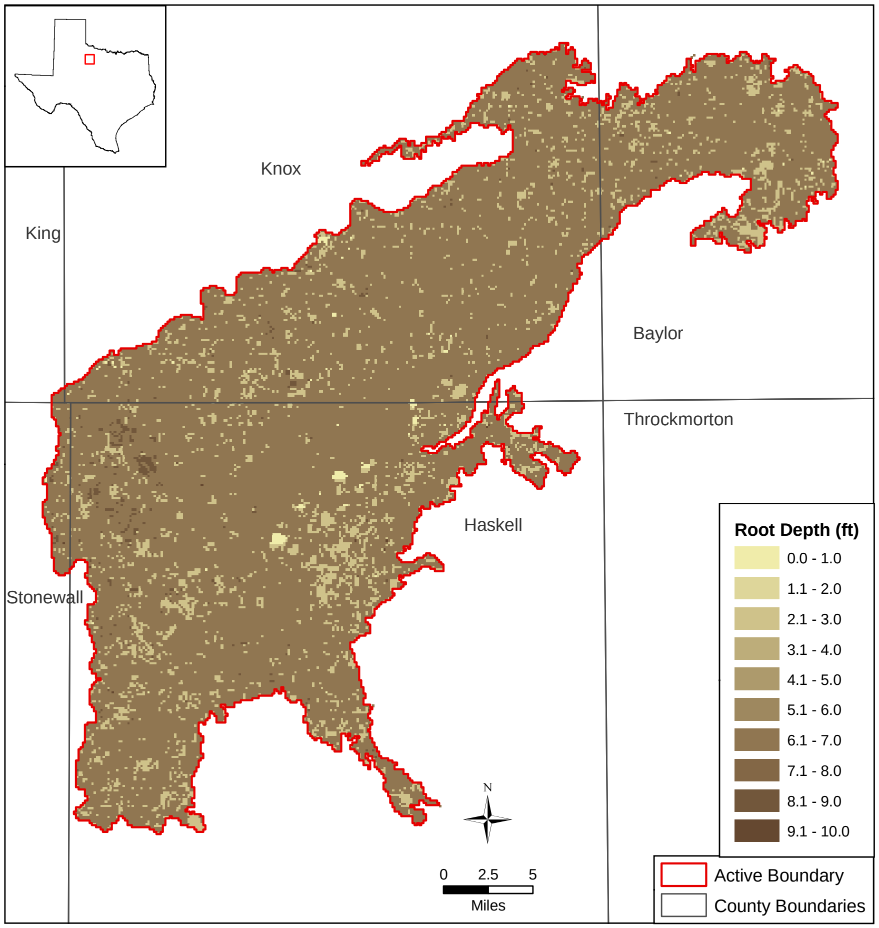



Vegetation Coefficient (Kc)

# Evapotranspiration




Maximum Evapotranspiration (PET x Kc)

