THORNHILL GROUP, INC.

Professional Hydrogeologists • Water Resources Specialists

March 24, 2023

John Elliott
Robertson County Water Supply Corporation
1418 W. Hwy 79
Franklin, TX 77856

Re: Aquifer Evaluation Report –
Robertson County WSC Permit Application for a Proposed Well to be Completed in the Simsboro Aquifer, Robertson County, Texas

Dear Mr. Elliot:

Per your request and in compliance with the rules of the Brazos Valley Groundwater Conservation District (BVGCD), Thornhill Group, Inc. (TGI) provides herein an evaluation of the projected effect of Robertson County Water Supply Corporation (RCWSC) producing an additional 524 acre-feet of water per year from a proposed new production well to be completed in the Simsboro aquifer north of the City of Franklin in central Robertson County. TGI conducted its evaluations and prepared this report in compliance with the rules and guidelines provided by the BVGCD, specifically in Rule 8.4(b)(7)(A) for wells capable of producing between 400 and 800 acre-feet per year. TGI's evaluations focused on assessing local aquifer conditions and parameters, and the extent to which production from the subject well may influence other groundwater users in the BVGCD. TGI's evaluations are based on previous investigations conducted within BVGCD, including permit applications and field-testing. Additionally, TGI relied upon reported data, published reports, the applicable groundwater availability model (GAM), and TGI's extensive experience with and knowledge of the Simsboro aquifer in Central Texas, within the BVGCD, and particularly in Robertson County. Specifically, TGI's work was conducted to accomplish the following goals:

- Assessing the local hydrogeologic setting, focusing on the physical characteristics and hydraulic parameters of the local Simsboro aquifer;
- Estimating and calculating the potential short-term and long-term drawdown at the well, including interference drawdown between wells;
- Establishing a target maximum proposed pumping rate for each well and for the aggregated well field;
- Modeling to assess the potential impacts (e.g., artesian pressure reduction) to the aquifer and other nearby well owners (e.g., drawdown); and,
- Providing this Hydrogeological Evaluation Report in compliance with District rules.

1106 South Mays Street, Suite 100 • Round Rock, Texas 78664
(512) 244-2172 • E-mail: consult@tgi-water.com
Licensed with the Texas Board of Professional Geoscientists (License Number: 50346)

For convenience, applicable illustrations and supporting documentation are included in the following attachments:

Attachment 1 – Figures
Attachment 2 – Reference Materials
Attachment 3 – Selected References

Proposed Pumping Location and Permit Pumping Rate

Figure 1 provides a map showing the locations of the proposed well and the approximate boundary of the property where the proposed well will be located. Proposed well identification, coordinates, and estimated land-surface elevation in feet above mean sea level (MSL) are as follows:

Well Identification	Latitude*	Longitude*	Est. Land Surface Elevation
Proposed Well No. 1	31° 4’ 14.89” N	96° 30’ 43.35” W	545 feet AMSL

*Coordinate system is NAD83 State Plane Texas Central (feet)

The proposed well is located between Franklin and Owensville east of Farm-to-Market 46 (FM 46). The well is located approximately 3.5 miles north of the county courthouse in the City of Franklin.

The proposed production capacity is 1,000 gallons per minute (gpm) and requested permit allocation is 518 acre-feet per year.

There are no other registered or permitted wells on the subject property where the proposed well site is located and the total acreage of the contiguous land owned by RCWSC is 7 acres. The nearest property lines are more than 160 feet from the proposed well. The nearest known exempt or non-exempt well reportedly completed within the Simsboro aquifer more than 7,110 feet from the proposed well. Therefore, the proposed well locations comply with the BVGCD rules regarding spacing between wells and allocation of acreage per well.

Hydrogeologic Conditions and Aquifer Characteristics

Surface Geologic Setting

Figure 2 is a Surface Geology Map illustrating that the subject property tract is located atop the Carrizo sand near the contact between the Carrizo sand and the Calvert Bluff formation. The Carrizo sand is the uppermost (youngest) unit of the Carrizo-Wilcox aquifer. The Carrizo-Wilcox aquifer is geologically updip from the outcrop areas of the Queen City and Sparta

aquifers; therefore, the Queen City and Sparta aquifers do not occur beneath the subject property.

While the Carrizo-Wilcox is mapped as a single Major Aquifer by the Texas Water Development Board (TWDB), it does not behave as a single aquifer within the BVGCD boundaries. In fact, it is comprised of four geologic units including, from deeper to shallower (older to younger), the Hooper formation, the Simsboro formation, the Calvert Bluff formation and the Carrizo Sand. The land surface is relatively flat across most of the property with elevations ranging mostly from an estimated 525 to 560 feet above MSL. Geologic units dip generally from northwest to southeast and dip angles generally increase downdip and with depth in the geologic section. Locally, the dip of the base of the Wilcox Group is approximately 75 feet per mile (see Attachment 3). There are no faults mapped at land surface across the subject property, although faulting associated with the Milano Fault Zone may occur updip and downdip of the property (see Attachment 3).

The Carrizo is present across all of the subject property, although it is likely to be relatively thin due to the dip of the formation and being near the contact with the Calvert Bluff formation. The base of the Carrizo Sands is likely about 50 to 100 feet below ground level (BGL).

The Calvert Bluff formation directly underlies the Carrizo and is a thick unit characterized by numerous and alternating relatively thin layers of clay, silt and sandy clays. The Calvert Bluff formation also contains numerous lignite seams ranging in thickness from less than one foot to more than 10 feet. Surface mining operations are ongoing in Robertson County in which lignite seams from the Calvert Bluff are mined to feed power plants. The Walnut Creek Mine is about 5 miles west of the proposed well. In some areas, the Calvert Bluff includes discontinuous sand channel deposits, with sand layers ranging from a few feet to more than 50 feet in thickness. Generally, the Calvert Bluff formation is considered a confining layer or aquitard between the Carrizo and Simsboro aquifers. However, the intermittent sand layers in the Calvert Bluff can be tapped locally to produce small to moderate quantities of water with variable water quality. Depth to the top of the Calvert Bluff is likely about 50 to 100 feet BGL across the subject property and the formation thickness likely ranges from 600 to 650 feet. Between 10 and 20 percent of the total thickness of Calvert Bluff consists of sand, so the net sand thickness typically ranges from 60 to 130 feet. Most Calvert Bluff wells are small-capacity wells used for domestic and stock purposes. Probably, most local wells are completed in zones of the Calvert Bluff formation that are under artesian conditions due to the significant stratification of the formation and discontinuity of sand layers. Figure 3 provides a map with wells identified within the BVGCD database within five (5) miles and the reported aquifer they are producing from.

Simsboro Aquifer Conditions and Hydraulic Parameters

The Simsboro formation forms the aquifer that will be tapped by the proposed well. Figure 4a Figure 4b provide maps at 1:1,000 scale showing the locations of the proposed well and all wells within a one-mile radius of the proposed well field. There are no Simsboro wells within one mile of the proposed well.

Based on GAM datasets and geologic maps and cross sections from the University of Texas Bureau of Economic Geology (BEG), the elevation of the top of the Simsboro Sand ranges from 105 to 205 feet below MSL across the subject property (see Attachment 3). Locally, the Simsboro dips (i.e., slopes) structurally from northwest to the southeast at an incline of between 70 and 80 feet per mile, and crops out (i.e., occurs at land surface) about 7 miles northwest of the proposed well site. Based on the geologic dip and land surface elevation, the depth to the top of the Simsboro should range from 490 to 560 feet BGL across the subject property. Records of wells within a five (5) mile radius generally along strike indicate that the depth to the top of the Simsboro likely ranges from approximately 650 to750 feet BGL near proposed well. The net sand thickness of the Simsboro ranges from 300 to 400 feet across the subject property (see Attachment 3).

TGI extracted hydraulic data for the subject property and nearby areas from the currently accepted version of the groundwater availability model (GAM) for the Central Portion of the Sparta, Queen City, and Carrizo-Wilcox Aquifers (Young, et al., 2018 and Young, et al., 2020). The following table provides a summary of average estimated parameters extracted from the GAM datasets for the local Simsboro aquifer at the proposed well site:

Parameter	GAM Estimates Range
Sand Thickness	300 to 400 feet
Hydraulic Conductivity	75 to 150 gpd/ft^2
Transmissivity	22,500 to 60,000 gpd/ft
Storage Coefficient	3.7x 10^{-4} to 5.0 x 10^{-4}

Figure 5 provides a hydrograph illustrating water-level measurements collected for nearby TWDB/BVGCD Simsboro monitoring wells (State Well No. 39-61-501 and 39-61-705) which are located near the City of Franklin and is about 3.5 miles east and southeast from the proposed well. According to SWN 39-61-501, the water level in 1979 was approximately 303 feet above MSL (123 ft BGL) and has declined by about 110 feet over almost 40 years, but over the last 10 years the rate of decline has relatively flattened. The current water-level elevation at 39-61-501 is approximately 190 feet above MSL, and the corresponding depth to water is about 236 feet BGL. The estimated current depth to water on the subject property will likely range from 200 to 230 feet BGL. Therefore, water levels will probably rise between 300 and 330 feet above the top of the aquifer in the new well, verifying that the local Simsboro is under artesian or confined conditions with hundreds of feet of artesian head.

Projected Effects of Proposed Pumping

The immediate impacts from production will be drawdown at the pumping well. As the well pumps, artesian pressure or potentiometric head around the well will decline forming a cone of depression. As production continues the cone of depression will extend radially from the well until an aquifer boundary is reached or the production rate reaches equilibrium with the captured groundwater flows. Due to the distance of the proposed well from the outcrop of the aquifer, reduction in artesian pressure is the only anticipated measurable effect from the proposed pumping. The aquifer will remain completely full and there will be only an infinitesimal reduction in storage. There may be some inter-aquifer leakage induced from the overlying Calvert Bluff confining layer and Carrizo aquifer; however, the amount of leakage will serve to lessen the artesian drawdown in the Simsboro and will likely not result in any identifiable water-level changes in the Calvert Bluff or Carrizo due to the stratification in the geologic layers.

Drawdown Simulations Using Analytical Modeling

TGI used an analytical modeling program based on the Theis non-equilibrium equation to calculate theoretical potentiometric head declines at and surrounding the proposed production well. TGI has used the Theis model for several submittals to the BVGCD as well as for evaluations and submittals to numerous districts across the State of Texas. The Theis model incorporates many assumptions, most of which are sufficiently satisfied in the local Simsboro aquifer. However, the Theis model assumes an aquifer that is uniform over an infinite area. To account for recharge boundaries and possible inter-aquifer leakage into the Simsboro, TGI modeled long-term pumping (i.e., from one to 10 years) by incorporating a leaky artesian storage coefficient. However, it is likely that, while the Theis model likely provides more reliable results within and near the well field, it probably overstates drawdown at distance from the pumping center. Also, the Theis model is more accurate for shorter pumping durations; therefore, the 10-year calculation likely overestimates drawdown from the well field.

