MEMORANDUM

TO: Robert Bradley, Texas Water Development Board

FROM: Stephanie Moore, Daniel B. Stephens & Associates, Inc.

DATE: August 23, 2019

SUBJECT: August 6, 2019 Stakeholder Advisory Forum

The team of Daniel B. Stephens & Associates, Inc. (DBS&A), Allan R. Standen LLC, and Blanton & Associates, Inc. (collectively referred to as the DBS&A Team) held the first Stakeholder Advisory Forum (SAF) on Tuesday, August 6, 2019, for the Cross Timbers Aquifer Conceptual Model Project. This memorandum discusses the SAF.

Stakeholder Advisory Forum Background

By statute, the Texas Water Development Board (TWDB) is required to develop numerical groundwater flow models for the major and minor aquifers in Texas. The Cross Timbers Aquifer was designated as a new minor aquifer in December 2017. As a precursor to developing the groundwater availability model (GAM), the DBS&A Team is developing the conceptual model for the Cross Timbers Aquifer to describe the best understanding of how groundwater moves through this system. Stakeholder participation is critical to the success of the TWDB GAM Program and development of these models. Section 2.0, Stakeholder Participation, of the TWDB GAM standards specifies the TWDB's requirements for stakeholder participation.

To comply with these standards, the DBS&A Team is requesting input and information from the public and private sectors including regional water planning groups, groundwater conservation districts (GCDs), Texas Commission on Environmental Quality, Texas Parks and Wildlife Department, Texas Department of Agriculture, water utilities, educational groups, agricultural interests, environmental interests, private landowners, industry, and groundwater consultants. The SAFs are designed to encourage participation in the project and to provide an understandable and convenient means to comment and ask questions. Three individual SAFs will be conducted by the DBS&A Team to encourage stakeholder and public participation. The August 6 SAF was the first one held for the project.

Stakeholder Advisory Forum Overview

SAF Date: Tuesday, August 6, 2019

SAF Location: Middle Trinity Groundwater Conservation District
930 North Wolfe Nursery Road
Stephenville, TX 76401

SAF Notices

The TWDB preferred method of SAF notification is by e-mail. Therefore, the DBS&A Team prepared individual e-mail notices to announce the August 6 SAF. Using stakeholder contact information lists provided by TWDB staff, the team distributed SAF notices by e-mail on July 12 (25 days before the SAF) and sent a reminder e-mail on July 29 (8 days before the SAF). One letter was sent by U.S. Mail on July 12 to a stakeholder without an e-mail account. For each e-mail notice, the team included information about the SAF, an outline of what would be discussed, and a project summary sheet.

SAF Purpose

The August 6 SAF was held to discuss development of the Cross Timbers Aquifer Conceptual Model, and as a general meeting to kick off the conceptual model development process and discuss the following topics as they related to the Cross Timbers Aquifer:

- Basics of groundwater flow in the aquifer
- Concepts of numerical groundwater flow modeling
- Planned approach for aquifer investigations and conceptual model development
- Request for relevant scientific data and conceptual model input information
- Project schedule
- Expectations of the conceptual model

SAF Attendance

There were 22 attendees at the SAF, as listed in the following table. Sign-in sheets are provided in Attachment 1.

Name	Affiliation
Alfonso Campos	County Judge, Erath County
Gary Kafer	Middle Trinity GCD/Office of State Representative J.D. Sheffield
Joe B. Cooper*	Middle Trinity GCD
Doug Shaw	Upper Trinity GCD
Mike McGuire	Rolling Plains GCD
Kyle Russell	Upper Trinity GCD
Cindy Ridgway	TWDB
Natalie Ballew	TWDB
Robert Bradley	TWDB
Kevin Smith	TWDB
Rick Shaffer	City of Weatherford
Tracy Mesler	Upper Trinity GCD

Name	Affiliation
Jill Garcia	Upper Trinity GCD
Blaine Hicks	Upper Trinity GCD
Johnny Wells	Middle Trinity GCD
Stephanie Keith	Middle Trinity GCD
Marc Halbert	W.T. Waggoner Estate, Inc.
Peter Schulmeyer	Collier Consulting
Stephanie Moore	DBS&A
Velma Danielson	Blanton & Associates, Inc.
Allan Standen*	Allan R. Standen LLC
Vince Clause*	Allan R. Standen LLC

* Attended the August 6 SAF, but did not sign in on the sign in sheet.

SAF Format

The SAF was held between 10:00 a.m. and 11:00 a.m. Stephanie Moore, Deputy Project Manager, DBS&A, opened the meeting, and introduced the elected officials, GCD managers, and TWDB staff who were in attendance.

Robert Bradley, TWDB, made a presentation regarding the TWDB GAM Program. Cindy Ridgway, TWDB, noted that the TWDB had created a website for Cross Timbers Aquifer Conceptual Model Project to track the project's progress, access a copy of today's presentation, a copy of the memorandum report for today's SAF, and other information regarding the project.

Stephanie Moore provided an overview of the project with assistance from Allan Standen. The PowerPoint presentation is provided as Attachment 2.

Copies of two TWDB handouts and two DBS&A Team handouts made available at the SAF are provided in Attachment 3.

SAF Questions/Answers, Comments/Observations

After the presentation concluded, there were several questions and comments from the audience. The DBS&A Team's responses to these questions or observations in response to audience comments, are summarized below.

Question 1. Is the TWDB updating other GAMs along with this one?

Yes, the TWDB is developing more regional models to use as living tools to look at issues such as cross flow that may cause the TWDB to reexamine other existing aquifer GAMs (e.g., the GAM for the Trinity Aquifer). The TWDB may then take steps, depending upon timing and resources, to determine what they should do next to either incorporate available data or identify data that are needed. The first step is to look at the data and determine if there is interaction.

Question 2. For the geophysical logs gathered to date, how many of these logs are for wells that are logged/completed to surface?

We will have a better answer at the next SAF, in summer of 2020. The logs the team has gathered are for wells with depths up to 600 feet and are close to the surface. Quite a few of these wells have gamma logs.

Question 3. How may many logs will the team be able to find that will provide good data?

There are thousands of wells with geophysical logs in the study area. These are being screened for both well depth and water quality. There are probably certain geographical areas where the team will need more data.

Question 4. A certain driller in the Montague area may have well information to be made available. Would the team want to use information for these wells?

Yes, having more data is helpful to the project to understand aquifer dynamics (e.g., aquifer communication at depth, water moving up into the Cross Timbers Aquifer from the Hickory Aquifer, etc.).

Question 5. What data and information does the team need from GCDs?

Whatever data and information that GCDs have available to fill data gaps would be beneficial (e.g., well logs, water use information, annual production data, unmeasured well data). Recent well information would be very helpful (e.g., new well logs or pumping test data, especially if there is an associated monitor well). Also, it will be important for the GCDs to review the interim project report and provide comments.

Question 6. Will the team be reaching out to other consultants for reports they may have prepared for other clients to use as part of this project?

Yes, if the reports were prepared for a public entity and are finalized, these reports are public and can be shared with the DBS&A Team for this project. The team reminded the audience that any information shared with the DBS&A Team will become public information, so please keep this point in mind when considering the release of information that may be proprietary.

Comment 1. For Montague, the team needs access to more public supply well data (e.g., dry wells in Wichita/Wilbarger area).

Observation: The team has reviewed information for these areas where work has been done, but does not yet know how productive the aquifer is in these areas. The team will not be starting from scratch and will certainly be reviewing and using previous peer-reviewed work by the Bureau of Economic Geology and others.

Comment 2. There was a 140-foot deep 4-inch well that was on line during the most recent drought.

Observation: The team will contact the Texas Commission on Environmental Quality and check

on public water supply well and other available data.

Comment 3. This aquifer and related issues present the team with a nightmare, but it is a good project to work on.

Observation: Yes, it is a complex aquifer and the team is planning to spend a lot of time on this project.

Attachment 1

Sign-In Sheets

Texas Water Development Board

Cross Timbers Aquifer Conceptual Model
Stakeholder Advisory Forum
August 6, 2019
Middle Trinity Groundwater Conservation District
930 North Wolfe Nursery Road
Stephenville, TX 76401

DBS&A
Daniel B. Stephens & Associates, Inc.
a Geo-Logic Company

SIGN-IN SHEET (please print)

NAME	AFFILIATION	MAILING ADDRESS/PHONE NO.	E-MAIL ADDRESS
Kyle Russell	Upper Trinity GCD	1854 W Hwy 199 Springtown, TX 76082	Kyle@uppertrinitygcd.com
Tracy Meeks	"	PO Box 539 Mineral TX 76255	tracymeeks@yahoo.com
Johnny Wells	MTGCD	930 Wolfe Nursery Rd Stephenville	mtgcd3@centurylink.net
Stephanie Keith	MTGCD	930 Wolfe Nursery Rd Stephenville	MTGCD4@centurylink.net
Marc Halbert	W.T. Waggoner Estate, Inc.	1700 Pearl St., Vernon, TX, 76385	marc@waggonerranch.com
Peter Schulwyn	Collier Consulting	590 E South Loop	peter@collierconsulting.com
Rick Shaffer	City of Weatherford	917 Eureka St Weatherford 76086	rshaffer@weatherfordtx.gov
* Gary Kafer	MTGCD St. Rep. JD Sheffield	RO Box 704, Gatesville, TX 76528 254-679-9016	gary.kafer@house.texas.gov

Texas Water Development Board

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DBS&A Daniel B. Stephens & Associates, Inc. a Geo-Logic Company

SIGN-IN SHEET (please print)

	NAME	AFFILIATION	MAILING ADDRESS/PHONE NO.	E-MAIL ADDRESS
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*	Robert Bradley	TWDB	512-936-0870 Austin, TX	robert.bradley@twdb.texas.gov
	Velma Danielson	Blanton	264 Centre Court, Suite 200 Austin, TX 78758	velma.danielson@blantonwaterlaw.com
*	Natalie Ballew	TWDB	512 463 2779	natalie.ballew@twdb.texas.gov
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	Jill Garcia	UTGCD	8117 Doreen Ave 817-523-5700	jill@uppertrinitygcd.com
	Blaine Hicks	UTGCD	1859 W Hwy 199 Springtown, TX 76082	Blaine@uppertrinitygcd.com
*	Alfonso Campos	Erath County		countyjudge@co.erath.tx.us

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SIGN-IN SHEET (please print)

NAME	AFFILIATION	MAILING ADDRESS/PHONE NO.	E-MAIL ADDRESS
Kevin Smith	TWDB	1700 N. Congress 512-475-1561	Kevin.Smith@twdb.texas.gov
MIKE McGUIRE	ROLLING PLAIN GCD GMA C	P.O. BOX 717 HUNDAY, TX 76371 940-422-1095	MMCGUIRE@RPGCD.ORG

Attachment 2

Presentation

Texas Water Development Board (TWDB) Groundwater Availability Modeling (GAM) Program

Robert Bradley (Contract Manager)
Groundwater Availability Modeling Program
Texas Water Development Board

Texas Water Development Board

Disclaimer

Unless specifically noted, this presentation does not necessarily reflect official Board positions or decisions.

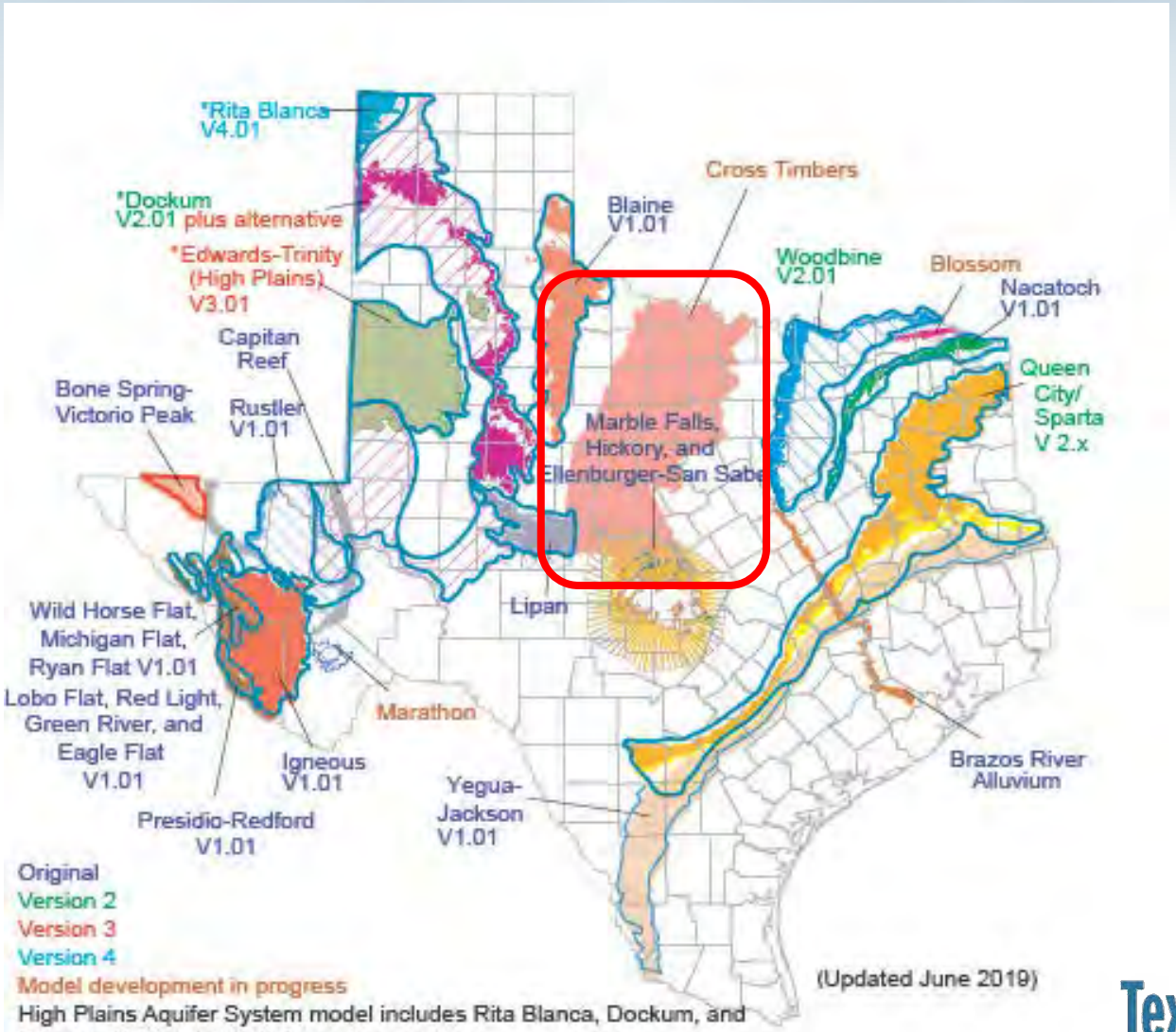
Agenda

- TWDB Introduction GAM
- Introduce Contract Team
- Daniel B. Stephens & Assoc., Inc. Presentation
  - *Introductions to Project Team*
  - *Schedule*
  - *Cross Timbers Overview*
  - *Current Objectives*
  - *Approach & Preliminary Data Review*
  - *Request for Data*
  - *Stakeholder Input*

GAM Program

- **Aim**: Develop groundwater flow models for the major and minor aquifers of Texas.
- **Purpose**: Tools that can be used to aid in groundwater resources management by stakeholders.
- **Public process**: Stakeholder involvement during model development process.
- **Models**: Freely available, standardized, thoroughly documented. Reports available over the internet.
- **Living tools**: Periodically updated.