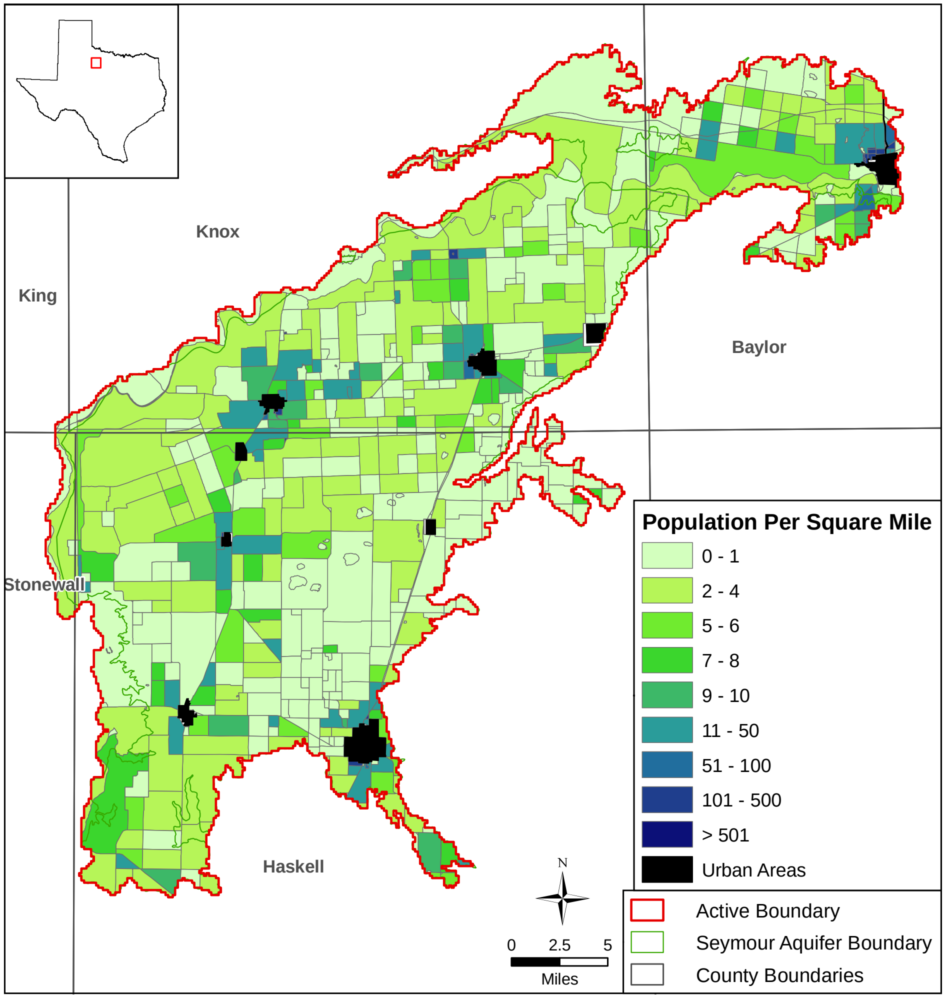



Root Extinction Depth

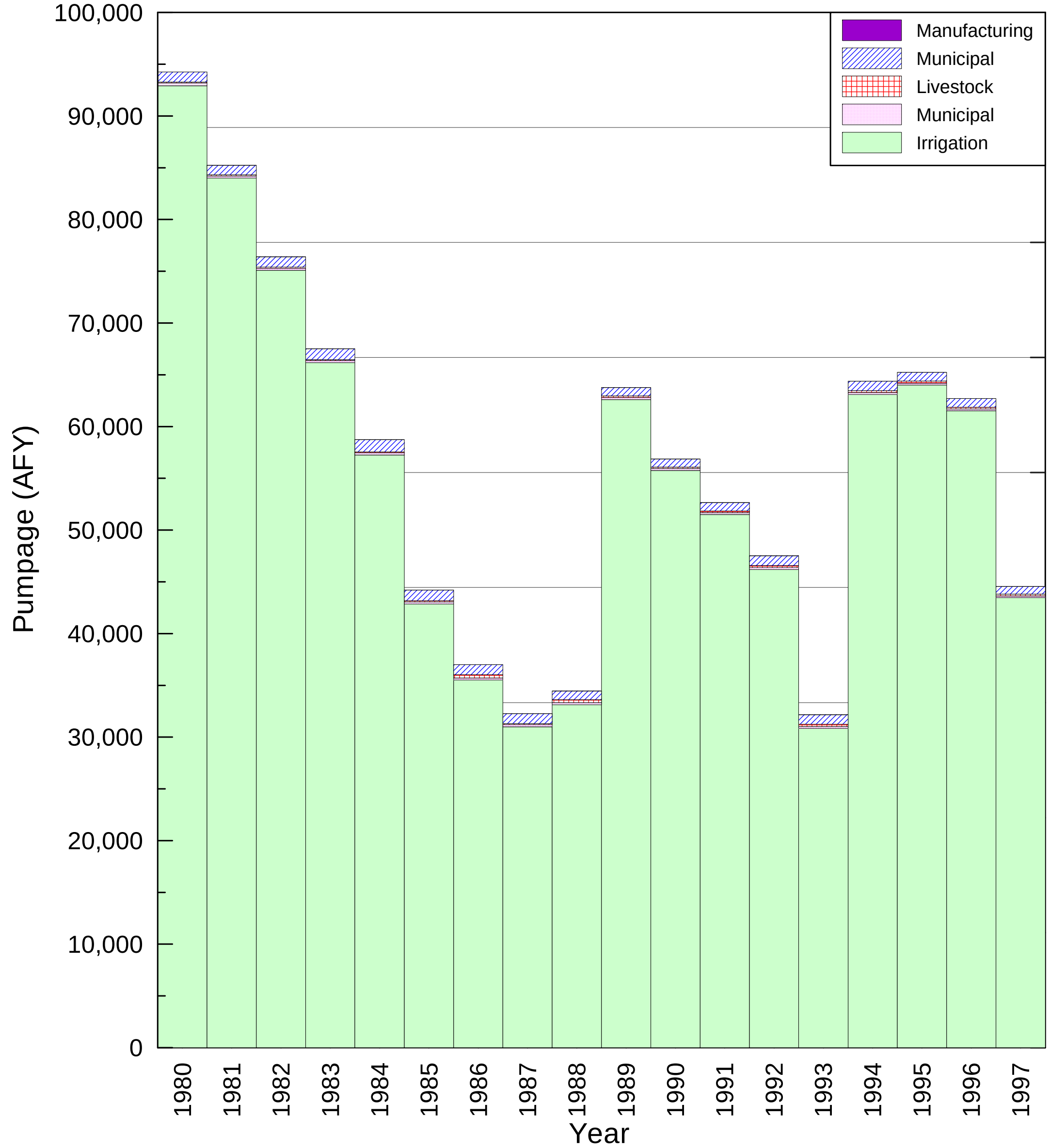
# Pumping

# Transient Model Calibration Period

- IRR, MFG, NIM, MUN, PWR, and STK pumping summed by county from Pumpamatic Master Pumping tables
- RD calculated by county from 1990 census block population data and RurDom factors