Figure 6 and Figure 7 provide the Theis-modeled drawdown contours for pumping periods of one (1) year and 10 years, respectively. Assuming a properly completed and highly efficient production well, the Theis model predicted drawdown in the proposed pumping well is 59 feet after one (1) year of continuous pumping, with an additional 7 feet of drawdown with continuous pumping for 10 years. The Theis calculation resulted in one-year interference drawdown of about 4 feet at the City of Franklin. The analytical model predicted drawdown after 10 years of 10 feet at Franklin, assuming continuous pumping of the maximum permitted volume. Predicted drawdown at Simsboro wells between one (1) and five (5) miles from the proposed wells will be less than 10 feet.

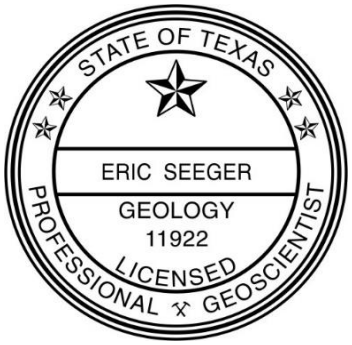
Conclusions

Based on our review of the BVGCD rules and the work conducted as described herein, TGI concludes the following:

- The proposed well and pumping amount can be completed and produced in accordance with the well spacing and production-based acreage (i.e., allocation) rules set forth by the BVGCD; and,
- Production from the proposed pumping will cause only infinitesimal reduction in aquifer storage as the Simsboro will stay completely full and groundwater in the formation will remain under considerable artesian pressure within the five-mile study radius.

We very much appreciate the opportunity to again assist you in our specialty. If you have any questions, please call.

Sincerely,
THORNHILL GROUP, INC.



The seal appearing on this document was authorized by Eric Seeger, P.G. on March 24, 2023.

Eric Seeger, P.G.
Senior Hydrogeologist

Attachments

ATTACHMENT 1 –
FIGURES

Explanation

- Proposed Well
- 160 Foot Radius
- 321 Foot Radius
- Approximate Robertson WSC Propoerty Boundary
- Robertson CAD Property

N

0 1,000 2,000 ft

Robertson County WSC

Figure 1 - Location Map

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Explanation

Proposed Well

Surface Geology

- Qal - Alluvium
- Er - Reklaw Formation
- Ec - Carrizo Sand
- Ecb - Calvert Bluff Formation

N

0 500 1,000 1,500 2,000 ft

Robertson County WSC

Figure 2 - Surface Geology

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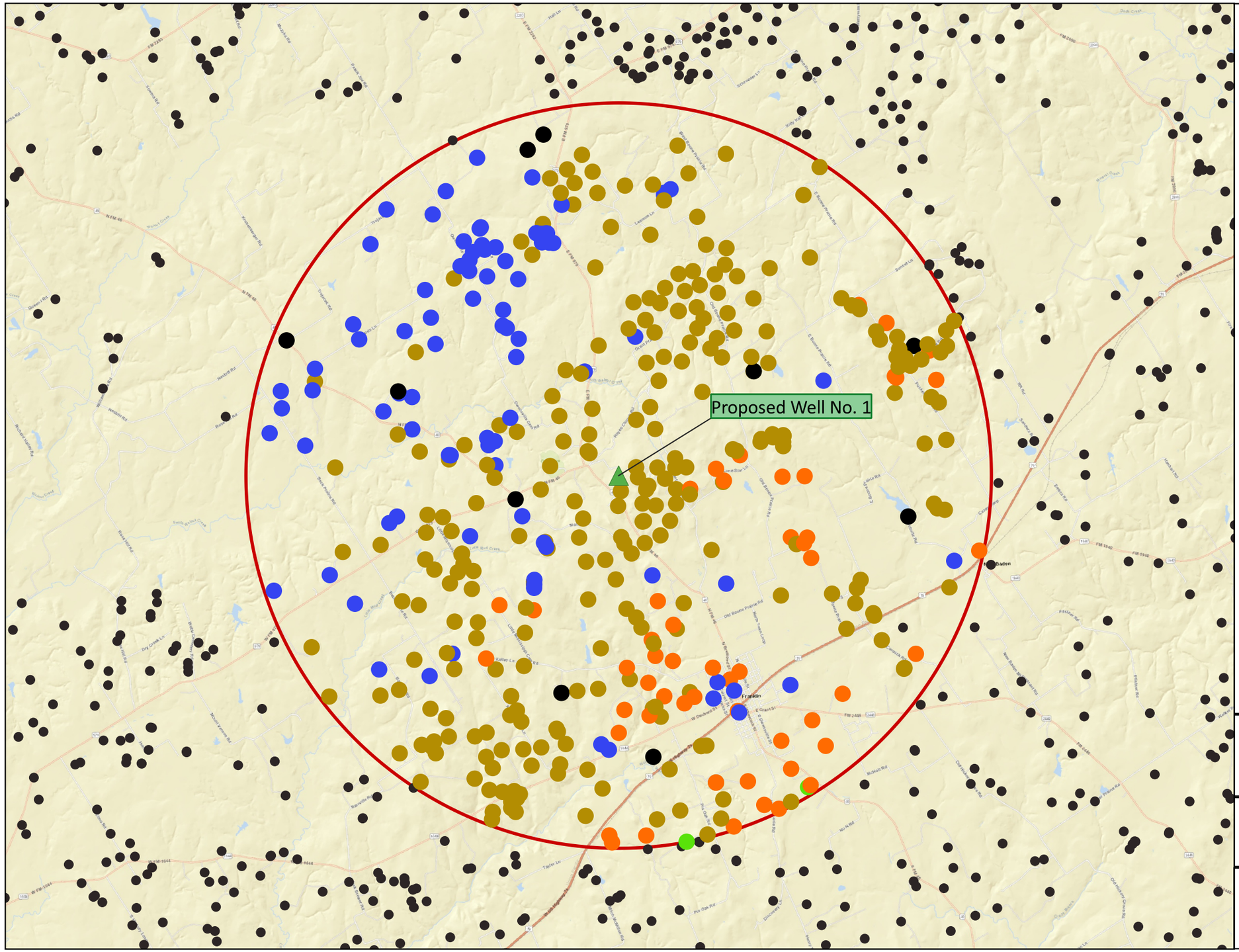

Explanation

- Proposed Well

BVGCD Registered or Permitted Well Within 5 Miles of Proposed Well by Aquifer

- Queen City
- Carrizo
- Calvert Bluff
- Simsboro
- Unknown

- BVGCD Registered or Permitted Well GreaterThan 5 Miles of Proposed Well
- 5 Mile Radius

N

0 10,000 20,000 ft

Robertson County WSC

Figure 3 - BVGCD Wells Within 5 Miles of Proposed Well

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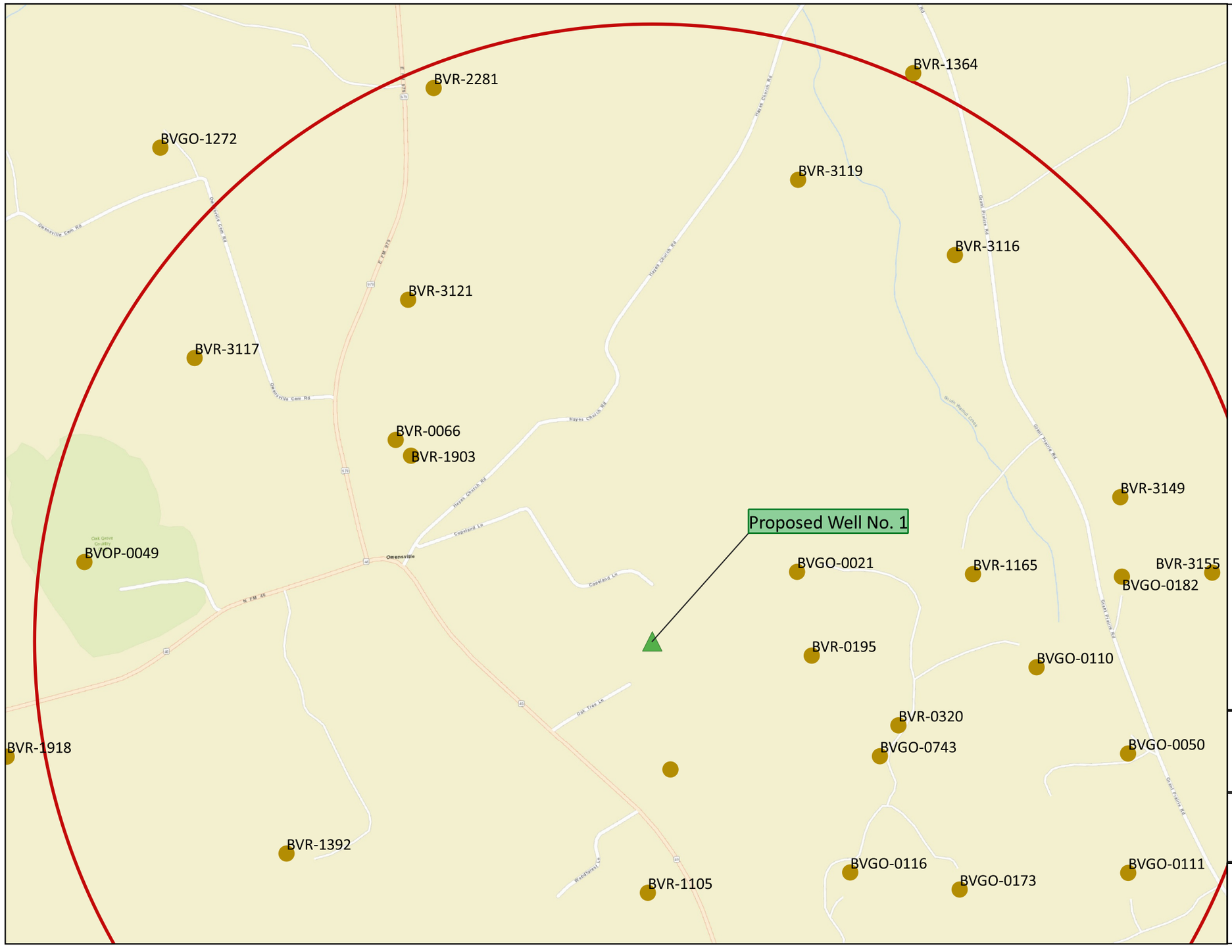

Explanation

- Proposed Well
- BVGCD Registered or Permitted Well
  - Carrizo
  - Calvert Bluff
- 1 Mile Radius