Minor Aquifers with Models



Texas Water Development Board

Why Stakeholder Advisory Forums?

- Keep stakeholders updated about the progress of the model
- Inform how the groundwater model can, should, and should not be used
- Provide stakeholders with the opportunity to provide input and data to assist with model development

Contact Information

Robert Bradley, P.G, C.T.C.M.
TWDB Contract Manager
512-936-0870
Robert.bradley@twdb.texas.gov

Cindy Ridgeway, P.G.
Manager of Groundwater Availability Modeling Section
512-936-2386
Cindy.ridgeway@twdb.texas.gov

Texas Water Development Board
P.O. Box 13231
Austin, Texas 78711-3231

Website information:
www.twdb.texas.gov/groundwater/models/gam/cstb/cstb.asp

Texas Water Development Board

Texas Water Development Board

Cross Timbers Aquifer Conceptual Model

Stakeholder Advisory Forum #1

August 6, 2019 Stephenville, Texas

DBS&A Daniel B. Stephens & Associates, Inc. a Geo-Logic Company

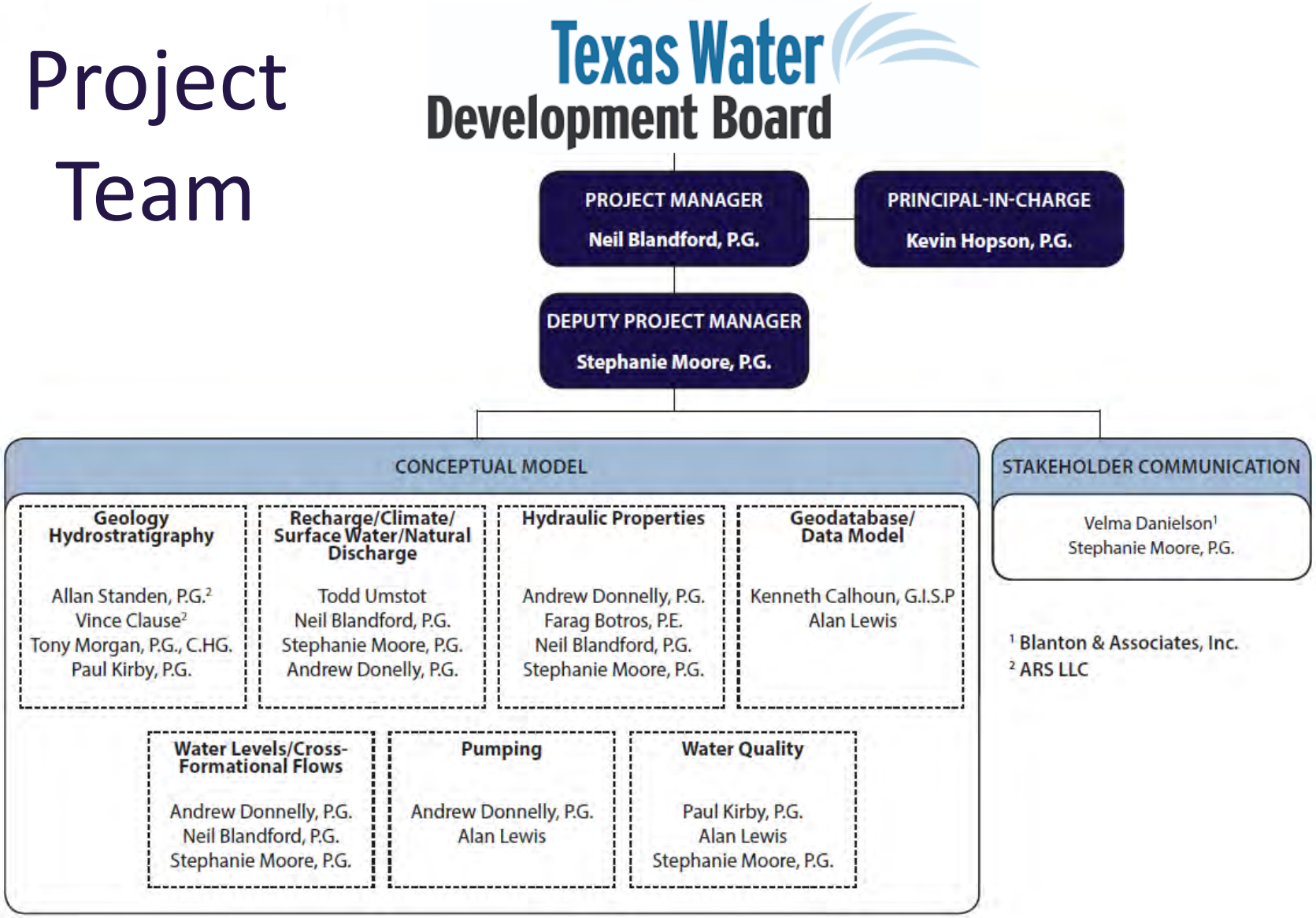
Allan R. Standen LLC Groundwater & Natural Resource Consulting

Blanton & Associates, Inc. Environmental Consulting • Planning • Project Management

Agenda

1. Introductions to Project Team
2. Schedule
3. Cross Timbers Overview
4. Current Objectives
5. Approach & Preliminary Data Review
6. Request for Data
7. Stakeholder Input

Project Team



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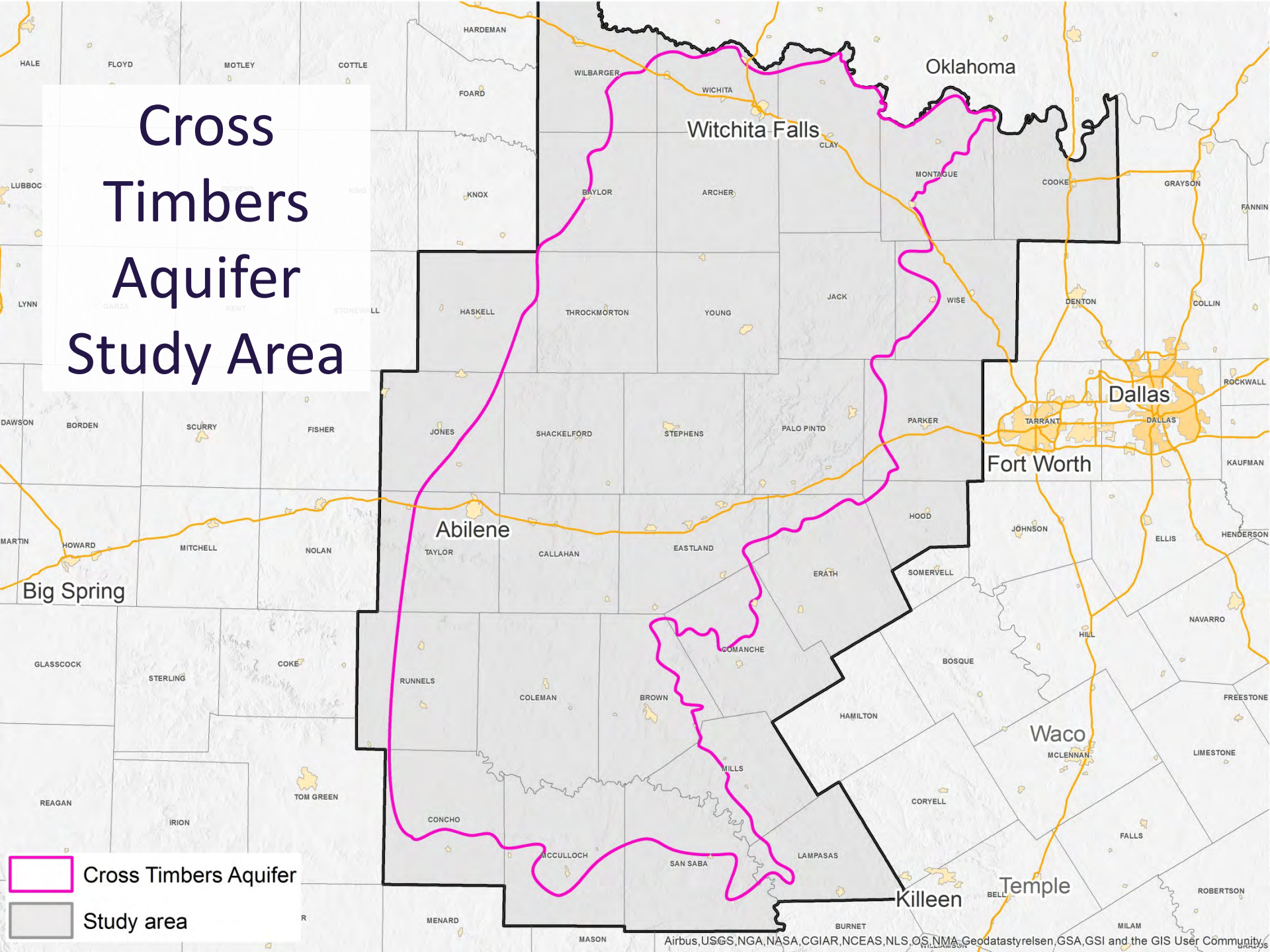
Allan R. Standen LLC
Groundwater & Natural Resource Consulting

Blanton & Associates, Inc.
Environmental Consulting • Planning • Project Management

Schedule

- Past: Cross Timbers Aquifer designated as minor aquifer in December 2017
- Current: Develop Conceptual Model
  - June 1, 2019 - Start date
  - June 1, 2020 - Interim Deliverable
  - March 31, 2021 - Study Completion Date
- Future: Groundwater Availability Model

Cross Timbers Aquifer Study Area



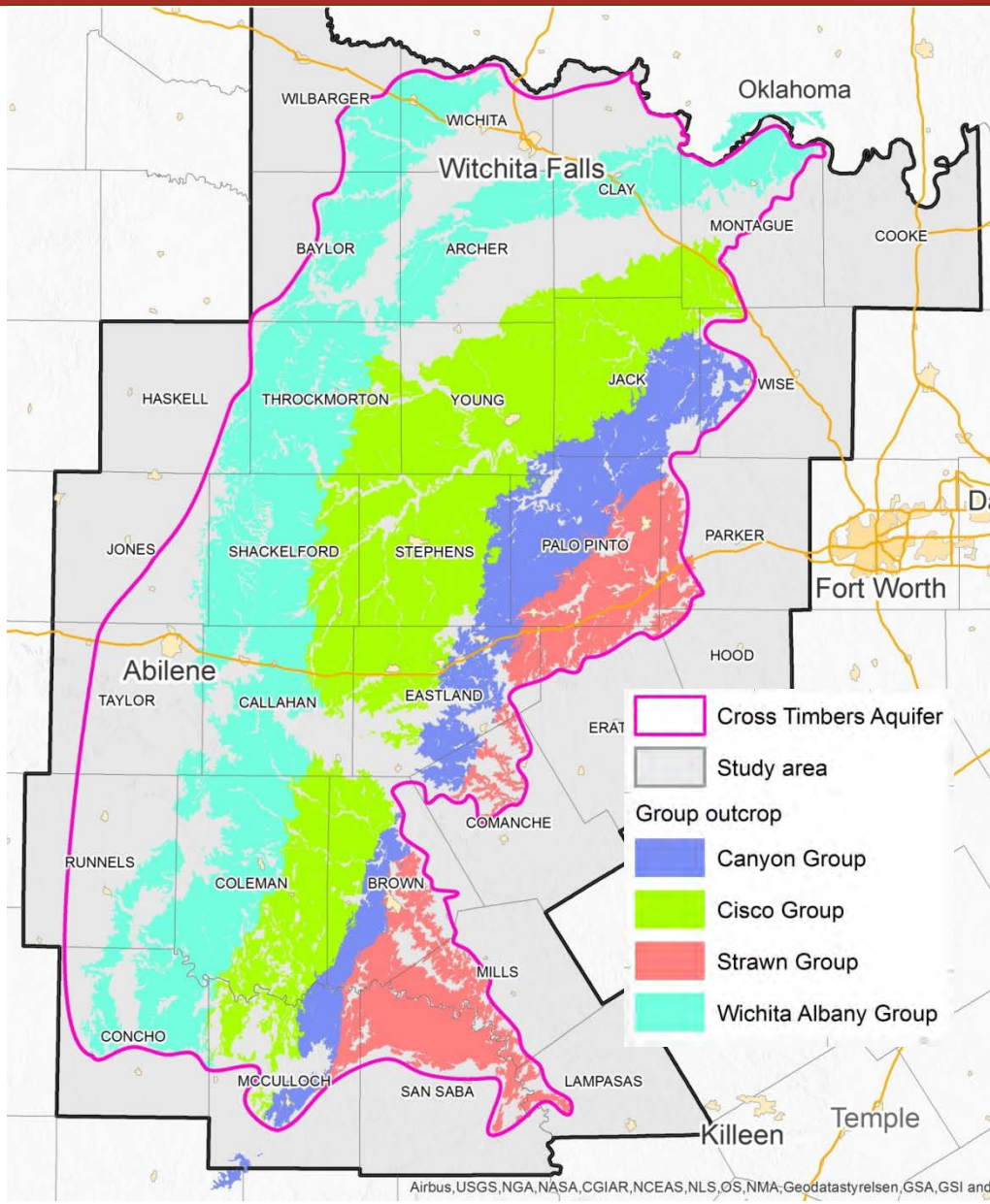
Geology

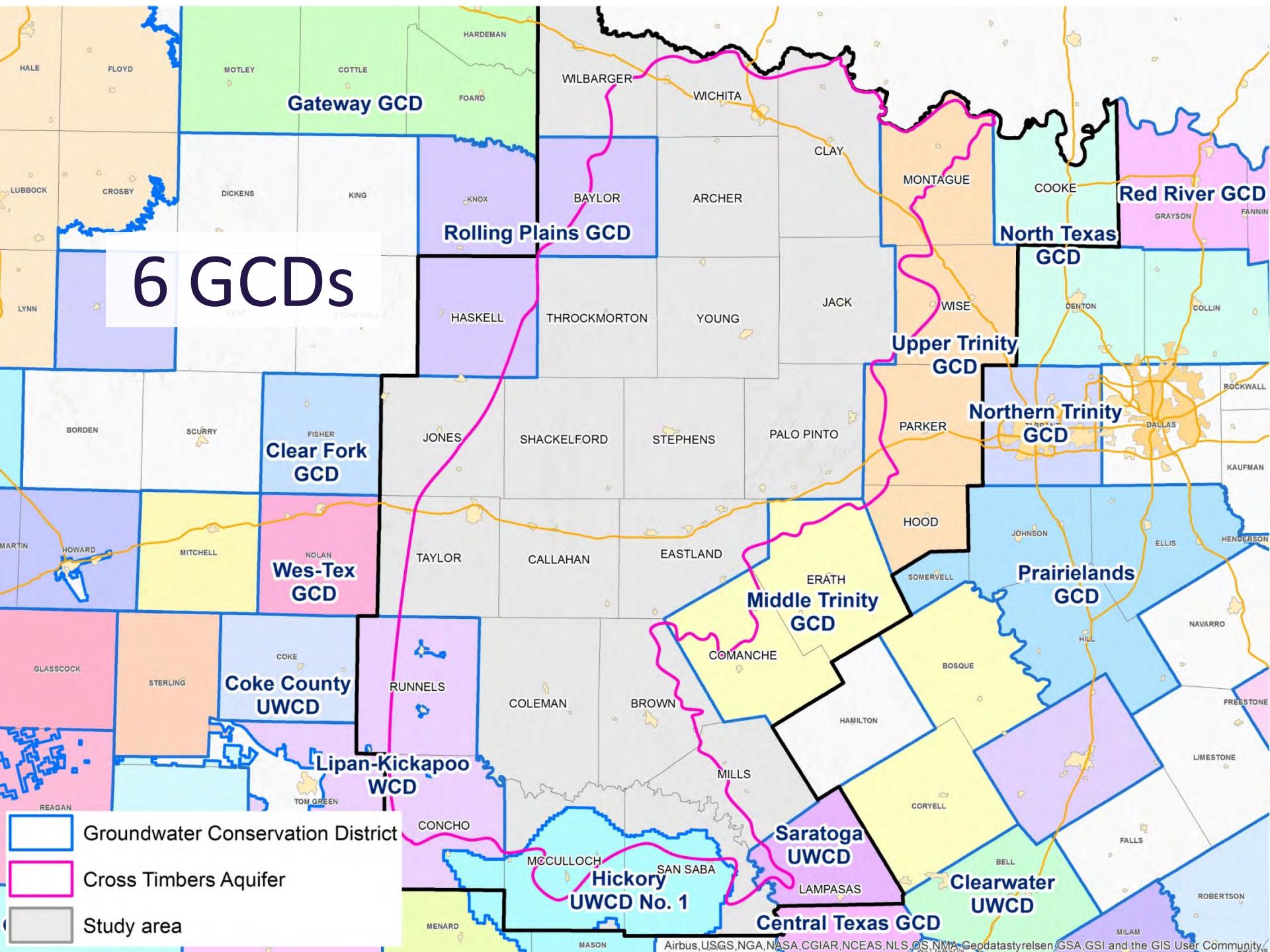
Four Paleozoic-age water-bearing formations (oldest to youngest):

- Strawn group
- Canyon group
- Cisco group
- Wichita group (Wolfcamp)

The aquifer is primarily composed of limestones, shales, and sandstones.