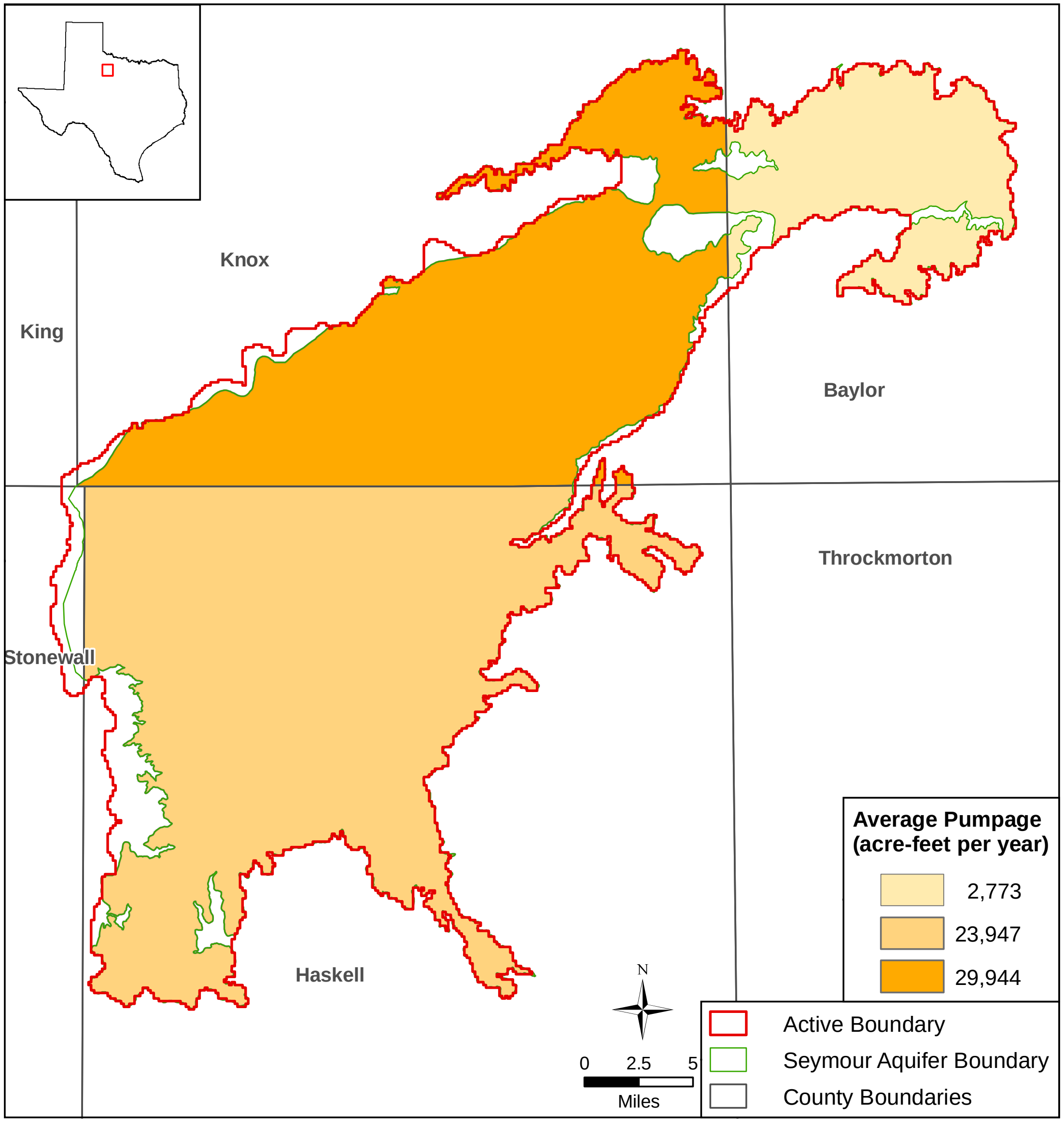


# Transient Model Calibration Period

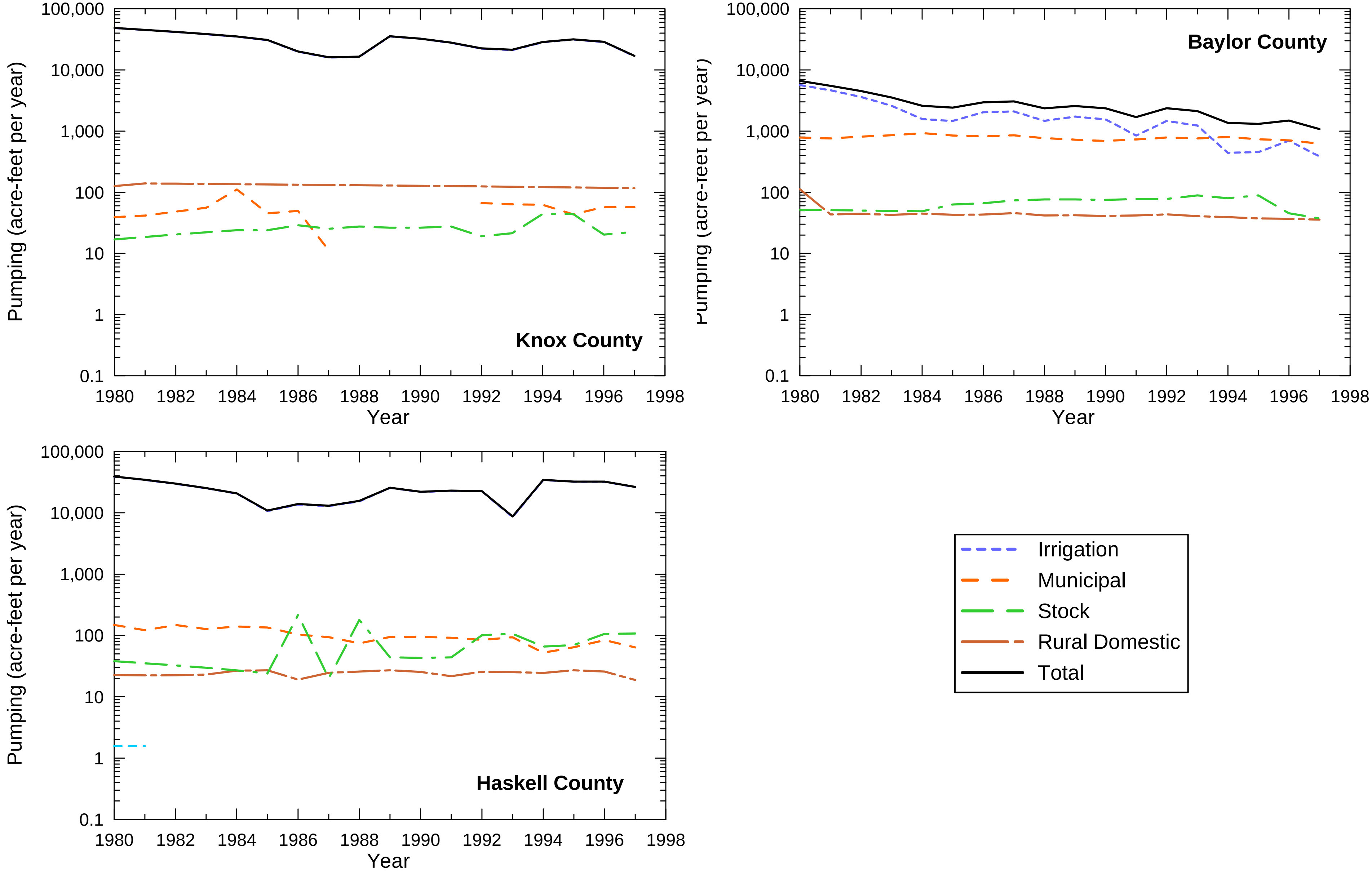



Irrigation – 97.74 %
Rural Domestic – 0.35 %
Livestock – 0.29 %
Municipal – 1.62 %
Manufacturing – 0 %
Mining – 0 %
Power – 0%

# Transient Model Calibration Period



# Transient Model Calibration Period



# Pre-1980 Pumping

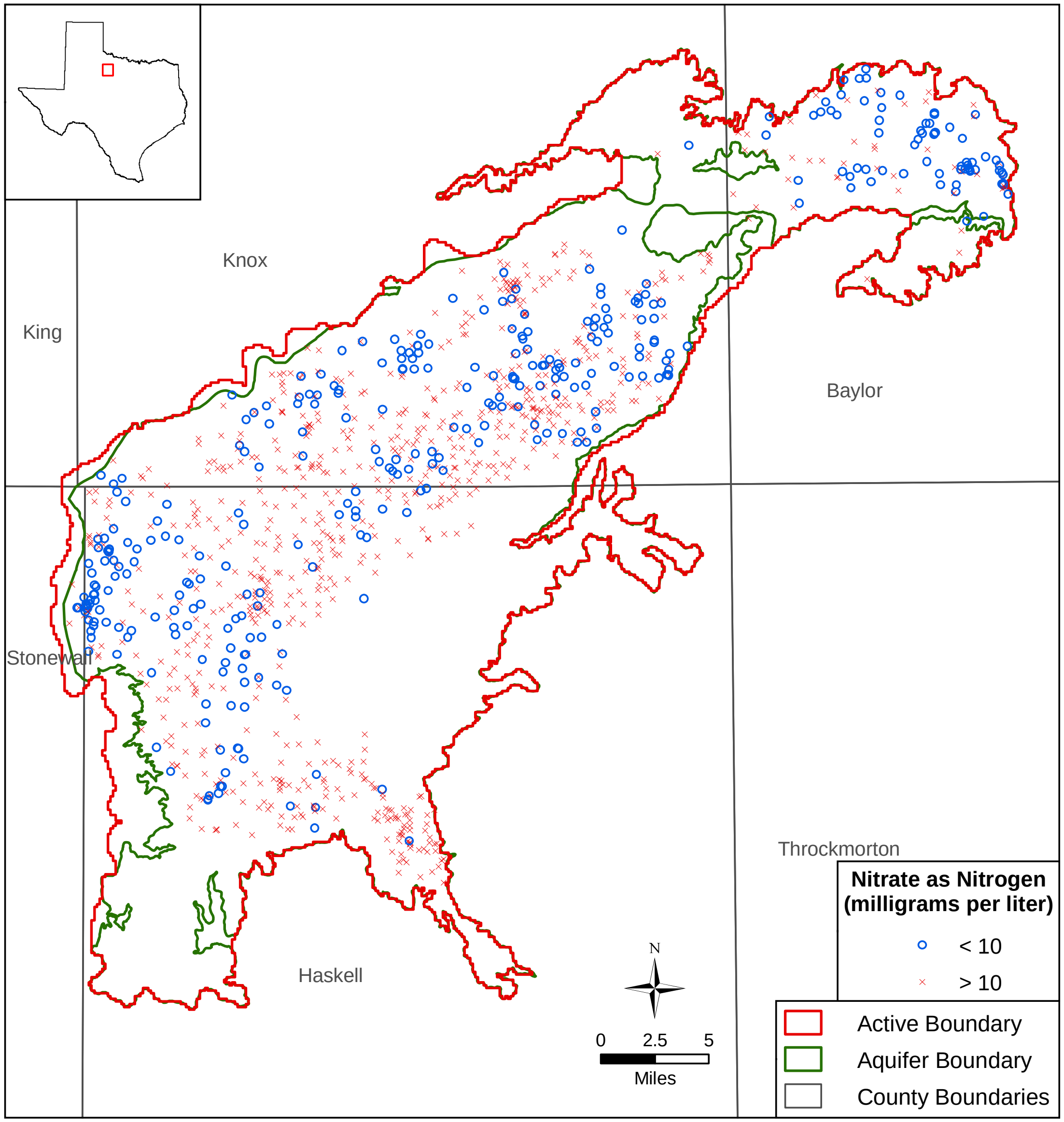
| Year | Baylor County | | | | | Haskell and Knox Counties | | | | | Haskell County | Knox County |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Preston (1978) | | | | TWDB (1981) | Ogilbee and Osborne (1962) | | R.W. Harden and Associates (1978) | | | TWDB (1981) | TWDB (1981) |
| | portion of Seymour Formation located west of the city of Seymour to the Knox-Baylor county line (i.e., portion of Seymour Aquifer considered by this study) | | | | entire county | portion of Seymour Aquifer considered by this study | | portion of Seymour Aquifer considred by this study | | | entire county | entire county |
| | Estimated Irrigation Pumpage (AF) | Estimated Municipal Pumpage (AF) | Estimated Industrial (AFY) | Estimated Rural Domestic and Livestock (AFY) | Irrigation (AF) entire county | Estimated Irrigation Pumpage (AF) | Estimated Pumpage for Other Purposes (AF) | Irrigation Pumpage (AF) | Public Supply Pumpage (AF) | Total Pumpage (AF) | Irrigation (AF) | Irrigation (AF) |
| 1900 | | | | | | | | | | 200 | | |
| 1910 | | | | | | | | | | 400 | | |
| 1920 | | | | | | | | | | 400 | | |
| 1930 | | | | | | | | | | 900 | | |
| 1940 | | | | | | <500 | | | | 1,200 | | |
| 1950 | | | | | | <500 | | 100 | 1,200 | 1,300 | | |
| 1951 | | | | | | <500 | | 900 | 1,200 | 2,100 | | |
| 1952 | 60 | | | | | 9,000 | | 6,700 | 1,200 | 7,900 | | |
| 1953 | 390 | | | | | 13,000 | | 9,900 | 1,200 | 11,100 | | |
| 1954 | 650 | | | | | 22,000 | | 16,800 | 1,200 | 18,000 | | |
| 1955 | 880 | 450 | | | | 45,000 | | 34,800 | 1,200 | 36,000 | | |