N

0 1,000 2,000 ft

Robertson County WSC

Figure 4a - BVGCD Wells Within 1 Mile of Proposed Well

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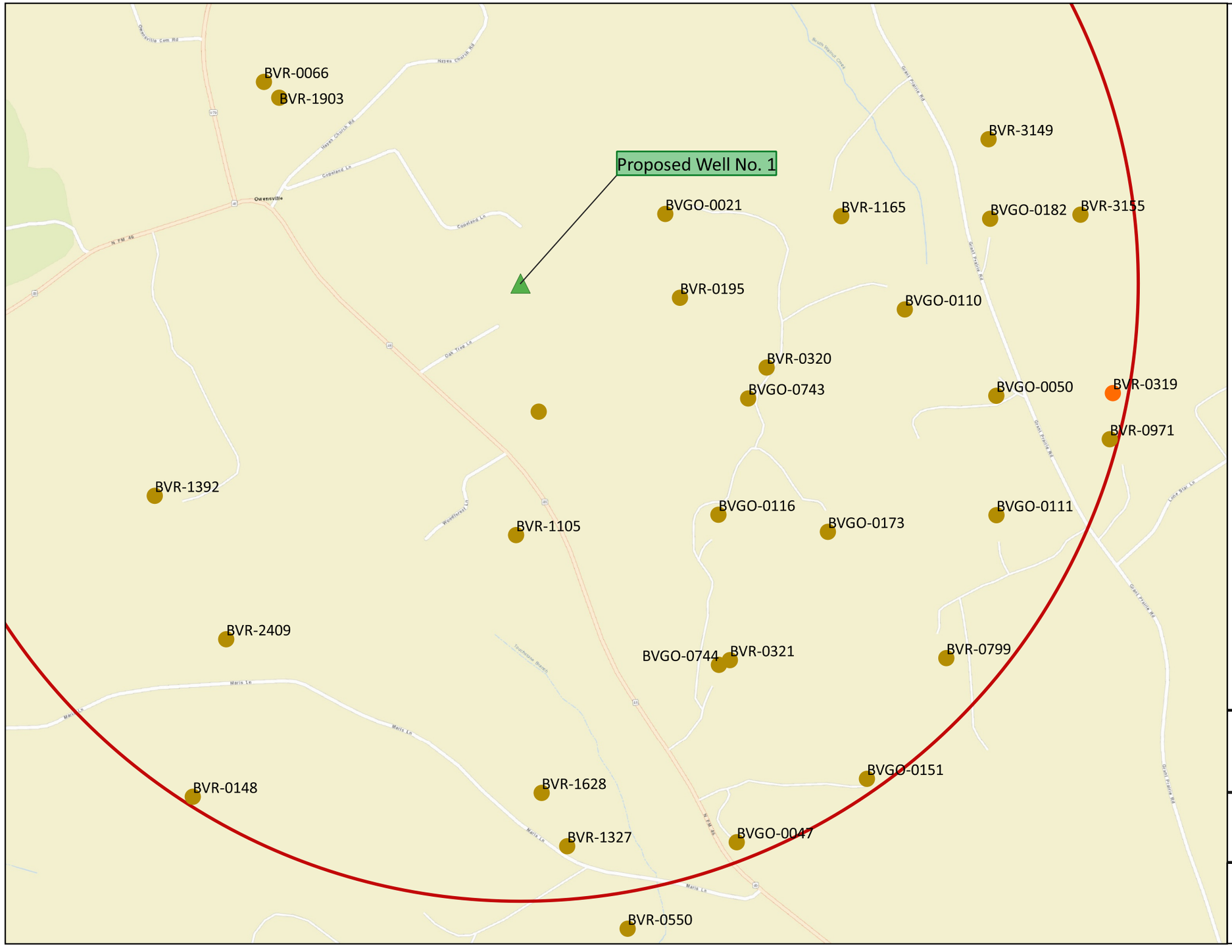

Explanation

- Proposed Well

BVGCD Registered or Permitted Well

- Carrizo
- Calvert Bluff
- 1 Mile Radius

N

0 1,000 2,000 ft

Robertson County WSC

Figure 4b - BVGCD Wells Within 1 Mile of Proposed Well

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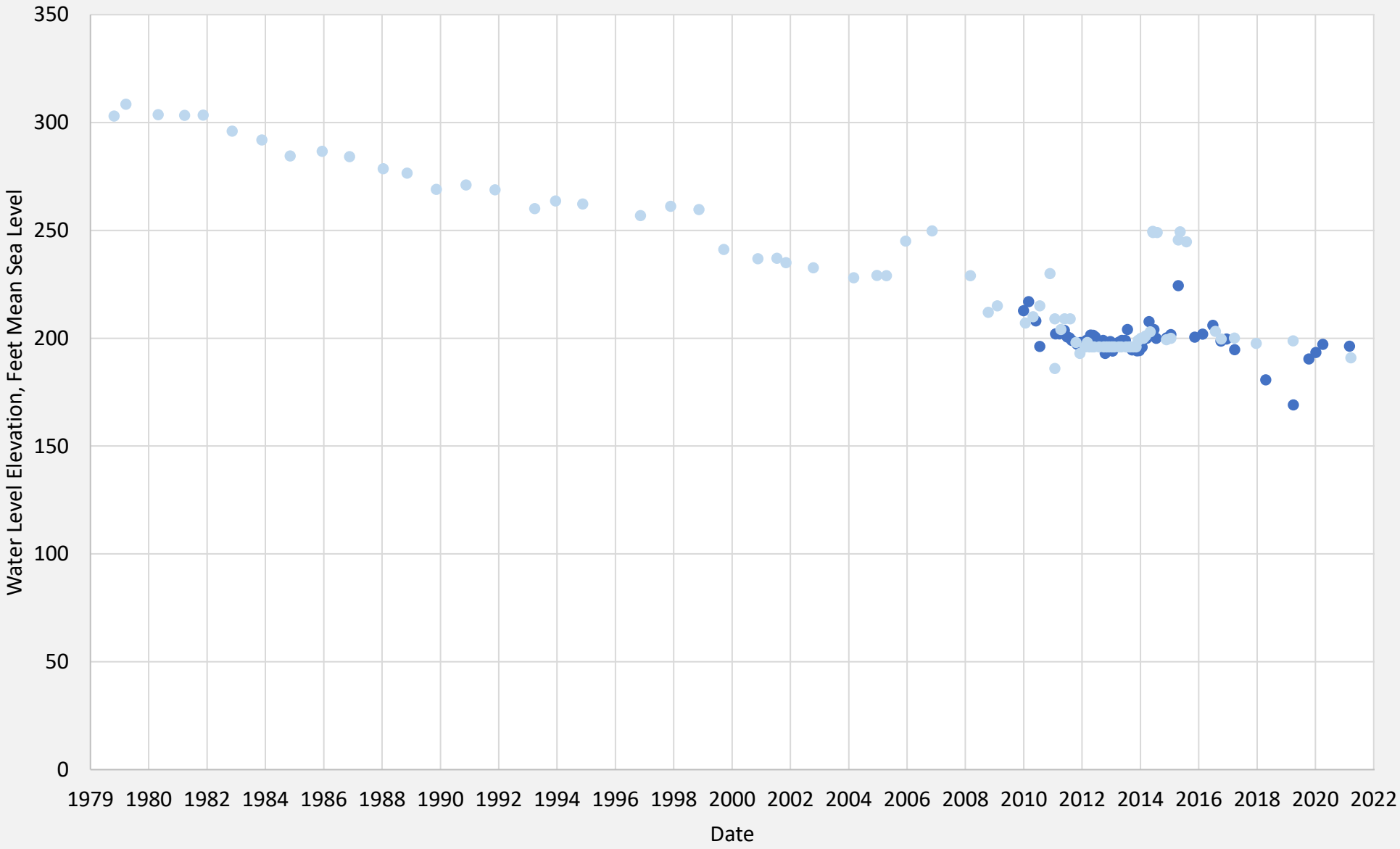
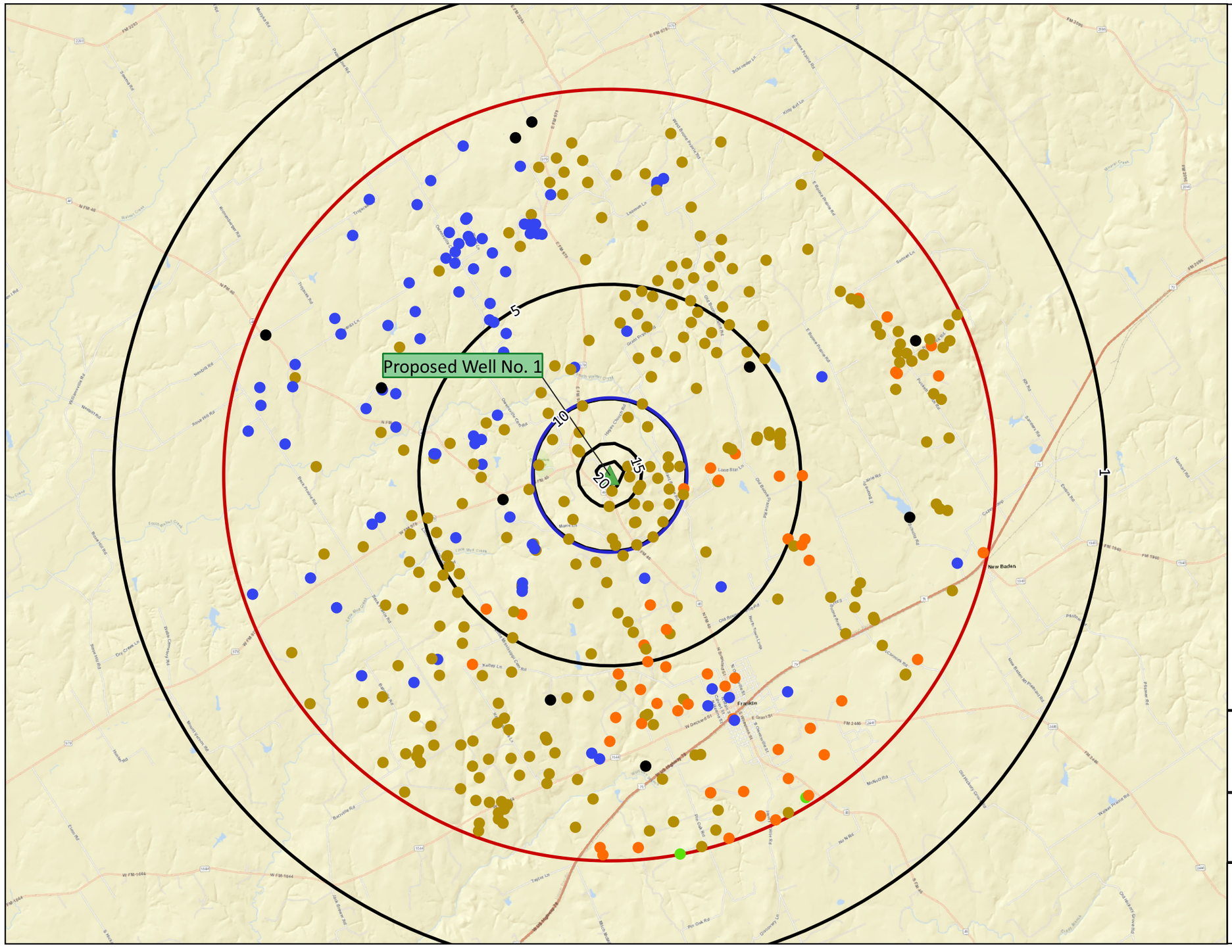
Figure 5. Historical Local Water Level





Explanation

Proposed Well

BVGCD Registered or Permitted Well Within 5 Miles of Proposed Well by Aquifer

- Queen City
- Carrizo
- Calvert Bluff
- Simsboro
- Unknown

1 Mile Radius

5 Mile Radius

1 Year Simulated Drawdown
Contour Interval = 5 Feet

Analytical model was used to simulate drawdown using the Theis equation. Transmissivity = 40,000 gpd/ft, Storage = 0.005, Time = 1 year.

