# Trinity Aquifer Characterization and Groundwater Availability Assessment Burnet County

Prepared by

Central Texas Groundwater Conservation District

and

Tom Partridge P.E.

May 2011

**Tom Partridge, P.E.**
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**Jonestown, Texas 78645**
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May 6, 2011

Mr. John Simmons, President
Central Texas Groundwater
Conservation District
P.O. Box 870
Burnet, Texas 78611

Re: Delivery of Trinity Aquifer Report

Dear Mr. Simmons,

This report was prepared by Tom Partridge, P.E. in direct cooperation with the District, as per contracts dated April 15, 2009 and March 5, 2011.

I have enjoyed working with the District in the preparation of this Report.

Sincerely,

STATE OF TEXAS
TOMMY R. PARTRIDGE
55072
REGISTERED
PROFESSIONAL ENGINEER

5/6/2011

Tommy R. Partridge, P.E. #55072
Engineering Firm No. 5812

# TABLE OF CONTENTS

## Executive Summary

The Central Texas Groundwater Conservation District ("District") was created in 2005 by the 79th Legislature with a directive to conserve, preserve, protect, and recharge the groundwater resources of Burnet County, and to prevent waste and degradation of quality of those groundwater resources.

The Board of Directors adopted a Management Plan (Plan) on April 16, 2007. The Texas Water Development Board (TWDB) issued a certificate on July 3, 2007 declaring the Plan to be in compliance with Texas Water Code §36.1071 and TAC 356.

The Plan identified the Trinity aquifer as the only major aquifer in the District, subdivided as follows:

(1) Upper Trinity aquifer – Paluxy + Glen Rose
(2) Middle Trinity aquifer – Hensell
(3) Lower Trinity aquifer – Hosston

The aquifer(s) were assigned as four layers in the Groundwater Availability Model (GAM) assessment as the Paluxy, Glen Rose, Hensell and Hosston. Each layer was assigned a drawdown as a selected management condition.

In January of 2009 the District began identifying strategic locations for monitoring wells and contacting land owners to obtain permission to install the wells. The plan was to have a "three well cluster" at various locations to monitor the Upper, Middle and Lower Trinity.

In April the District enlisted the help of Tom Partridge, P.E. to provide hydrogeologic support to the project. On April 23, 2009, drilling began on a well (Smith 2) approximately 50 feet east of an existing (Smith 1) Glen Rose well (Upper Trinity) in the north east corner of the District near Oakalla. Intentions were to drill through the Hensell layer of the Trinity (Middle Trinity), noting the base, and complete a well in the Hosston layer of the Trinity (Lower Trinity). A second well would then be completed in the Hensell layer. This would provide three Trinity water level monitor wells at this location. However, the Middle Trinity was found to be underlain by the Smithwick Shale at 360 feet. Drilling continued to 700 feet with no indication of the Lower Trinity being present.

Still in search of three layers of the Trinity aquifer, subsequently the decision was made, to drill a well approximately twelve miles west of the Oakalla location (Jeffcoat 1). Drilling commenced on May 7, 2009. The Glen Rose limestone was found to overlie the Ellenburger at 180 feet. The Middle and Lower Trinity were both absent. The well was completed in the Ellenburger at 640 feet. The results of these two wells were inconsistent with the Management Plan, indicating the Plan required updating.

In total, the District supervised the drilling, completion and installation of ten monitoring wells beginning April 23, 2009 with the Smith 1 well and concluding July 27, 2009 with the Robinson well to assess the Trinity aquifer within the District. Additionally, a more detailed review of available literature and existing well data for the Trinity aquifer was conducted.

This report provides updated information in regard to the hydrogeology and the available groundwater associated with the Trinity aquifer in the District, and provides the basis for updating the Management Plan.

## 1.0 Introduction

The Central Texas Groundwater Conservation District ("District") was created in 2005 by the 79th Legislature with a directive to conserve, preserve, protect, and recharge the groundwater resources of Burnet County, and to prevent waste and degradation of quality of those groundwater resources. The boundaries of the District are coextensive with the boundaries of Burnet County. The citizens of Burnet County confirmed creation of the District by an election held on September 21, 2005.

The Board of Directors adopted a Management Plan (Plan) on April 16, 2007. The Plan was sent to the Texas Water Development Board (TWDB). The TWDB issued a certificate to the District on July 3, 2007 declaring the Plan to be administratively complete and in compliance with Texas Water Code §36.1071 and TAC 356.

The Plan identified the Trinity aquifer as the only major aquifer in the District. The Trinity aquifer outcrops in essentially the eastern part of the District (Figure 1). The geologic and hydrologic units are shown on Table 1. The Trinity is overlain at the higher inter-stream elevations by the Fredericksburg Group consisting primarily of the Walnut Formation which is not a source of groundwater.

The Plan identified three Trinity aquifer subdivisions as follows:

(4) Upper Trinity aquifer – Paluxy + Glen Rose

(5) Middle Trinity aquifer – Hensell

(6) Lower Trinity aquifer – Hosston

The aquifer(s) were assigned as four layers in the Groundwater Availability Model (GAM) assessment as the Paluxy, Glen Rose, Hensell and Hosston. Each layer was assigned a drawdown as a selected management condition.

In January of 2009 we began identifying strategic locations and contacting land owners who were willing to allow us to drill and equip monitor wells within the Trinity aquifer. Our plan was to have a “three well cluster” of water level monitor wells at various locations throughout the District. Each cluster would provide water levels within each of the three layers of the Trinity (upper, middle and lower). On March 27, 2009 we installed monitoring equipment in an existing Glen Rose well (upper Trinity) in the north east corner of the District near Oakalla, Texas.

In April we enlisted the help of Independent Consulting Engineer Tom Partridge, P.E. to provide the technical hydrologic experience needed for the project. On April 23, 2009 we began drilling a well (Smith 2) approximately 50 feet east of the existing well at Oakalla. Our intentions were to drill to whatever depth required to drill through the Hensell layer of the Trinity (middle Trinity), noting the base, and complete a well in the Hosston layer of the Trinity (lower Trinity). We would then drill a second well and complete it in the Hensell layer, based on the information noted during the drilling of the Hosston well. This would provide three Trinity water level monitor wells at this same location (the three well clusters). However, the Middle Trinity was found to be underlain by the Smithwick Shale, which was found at 360 feet. We decided to keep drilling to see how thick it may be and what if anything is below. We finally quit drilling at 700 feet with no indication of a change.

As drilling continued through the Smithwick Shale Tom began to compare the information we were getting from the drilling with the information in Report 195[i] from the Texas Water Development Board that supported our findings, which was that the Glen Rose directly overlaid the Paleozoic rocks.

Still in search of three layers of the Trinity aquifer, we decide to drill a well approximately twelve miles west of the Oakalla location (Jeffcoat 1). On May 7th the drilling provided more questions than answers. We begin drilling with Glen Rose limestone at the surface followed by Ellenburger at 180 feet. No Hensell!! We completed the well at 640 feet with an estimated yield of 100 gallons per minute (gpm). This certainly doesn't fit with what we have in the Management Plan or anything else with the exception of Report 195.

District staff supervised the drilling, completion and installation of ten monitoring wells beginning April 23, 2009 with the Smith 1 well and concluding July 27, 2009 with the Robinson well to assess the Trinity aquifer within the District. Further, a more detailed review of available literature and existing well data for the Trinity aquifer was also conducted. The information contained in this report is not intended to provide the discovery of new information about the Trinity aquifer but to support the information contained in publications referred to in this report.

The assessments indicate that the District Management Plan needs to be updated to reflect the data and information contained in this report.

The District Management Plan established 3,600 acre feet per year as the volume of annual available groundwater for the Trinity aquifer in the District. This report provides updated information in regard to available groundwater within the Trinity aquifer in the District.

## 2.0 Monitoring Well Program

The ten monitoring wells installed in the Trinity aquifer area are shown on Figure 2. Seven of these wells were installed in the Trinity aquifer; three were installed in the Ellenburger aquifer, which underlies the Trinity. Six of the seven Trinity wells and two of the three Ellenburger wells have programmable water level transducers installed. Generally, the transducers record the water level hourly. The District has also installed a transducer in a well which records the change in barometric pressure. This provides the ability to correct water level readings by removing the influence of changes in barometric pressure. Also shown on Figure 2 are six existing wells which the District equipped with programmable water level transducers.

The details of construction for the monitoring wells installed by the district are given in Table 2. Ground surface elevations were determined via GPS and USGS topographic data installed on ArcView. The ArcView appeared more reliable. Lithologic logs for the wells are provided in Attachment A.

## 3.0 Privately Owned Wells

Privately owned wells installed since the year 2000 are shown on (Figure 3). Of these, approximately 600 Texas Department of Licensing and Regulations well reports were reviewed for the development of this study. These Well Reports almost always include basic information such as well location (latitude and longitude) well depth, packer depths, completion interval and lithologic log. The reports will quite often include ground elevation determined by GPS, estimated well yield, and depth to water. Where the well reports contain useful data, but do not include ground elevation, ArcView was used to assign the ground surface elevation. The lithologic logs vary greatly in usefulness. Some logs contain a relatively definitive description, while others provide little useful data. Some have ground elevation and depth to water, but the lithologic log is poor. However, the most limiting feature of the well reports is that most of the wells were drilled for individual home use, and were terminated when an adequate supply was found. Also, if the well produced greater than about 50 gallons per minute (gpm), the depth may have been limited by the inability of the air compressor to lift the water. Thus, in many cases, the deeper formations were not penetrated. Conversely, the wells penetrating the deeper formations are the lower producers because drilling was continued looking for an adequate supply.

The primary data developed from the well reports are bed boundary elevations. Ground water elevation data are useful, except the elevation applies only to the date the well was completed, or the pump was installed. Bed boundary elevations were averaged for each of the Texas grid cells. The average value was assigned to the center of the cell. Consequently, these data supplement the data from the monitoring wells installed by the District and are not specific data control points. It is noted that the ground elevation for the monitoring wells (Table 2) were also determined from ArcView.