The Project study area extends from the eastern edge of the Blaine Aquifer to the Ouachita Fold Belt and from southern Oklahoma to the Llano Uplift area in Central Texas.




6 GCDs
Gateway GCD
Rolling Plains GCD
Red River GCD
North Texas GCD
Upper Trinity GCD
Northern Trinity GCD
Clear Fork GCD
Wes-Tex GCD
Middle Trinity GCD
Prairielands GCD
Coke County UWCD
Lipan-Kickapoo WCD
Saratoga UWCD
Hickory UWCD No. 1
Clearwater UWCD
Central Texas GCD
HALE
FLOYD
MOTLEY
COTTLE
HARDEMAN
FOARD
WILBARGER
WICHITA
CLAY
MONTAGUE
COOKE
GRAYSON
FANNIN
LUBBOCK
CROSBY
DICKENS
KING
KNOX
BAYLOR
ARCHER
LYNN
HASKELL
THROCKMORTON
YOUNG
JACK
WISE
DENTON
COLLIN
ROCKWALL
DALLAS
KAUFMAN
PARKER
BORDEN
SCURRY
FISHER
JONES
SHACKELFORD
STEPHENS
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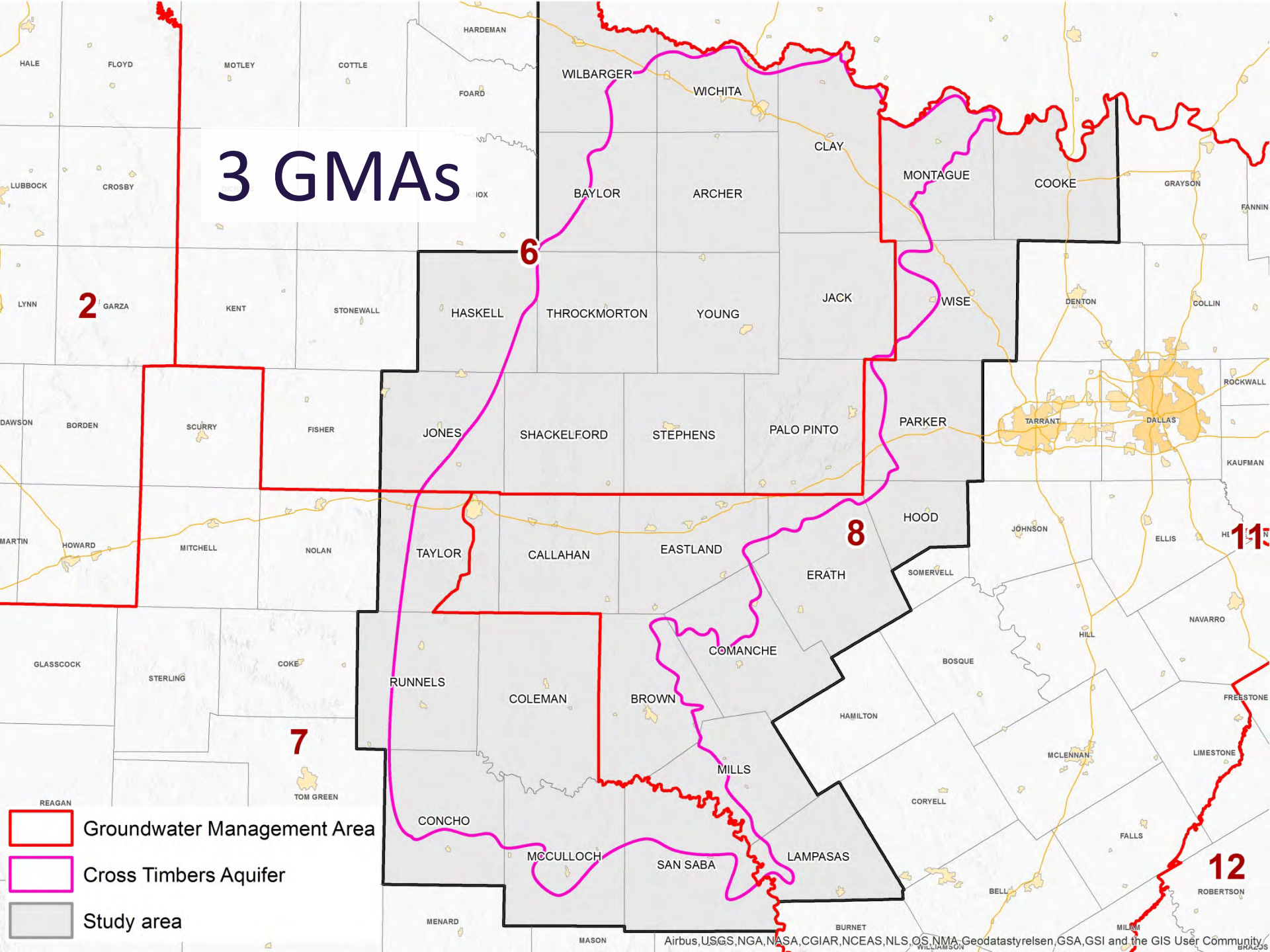
ELLIS
HENDERSON
SOMERVELL
MARTIN
HOWARD
MITCHELL
NOLAN
TAYLOR
CALLAHAN
EASTLAND
ERATH
COMANCHE
HAMILTON
BOSQUE
HILL
NAVARRO
FREESTONE
LIMESTONE
GLASSCOCK
STERLING
COKE
RUNNELS
COLEMAN
BROWN
MILLS
CORYELL
FALLS
BELL
ROBERTSON
REAGAN
TOM GREEN
CONCHO
MCCULLOCH
SAN SABA
LAMPASAS
MILAM
MENARD
MASON
Groundwater Conservation District
Cross Timbers Aquifer
Study area
Airbus,USGS,NGA,NASA,CGIAR,NCEAS,NLS,OS,NMA,Geodatastyrelsen,GSA,GSI and the GIS User Community


3 GMAs
HALE
FLOYD
MOTLEY
COTTLE
HARDEMAN
FOARD
WILBARGER
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CLAY
MONTAGUE
COOKE
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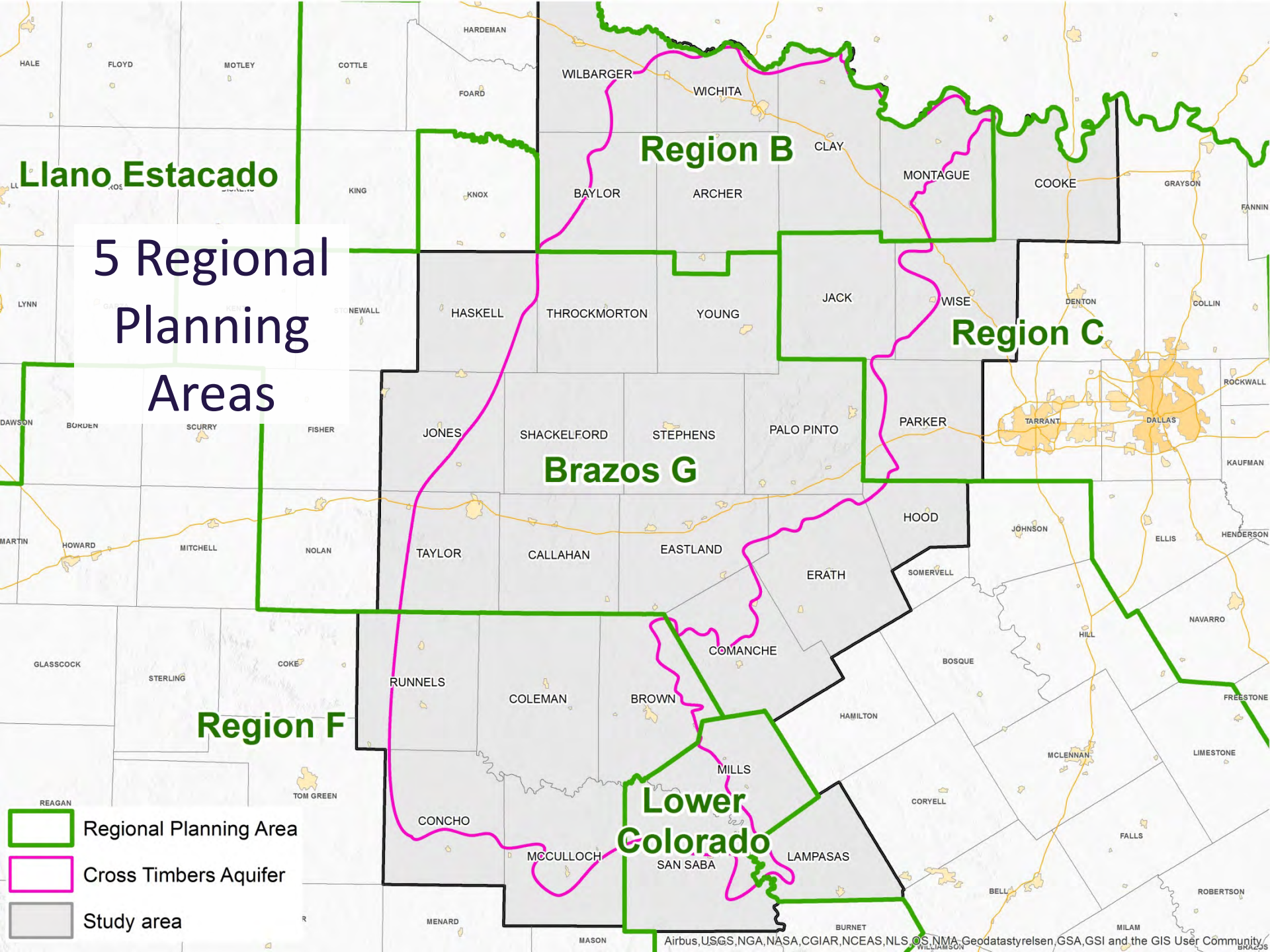
TOM GREEN
CORYELL
CONCHO
FALLS
MCCULLOCH
SAN SABA
LAMPASAS
12
ROBERTSON
BELL
MENARD
MASON
BURNET
Groundwater Management Area
Cross Timbers Aquifer
Study area
Airbus,USGS,NGA,NASA,CGIAR,NCEAS,NLS,OS,NMA,Geodatastyrelsen,GSA,GSI and the GIS User Community


5 Regional Planning Areas
Llano Estacado
Region B
Region C
Brazos G
Region F
Lower Colorado
Regional Planning Area
Cross Timbers Aquifer
Study area
HARDEMAN
WILBARGER
WICHITA
CLAY
MONTAGUE
COOKE
GRAYSON
FANNIN
HALE
FLOYD
MOTLEY
COTTLE
FOARD
KING
KNOX
BAYLOR
ARCHER
LYNN
HASKELL
THROCKMORTON
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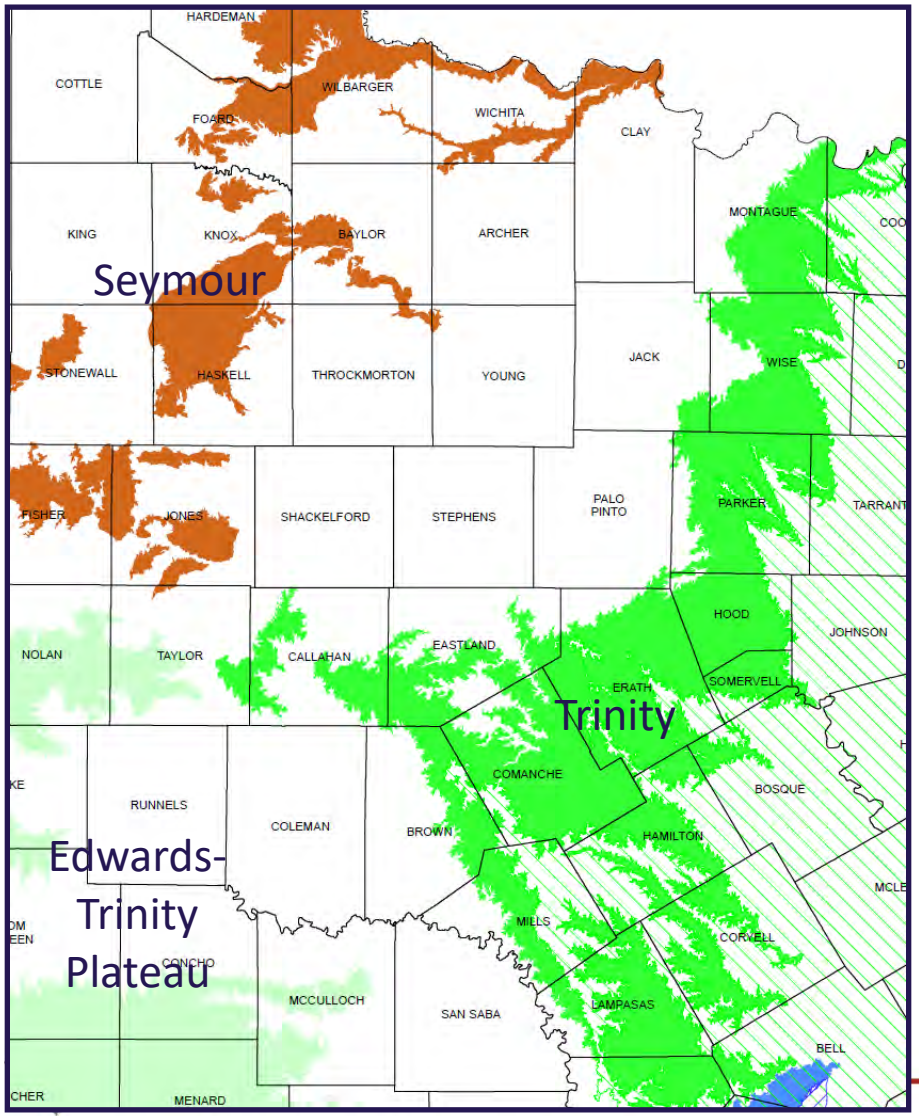
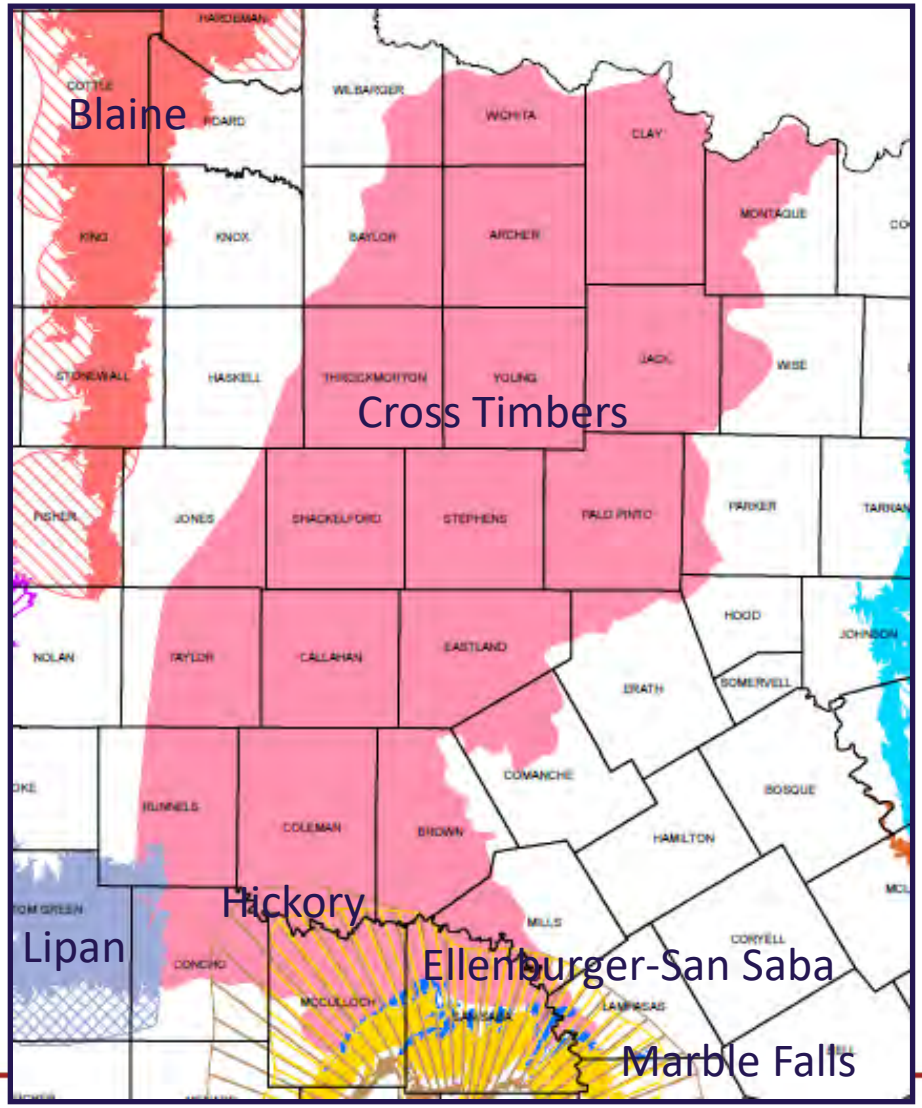
Major Aquifers