N

0 8,000 16,000 ft

Robertson County WSC

Figure 6 - Theis - Simulated Drawdown After 1 Year

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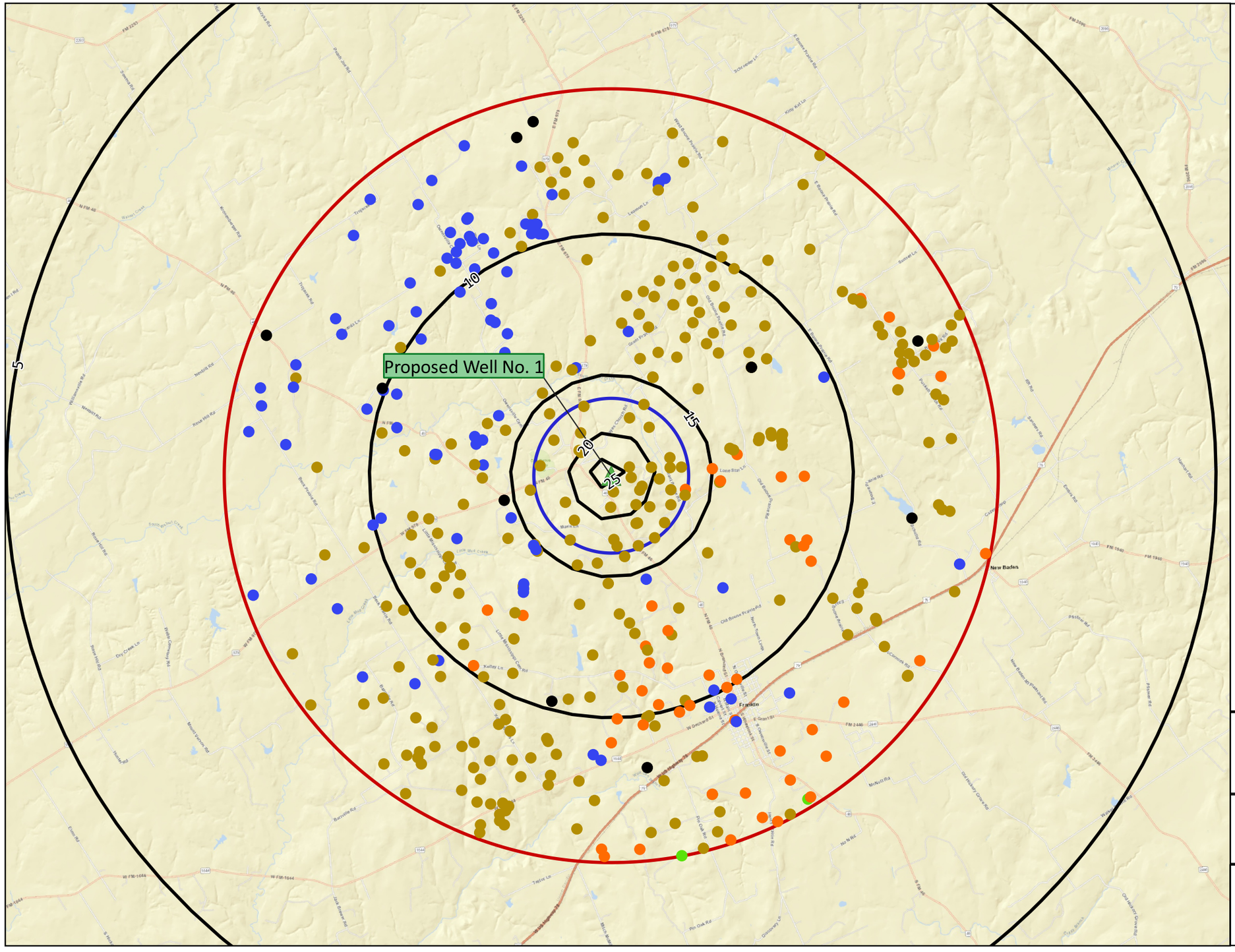

Explanation

Proposed Well

BVGCD Registered or Permitted Well Within 5 Miles of Proposed Well by Aquifer

- Queen City
- Carrizo
- Calvert Bluff
- Simsboro
- Unknown

1 Mile Radius

5 Mile Radius

10 Year Simulated Drawdown
Contour Interval = 5 Feet

Analytical model was used to simulate drawdown using the Theis equation. Transmissivity = 40,000 gpd/ft, Storage = 0.005, Time = 10 year.

N

0 8,000 16,000 ft

Robertson County WSC

Figure 7 - Theis - Simulated Drawdown After 10 Year

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ATTACHMENT 2 –
REFERENCE MATERIALS

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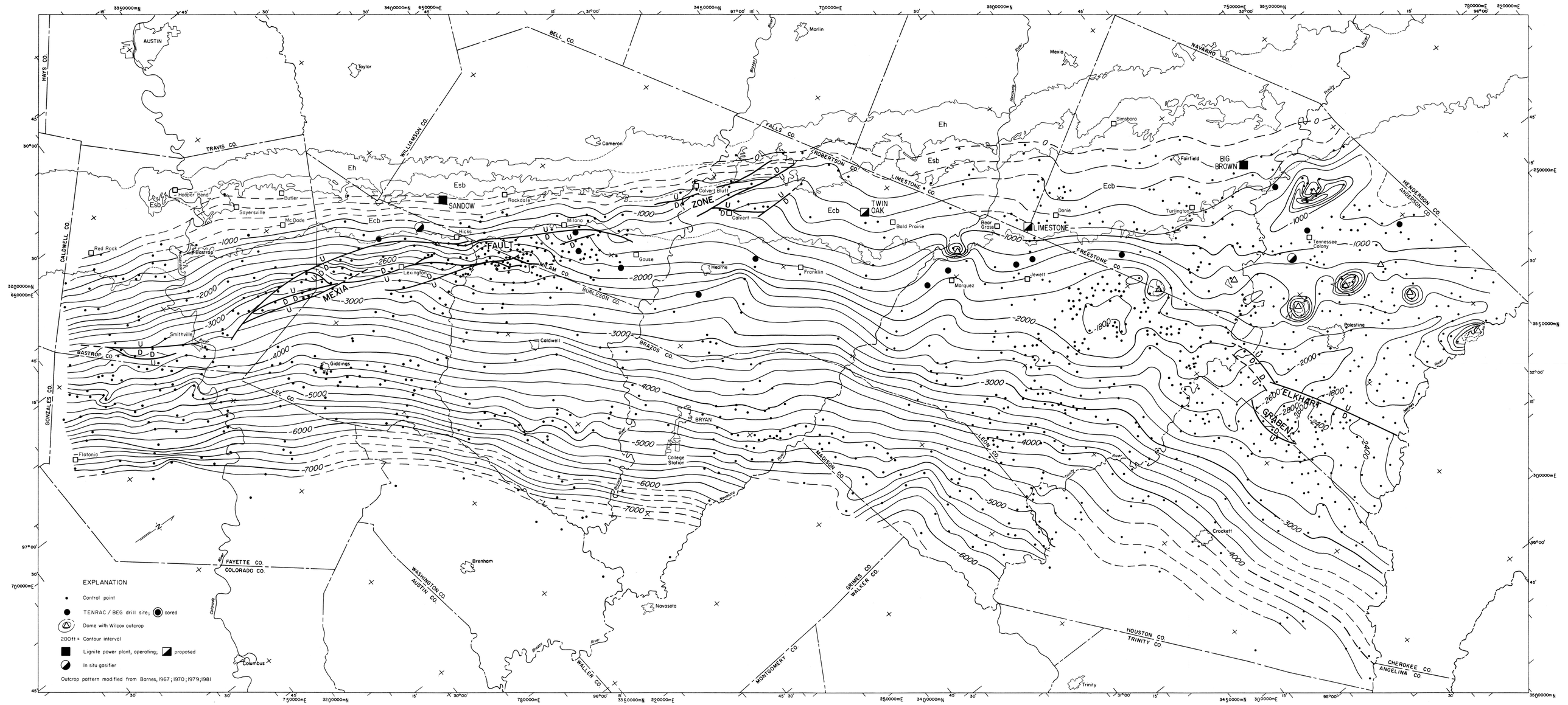

Base map adapted from Army Map Service base maps, 10,000-meter Universal Transverse Mercator grid, zones 14 and 15. Cartography by John T. Ames under the supervision of Richard L. Dillon.

by W. B. Ayers, Jr., and Amy H. Lewis

PLATE 2. WILCOX STRUCTURE MAP

1985

Generalized structure map drawn on the base of the Wilcox Group (sea-level datum) shows regional dip to the southeast. The angle of dip increases from the northeast (1/2°) to the southwest (2°). Major structural elements are the Mexia Fault Zone, the Elkhart Graben, salt structures in Anderson and Freestone Counties, and the East Texas Basin (fig. 2).

QAe1984-2

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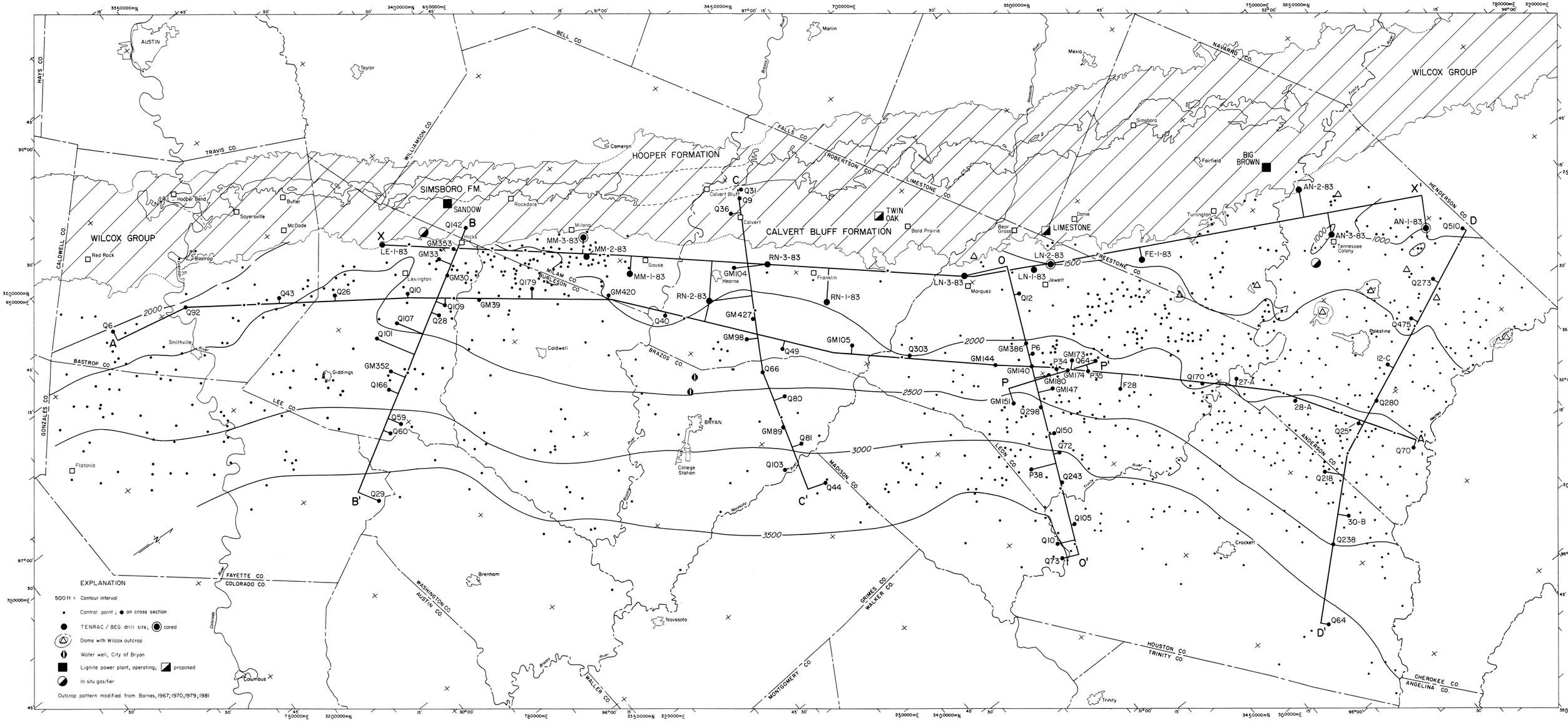