In summary, the maps presented later in this report were derived using ArcView for elevation control. The contour interval on ArcView is 20 feet. Therefore, general smoothing (i.e. averaging) was applied to the contouring. The resulting maps were then reviewed for general reasonableness and were also compared to the available maps from the literature. Maps from Klemt, et. Al., 1975, and Duffin and Musick, 1991, are included in this report. Although not included in this report, Figures 6 & 8 from Ashworth, 1983 are indicative along strike of the

Trinity Group underlying the Hill Country. The Trinity Group underlying Burnet County is generally similar to that underling southern Gillespie and northwestern Kendall County.

## 4.0 Geologic Setting

The geologic setting affecting groundwater in the District is geologic history and structure. The Trinity aquifer was deposited during a major transgression marked by several minor regressions during the early Cretaceous period. This resulted in the present day sequence of sandstone, shale and limestone comprising the Trinity aquifer (Burne & Duffin, 1983).

Structurally, the dip of the Trinity beds is east/southeast. Klemt, et.al (1975) presents a map (Figure 4) showing the approximate altitude of the base of the Antlers & Travis Peak formations (i.e. the base of the Trinity). The same map (Figure 5) was developed using District well data, and is similar.

Hydrogeologic cross-sections (Figures 6, 7, & 8) depict the distribution of the Trinity beds within the District. Cross-section locations are shown on Figure 4. The cross-sections support Klemt, et.al. (1975), from the standpoint that in the northwestern part of the Trinity aquifer area, the Glen Rose directly overlies the Ellenburger, with the Hensell Sand and Cow Creek Limestone not being present. Although not depicted on the cross-sections, there are areas in the western part of the Trinity aquifer area where the Cow Creek is not present, and the Hensell directly overlies the Ellenburger. Also, in the southeastern part of the District, the Hensell is less well defined lithologically. And, near the Hensell outcrop in the general area of SH-1431, the unit may be only partially saturated.

The eastern part of the Trinity area is underlain by, for the purpose of this report, undifferentiated Smithwick Shale/Marble Falls Limestone. Brune and Duffin (1983) describe as expected, underlying Travis County, the Smithwick overlying the Marble Falls, which in turn overlies the Ellenburger. They report the depth of the Ellenburger to be 4,000 feet below land surface in western Travis County. Adkins and Arick (1930), report Smithwick overlying the Marble Falls in western Bell County. Thus, since the Ellenburger is present in the western part of the Trinity area, the Marble Falls should be present to the east. It is noted that the driller identified the samples below 695 feet in the Mattingly well as Marble Falls. However, the samples did not react to hydrochloric acid. Whichever formation is actually present, it is not a producer of groundwater. The approximate subsurface boundary between the Ellenburger and Smithwick/Marble Falls is shown on Figure 9.

The District Management Plan also indicates the Hickory aquifer underlies almost all of the Trinity area. None of the wells installed have penetrated the Hickory. Thus, it is probably too deep to be practically accessible with a typical air rotary drilling rig. If the Ellenburger is 4,000 feet below ground in eastern Burnet County, the Hickory is even deeper.

## 5.0 Trinity Aquifer Subdivisions

### 5.1 Hosston

As shown on the hydrogeologic cross-sections, the Hosston is present in the extreme eastern and southeastern part of the District. The outcrop equivalent of the Hosston is the Sycamore Sand, which outcrops along the Colorado River (Figure 1). Well yields are often small, generally less than 20 gallons per minute (gpm). Brune and Duffin, (1983) characterize the unit as generally non- water bearing, except beneath the surface of Lake Travis where more permeable facies exist. The well data from southeastern Burnet County appear to support their conclusion. The Hosston, some distance north of Lake Travis, is generally thin and not a significant source of groundwater. The Hosston at the Mattingly well (Well No. 6) produced no measurable groundwater. The Hosston was not found in the western or northwestern part of the Trinity aquifer area of the District.

The Hosston is not considered a significant source of groundwater in the District.

### 5.2 Cow Creek Limestone Member

The Cow Creek ranges in thickness from 35 feet in the west to about 140 feet in the east. The Cow Creek is defined as the interval from the base of the Hensell Sand to the Hosston or the Ellenburger/Smithwick.

The Cow Creek, being below the Hensell sand is saturated, but yielded no significant groundwater during drilling of the District wells.

The Cow Creek is not considered a significant source of groundwater in the District.

### 5.3 Hensell Sand Member

The Hensell Sand is the primary source of groundwater in the Trinity aquifer of the District. Except for wells completed in the Ellenburger below the Trinity in the western part of the Trinity area, the vast majority of wells are completed in the Hensell.

The altitude of the top of the Hensell Sand is shown on Figure 10 (Klemt, 1975). Shown on Figure 11 is the top of the Hensell based upon District well data. The only significant difference is the area where the Hensell is not present. The thickness of the Hensell is shown on Figure 12.

Well yields in the Hensell are generally in the range of 10-40 gpm (Figure 13). However, along the Hwy. SH-29, well yields are frequently estimated to be greater than 50 gpm, and even up to 100+ gpm. A City of Burnet well was operated at 250 gpm for short periods (Mount, 1963). Grain size distribution curves from the Brown No. 1 well and the Smith No. 2 well are provided in Attachment B. The sample from the Brown well is coarser and generally supports the higher well yields along SH-29.

The altitude of water levels in the Hensell Sand are shown for spring, 1967 after Klemt, 1975 (Figure 14). A similar map was prepared by Duffin & Musick, 1991 for spring, 1986 (Figure 15). They also prepared the map (Figure 16), which shows groundwater from the Trinity flowing east and southeast toward cones of depression in Williamson and Travis counties. A water elevation map for summer, 2009, using District well data is shown on Figure 17. It is noted that the lower groundwater gradient along SH-29 on the water level maps for 1986 and 2009 generally support the area of higher well yields (Figure 13).

It is difficult to compare water level changes using maps with 100 ft. contour intervals. Therefore, a common point was selected for all three maps, and is the location of the 849 ft. reading on the Duffin & Musick Map (Figure 15). The readings are approximately as follows: 1967 – 900 ft., 1986 – 849 and 2009 – 850. Thus, it appears water levels declined about 50 ft. from 1967 to 1986, but have since remained about the same.

It is noted the District has water level probes in both the Smith (Well No. 1) and Fischer (Well No. 9) wells to monitor future changes.

## 5.4 Glen Rose Limestone

The Glen Rose overlies the Hensell Sand and is a limited source of groundwater in the District. The primary limitation is saturated thickness. The potentiometric head above the Hensell Sand is shown on Figure 18. As shown, the water level in the Hensell is below the top of the sand in the south central part of the Trinity area. Specifically, the water level in the Mattingly and Simmons wells were below the top of the sand. Thus, the overlying Glen Rose in this area is “probably” un-saturated.

At the Smith well (Well No. 1) to the northeast, the water levels in the Glen Rose and Hensell are essentially the same. The Glen Rose yielded 10-15 gpm during the drilling of the monitoring well.

Thus, the Glen Rose is a source of groundwater in the District, but is dependent upon location.

## 5.5 Paluxy Formation

The Paluxy overlies the Glen Rose and is present in the upland inter-stream areas. The formation is thin and unrecognizable during drilling.

The Paluxy is not a source of groundwater in the District.

## 6.0 Available Groundwater

The District Management Plan establishes 3600 ac-ft/yr. as the groundwater available for permitting, while 35,749 ac-ft/yr. is Trinity Aquifer Recharge. The available groundwater is believed to be actually closer to the recharge value of 35,749 ac-ft/yr., as discussed below.

Mace, et.al. (2000) tabulated (Table 3) a summary of recharge rates as percent of rainfall in the Trinity aquifer in the Hill Country. A calibrated rate of 4% was used by the authors of the Mace Report.

Brune and Duffin (1983) used 4%, based upon Ashworth (1983), in their report to calculate recharge to the Trinity in western Travis County. It is noted Ashworth was included in the Mace tabulation given in Table 3.

LBG – Guyton Associates used 4% infiltration in combination with a recharge factor to account for actual precipitation to model the Trinity and Ellenburger in Gillespie County.

The area of recharge within the District for the Trinity aquifer is about 420,944 acres (memo, TCB, June, 2008). Using 4% infiltration as per the aforementioned reports, 30 inches for average annual precipitation (Tx. Dept. of Water Resources, Climatic Atlas, 1983), and the acreage above, the available groundwater is 42,094 ac ft/yr.

## 7.0 Conclusions

The following conclusions are drawn based upon the updated information.

1. The Trinity aquifer in the District is not comprised of four distinct and significant sources of groundwater as per the Management Plan. The Paluxy is clearly not a source of groundwater. The Hosston (Lower Trinity) is generally characterized by small well yields, and is geographically limited to the southeastern corner of the District. The Cow Creek is saturated with groundwater, but well yields are low and the formation is not considered a significant potential groundwater source. The Glen Rose Limestone is considered a source of groundwater. Well yields are sufficient for domestic and livestock use, but the formation is geographically limited due to being un-saturated or having a low saturated thickness.

   The Hensell Sand is the only areally extensive source of groundwater in the Trinity area except the northwestern corner where the Hensell is not present. The majority of Trinity wells are completed in the Hensell Sand.

   In summary, the Trinity aquifer in the District is comprised of one primary source of groundwater (the Hensell), with three subsidiary sources (Hosston, Cow Creek and Glen Rose). Thus, from a practical standpoint, the Trinity aquifer should be managed as a "single" aquifer, with well installation proceeding with the objective being to develop a water supply utilizing the aquifer(s) present at any particular location.

2. Recharge based upon 4% infiltration of precipitation is consistent with common practice. The available groundwater in the Trinity area of the District is on the order of 42,000 ac-ft/yr.

## 8.0 References

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Preston, R.D., Pavlicek, D. J., Bluntzer, R.L., and Derton, J., 1996, The Paleozoic and Related Aquifers of Central Texas, Texas Water Development Board Report No. 346, March 1996.

Texas Dept. of Water Resources, Climatic Atlas of Texas, LP – 192, December, 1983.