Minor Aquifers

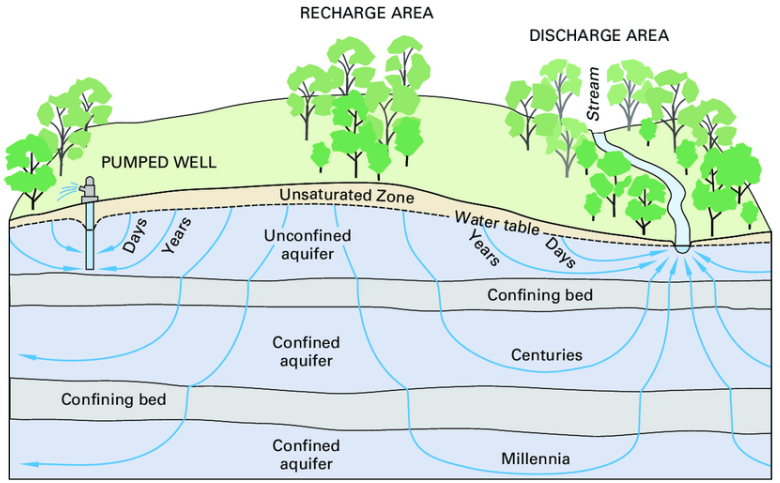


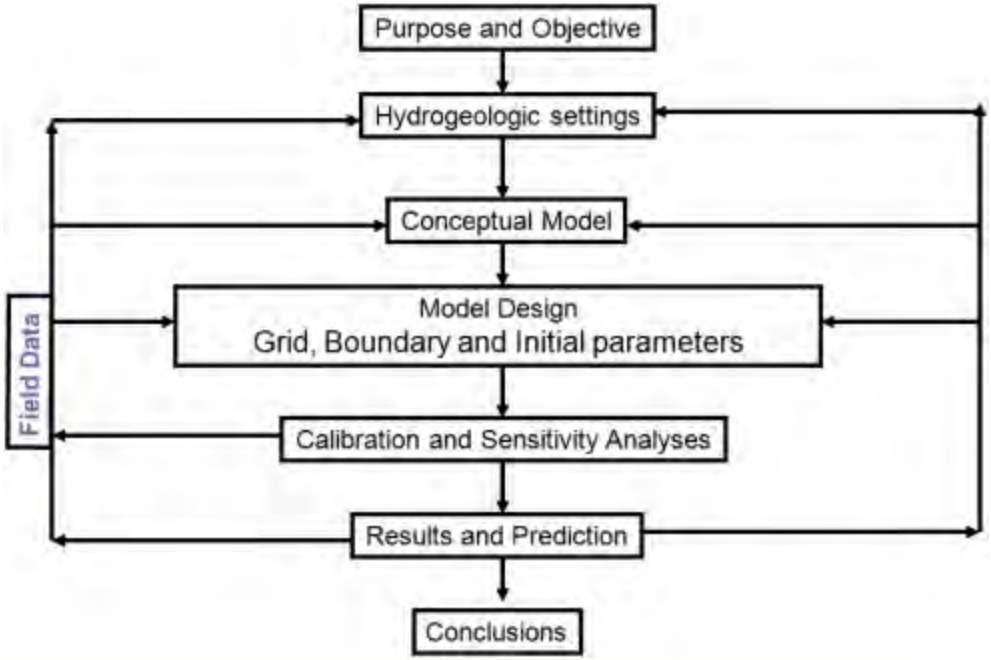
Project Objectives

- Develop a conceptual model of the Cross Timbers Aquifer
  - Describe the best understanding of how groundwater moves through the aquifer system
- Future Goal: Develop numerical groundwater flow model (GAM) of the Cross Timbers Aquifer

Conceptual Model

- Basics of groundwater flow in the aquifer
- Concepts of numerical groundwater flow modeling
- Planned approach for aquifer investigations and conceptual model development
- Expectations of the conceptual model

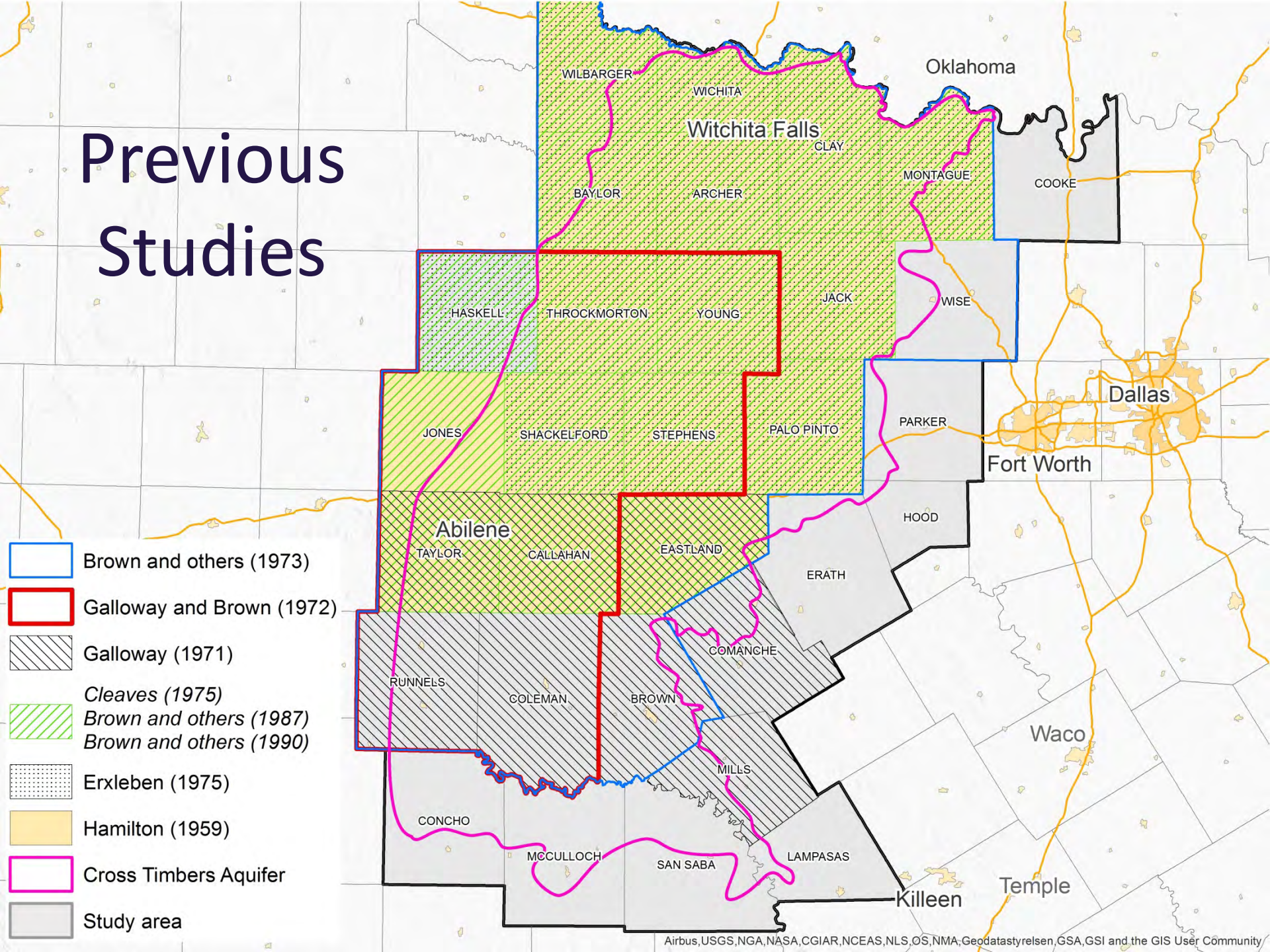




Components of Conceptual Model

1. Physiography and climate
2. Geology
3. Hydrostratigraphy
4. Hydrostratigraphic framework
5. Water levels and regional groundwater flow
6. Recharge
7. Rivers, streams, reservoirs, springs and other surface water features
8. Hydraulic properties
9. Subsidence
10. Discharge
11. Water quality

Previous Studies

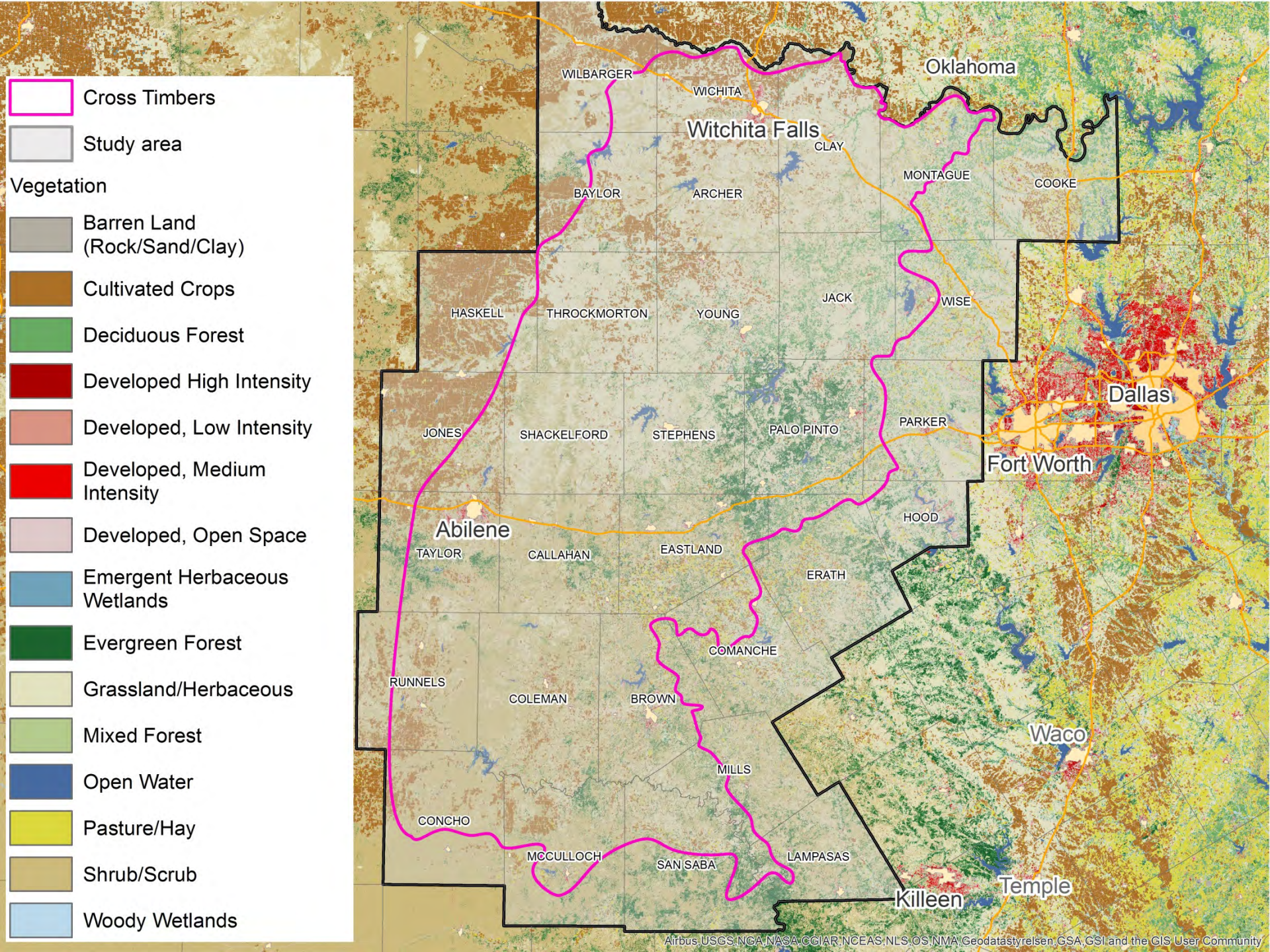


Previous Studies

- Oliver and Kelley (2014)
- Nicot and others (2013)
- Brown and others (1990)
- Brown and others (1987)
- Cleaves (1975)
- Erxleben (1975)
- Brown and others (1973)
- Galloway and Brown (1972)
- Galloway (1971)
- Hamilton (1959)