Base map adapted from Army Map Service base maps. 10,000-meter Universal Transverse Mercator grid, zones 14 and 15. Cartography by John T. Ames under the supervision of Richard L. Dillon.

by W. B. Ayers, Jr., and Amy H. Lewis

PLATE 3. WILCOX ISOPACH MAP AND LOCATIONS OF CROSS SECTIONS

1985

The Wilcox Group thickens from less than 1,000 ft (305 m) on the north to more than 3,500 ft (1,065 m) at the basinward margin of the study area. The local increase in thickness in central Lee County is attributed to syndepositional movement along the Mexia Fault Zone (fig. 2 and pl. 2).

GAm1984-3

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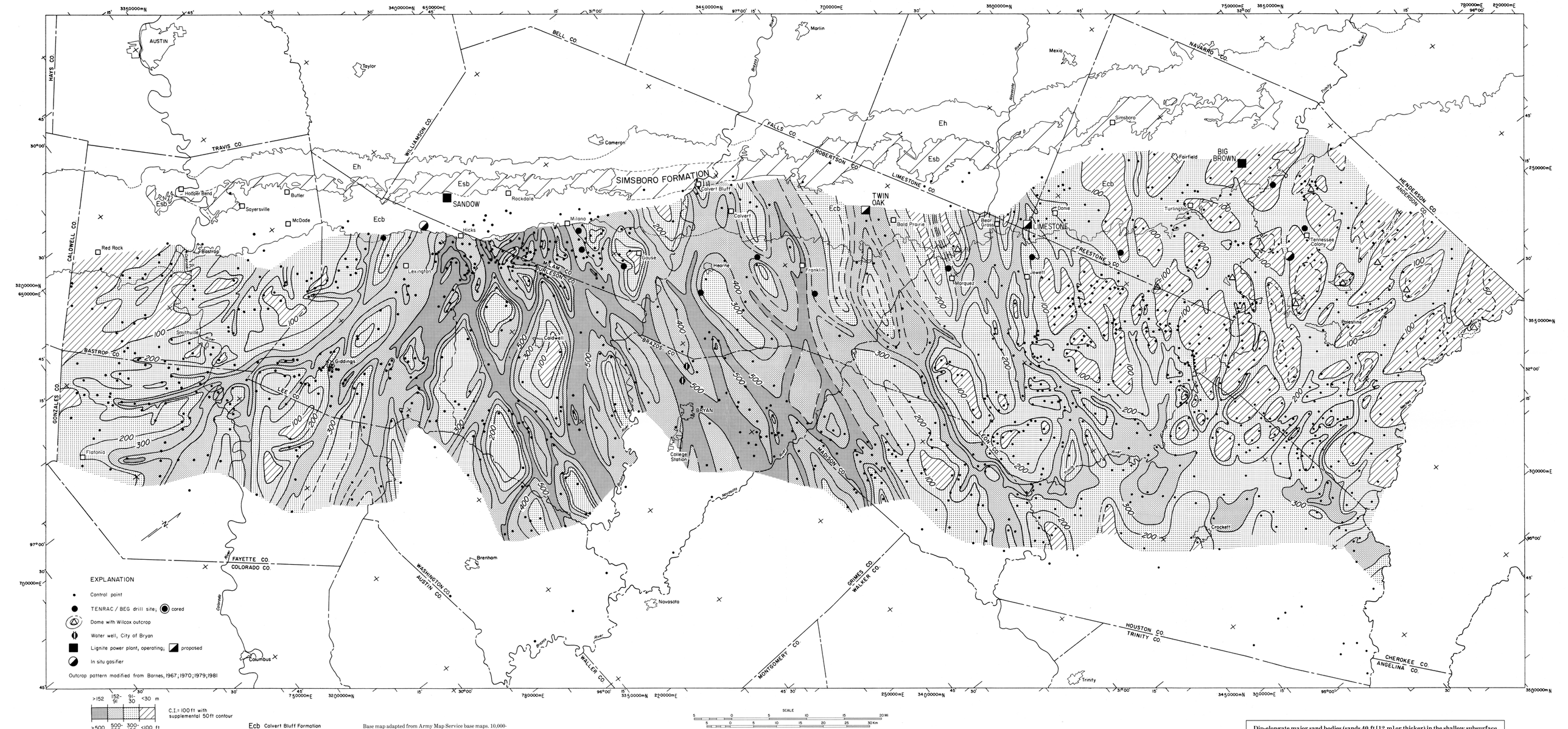

Base map adapted from Army Map Service base maps. 10,000-meter Universal Transverse Mercator grid, zones 14 and 15. Cartography by John T. Ames under the supervision of Richard L. Dillon.

by W. B. Ayers, Jr., and Amy H. Lewis

PLATE 5. SIMSBORO FORMATION, MAJOR-SAND ISOLITH MAP

1985

Dip-elongate major sand bodies (sands 40 ft [12 m] or thicker) in the shallow subsurface are straight; they bifurcate, displaying a deltaic geometry, in Fayette County and terminate in small delta lobes in Houston County. When projected updip, sand-body trends southwest of Leon County (Rockdale fluvial-deltaic system) intersect at a broad locus in Coryell County (fig. 3). Sand-body trends in Anderson and Houston Counties (secondary fluvial system with sources to the north and northeast) are directed into the axis of the East Texas Basin (fig. 2 and pl. 2).

QAs1984-5

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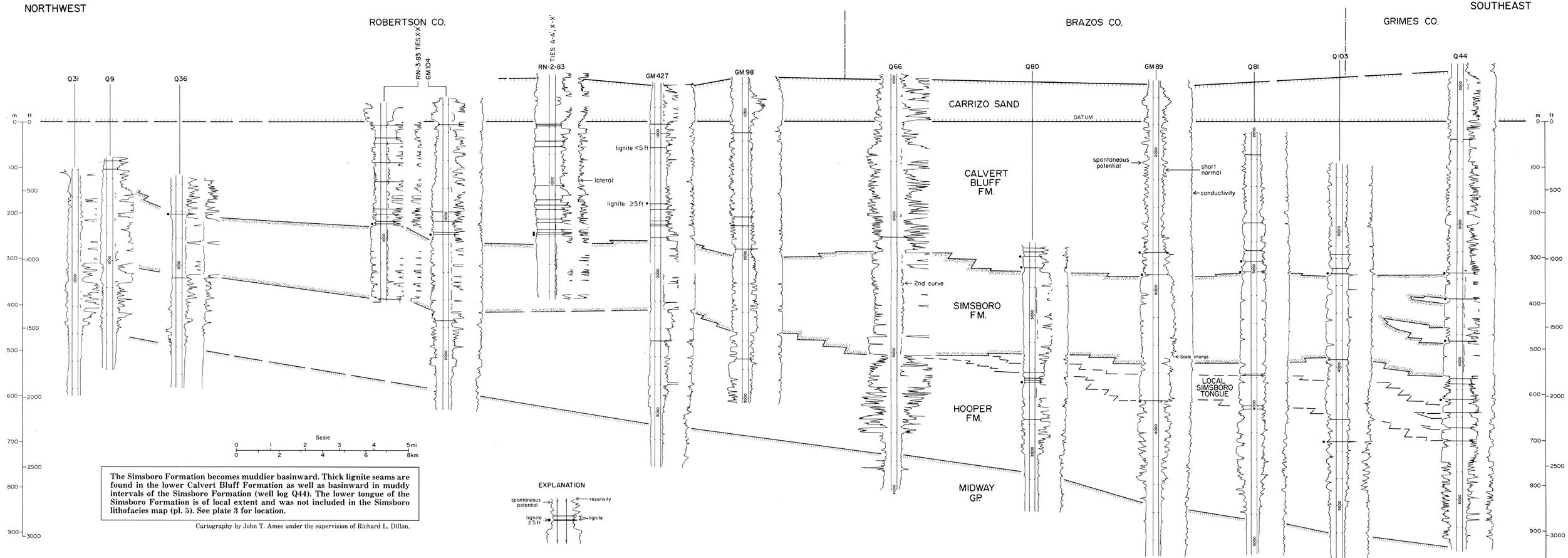
W. L. FISHER, DIRECTOR

PLATE 8
THE WILCOX GROUP AND CARRIZO SAND
(PALEOGENE) IN EAST-CENTRAL TEXAS:
DEPOSITIONAL SYSTEMS AND DEEP-BASIN LIGNITE



The Simsboro Formation becomes muddier basinward. Thick lignite seams are found in the lower Calvert Bluff Formation as well as basinward in muddy intervals of the Simsboro Formation (well log Q44). The lower tongue of the Simsboro Formation is of local extent and was not included in the Simsboro lithofacies map (pl. 5). See plate 3 for location.

Cartography by John T. Ames under the supervision of Richard L. Dillon.

by W. B. Ayers, Jr., and Amy H. Lewis

PLATE 8. CROSS SECTION C-C'

1985

QAe1984-8

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PLATE 22
THE WILCOX GROUP AND CARRIZO SAND
(PALEOGENE) IN EAST-CENTRAL TEXAS:
DEPOSITIONAL SYSTEMS AND DEEP-BASIN LIGNITE

X

SOUTHWEST

LEE CO. | MILAM CO. | ROBERTSON CO.

LE-1-83 | MM-2-83 | MM-3-83 | MM-1-83 | TIES A-A', C-C' | RN-2-83 | TIES C-C' | RN-3-83 | RN-1-83 | MATCH LINE

m ft
0 0
100 200
200 400
300 600
400 800
500 1000
600 1200
700 1400
800 1600

CARRIZO SAND

CALVERT BLUFF FM.

333-343

lignite

LOWER CALVERT BLUFF

809-836

DATUM

SIMSBORO FM.

HOOPER FM.

CARRIZO SAND

CALVERT BLUFF FM.

SIMSBORO FM.

HOOPER FM.

X'

ROBERTSON CO. | LEON CO. | FREESTONE CO. | ANDERSON CO.