| 1956 | 3,130 | 820 | | | | 76,500 | 2,900 | 63,800 | 1,200 | 65,000 | | |
| 1957 | 2,180 | 640 | | | | | | 46,800 | 1,300 | 48,100 | | |
| 1958 | 1,380 | 610 | | | 3,371 | | | 34,500 | 1,800 | 36,300 | 29,533 | 19,276 |
| 1959 | 2,750 | 500 | | | | | | 17,900 | 1,600 | 19,500 | | |
| 1960 | 2,740 | 670 | | | | | | 54,600 | 1,800 | 56,400 | | |
| 1961 | 1,550 | 580 | | | | | | 36,200 | 1,600 | 37,800 | | |
| 1962 | 2,990 | 590 | | | | | | 60,200 | 1,900 | 62,100 | | |
| 1963 | 3,580 | 640 | | | | | | 56,800 | 1,800 | 58,600 | | |
| 1964 | 5,060 | 680 | | | 6,039 | | | 64,400 | 1,500 | 65,900 | 66,075 | 34,894 |
| 1965 | 4,990 | 680 | | | | | | 53,000 | 2,100 | 55,100 | | |
| 1966 | 4,850 | 630 | | | | | | 51,100 | 2,000 | 53,100 | | |
| 1967 | 3,850 | 660 | | | | | | 51,600 | 1,900 | 53,500 | | |
| 1968 | 2,100 | 670 | | | | | | 26,500 | 1,700 | 28,200 | | |
| Jan-69 | | 42.4 | | | | | | | | | | |
| Feb-69 | | 37.4 | | | | | | | | | | |
| Mar-69 | | 36.5 | | | | | | | | | | |
| Apr-69 | | 51.4 | | | | | | | | | | |
| May-69 | | 56.3 | | | | | | | | | | |
| Jun-69 | 3,770 | 71.5 | 150 | 350 | 6,108 | | | 32,000 | 1,700 | 33,700 | 37,696 | 49,874 |
| Jul-69 | | 133.4 | | | | | | | | | | |
| Aug-69 | | 128.4 | | | | | | | | | | |
| Sep-69 | | 43.1 | | | | | | | | | | |
| Oct-69 | | 39.5 | | | | | | | | | | |
| Nov-69 | | 51.7 | | | | | | | | | | |
| Dec-69 | | 36.4 | | | | | | | | | | |
| 1970 | | | | | | | | 41,900 | 1,900 | 43,800 | | |
| 1971 | | | | | | | | 51,200 | 1,700 | 52,900 | | |
| 1972 | | | | | | | | 34,800 | 1,500 | 36,300 | | |
| 1973 | | | | | | | | 24,000 | 1,600 | 25,600 | | |
| 1974 | | | | | 5,364 | | | 63,600 | 1,600 | 65,200 | 41,639 | 44,705 |
| 1975 | | | | | | | | 25,100 | 1,600 | 26,700 | | |
| 1976 | | | | | | | | 39,100 | 1,700 | 40,800 | | |
| 1977 | | | | | | | | | | | | |
| 1978 | | | | | | | | | | | | |
| 1979 | | | | | 794 | | | | | | 38,013 | 51,283 |