Approach: Physiography and Climate

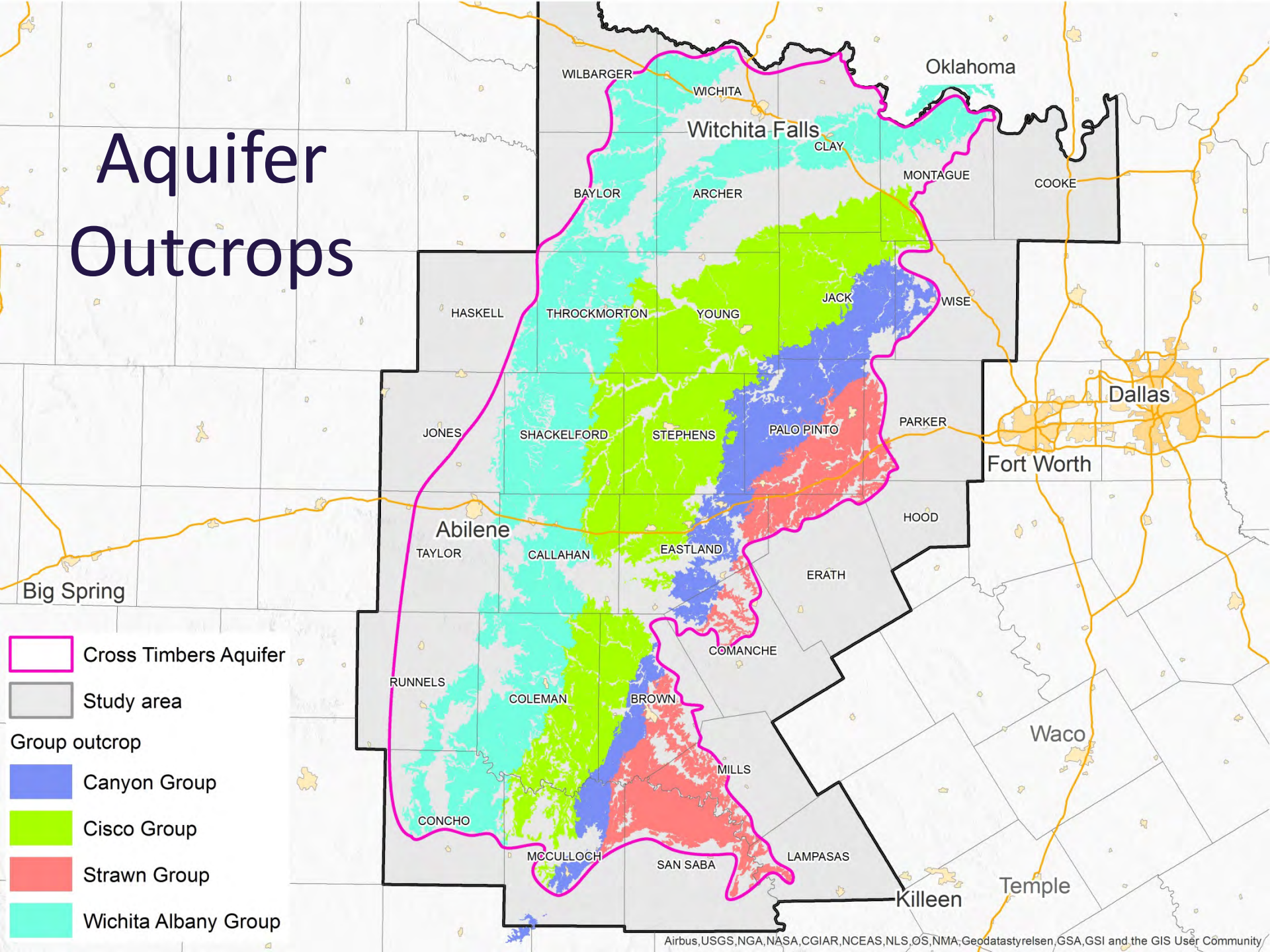
- Compile, analyze and summarize all available data
- Describe areal extent and topography
- Analyze spatial and temporal variability in
  - temperature
  - precipitation
  - evaporation
- Summarize soil properties and vegetation


Cross Timbers
Study area
Vegetation
Barren Land (Rock/Sand/Clay)
Cultivated Crops
Deciduous Forest
Developed High Intensity
Developed, Low Intensity
Developed, Medium Intensity
Developed, Open Space
Emergent Herbaceous Wetlands
Evergreen Forest
Grassland/Herbaceous
Mixed Forest
Open Water
Pasture/Hay
Shrub/Scrub
Woody Wetlands
Oklahoma
WILBARGER
WICHITA
Witchita Falls
CLAY
MONTAGUE
COOKE
BAYLOR
ARCHER
JACK
WISE
HASKELL
THROCKMORTON
YOUNG
Dallas
PARKER
JONES
SHACKELFORD
STEPHENS
PALO PINTO
Fort Worth
HOOD
Abilene
TAYLOR
CALLAHAN
EASTLAND
ERATH
COMANCHE
RUNNELS
COLEMAN
BROWN
Waco
MILLS
CONCHO
MCCULLOCH
SAN SABA
LAMPASAS
Killeen
Temple
Airbus, USGS, NGA, NASA, CGIAR, NCEAS, NLS, OS, NMA, Geodatastyrelsen, GSA, GSI and the GIS User Community

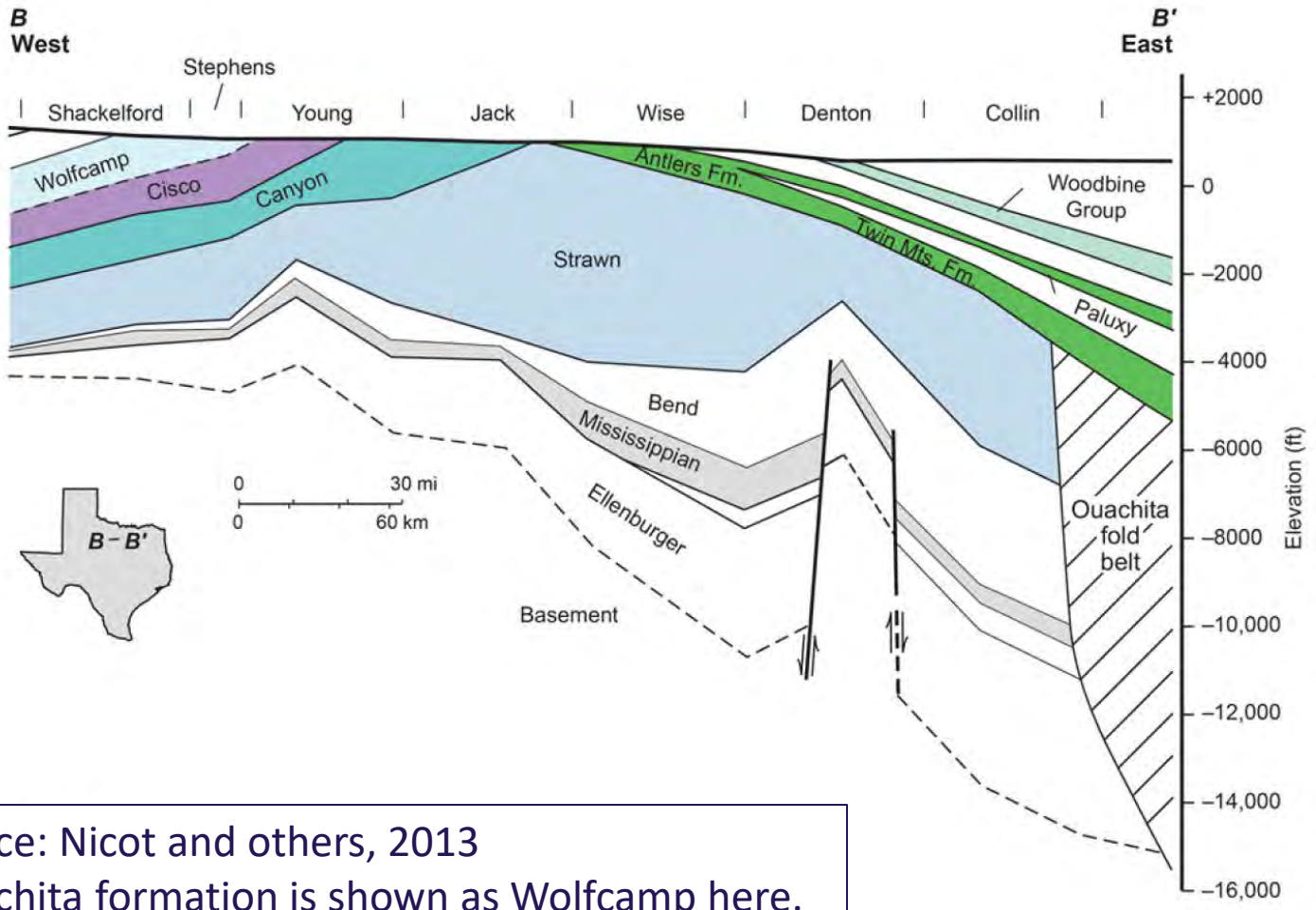
Approach: Geology & Aquifer Extent

- Evaluate geology and aquifer extent
- Recommend boundaries for future GAM

Aquifer Outcrops

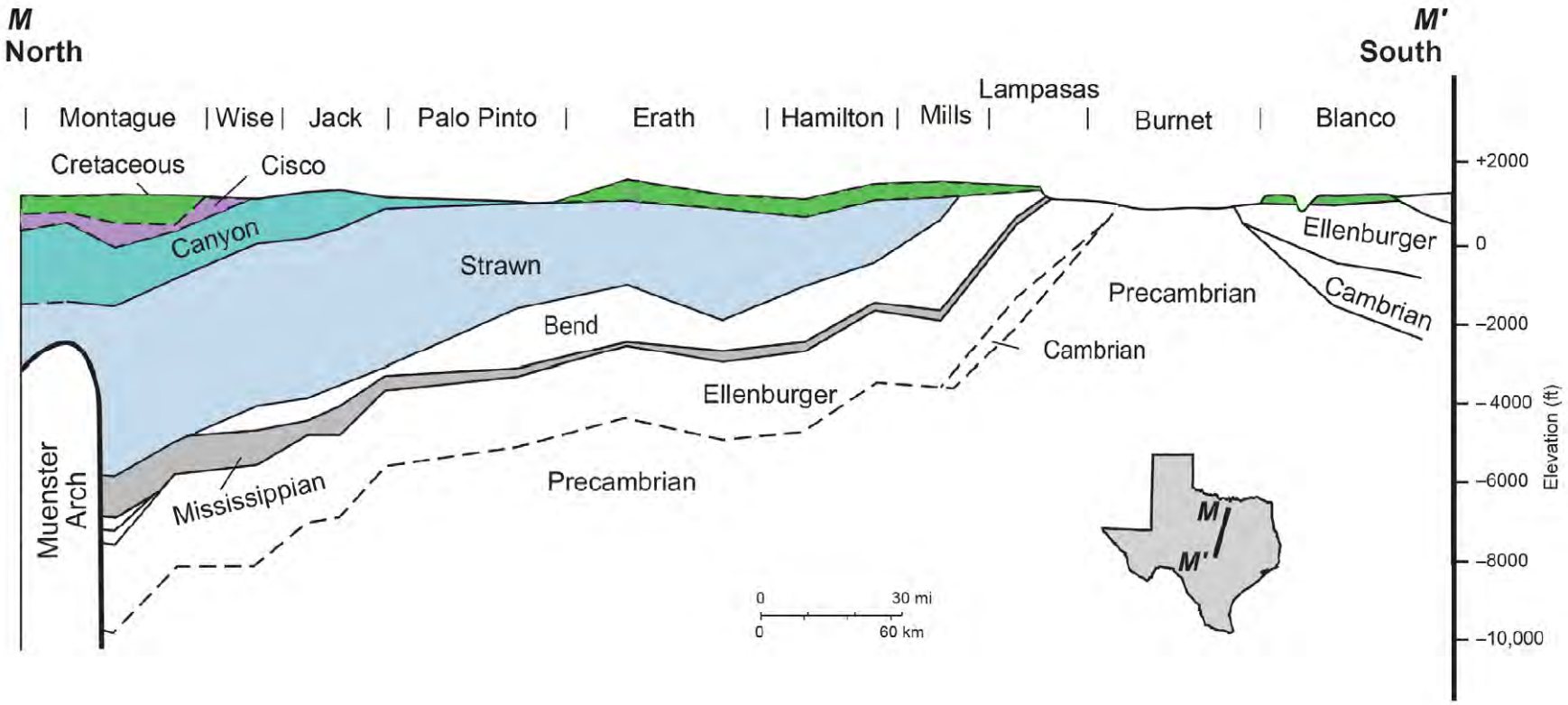


Geology



Source: Nicot and others, 2013
* Wichita formation is shown as Wolfcamp here.

Geology



Source: Nicot and others, 2013

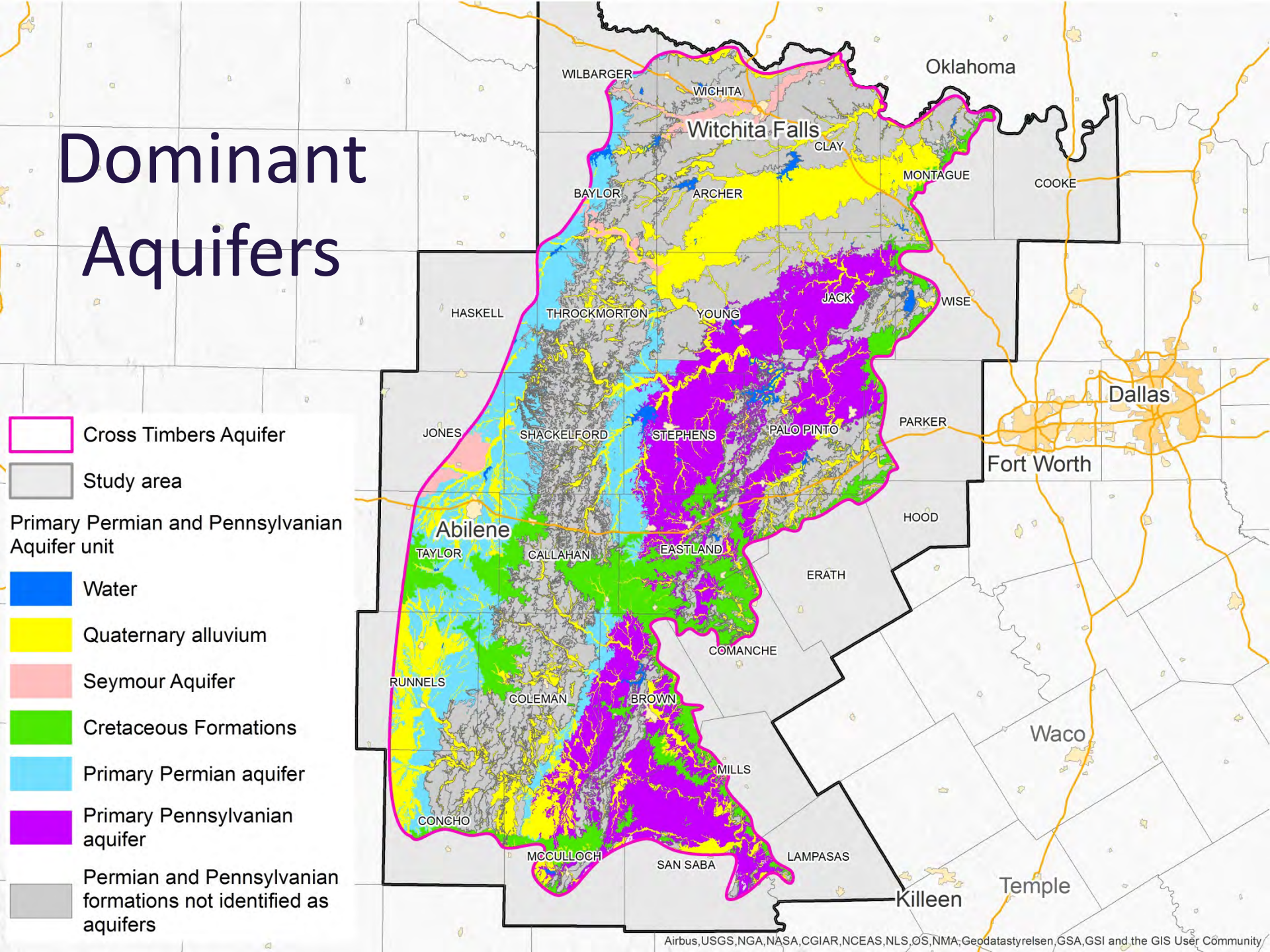
Approach: Hydrostratigraphy

- Compile and analyze all available data
- Refine initial stratigraphic column

Approach: Hydrostratigraphic Framework

- Develop well database using all available data
- Collect new data well possible (in-kind support)
- Goal: 150 well control points for each county
- Determine model layer surfaces
- Correlate model surfaces across study area
- Extend net sandstone isopachs across study area
- Determine injection intervals from RRC database
- Create net sandstone isopachs for each model layer
- Incorporate all info into 3D hydrostratigraphic model (Leapfrog)