Turner, Collie, & Braden, Memo June, 2008.

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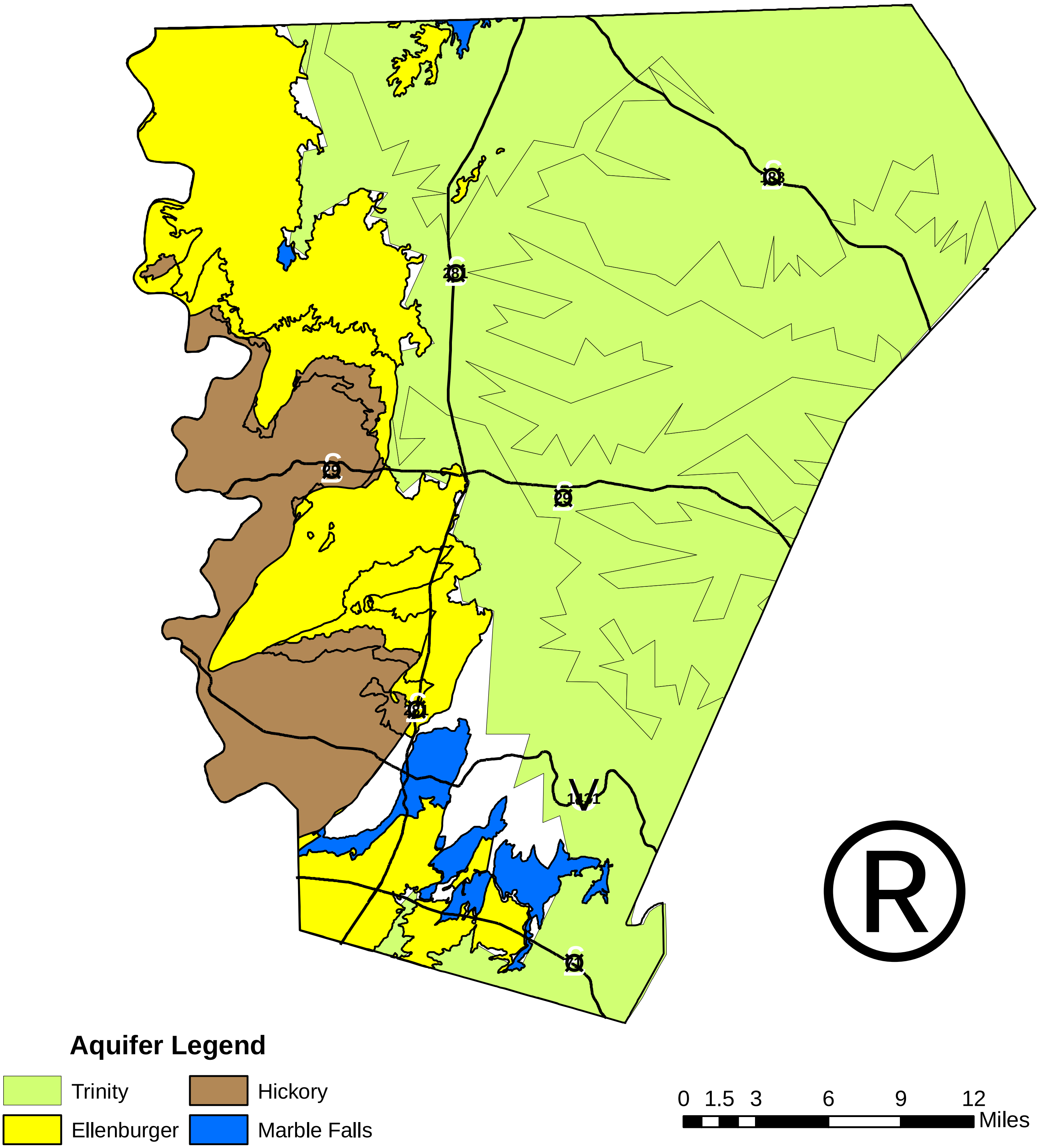
[i] Texas Water Development Board, *TWDB Report 195: Ground-Water Resources of Part of Central Texas with Emphasis on the Anglers and Travis Peak Formations* by William B. Klemt, Robert D. Perkins and Henry J. Alvarez, 1975.