# Groundwater Quality

# Groundwater Quality

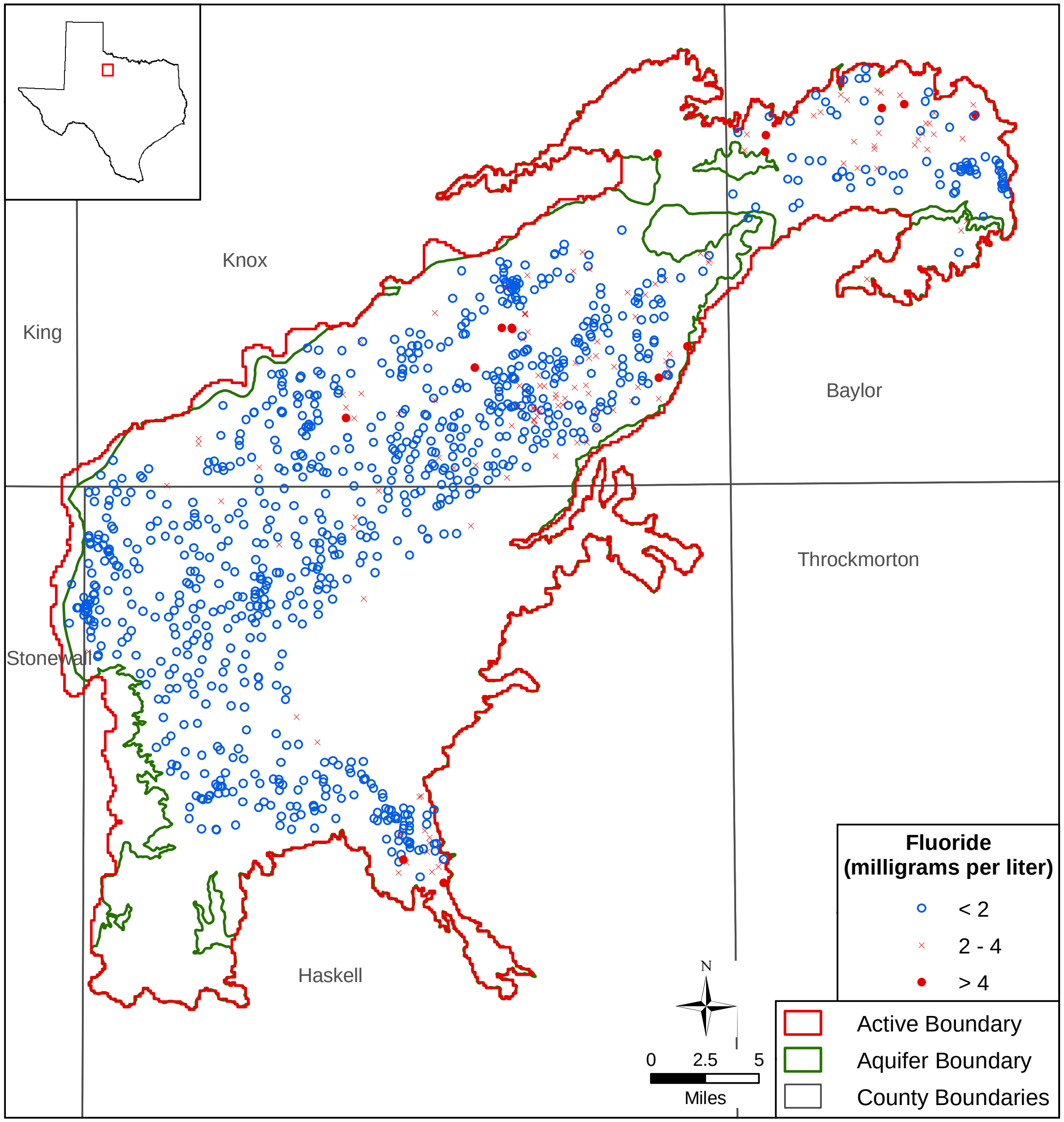
- **Water Quality Measures Compared to Screening Levels for Drinking Water Supply and Irrigation**
- **Drinking Water**
  - National Primary Drinking Water Regulations – 40 CFR 141 - legally enforceable standards to protect human health from contaminants in drinking water
  - National Secondary Drinking Water Regulations – 40 CFR 143 - guidelines to prevent aesthetic effects (taste, odor, color), cosmetic effects (staining) in drinking water, and technical effects (corrosion, expense of treatment)
- **Irrigation Water Screening Levels**
  - Based on crop tolerances
  - Major irrigated crops: cotton, wheat, peanuts