Dominant Aquifers



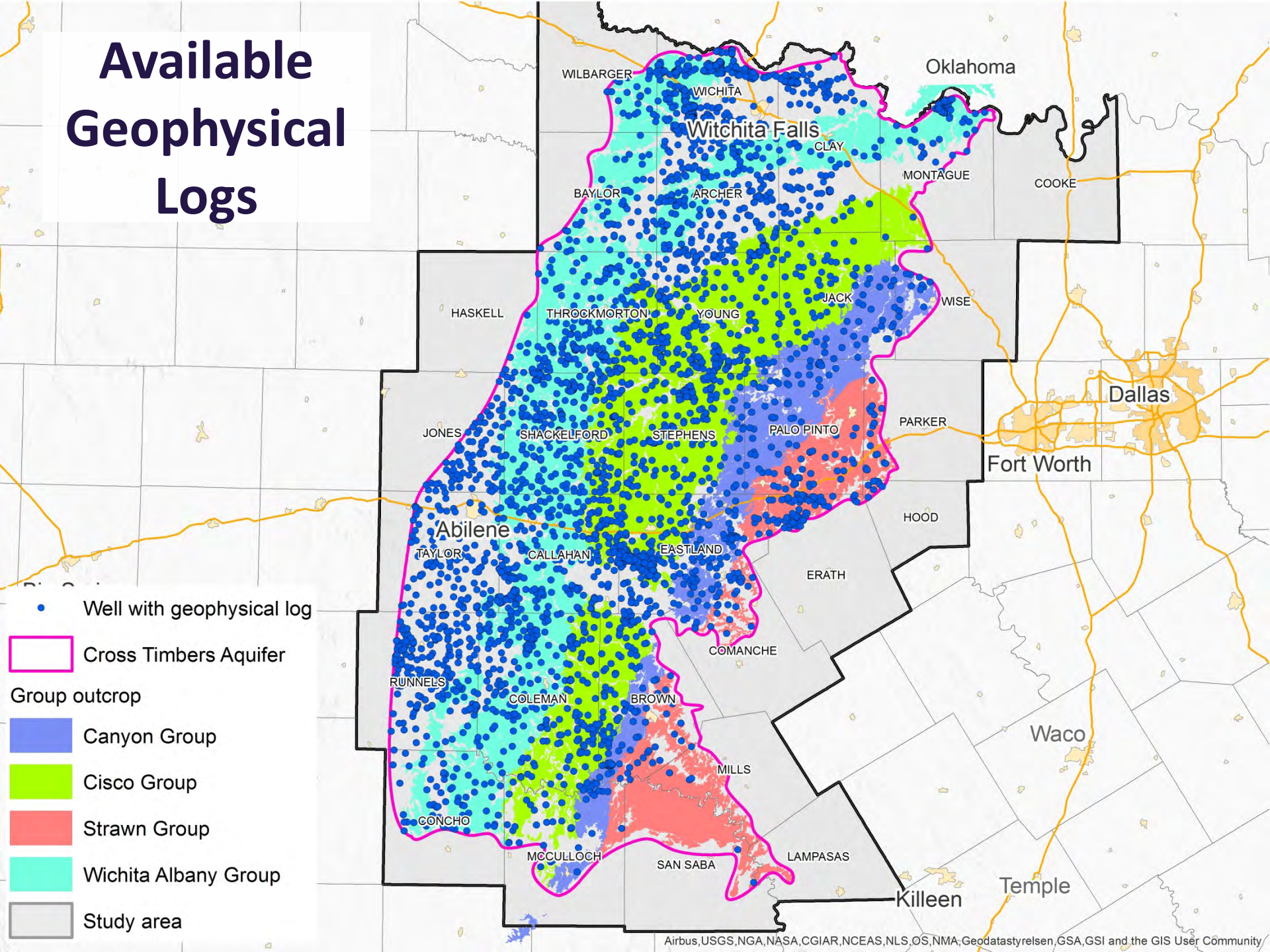
Preliminary Stratigraphic Column and Model Layers

Cross Timbers Aquifer Stratigraphic Column

Era	System	Series	Group	Formation	Member	Sandstone Units	Lithology	Layer
Cenozoic	Quaternary (1,327)						Sand, Clay	1
				Leona (20)			Sand, Clay	
				Seymour (199)			Sand, Clay	
Mesozoic	Cretaceous (15)			Edwards (56)			Limestones	2
				Trinity (721)	Antlers (1,437)		Sand	
					Travis Peak (96)		Limestone/Sandstone	
					Twin Mtn (857)		Sandstone/Shale	
					Hosston (17)		Sandstone/Shale	
Paleozoic (141)	Permian (57)	Leonard (12)	Clear Fork (159)	Choza (74)			Limestone	3
				Vale (46)	Bullwagon		Dolomite	
							Sandy Shale	
				Arroyo (77)	Standpipe		Limestone	
					Sprayberry		Silty Shale	
							Limestone	
			Wichita (619)	Leuders (161)			Limestone	
		Wolf Camp (46)		Clyde	Dean		Limestone/Shale	4
				Belle Plains			Limestone	
				Admiral			Mudstone/Shale	
				Putnam			Shale/Limestone	
				Coleman Junction			Limestone	
				Moran	Sedwick; Dothan; Camp Colorado; Stockwether; L. Stockwether; Saddle Creek; Flippen	Moutray; Upper Frye; Lower Frye; Tannehill; Bluff Creek	Alternating Limestone and Sandstone	
				Pueblo (74)				
	Pennsylvanian	Virgilian	Cisco (697)	Harpersville (63)			Shale/Limestone	5
				Thrifty (314)	Chaffin	Cook; Upper Hope	Alternating Limestone and Sandstone	
					Parks Mountain			
					Breckenridge		Limestone	
					Speck Mountain	Lower Hope; King; Swastika	Alternating Limestone and Sandstone	
				Graham (302)	Ivan			
					Wayland			
					Gunsight		Limestone	
					Bluff Creek	McMinan	Alternating Limestone and Sandstone	
		Missourian	Canyon (262)	Caddo Creek	Home Creek		Limestone	6
					Colony Creek (189)		Shale	7
				Brad	*Ranger		Limestone	
					Placid (60)		Shale	
				Winchell	Wolf Mountain		Sandstone/Shale	
				Grafford	Cedarton		Shale	
					Adams Branch		Limestone	
					Brownwood		Shale	
				Palo Pinto (62)	Wiles, Wynn		Limestone/Shale	
			Strawn (208)	Mineral Wells (48)	Dog Bend	Turkey Creek	Limestone/Sandstone	
					Village Bend		Limestone	
		Desmoinesian		Millsap Lake	Grindstone Creek		Shale/Sandstone	8
					Lazy Bend		Shale/Sandstone	
				Lower Strawn			Shale/Sandstone	
			Bend (Atoka Series)	Smithwick			Shale/Sandstone	
				Marble Falls (61)			Limestone	

Blue = TWDB aquifer # of wells
Yellow = LS used in correlation, likely not an aquifer

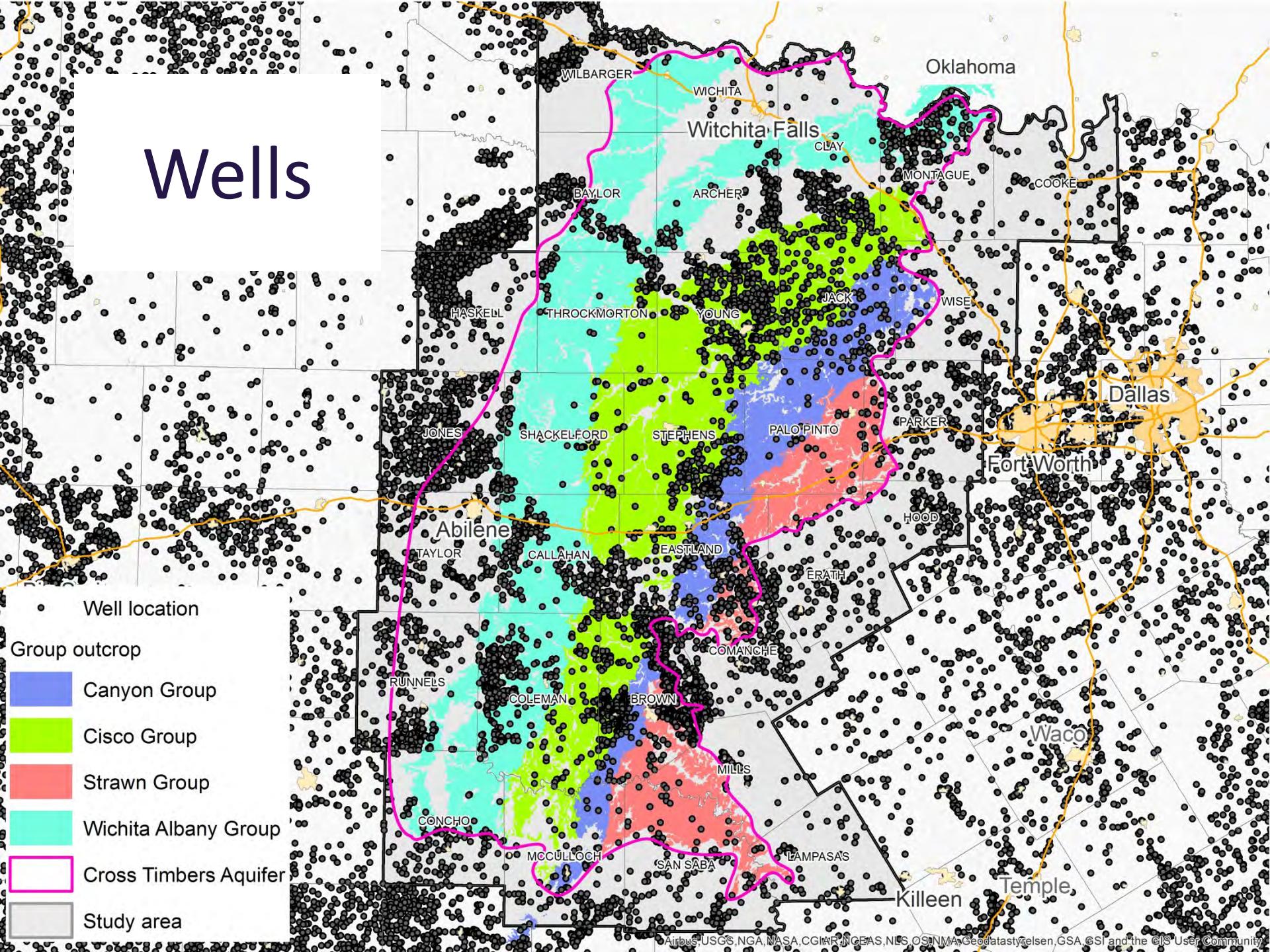
Available Geophysical Logs



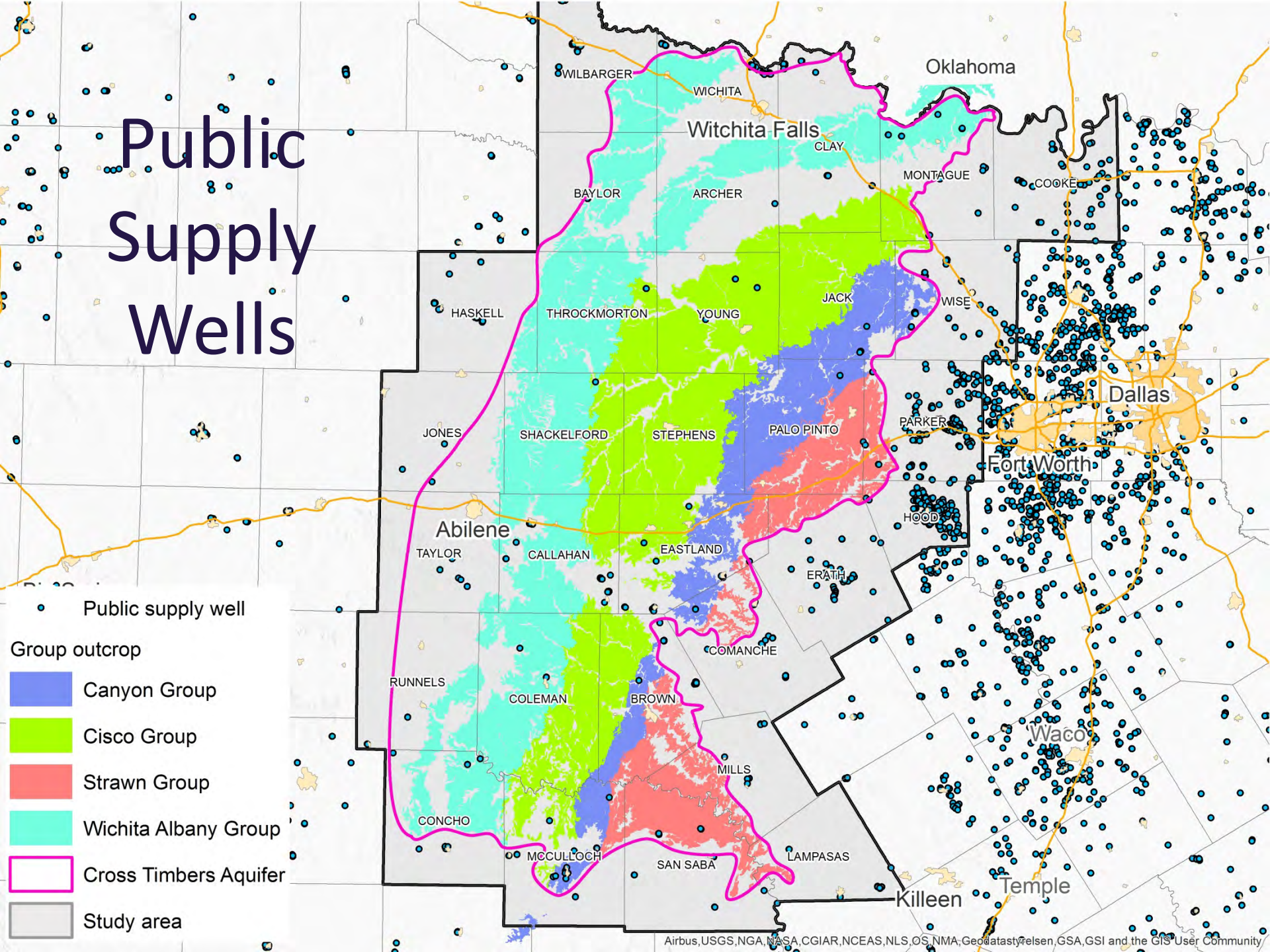
Approach: Water Levels and Regional Flow