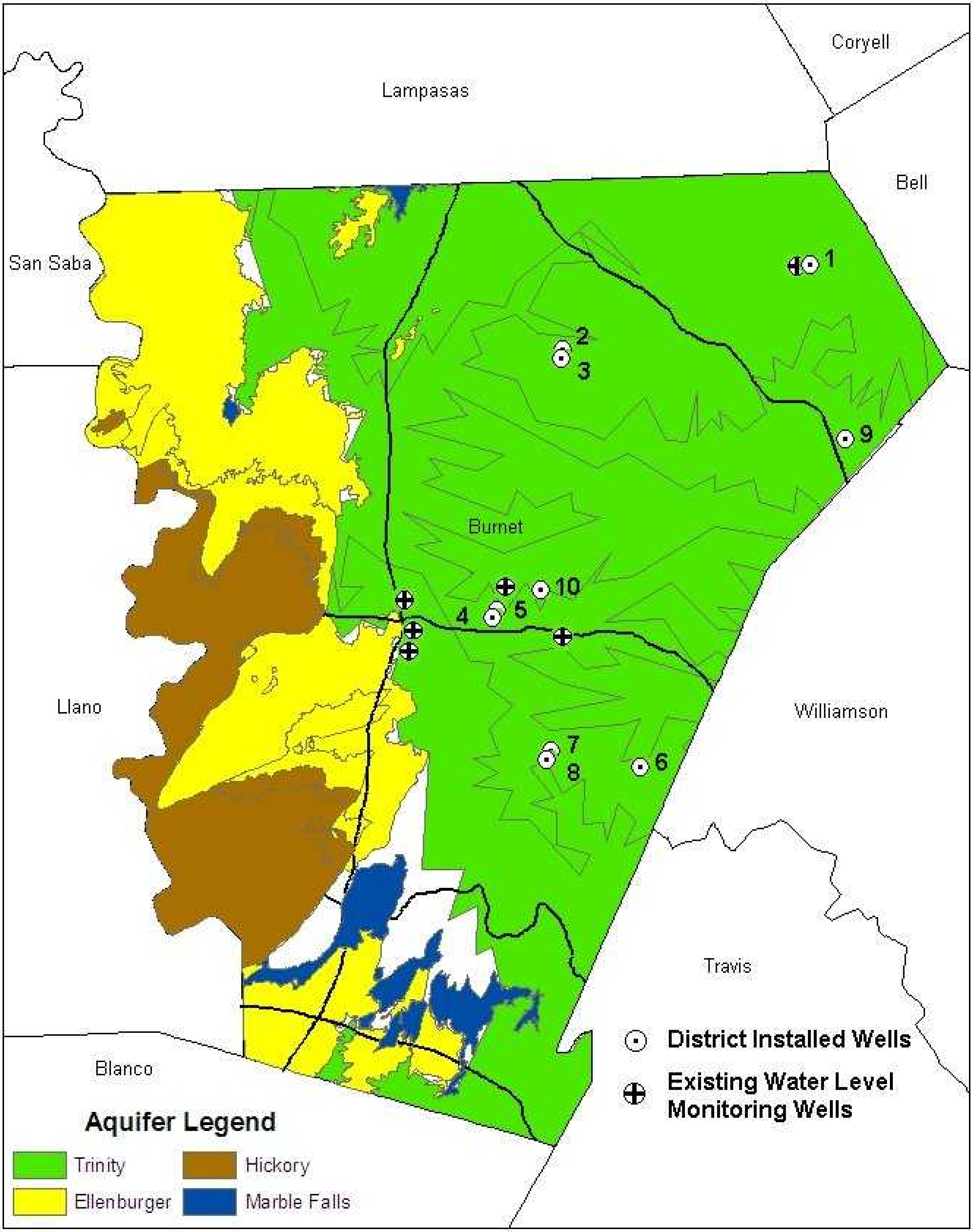
# LIST OF FIGURES

# Figure 1
# Aquifer Map

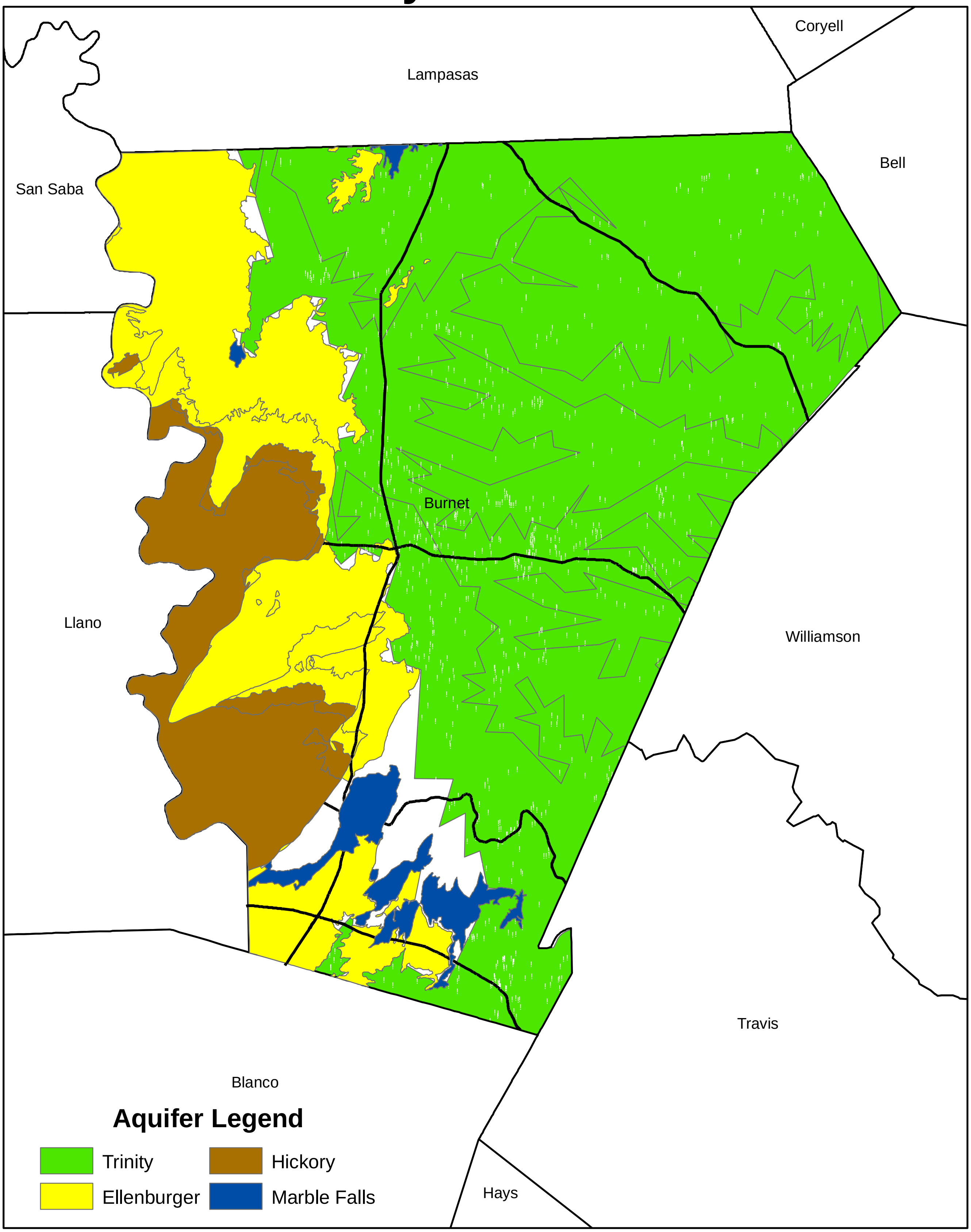


# Figure 2

# Monitor Well Locations

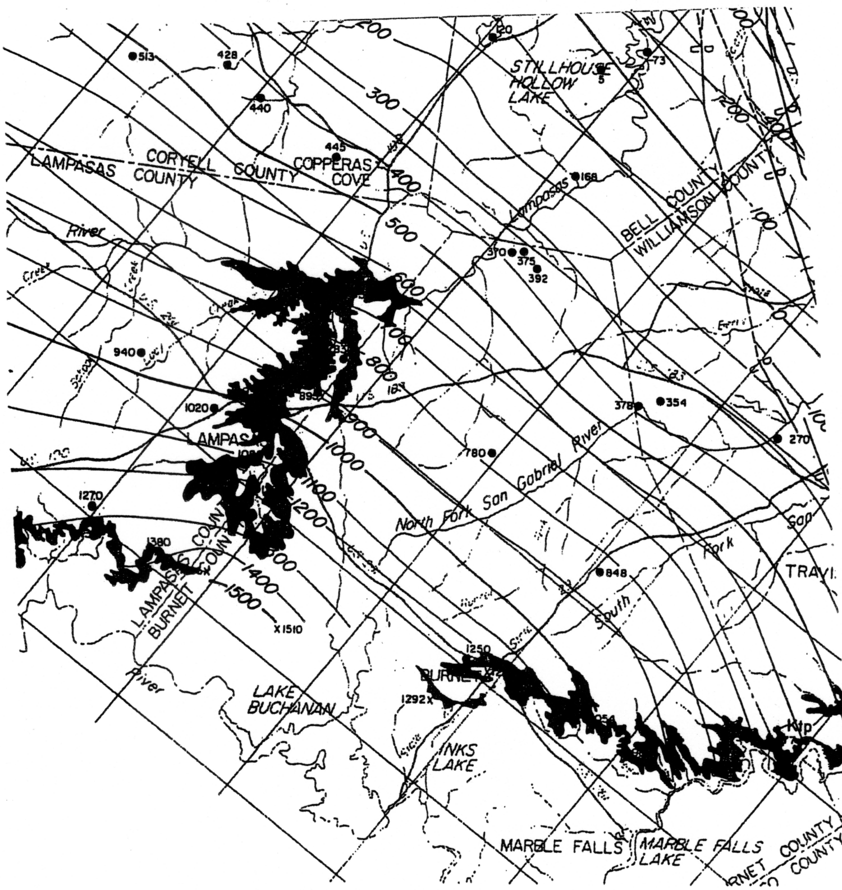


# Figure 3
# Privately Owned Wells



# Figure 4

## Approximate Altitude of the Base of the Antlers and Travis Peak Formations




EXPLANATION

845 e
Well used for control
Number indicates altitude of the base of the Antlers or Travis Peak Formations
"e" indicates estimated

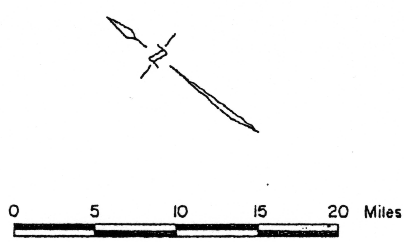
X
835
Outcrop control point

—— 100 ——
Line showing approximate altitude of the base of the Antlers or Travis Peak Formations
*Interval 100 feet*
Datum is mean sea level

Ka
Outcrop of the Antlers (Ka) and the Travis Peak (Ktp) Formations

Contact
Dashed where covered or approximately located

U
D
Fault
U, upthrown side; D, downthrown side
Dashed where approximately located