NORTHEAST

MATCH LINE | TIES O-O' | LN-3-83 | LN-2-83 | FE-1-83 | AN-2-83 | AN-3-83 | AN-1-83

CARRIZO SAND

(UPPER) MIDDLE CALVERT BLUFF

187-207

CALVERT BLUFF FM.

CALVERT BLUFF FM.

DATUM

SIMSBORO FM.

SIMSBORO FM.

lignite

U. CALVERT BLUFF

334-374

1031-1041

UPPER HOOPER

HOOPER FM.

MIDWAY GP.

m ft
0 0
100 200
200 400
300 600
400 800
500 1000
600 1200
700 1400
800 1600

Scale
0 5 10 mi
0 5 10 15 km

EXPLANATION
Zone of thick lignite
(1 or more seams ≥5 ft [1.5 m])
333-343 ■ Cored interval

Geophysical logs from Texas Energy and Natural Resources Advisory Council/ Bureau of Economic Geology wells show the stratigraphic occurrence of deep lignite (200 to 2,000 ft [61 to 610 m]) in east-central Texas. Thick lignite seams (seams 5 ft [1.5 m] or thicker) are found in the (a) upper Hooper Formation on the northeast, (b) lower Calvert Bluff Formation on the southwest, and (c) upper Calvert Bluff Formation on the northeast. Lateral continuity of individual lignite seams within the zones is neither implied nor true; wells were drilled in low-sand (floodbasin) areas between major-sand axes, which limit seam continuity. See plate 3 for location. Full-scale geophysical well logs are available from the Bureau of Economic Geology.

Cartography by John T. Ames under the supervision of Richard L. Dillon.

by W. B. Ayers, Jr., and Amy H. Lewis

PLATE 22. LIGNITE CROSS SECTION X-X'

1985

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W. L. FISHER, DIRECTOR

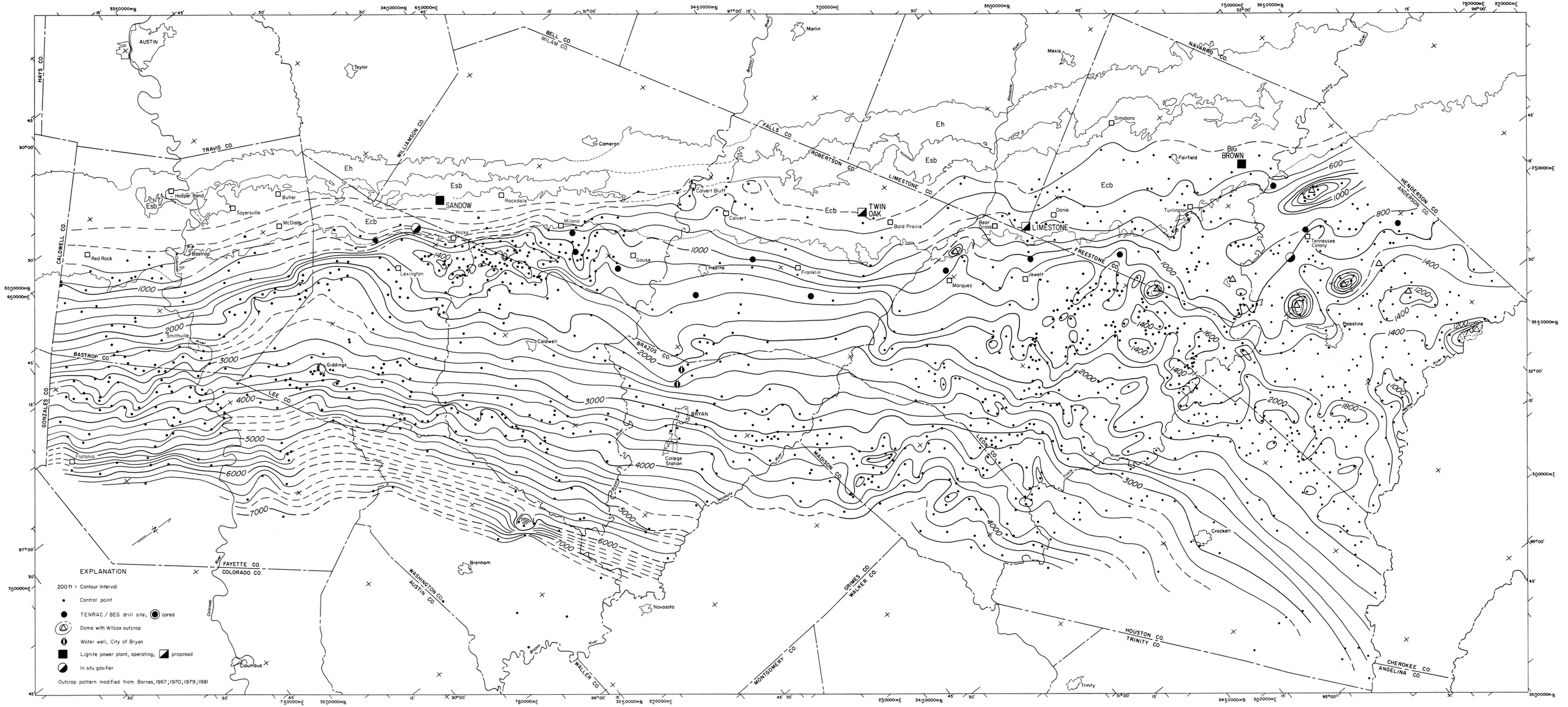


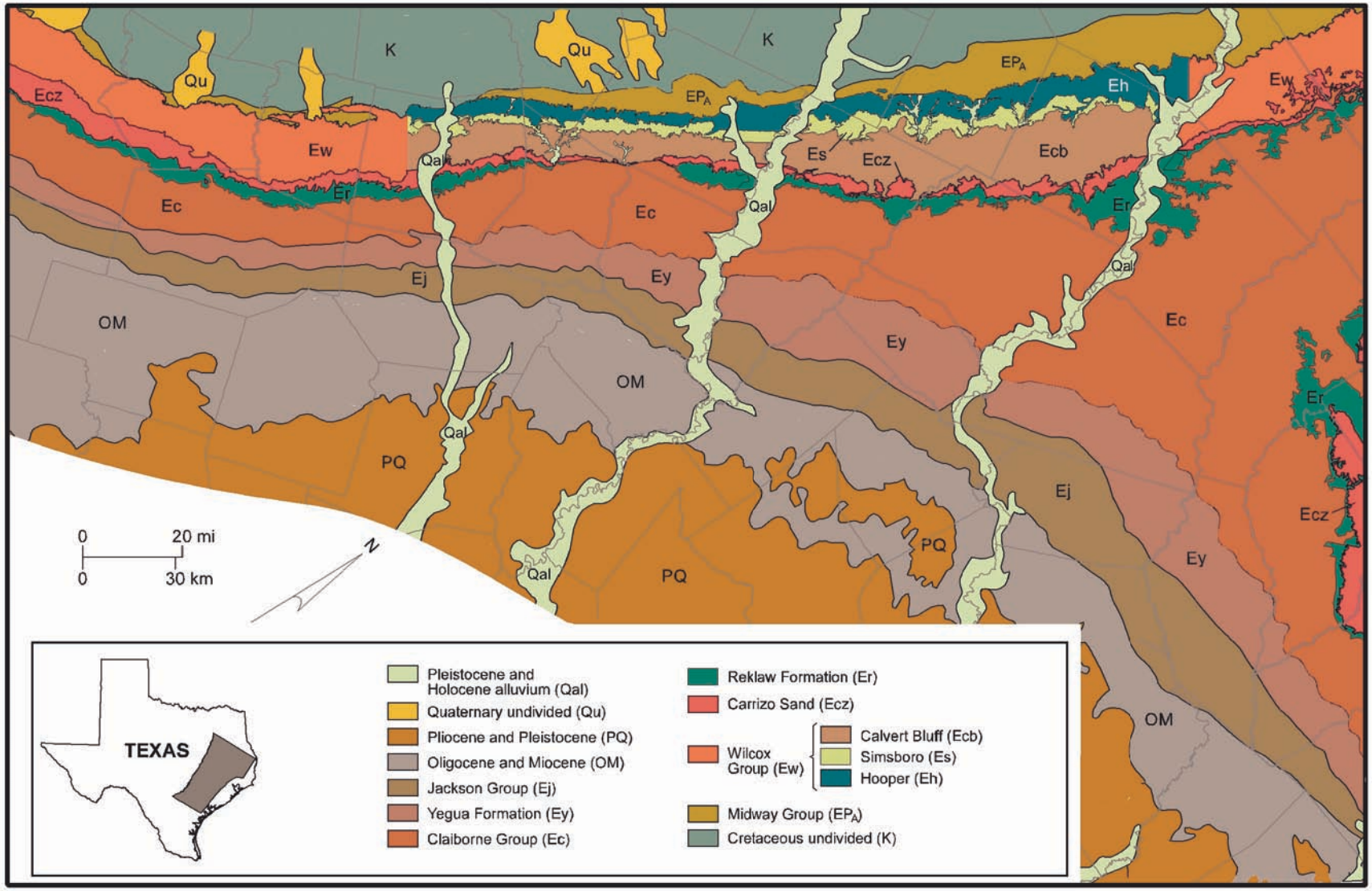
PLATE 28. SIMSBORO OVERBURDEN MAP

1985

by W. B. Ayers, Jr., and Amy H. Lewis

The depth to the top of the Simsboro (Simsboro overburden) provides an estimate of the depth required to test the entire lignite-bearing Calvert Bluff Formation.

QAe1984-28



QAd1815c

Figure 11. Generalized map of surface geology in the study area. The Wilcox Group is not subdivided into formations south of the Colorado River or north of the Trinity River. Claiborne Group shown on map does not include Yegua Formation, Reklaw Formation, and Carrizo Sand. Modified from Bureau of Economic Geology (1992).