- Compile, analyze, summarize all available data
  - 1950s to present
- Evaluate cross formation flow between
  - overlying aquifers, the Trinity and Seymour
  - underlying Llano Uplift in southern area
  - between Paleozoic units that comprise the aquifer

Wells


Oklahoma
WILBARGER
WICHITA
Witchita Falls
CLAY
MONTAGUE
COOKE
BAYLOR
ARCHER
JACK
WISE
HASKELL
THROCKMORTON
YOUNG
Dallas
JONES
SHACKELFORD
STEPHENS
PALO PINTO
PARKER
Fort Worth
HOOD
Abilene
TAYLOR
CALLAHAN
EASTLAND
ERATH
COMANCHE
RUNNELS
COLEMAN
BROWN
Waco
MILLS
CONCHO
MCCULLOCH
SAN SABA
LAMPASAS
Killeen
Temple
Well location
Group outcrop
Canyon Group
Cisco Group
Strawn Group
Wichita Albany Group
Cross Timbers Aquifer
Study area
Airbus, USGS, NGA, NASA, CGIAR, NGEAS, NLS, OSNMA, Geodatastyrelsen, GSA, GSI and the GIS User Community

Public Supply Wells



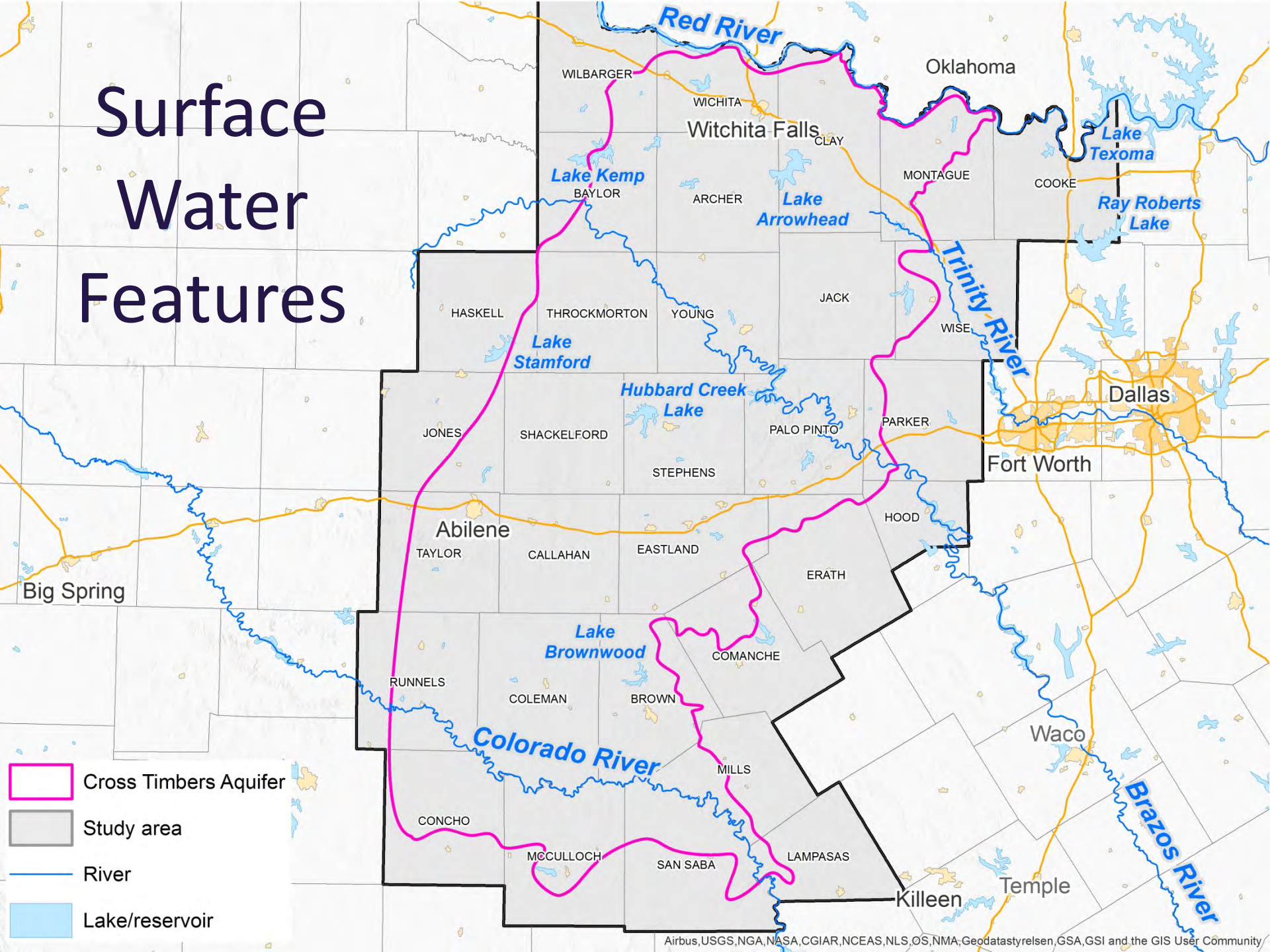
Approach: Recharge

- Compile, analyze, summarize all available data
- Use PRMS-IV (Markstrom and others, 2015) to estimate spatial and temporal distribution of recharge
  - Soil water-balance, distributed parameter model
  - Site-specific climate, topography, geology, soils and vegetation data
  - Daily time step, aggregate into annual values and long term averages
  - Time period depends on data availability

Approach: Rivers, streams, reservoirs, springs and other surface water features

- Compile, analyze, summarize all available data
- Estimate base flow
- Identify gaining and losing stream reaches
- Correlate gaining and losing reaches with aquifer outcrops

Surface Water Features



Approach: Hydraulic Properties

- Compile, analyze, summarize all available data
- Estimate aquifer transmissivity using the Walton (1971) method
  - Need specific capacity tests with pumping rate, duration and drawdown
- Estimate storage coefficients as data allows
  - Need specific capacity tests with monitoring well observations

Approach: Subsidence

- Compile, analyze, summarize all available data
- Likely not issue for Cross Timbers

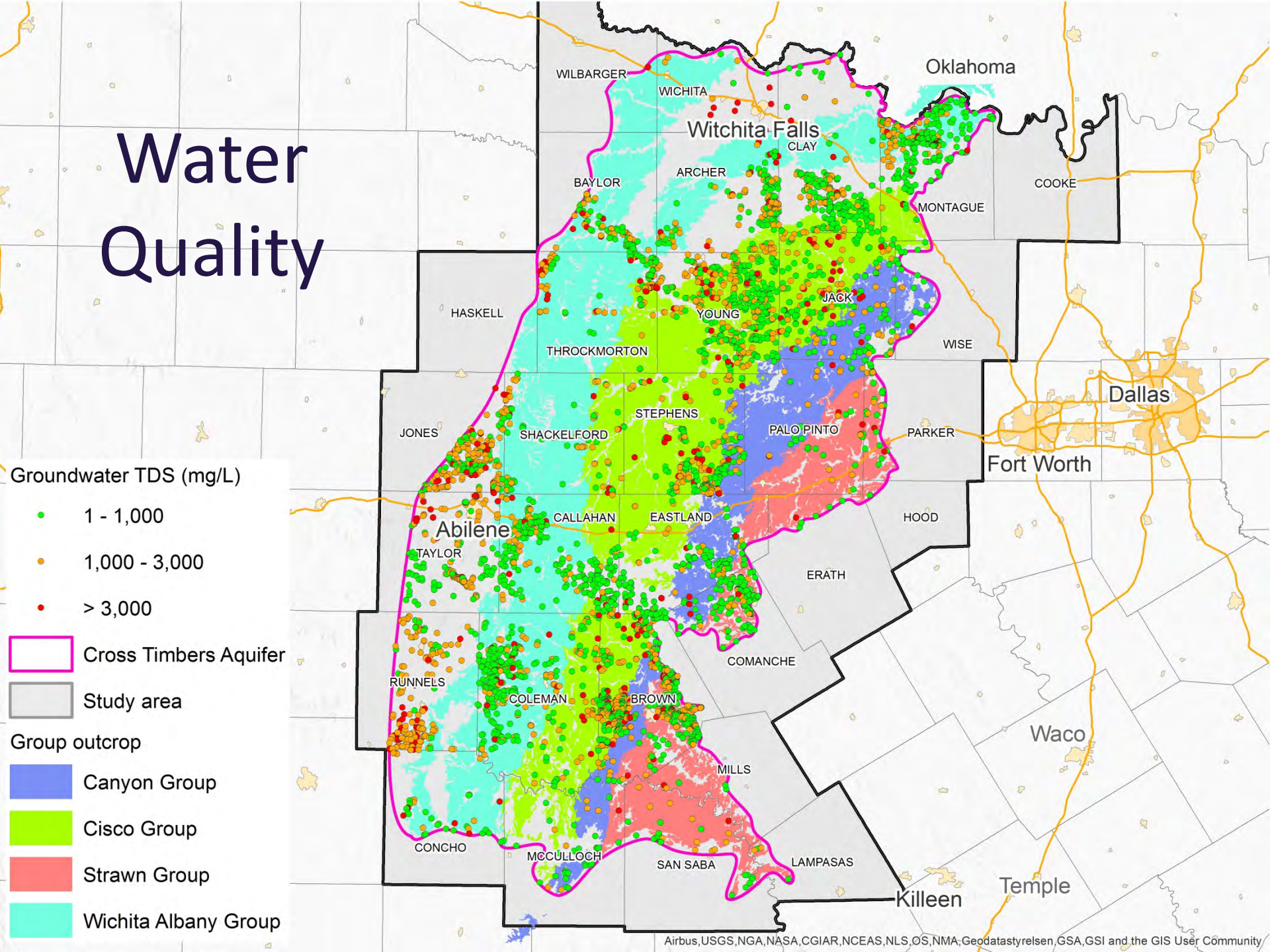
Approach: Discharge

- Compile, analyze, summarize all available data
- Discharge to springs and evapotranspiration
- Groundwater withdrawals (pumping)
  - USGS and TWDB water use data
  - GCDs
  - Railroad Commission for mining use

Approach: Water Quality

- Compile, analyze, summarize all available data
- About 2,000 wells with basic water quality data
- About 300 wells with metals, radionuclides, or isotopes
- Important for analysis of cross formational movement

Water Quality



Expectations

- Build a model
- Compile and analyze all available data
- Document and organize data according to TWDB GAM standards
- On time and on budget

Current Project Schedule

- June 1, 2019 - Start date
- August 6, 2019 - SAF1
- June 1, 2020 - Interim Deliverable
- July 2020 - SAF2*
- March 31, 2021 - Study Completion Date
- April 2021 - SAF3*

**tentative dates*

Data Requests

- Well locations and construction information
- Geophysical logs
- Water level data
- Production data (water use information)
- Aquifer test data
- Deadline: October 2019

Contact Info

https://www.twdb.texas.gov/groundwater/ models/gam/cstb/cstb.asp

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Velma Danielson
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velma.danielson@blantonassociates.com
210-854-9374

Texas Water Development Board

Thank you!

Cross Timbers Aquifer Conceptual Model

Stakeholder Advisory Forum #1

August 6, 2019

DBS&A Daniel B. Stephens & Associates, Inc. a Geo-Logic Company

Allan R. Standen LLC Groundwater & Natural Resource Consulting

Blanton & Associates, Inc. Environmental Consulting • Planning • Project Management

Attachment 3

Handouts

WATER for TEXAS

Texas Water Development Board

www.twdb.texas.gov

Groundwater Availability Modeling

Groundwater, along with surface water, is important for maintaining the viability of the state's natural resources, health, and economic development. The projected 70 percent increase of the state's population by the year 2070, coupled with the constant threat of drought, makes it imperative that Texas develop effective plans to meet future water needs. Effective planning, however, requires accurate assessments of the availability of water, and accessing the availability of groundwater is often much more difficult than assessing that of surface water. Surface water is easily observed at the land surface, and the response of rivers and lakes to rainfall can be repeatedly measured over time. Groundwater is more difficult to observe and measure because it resides below the land surface and responds to rainfall much more slowly than rivers and lakes do. Aquifer systems are complex due to flows into and out of the aquifer, the interaction between surface water and groundwater, and the uncertainty of aquifer properties.

Because of this complexity, computer models are excellent tools for assessing the effect of groundwater use on groundwater availability. Groundwater availability modeling is the process of developing and using computer programs to estimate future trends in the amount of water available in an aquifer and is based on hydrogeologic principles, actual aquifer measurements, and guidance from persons with interest in the models and the program.

What is the goal of the program?

Recognizing the importance of accurate groundwater availability estimates, the 76th Texas Legislature approved initial funding for the Groundwater Availability Modeling Program in 1999. The program's goal is to provide useful and timely information for determining groundwater availability for the citizens of Texas. The Groundwater Availability Modeling Program produces standardized, thoroughly documented, and publicly available groundwater models. These models are important tools for groundwater conservation districts and regional water planning groups in evaluating water management strategies and assessing present and future groundwater availability trends under normal and drought conditions.

Are other groups involved in the program?

Stakeholder involvement is critical to the success of the program. The Texas Water Development Board (TWDB) relies on stakeholders participating in stakeholder advisory forums to voice concerns and provide information. Stakeholder input ensures the models address the important water resource issues for each aquifer represented in the models. The forums typically consist of representatives from groundwater conservation districts, regional water planning groups, the Texas Commission on Environmental Quality, the Texas Department of Agriculture, the Texas Parks and Wildlife Department, industry, water utilities, higher education, agriculture, and private landowners.

What information does a groundwater availability model include?

Groundwater availability models include comprehensive information on each aquifer, such as recharge (amount of water entering the aquifer); geology and how that conveys into the framework of the model; rivers, lakes, and springs; water levels; aquifer properties; and pumping. Each model is calibrated to ensure that the models can reasonably reproduce past water levels and groundwater flows.

How many models have been developed for the major aquifers?

The nine major aquifers in Texas currently require 16 different models to provide full coverage. The TWDB developed four of the models: (1) the Hill Country segment of the Trinity Aquifer, (2) the northern segment of the Edwards Aquifer, (3) the southern part of the Gulf Coast Aquifer, and (4) the Edwards-Trinity (Plateau) and Pecos Valley aquifers. TWDB contractors have developed six of the current models: (5) the High Plains Aquifer System (originally two models: the northern and southern parts of the Ogallala Aquifer); the (6) northern, (7) central, and (8) southern parts of the Carrizo-Wilcox Aquifer; (9) the Seymour Aquifer; and (10) the Barton Springs segment of the Edwards Aquifer. Groundwater conservation districts in Groundwater Management 8 funded the update of (11) the northern segment of the Trinity Aquifer (originally developed by a TWDB-contractor team). The TWDB and a contractor developed a model of (12) the central Gulf Coast Aquifer. The Lone Star Groundwater Conservation District and the Harris-Galveston and Fort Bend Subsidence Districts funded a project for the U.S. Geological Survey to update the original model of (13) the northern part of the Gulf Coast Aquifer. The U.S. Geological Survey in cooperation with the U.S. Department of Defense and the Edwards

Aquifer Authority developed a model for (14) the San Antonio segment of the Edwards Aquifer. El Paso Water Utilities and the U.S. Geological Survey supported the development of models for the (15) Mesilla and (16) Hueco Bolsons aquifers.