# FIGURE 5
## STRUCTURE MAP
## BASE OF TRINITY AQUIFER
## (i.e. Top of Paleozoic)

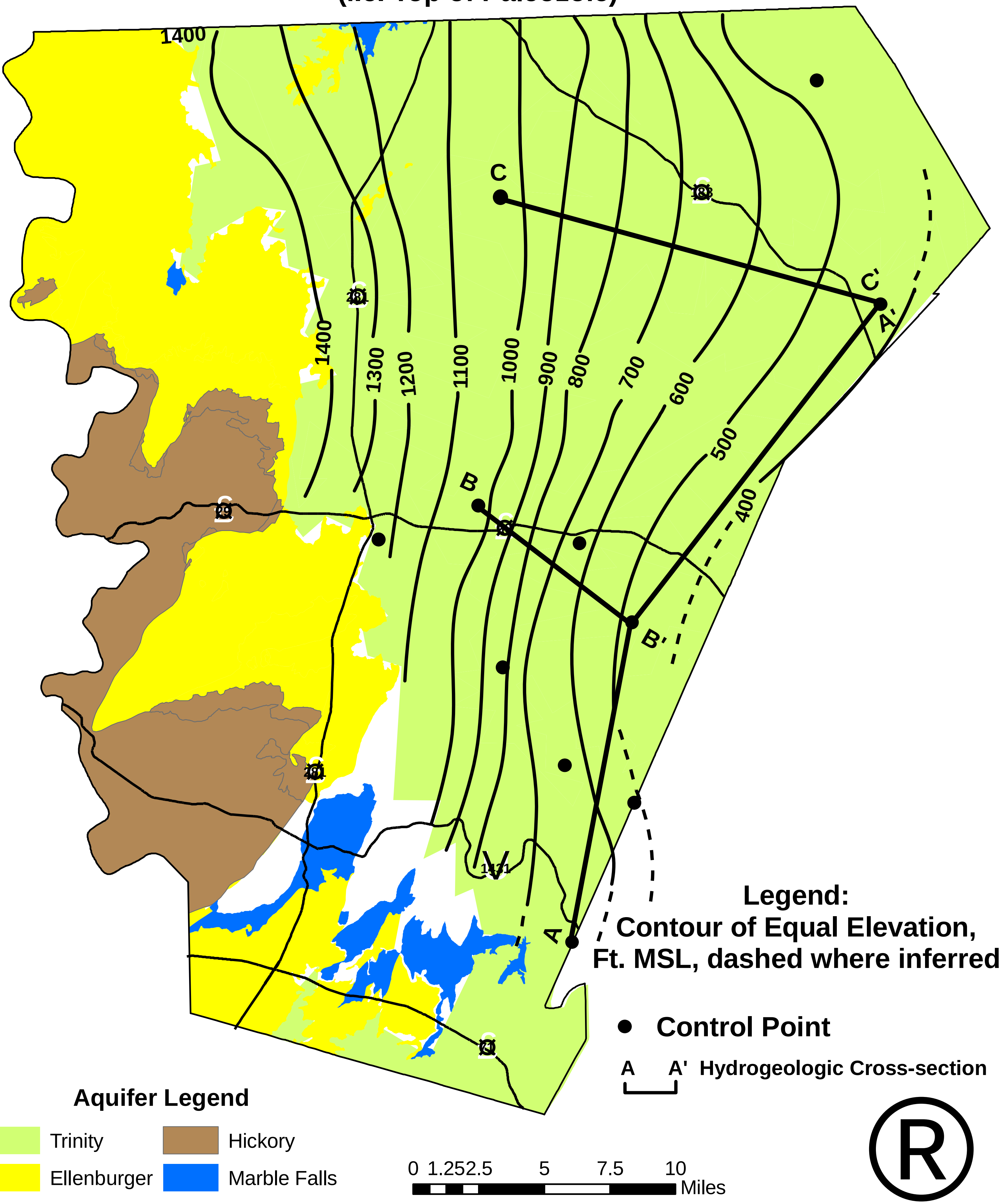
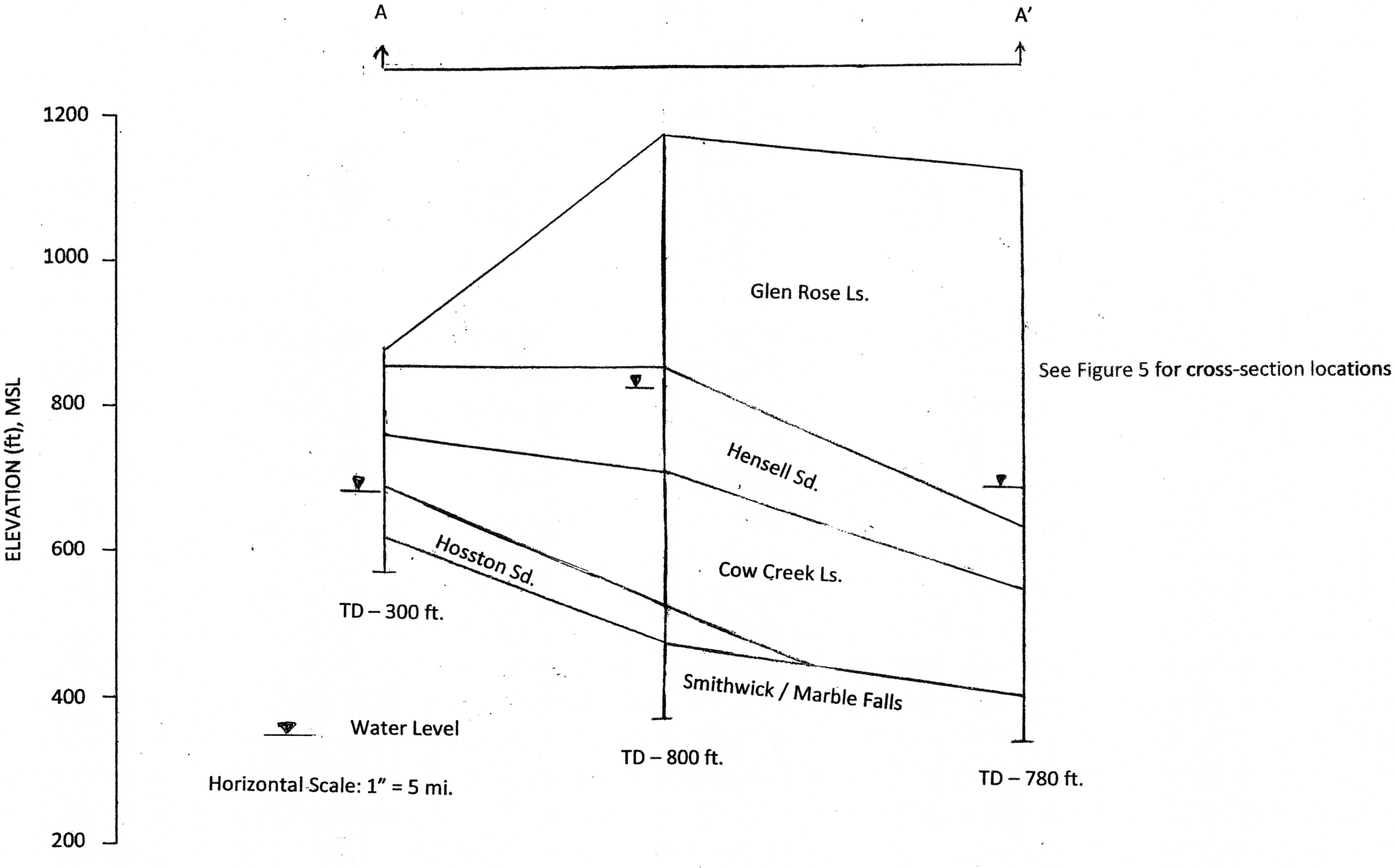
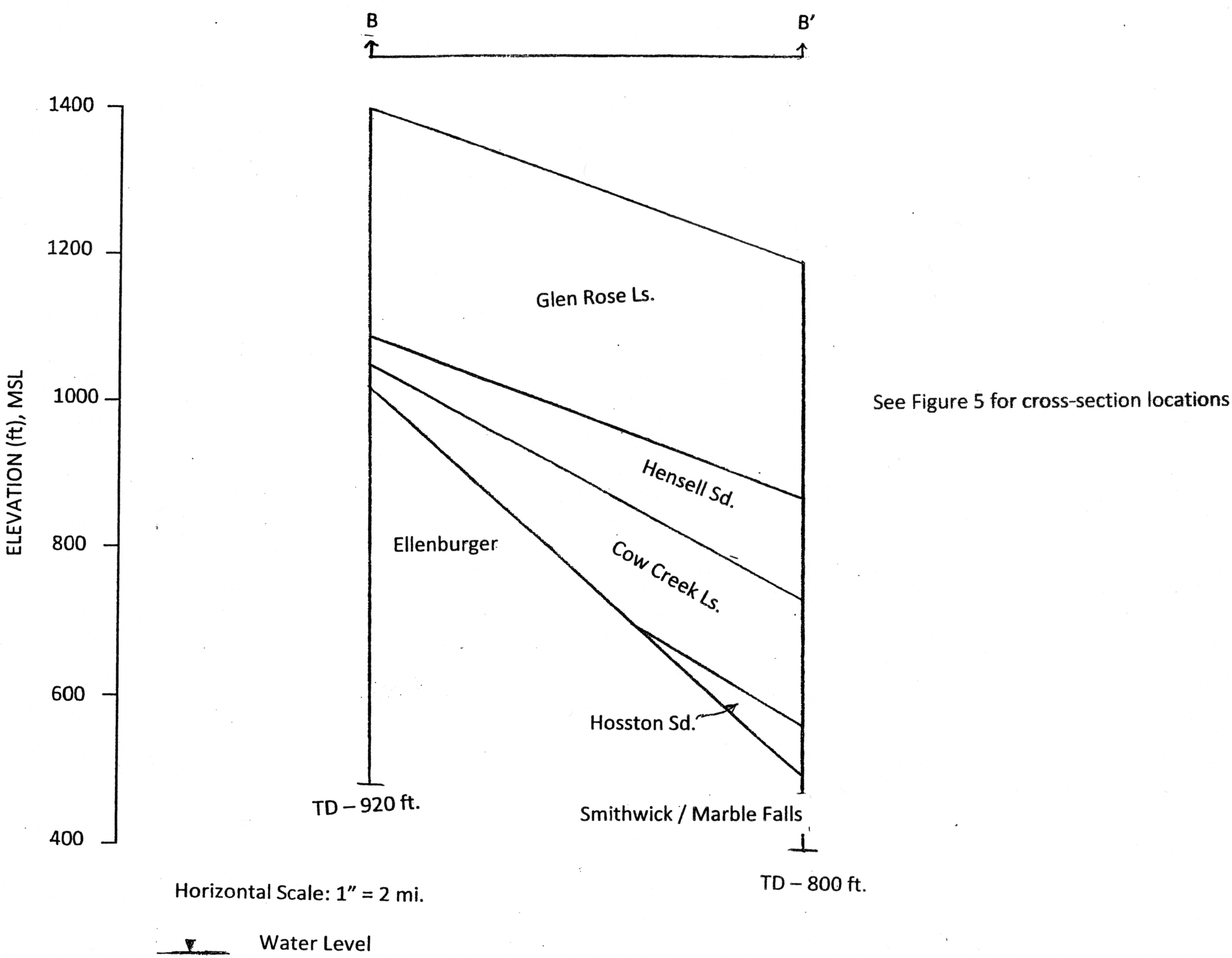


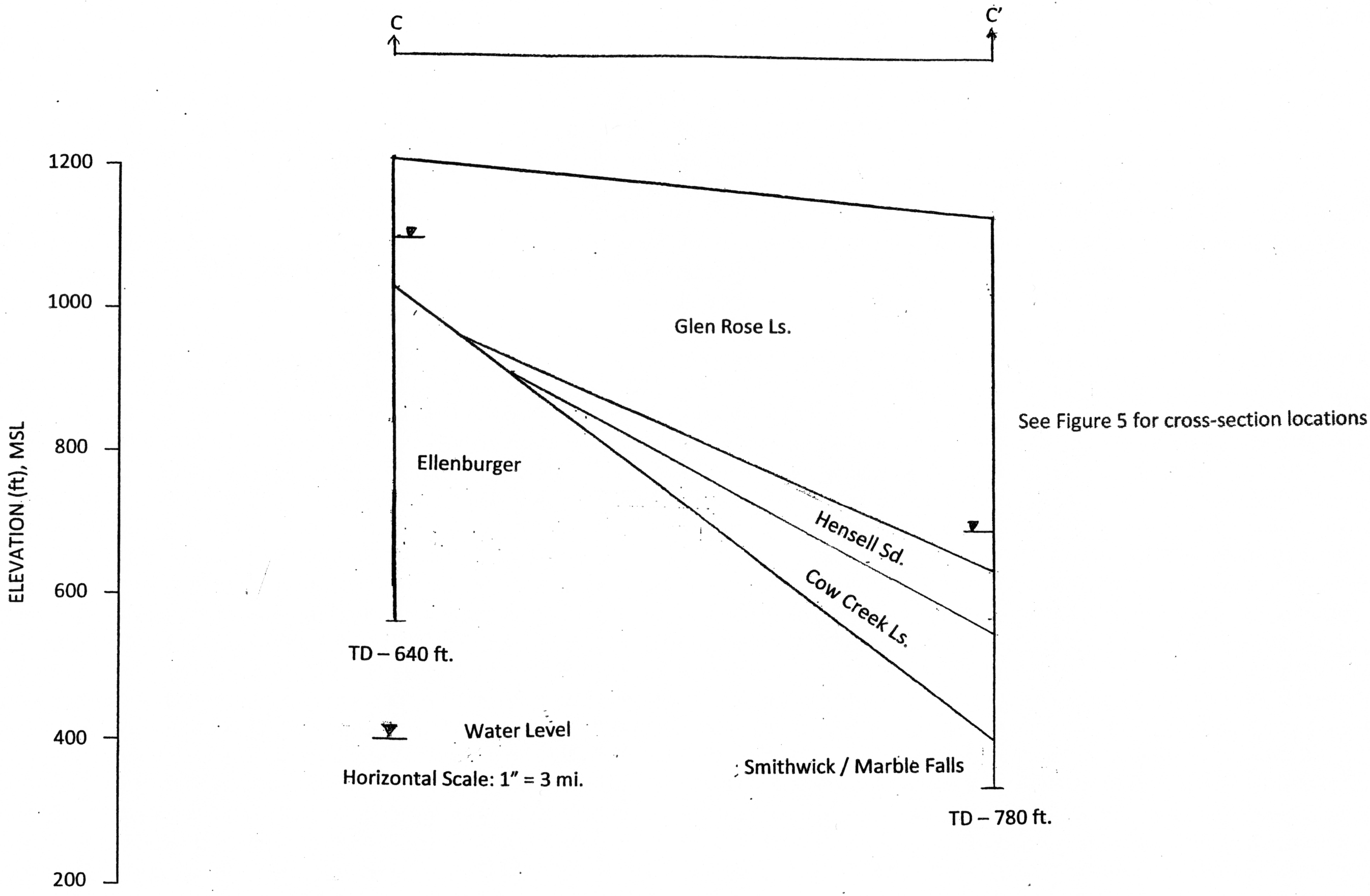
FIGURE 6
Hydrogeologic Cross-Section A – A'