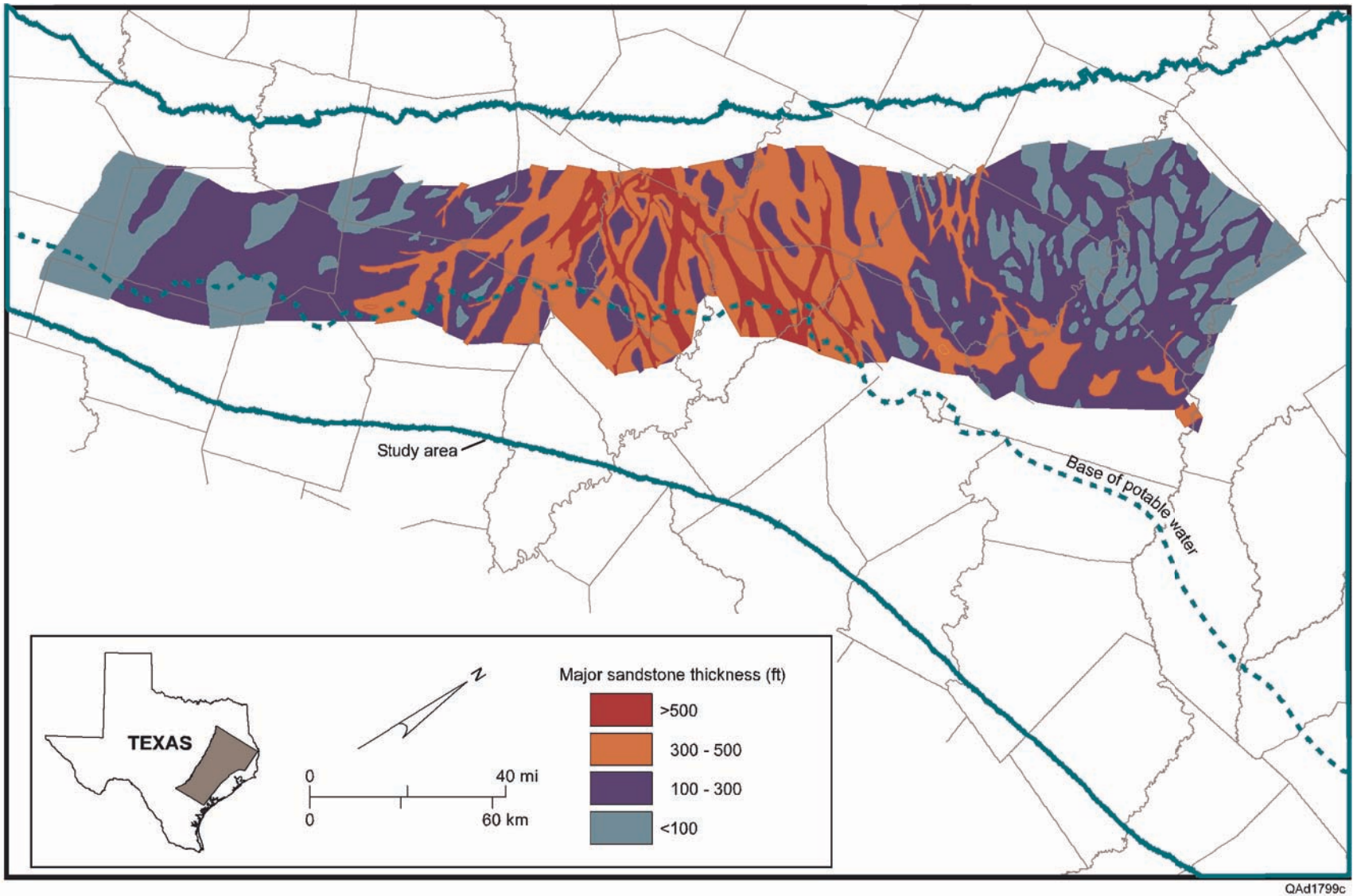


Figure 12. Thickness of major sandstones in the Simsboro Formation in the study area. Modified from Ayers and Lewis (1985).

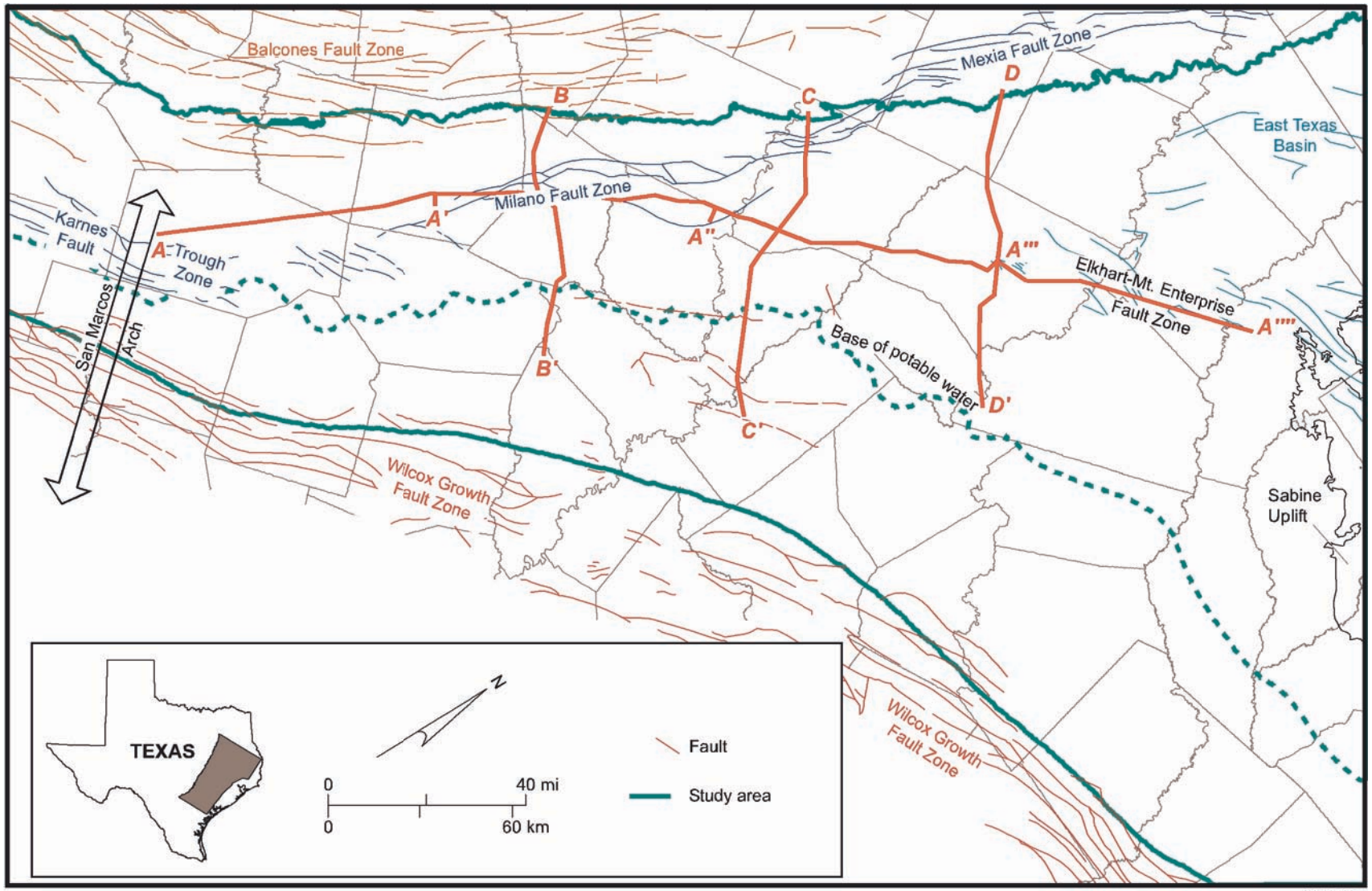


Figure 14. Geologic structure in the study area. Modified from Ewing (1990). Lines of sections shown in figures 15 and 16.

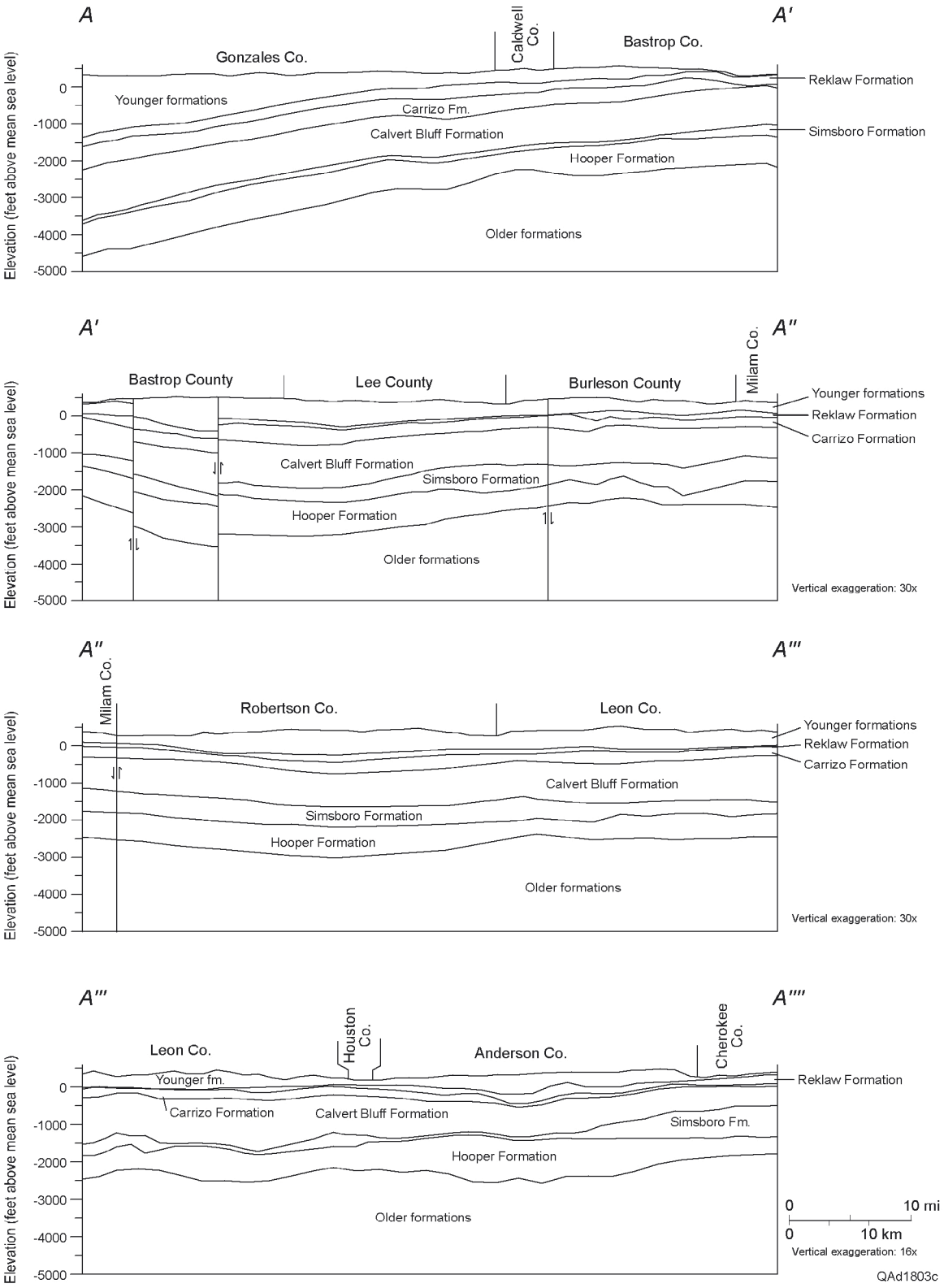


Figure 15. Vertical strike-oriented profile of the formations making up the Carrizo–Wilcox aquifer and adjacent formations. Strike section A–A⁗ shown in figure 14.