# Nitrate as Nitrogen




69% of
1,123 wells sampled
above primary
screening level
of 10 mg/L

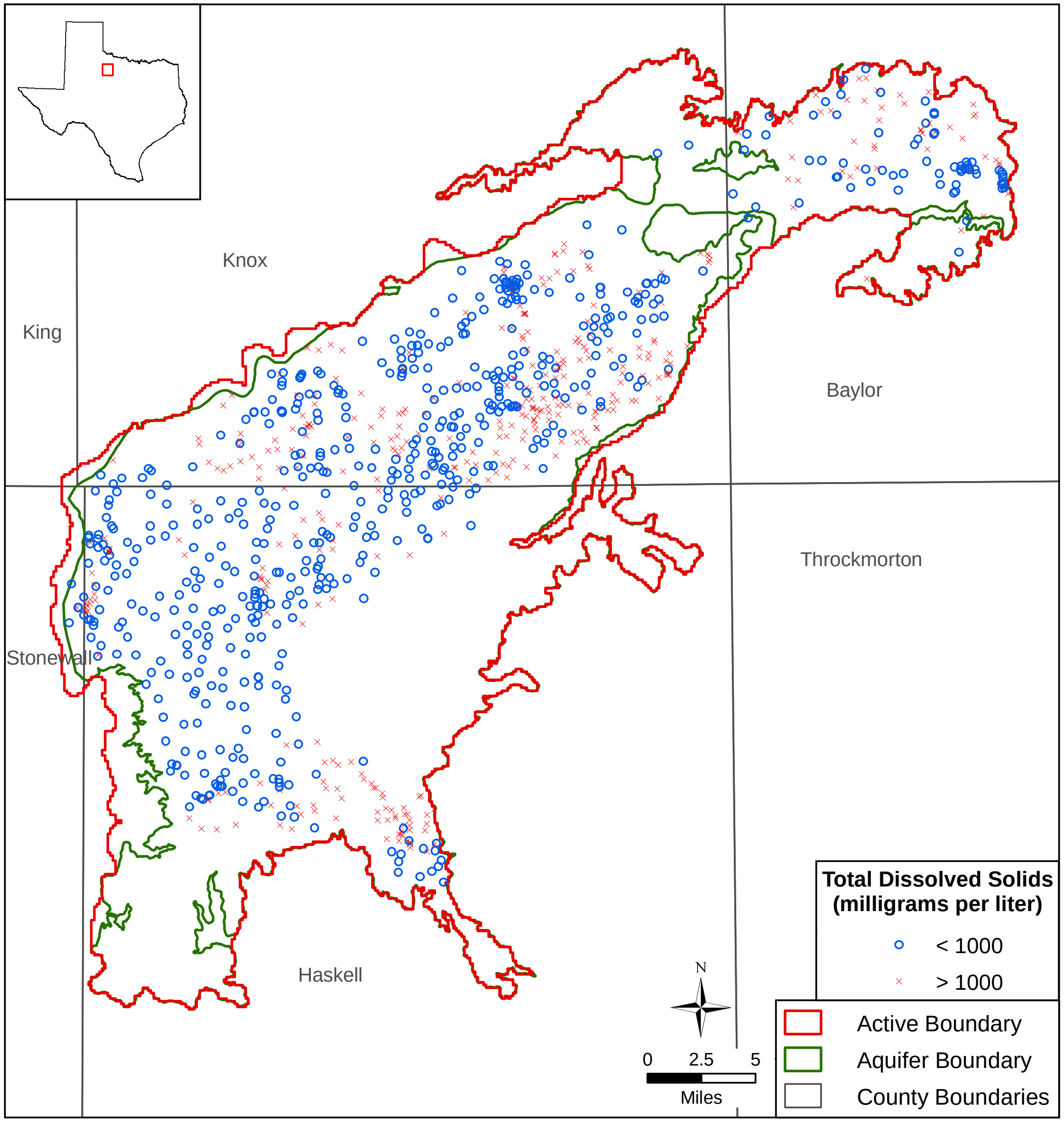
# Fluoride




1.5% of 1,030 wells sampled above primary screening level of 4 mg/L

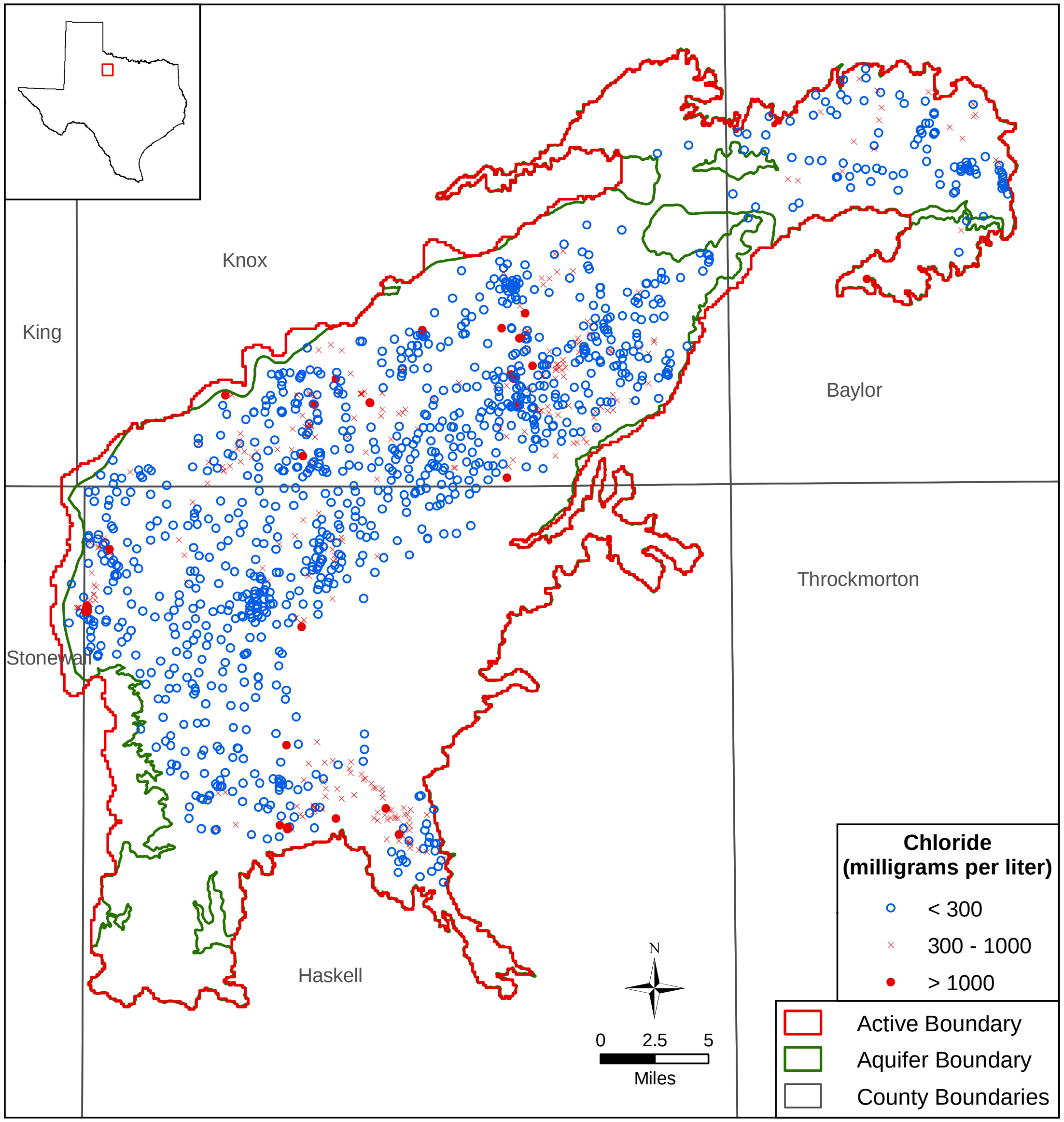
14% of 1,030 wells sampled above secondary screening level of 2 mg/L