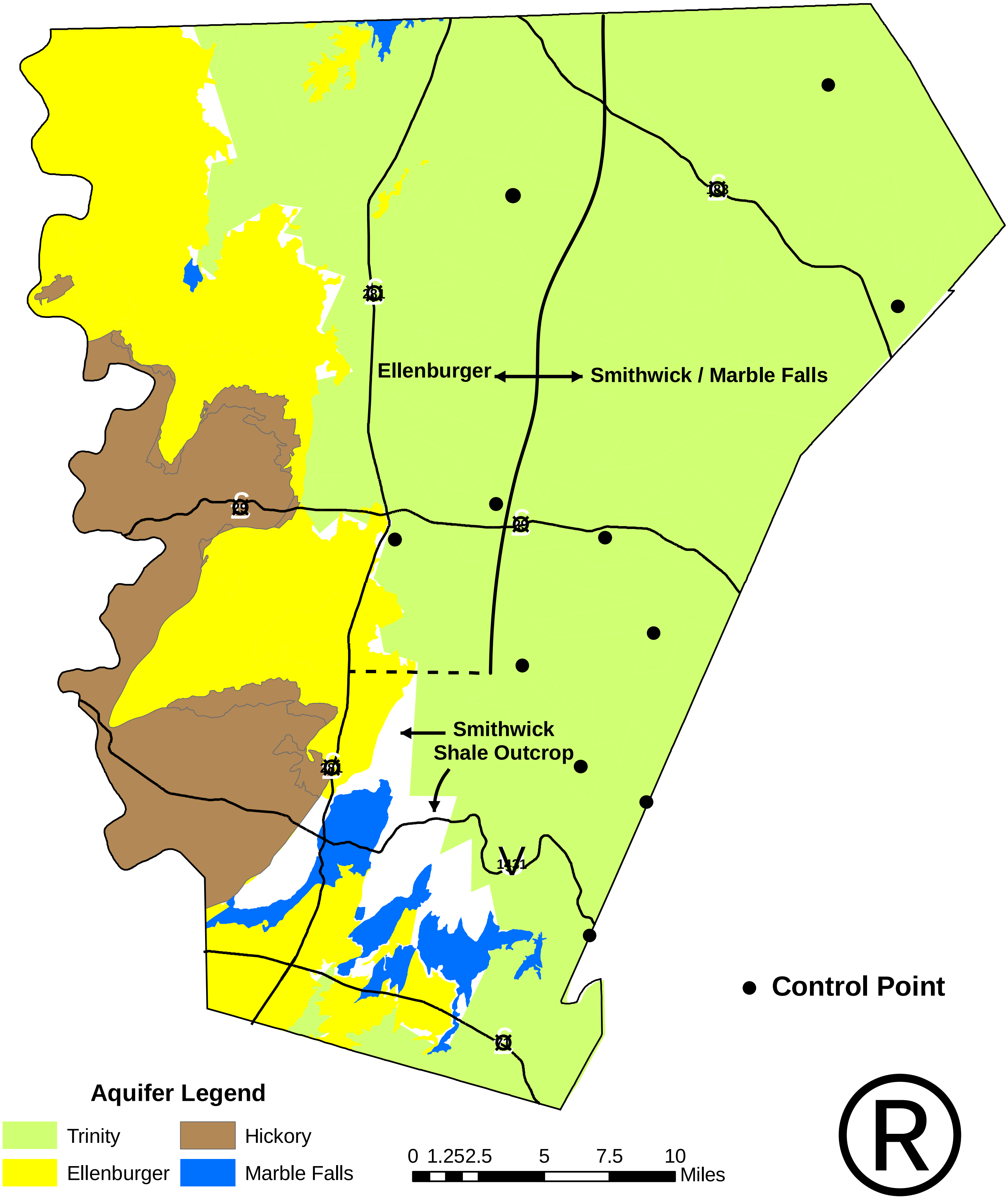
# FIGURE 7
## Hydrogeologic Cross-Section B – B'



## FIGURE 8
## Hydrogeologic Cross-Section C – C'

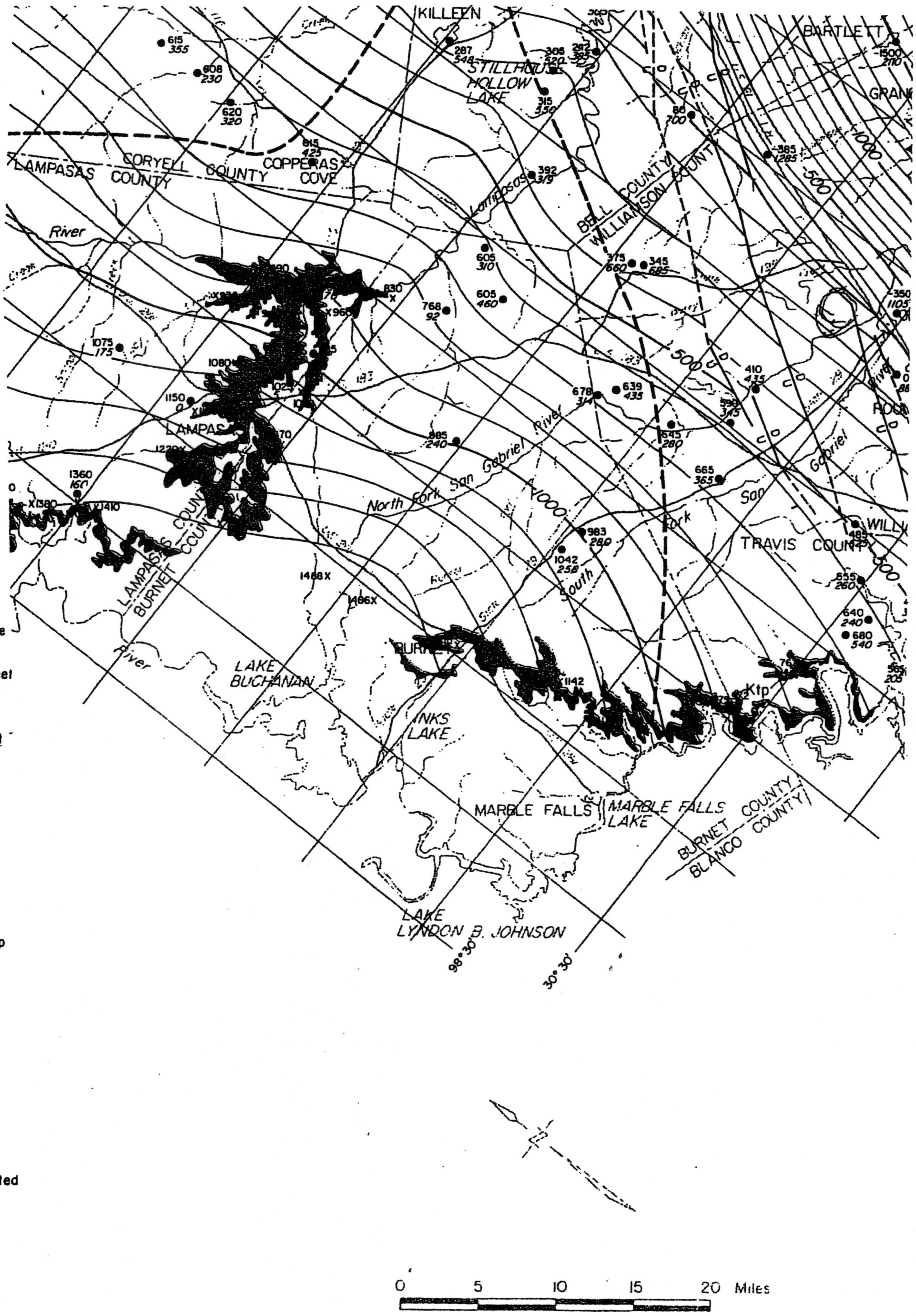


# FIGURE 9
## APPROXIMATE BOUNDARY
## (ELLENBURGER / SMITHWICK / MARBLE FALLS)



# Figure 10

## Approximate Altitude of and Depth to Top of the Travis Peak Formation




EXPLANATION

-895
1500

Well used for control
Top number indicates altitude of top of the Travis Peak Formation, (top of Hensell Member and top of calcareous facies), in feet above or below (−) mean sea level
Bottom number indicates depth to top of the Travis Peak Formation, in feet below land surface

x
1050

Outcrop control point
Number indicates altitude of top of the Travis Peak Formation, in feet above mean sea level

——900——

Line showing approximate altitude of top of the Travis Peak Formation
Interval 100 feet
Datum is mean sea level