How are the models being used?

Completed models have already proven valuable to water planning. Statute requires groundwater conservation districts and regional water planning groups to use values of total pumping and modeled available groundwater, based on the desired future conditions of relevant aquifers located within 16 groundwater management areas, in their management and regional water plans. Groundwater availability models have been and will continue to be used to estimate the modeled available groundwater for each aquifer for each groundwater conservation district, as appropriate and applicable.

Will the models be updated?

The success of the Groundwater Availability Modeling Program depends on the continued interest and support of stakeholders and the Texas Legislature. Ongoing interest is vital to ensure that the most up-to-date model information will be available to address groundwater resource issues for each aquifer. Continued funding is required to update existing models and develop models for the minor aquifers. The original models for the major aquifers, representing 95 percent of groundwater used in Texas, were completed by October 1, 2004. Nearly all of these models have undergone updates as new data and improved modeling techniques have been made available.

Information and reports on the existing models are available to the public on the TWDB's website, and the currently completed models are available upon request via a download from Amazon Drive.

Where may I get more information?

Please contact Larry French at (512) 463-5067 or Cindy Ridgeway at (512) 936-2386 or visit www.twdb.texas.gov/groundwater/models for more information about the Groundwater Availability Modeling Program.

WATER for TEXAS

Texas Water Development Board

www.twdb.texas.gov

The Role of Modeled Available Groundwater in Regional Water Planning

What is modeled available groundwater?

Groundwater is regulated locally by groundwater conservation districts except in locations that do not have a district. Districts may issue permits that regulate pumping of groundwater and spacing of wells within their jurisdictions. Multiple districts within a single groundwater management area determine the desired future conditions of relevant aquifers within that area. (Desired future conditions are the desired, quantified conditions of groundwater resources, such as water levels, water quality, spring flows, or volumes, at a specified time or times in the future or in perpetuity.) TWDB staff then translate those desired future conditions into modeled available groundwater values using the groundwater availability models (or other approaches if a groundwater availability model is not applicable). A modeled available groundwater value is the amount of groundwater production, on an average annual basis, that will achieve a desired future condition. The desired future condition in a specific location may not be achieved if pumping quantities exceed the modeled available groundwater volume over a long term.

How are modeled available groundwater volumes used in the regional water plans?

Regional water plans consider the volume of groundwater that is anticipated to be actually pumped during a drought in any planning decade. Texas Water Code requires that regional water plans be "consistent with the desired future conditions..." (Texas Water Code Section 16.053(e)(2-a)). Water planning rules require that regional water planning groups "shall use Modeled Available Groundwater volumes for groundwater availability" unless there is no modeled available groundwater volume (Title 31 Texas Administrative Code Section 357.32(d)).

Regional water planning requirements do mean that

- the regional water planning process focuses on anticipated pumping volumes in each planning decade rather than on permit volumes;
- the total anticipated pumping volume in any planning decade may not exceed the modeled available groundwater volume in any county-aquifer location (total pumping volume includes the quantities both from existing water supplies and from any recommended water management strategies);
- planning groups may not recommend water management strategy supply volumes that result in exceeding (e.g., "overdrafting") the modeled available groundwater volumes; and
- in the absence of specific information about how groundwater will be managed to meet desired future conditions in a particular location, planning groups may have to develop their own planning basis for allocating the modeled available groundwater volume to complete their regional water plans. The allocation of groundwater may impact the identified water needs and/or the strategy options available to meet needs.

Regional water planning requirements do not mean that

- planning groups may modify groundwater permits that districts have already issued or limit future permits that districts may issue;
- districts must consider whether a project is in an adopted regional water plan when determining whether to issue a groundwater permit; or
- planning groups may modify the desired future conditions (or modeled available groundwater volume) within their planning area through the regional water planning process[1].

Only districts in groundwater management areas can modify desired future conditions.

[1] *Per Rule 357.32, if no groundwater conservation district exists within a region, for example the northeast Texas region, then the region may determine the availability of groundwater for planning purposes if it is physically compatible with the desired future condition. If there is a groundwater conservation district in the region, then the region can request a modeled available groundwater (MAG) peak factor (greater than 100 percent of the MAG) in any aquifer-region-county-basin split if it does not prevent the groundwater conservation district from achieving the associated desired future condition.*

Texas Water Development Board

1700 Congress Ave
Austin, TX 78701

SUMMARY: DEVELOPING A CONCEPTUAL MODEL FOR THE CROSS TIMBERS AQUIFER

OVERVIEW

The team of Daniel B. Stephens & Associates, Inc. (DBS&A), Allan R. Standen LLC, and Blanton & Associates, Inc. (the DBS&A Team) was retained by the Texas Water Development Board (TWDB) to develop a conceptual model for the Cross Timbers Aquifer (the Project). The conceptual model will be used at a later date to develop a groundwater availability model (GAM) of this aquifer.

PROJECT SUMMARY

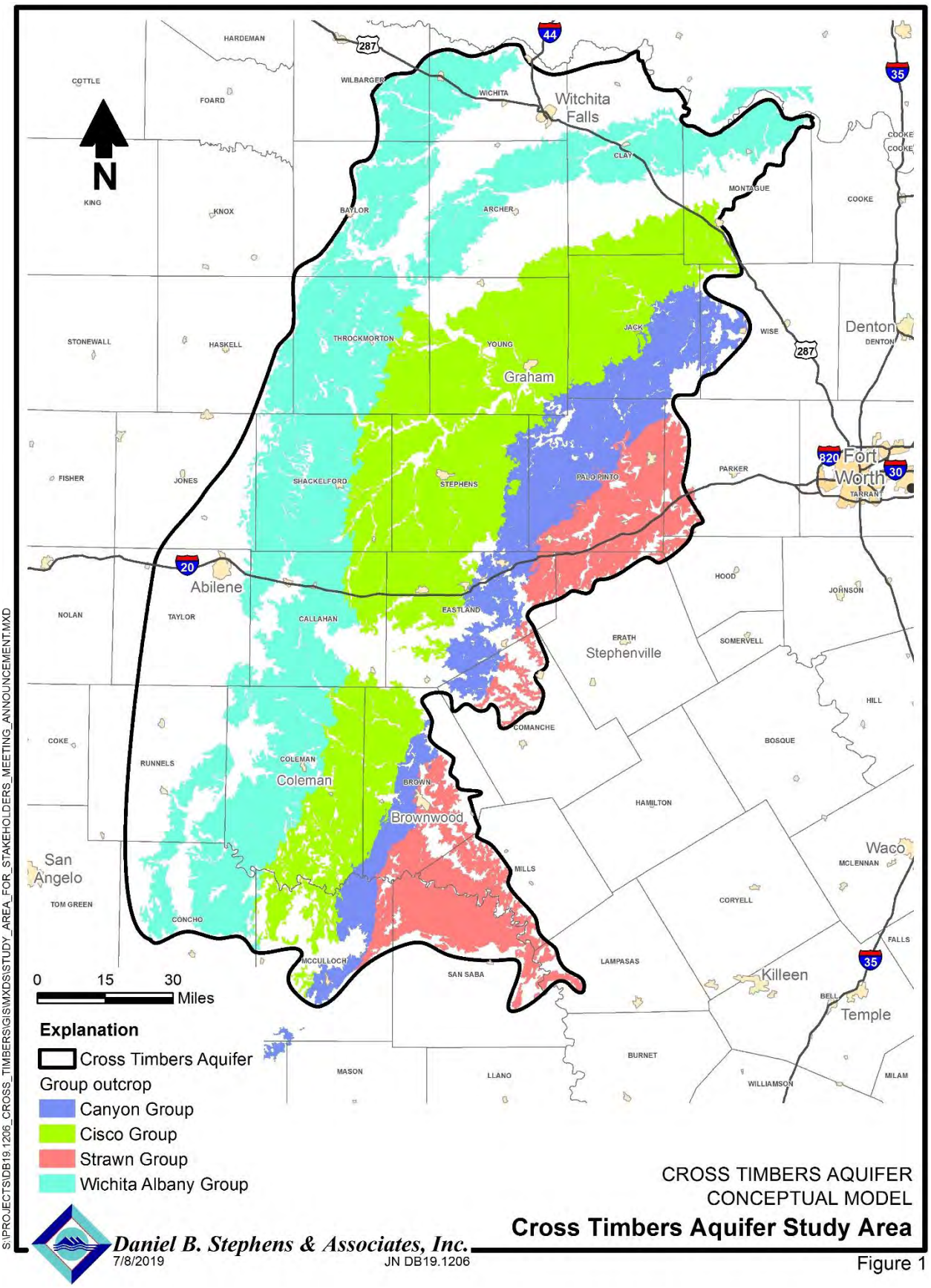
By statute, the TWDB is required to develop numerical groundwater flow models of the major and minor aquifers in Texas. The Cross Timbers Aquifer was designated as a new minor aquifer in December 2017. The aquifer consists of four Paleozoic-age water-bearing formations including, from oldest to youngest, the Strawn, Canyon, Cisco, and Wichita groups. The aquifer is primarily composed of limestones, shales, and sandstones.

As a precursor to developing the GAM, the DBS&A Team will develop the conceptual model for the Cross Timbers Aquifer to describe the best understanding of how groundwater moves through the aquifer system. To develop this conceptual model, the DBS&A Team will compile and analyze data related to physiography and climate, geology and aquifer extent, hydrostratigraphy, hydrostratigraphic framework, water levels and regional groundwater flow, recharge, rivers, streams, reservoirs, springs and other surface water features, hydraulic properties, discharge, and water quality in the study area. The DBS&A Team will also collect, analyze, and interpret available data related to the Cross Timbers Aquifer including possible flows between the overlying Trinity and Seymour aquifers and underlying geologic units, and flows between the Paleozoic units that comprise the aquifer. The DBS&A Team will also investigate and recommend an appropriate boundary for the future GAM.

The Project study area extends from the eastern edge of the Blaine Aquifer to the Ouachita Fold Belt and from southern Oklahoma to the Llano Uplift area in Central Texas (See **Figure 1**). Data analysis will include predevelopment to at least 2015 or more recent times.

Stakeholder Participation

As part of the process to develop the conceptual model, the DBS&A Team will request input and information from the public and private sector including regional water planning groups, groundwater conservation districts, Texas Commission on Environmental Quality, Texas Parks and Wildlife Department, Texas Department of Agriculture, water utilities, educational groups, agricultural interests, environmental interests, private landowners, industry, and groundwater consultants.


HARDEMAN
COTTLE
FOARD
WILBARGER
WICHITA
Witchita Falls
CLAY
COOKE
MONTAGUE
KING
KNOX
BAYLOR
ARCHER
STONEWALL
HASKELL
THROCKMORTON
YOUNG
JACK
WISE
Denton
DENTON
Graham
FISHER
JONES
SHACKELFORD
STEPHENS
PALO PINTO
PARKER
Fort Worth
TARRANT
Abilene
NOLAN
TAYLOR
CALLAHAN
EASTLAND
HOOD
JOHNSON
ERATH
Stephenville
SOMERVELL
COKE
RUNNELS
COLEMAN
Coleman
BROWN
Brownwood
COMANCHE
BOSQUE
HILL
HAMILTON
San Angelo
TOM GREEN
CONCHO
MILLS
Waco
MCLENNAN
CORYELL
FALLS
MCCULLOCH
SAN SABA
LAMPASAS
Killeen
BELL
Temple
MASON
LLANO
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Explanation
Cross Timbers Aquifer
Group outcrop
Canyon Group
Cisco Group
Strawn Group
Wichita Albany Group
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Daniel B. Stephens & Associates, Inc.
7/8/2019
JN DB19.1206
CROSS TIMBERS AQUIFER
CONCEPTUAL MODEL
Cross Timbers Aquifer Study Area

Figure 1

Three stakeholder advisory forums are planned for the Project:

- The first one will be held when the Project is initiated (August 2019);
- The second one will be held approximately mid-way through the project (summer 2020);
- The third one will be held after the DBS&A Team submits its final draft deliverables to the TWDB (March 2021).

All three forums are open to the public.

PROJECT PERIOD

The DBS&A Team began work on the Project in June 2019, and are scheduled to complete work by March 2021, when the team submits its final report to the TWDB.

PROJECT CONTACT INFORMATION

Questions about this project should be directed to the following team members:

- DBS&A Team Project Manager, Mr. Neil Blandford, Principal Hydrologist/Senior Vice President, DBS&A, at nblandford@geo-logic.com or at (505) 822-9400
- Ms. Stephanie J. Moore, Senior Hydrologist, DBS&A, at smoore@geo-logic.com or (512) 651-6013
- Ms. Velma R. Danielson, Senior Project Manager, Blanton & Associates., Inc. at velma.danielson@blantonassociates.com or at (210) 854-9374.

More information is also available from the TWDB's project's primary contact, Mr. Robert Bradley, at robert.bradley@twdb.texas.gov or (512) 936-0870.

Cross Timbers Aquifer - Preliminary Stratigraphic Column **Subject to Revision**

Era	System	Series	Group	Formation	Member	Sandstone Units	Lithology	Layer
Cenozoic	Quaternary (1,327)						Sand, Clay	1
				Leona (20)			Sand, Clay	
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							Sandy Shale	
				Arroyo (77)	Standpipe		Limestone	
					Sprayberry		Silty Shale	
							Limestone	
			Wichita (619)	Leuders (161)			Limestone	
				Clyde	Dean		Limestone/Shale	4
				Belle Plains			Limestone	
		Wolf Camp (46)		Admiral			Mudstone/Shale	
				Putnam			Shale/Limestone	
				Coleman Junction	Sedwick; Dothan; Camp Colorado; Stockwether; L. Stockwether; Saddle Creek; Flippen		Limestone	
				Moran		Moutray; Upper Frye; Lower Frye; Tannehill; Bluff Creek	Alternating Limestone and Sandstone	5
				Pueblo (74)				
	Pennsylvanian	Virgilian	Cisco (697)	Harpersville (63)		Cook; Upper Hope	Shale/Limestone	
				Thrifty (314)	Chaffin		Alternating Limestone and Sandstone	
					Parks Mountain			
					Breckenridge		Limestone	
					Speck Mountain	Lower Hope; King; Swastika	Alternating Limestone and Sandstone	
				Graham (302)	Ivan			
					Wayland			
					Gunsight		Limestone	
					Bluff Creek	McMinan	Alternating Limestone and Sandstone	
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		Missourian			Colony Creek (189)		Shale	7
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					Placid (60)		Shale	
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				Grafford	Cedarton		Shale	
					Adams Branch		Limestone	
					Brownwood		Shale	
				Palo Pinto (62)	Wiles, Wynn		Limestone/Shale	
			Strawn (208)	Mineral Wells (48)	Dog Bend	Turkey Creek	Limestone/Sandstone	
					Village Bend		Limestone	
		Desmoinesian		Millsap Lake	Grindstone Creek		Shale/Sandstone	8
					Lazy Bend		Shale/Sandstone	
				Lower Strawn			Shale/Sandstone	
			Bend (Atoka Series)	Smithwick			Shale/Sandstone	
				Marble Falls (61)			Limestone	

Blue = TWDB aquifer # of wells
Yellow = LS used in correlation, likely not an aquifer