# Total Dissolved Solids




40% of
977 wells sampled
above secondary
screening level
of 1,000 mg/L

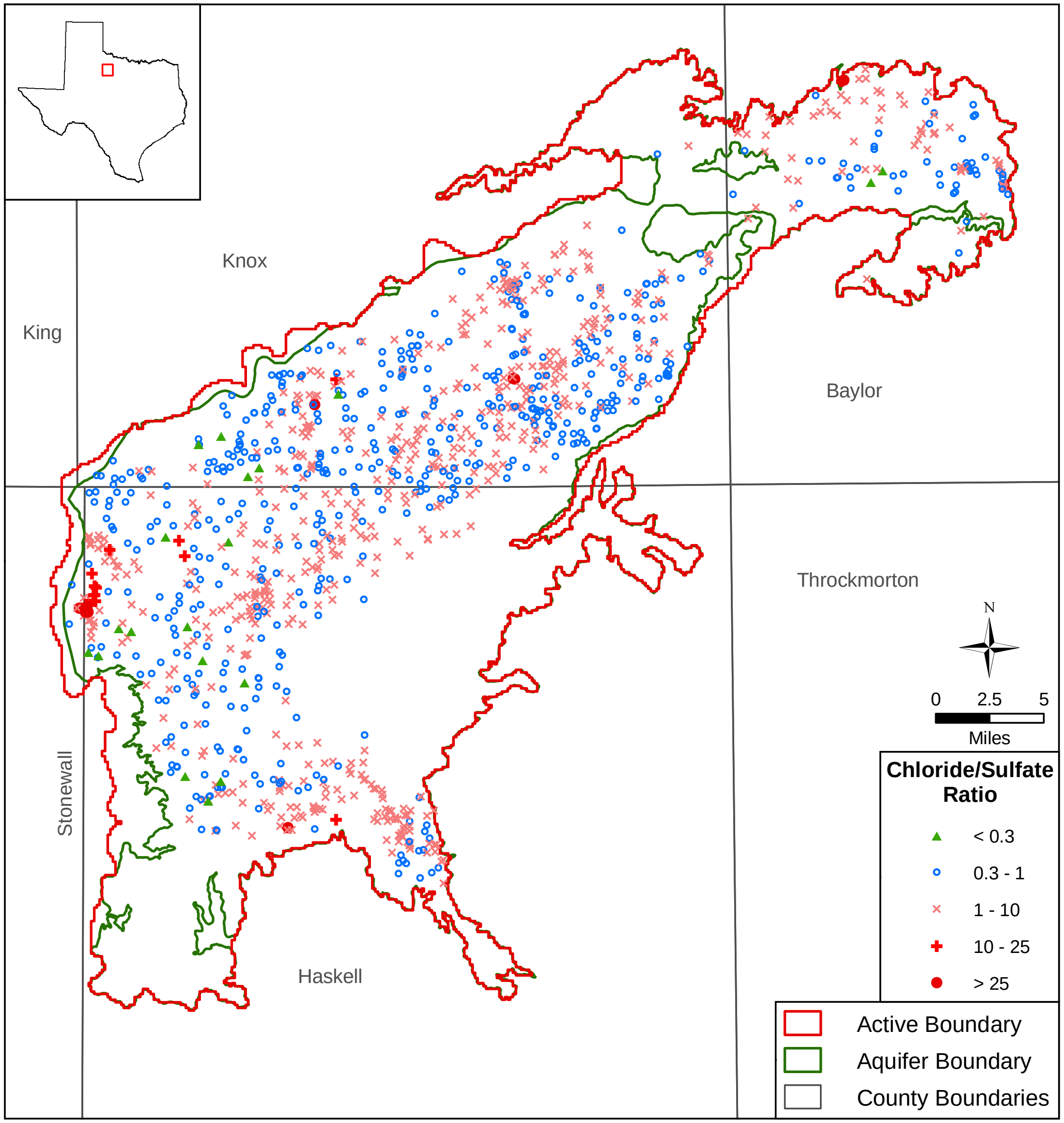
# Chloride



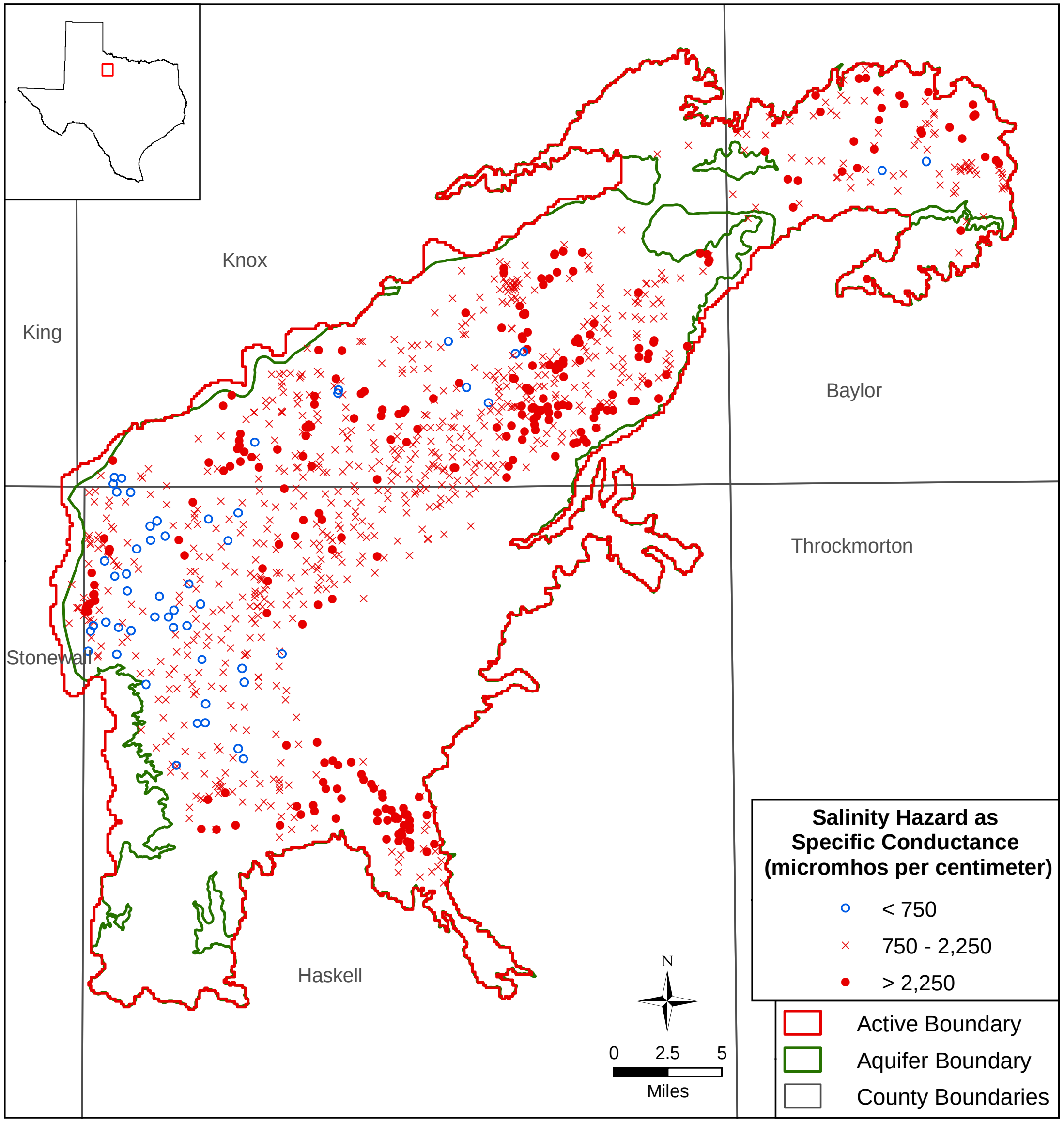

24% of
1,326 wells sampled
above secondary
screening level
of 300 mg/L

2.4% of
1,326 wells sampled
above irrigation
screening level
of 1,000 mg/L

# Chloride/Sulfate Ratio



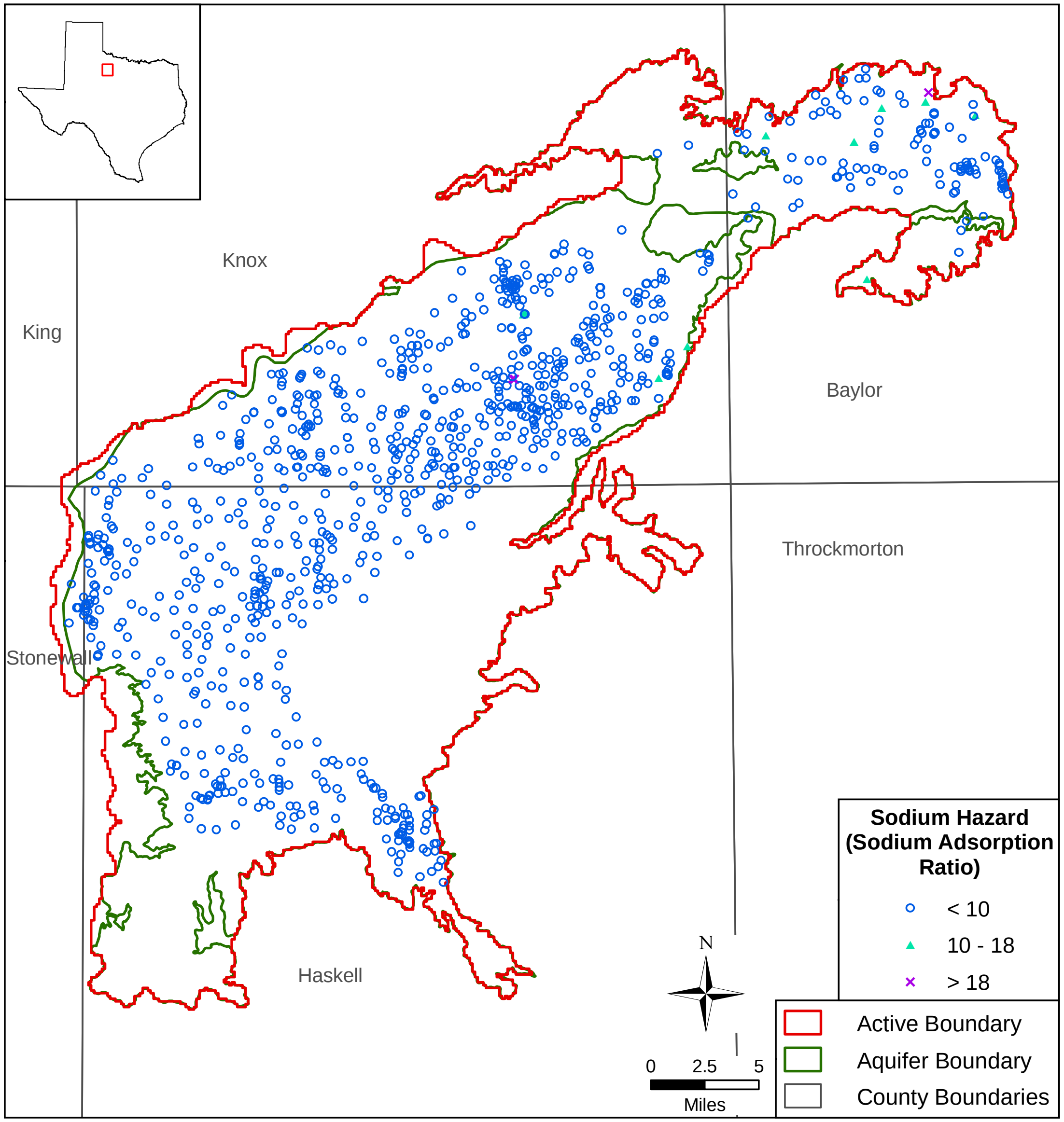
# Salinity Hazard




95% of
1,056 wells sampled
high hazard
(750-2,250 µmhos/cm)

25% of
1,056 wells sampled
very high hazard
(>2,250 µmhos/cm)