Ka

Outcrop of the Antlers (Ka) and the Travis Peak (Ktp) Formations

Contact
Dashed where covered or approximately located

U
D

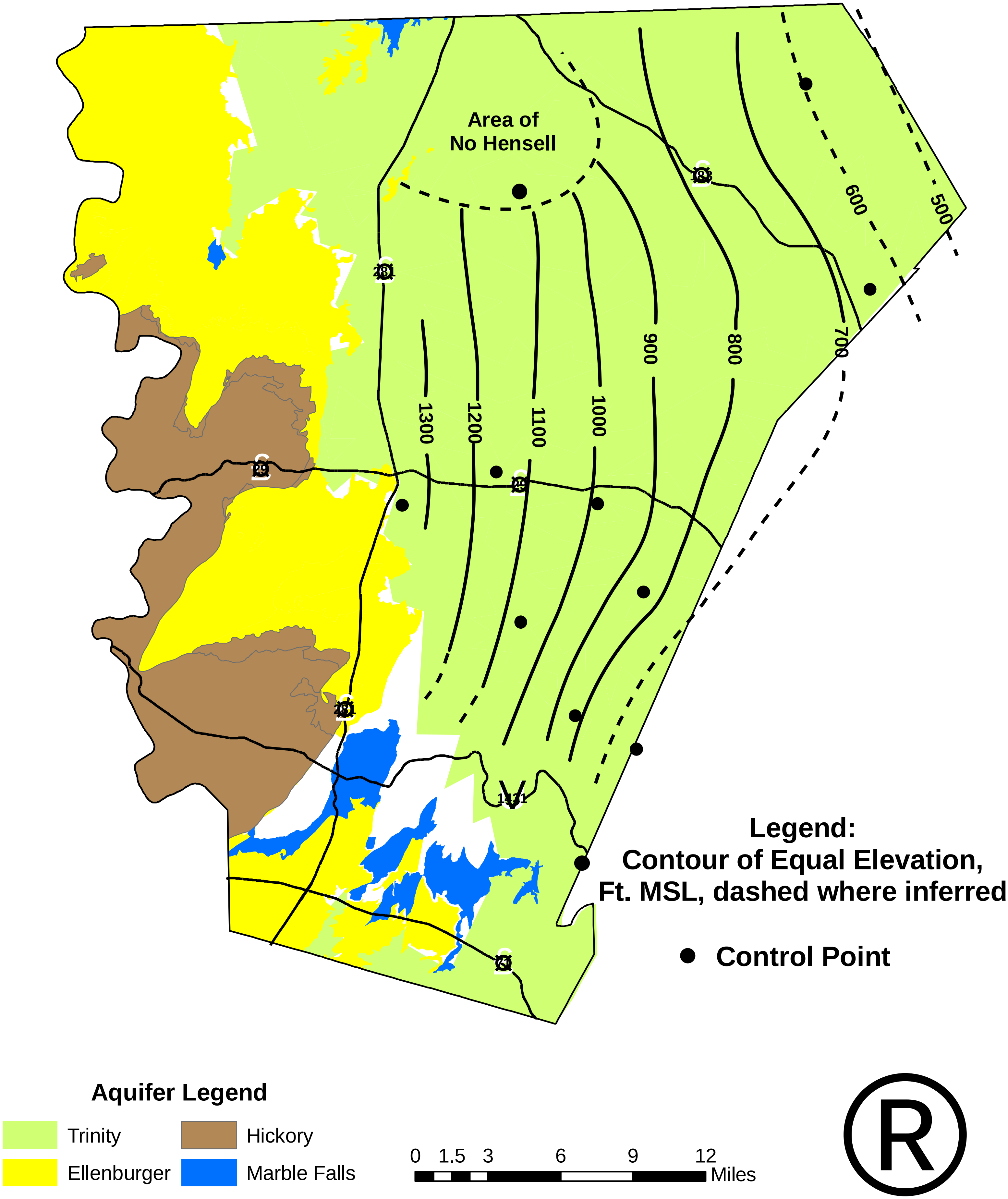
Fault
U, upthrown side; D, downthrown side
Dashed where approximately located

Approximate downdip limit of fresh to slightly saline water in the Hensell Member

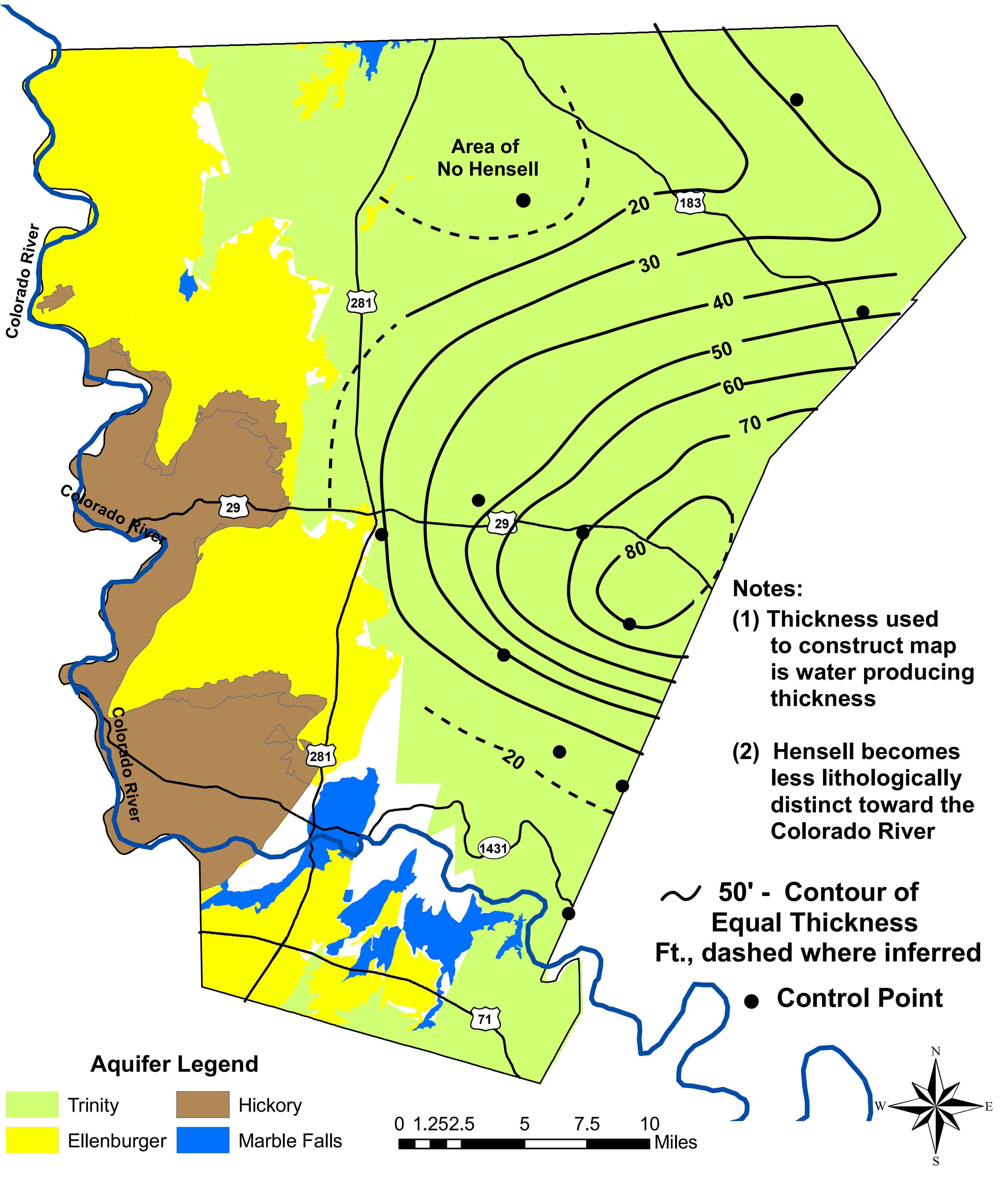
Approximate downdip limit of the sand facies in the Hensell Member

Approximate eastern limit of the calcareous facies of the Travis Peak Formation

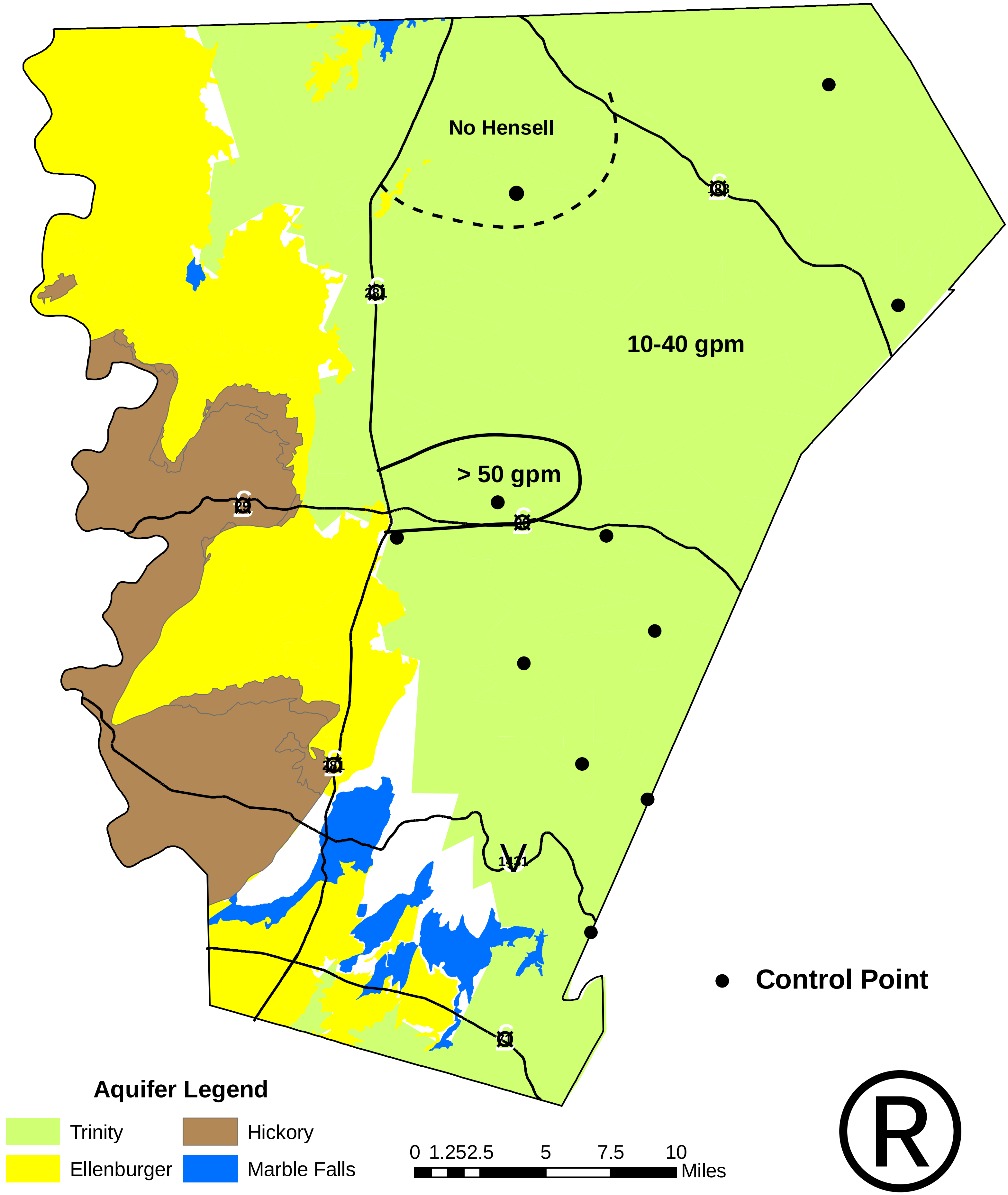
## FIGURE 11
## ELEVATION OF TOP OF HENSELL SAND