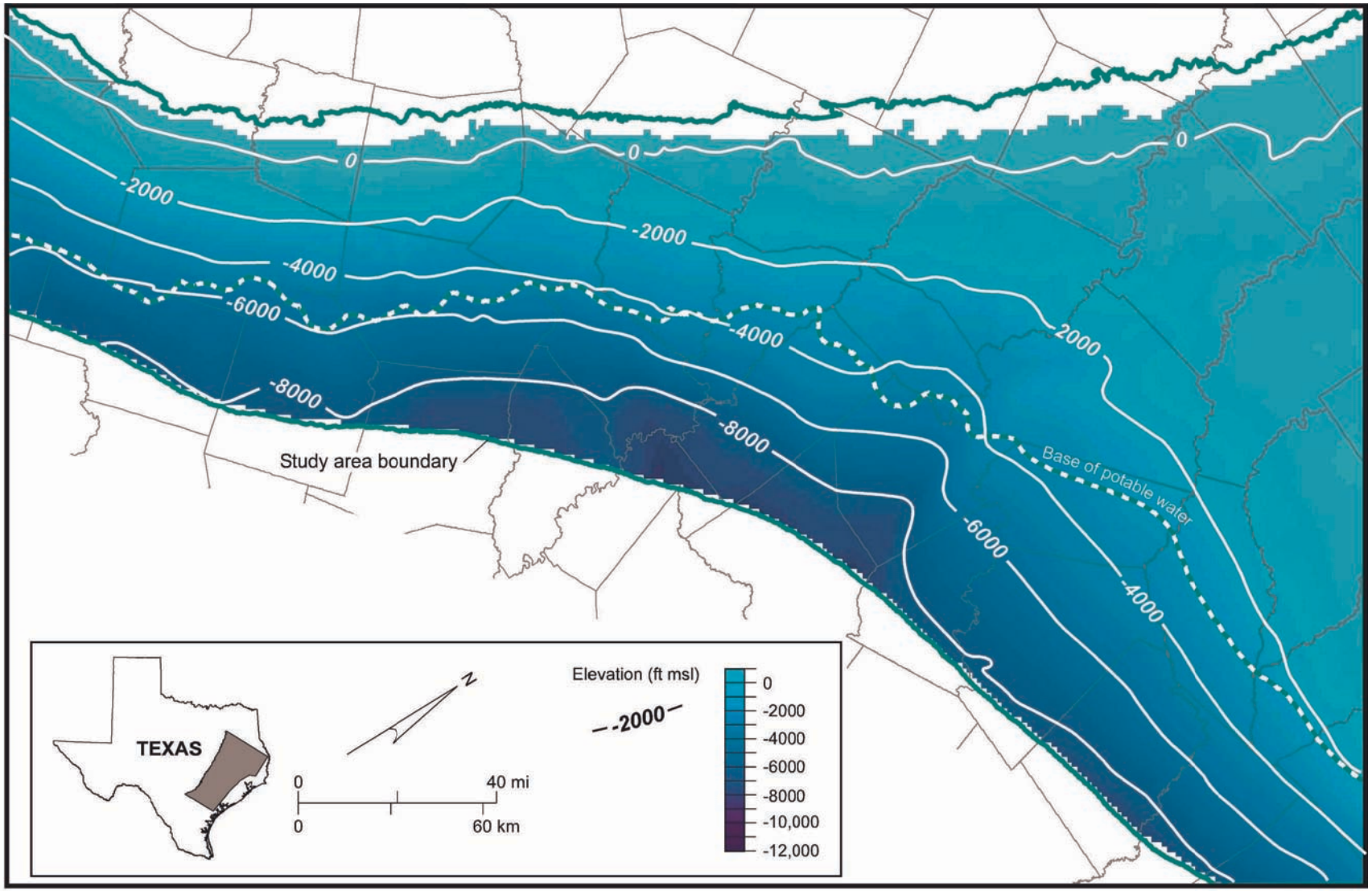


Figure 19. Elevation of the base of the Calvert Bluff Formation (top of Simsboro Formation).

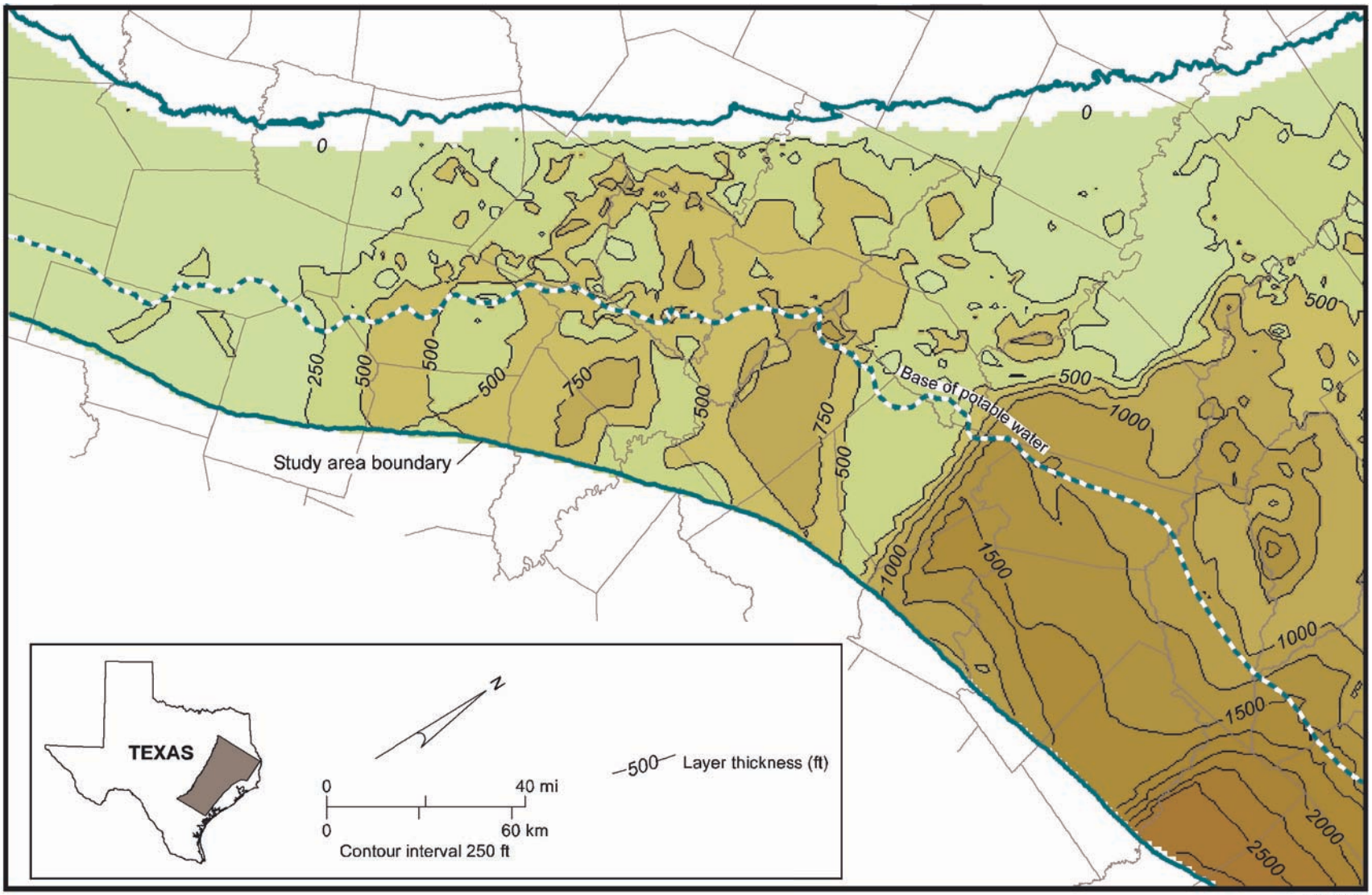


Figure 24. Total thickness of the Simsboro Formation.

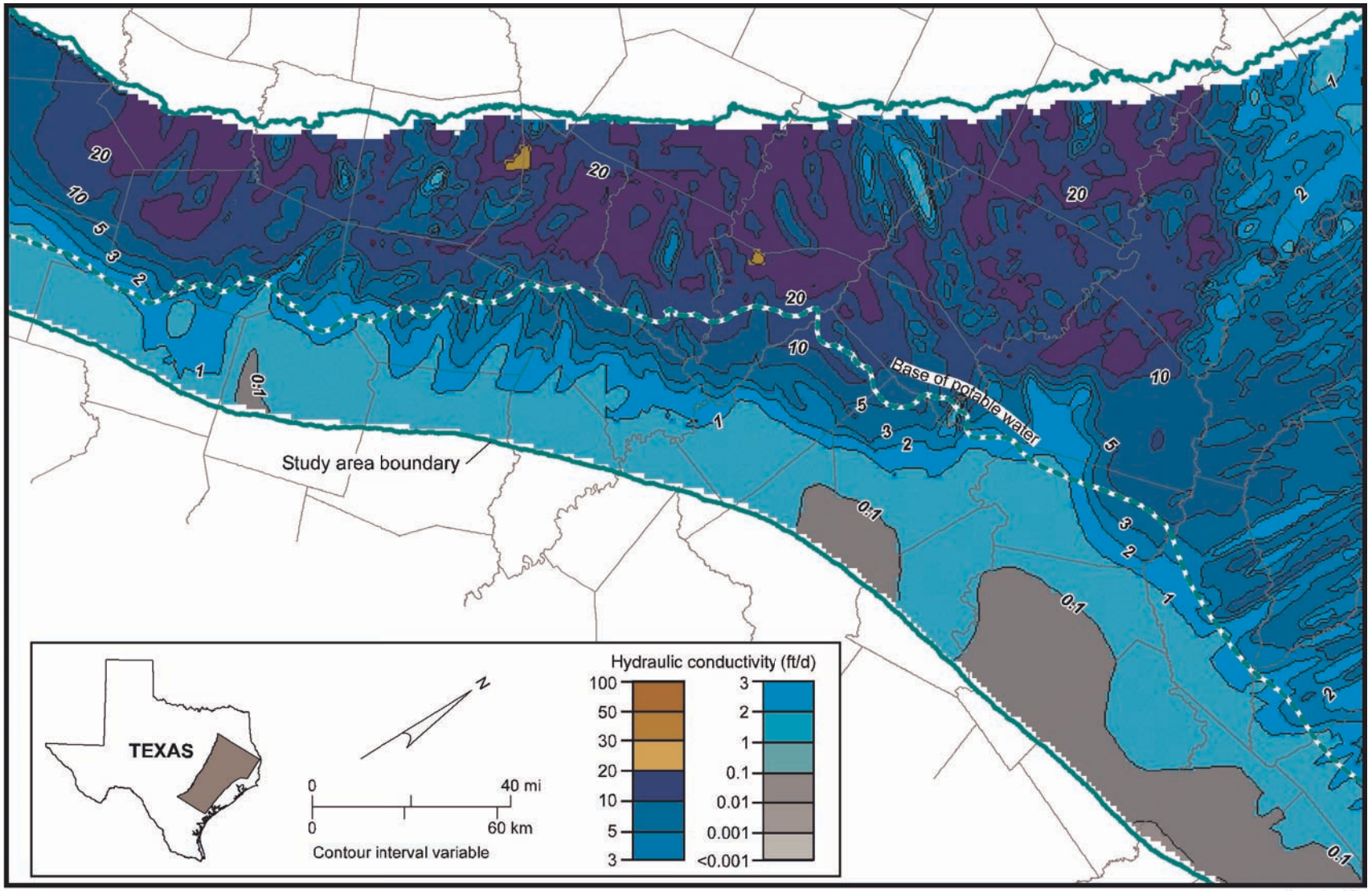


Figure 49. Map of average hydraulic conductivity in the Simsboro Formation. Method of calculation described in text.

ATTACHMENT 3 –
SELECTED REFERENCES

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