# Sodium Hazard

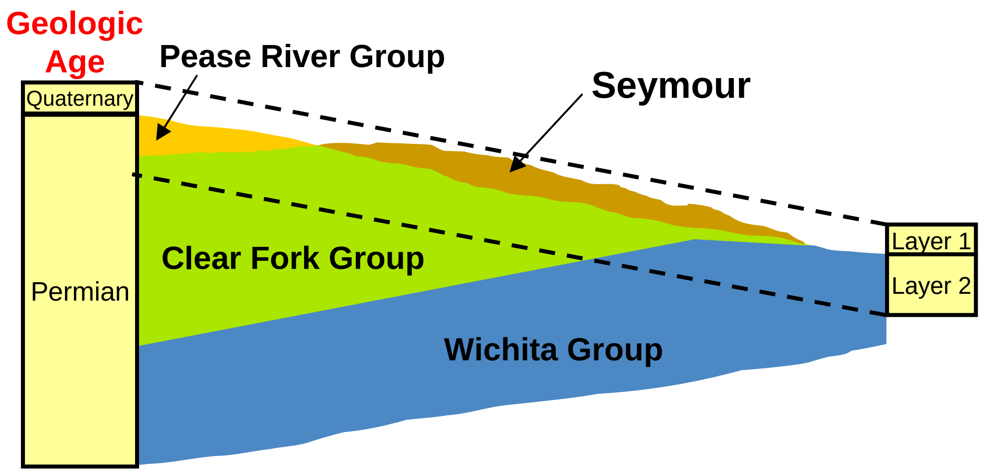


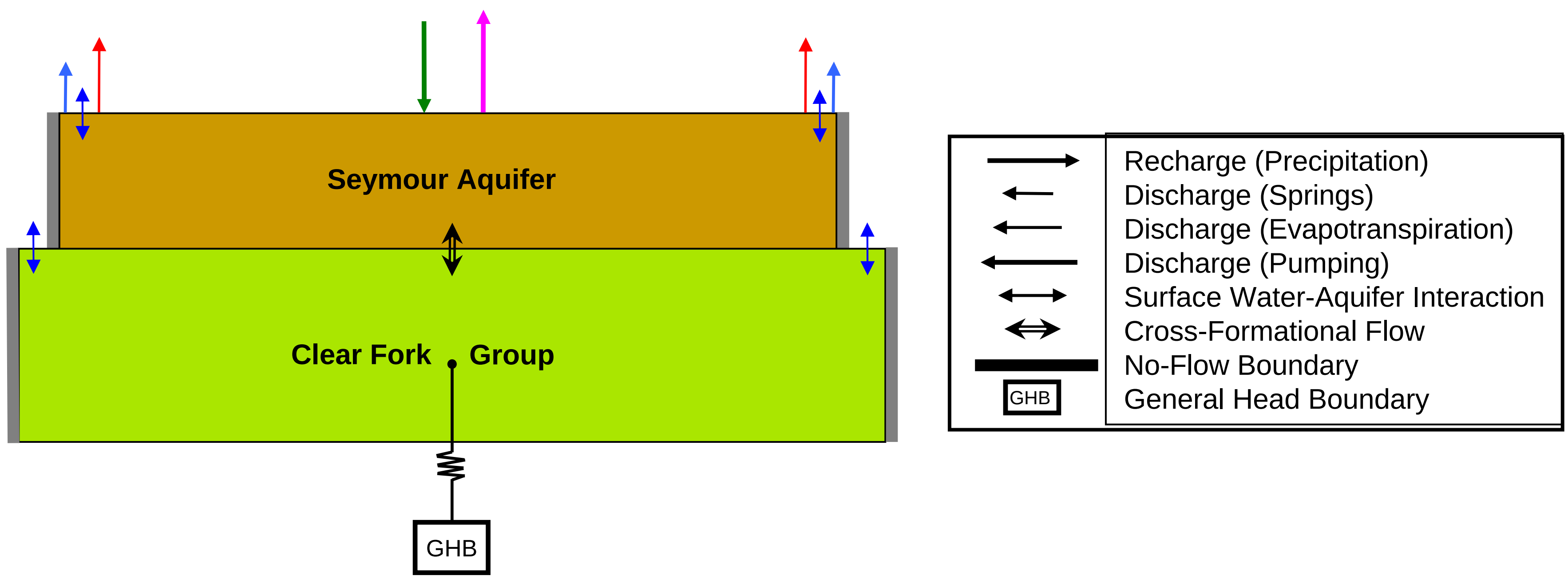

0.3% of
970 wells sampled
high hazard
(10-18)

0% of
970 wells sampled
very high hazard
(>18)

# Conceptual Model of Groundwater Flow

# Conceptual Model



# Conceptual Model

- Steady-state period – pre-1880
  - Minimal recharge by precipitation
  - High discharge by evapotranspiration
  - Discharge to springs and river
  - Aquifer recharge and natural aquifer discharge balanced
- 1880 to 1910
  - Decreased recharge by precipitation
  - Increased discharge by evapotranspiration
  - Continued discharge to some springs probably at a reduced rate
  - Natural aquifer discharge greater than aquifer recharge

# Conceptual Model (cont’d)

- 1910 to 1940s
  - Maximum recharge by precipitation
  - Minimum discharge by evapotranspiration
  - Possible increased discharge to springs
  - Aquifer recharge greater than aquifer discharge
- Since 1940s
  - High recharge by precipitation
  - Moderate discharge by evapotranspiration
  - Continued discharge to springs and river
  - No significant, permanent drawdown or gain to storage

# GAM Schedule

# GAM Schedule

- Project start – March 2008
- Conceptual model meeting with TWDB – March 4, 2009
- Draft conceptual model report – March 12, 2009
- Steady-state model calibration meeting with TWDB – June 2009
- Transient model calibration meeting with TWDB – July 2009
- Draft Model Report to TWDB – September 10, 2009

# GAM Schedule (cont'd)

- TWDB and stakeholder review comments – November 10, 2009
- Project Review Meeting – November 2009
- Model Implementation Seminar for TWDB – December 2009
- Final Model Report to TWDB – January 7, 2010

**Refined Seymour Aquifer Groundwater Availability Model**
**Haskell, Knox, and Baylor Counties**
**Stakeholder Advisory Forum #2**
**April 27, 2009 in Munday, Texas**
**Attendance List, Discussion, Questions and Answers**

## ATTANDANCE LIST

| Name | Affiliation |
|---|---|
| Toya Jones | INTERA, Inc |
| Shirley Wade | Texas Water Development Board |
| Joe Shephard (& wife) | City of Seymour |
| Ray Brady | RMBJ Geo, Inc |
| Mike McGuire | Rolling Plains Groundwater Conservation District |
| N.E. Deweber | Baylor Water Supply |
| Tommy Holub | Baylor Water Supply |
| David Kuehler | North Central Texas Municipal Water Authority |
| Adam Bonner | AgriLife Extension Service |

PRESENTATION

The Stakeholder Advisory Forum on the conceptual model for the refined Seymour Aquifer groundwater availability model for Haskell, Knox, and Baylor counties was held on Monday, April 27, 2009 at 1:00 p.m. at the Perry Patton Community Center located at 131 West Cisco Street in Munday, Texas.

The presentation topics for this form included:

- Groundwater availability modeling overview
- Definition of a conceptual model
- Key data sources
- Model area setting
- Previous modeling study
- Structure
- Water levels
- Hydraulic properties
- Recharge
- Natural discharge
- Pumping
- Groundwater quality
- Conceptual model of flow
- Groundwater availability model schedule

## DISCUSSION

Attendees from Baylor County Water Supply indicated that some wells in Baylor County are down.

Mike McGuire stated the water level in one well has declined 10 feet in the last 4 months.

## QUESTIONS AND ANSWERS

*Question by Toya Jones: How are rivers and spring flowing now relative to historically?*
Answer: The Brazos River is running well and some springs are flowing as usual. One attendee indicated that springs on his place west of Rhineland are running as usual. Another attendee indicated that springs on his place about 5 miles northwest of the city of Seymour stopped flowing about 2 years ago.

*Question by Toya Jones: Is the hydraulic conductivity in Baylor County lower than that in Haskell and Knox counties as indicated by the data?*
Answer: Well yields in Baylor County are typically lower, running about 100 gallons per minute with some up to 200 gallons per minute, but not really any in the 500 gallon per minute or higher range. Some wells in Knox County yield up to 500 gallons per minute.

*Question by Toya Jones: Does the Brazos River in Baylor County recharge the Seymour Aquifer?*
Answer: Probably not because the river is salty and the aquifer is not.

*Question by Toya Jones: Is pumping in Baylor County significantly lower as indicated by the data?*
Answer: Pumping in Baylor County has increased in the last 10 years but during the calibration period of 1980 through 1997 the pumping presented is probably correct.

*Question by Toya Jones: Which do you think is more accurate, the lower historical irrigation pumpage given for Haskell and Knox counties in R.W. Harden and Associations (1978)or the higher historical irrigation pumpage reported in TWDB (1981)?*
Answer: Many wells in Haskell and Knox counties were powered by butane when R.W. Harden and Associates (1978) did their investigation. If they used only kilowatts to estimate irrigation pumpage, the irrigation pumpage in R.W. Harden and Associates (1978) may be low. Toya Jones indicated that R.W. Harden and Associates (1978) mentioned butane powered irrigation wells, but they did not clearly explain how they determined pumpage for those wells. Attendees indicated that irrigation was less efficient in the past, less irrigation occurred in the past, and pivot irrigation began in the area in 1980.

*Question by Toya Jones: What do you think of the theory that the aquifer dewatered in the late 1800s and then rewet in the early 1900s?*
Answer: Droughts may also have contributed to dewatering of the aquifer.