# FIGURE 12
# ISOPACH MAP
# HENSELL SAND

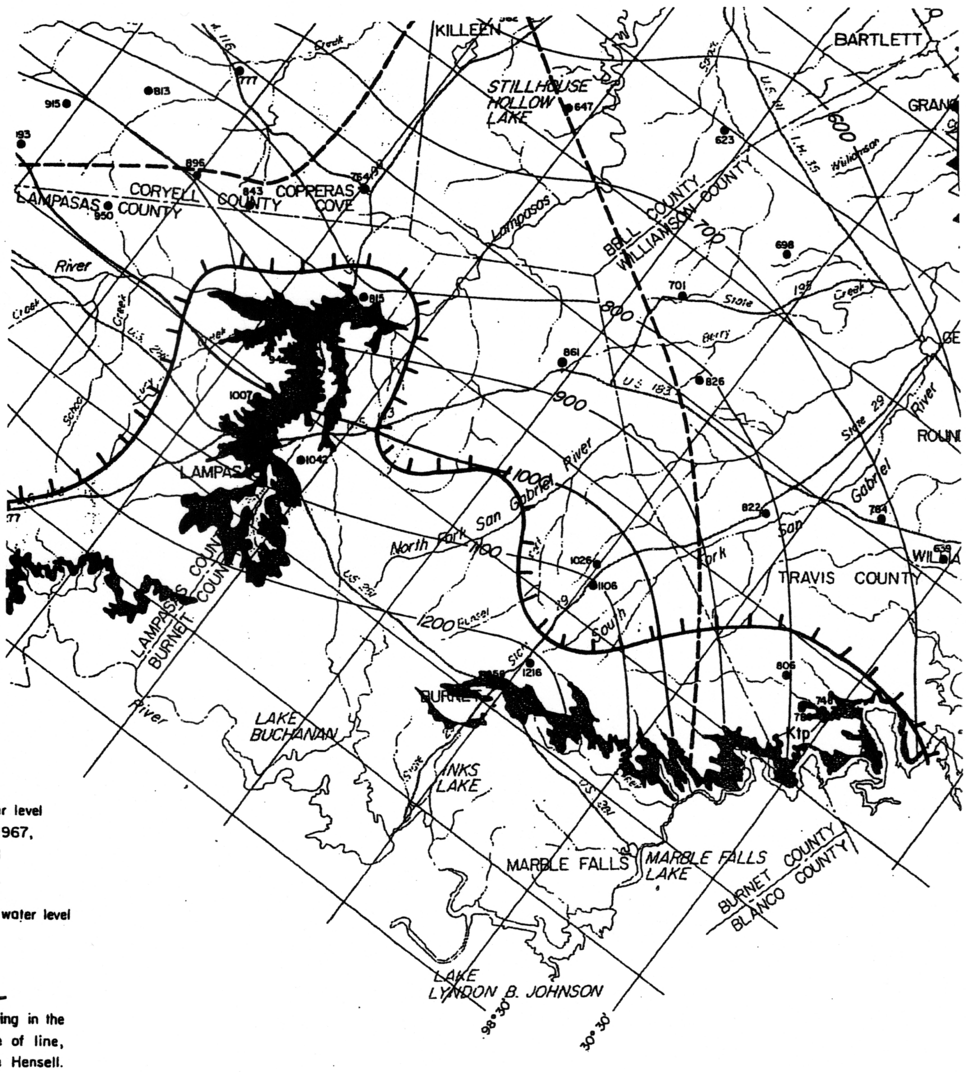


# FIGURE 13
# MIDDLE TRINITY AQUIFER
# DRILLING PRODUCTION ESTIMATES



# Figure 14

## Approximate Altitude of Water Levels in Wells Completed in the Hensell Member of the Travis Peak Formation, Spring 1967




EXPLANATION

● 550
Well used for control
Number indicates altitude of water level of the Hensell Member, Spring 1967, in feet above mean sea level

500
Line showing approximate altitude of water level
Interval 100 feet
Datum is mean sea level

Approximate downdip extent of dewatering in the Hensell Member. On the hachured side of line, the water level is below the top of the Hensell.

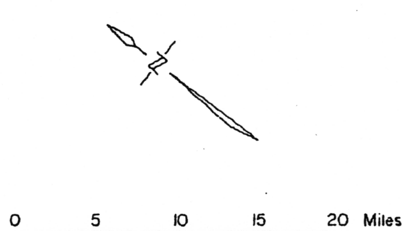
Ka
Outcrop of the Antlers (Ka) and the Travis Peak (Ktp) Formations

Contact
Dashed where covered or approximately located

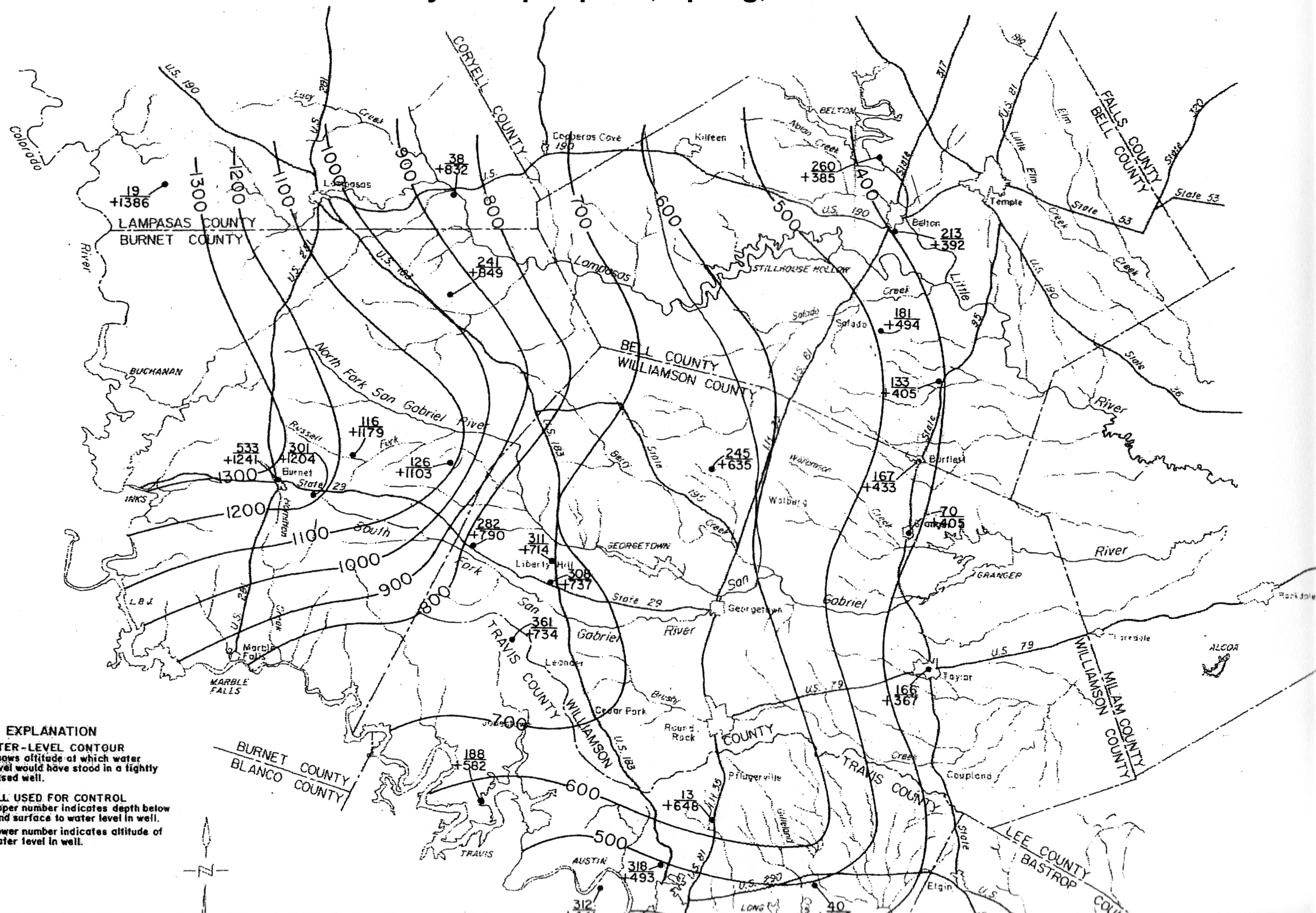
Approximate downdip limit of fresh to slightly saline water in the Hensell Member

Approximate downdip limit of the sand facies in the Hensell Member

Approximate eastern limit of the calcareous facies of the Travis Peak Formation



# Figure 15
## Approximate Altitude of Water Levels In Selected Wells Completed in the Trinity Group Aquifer, Spring, 1986

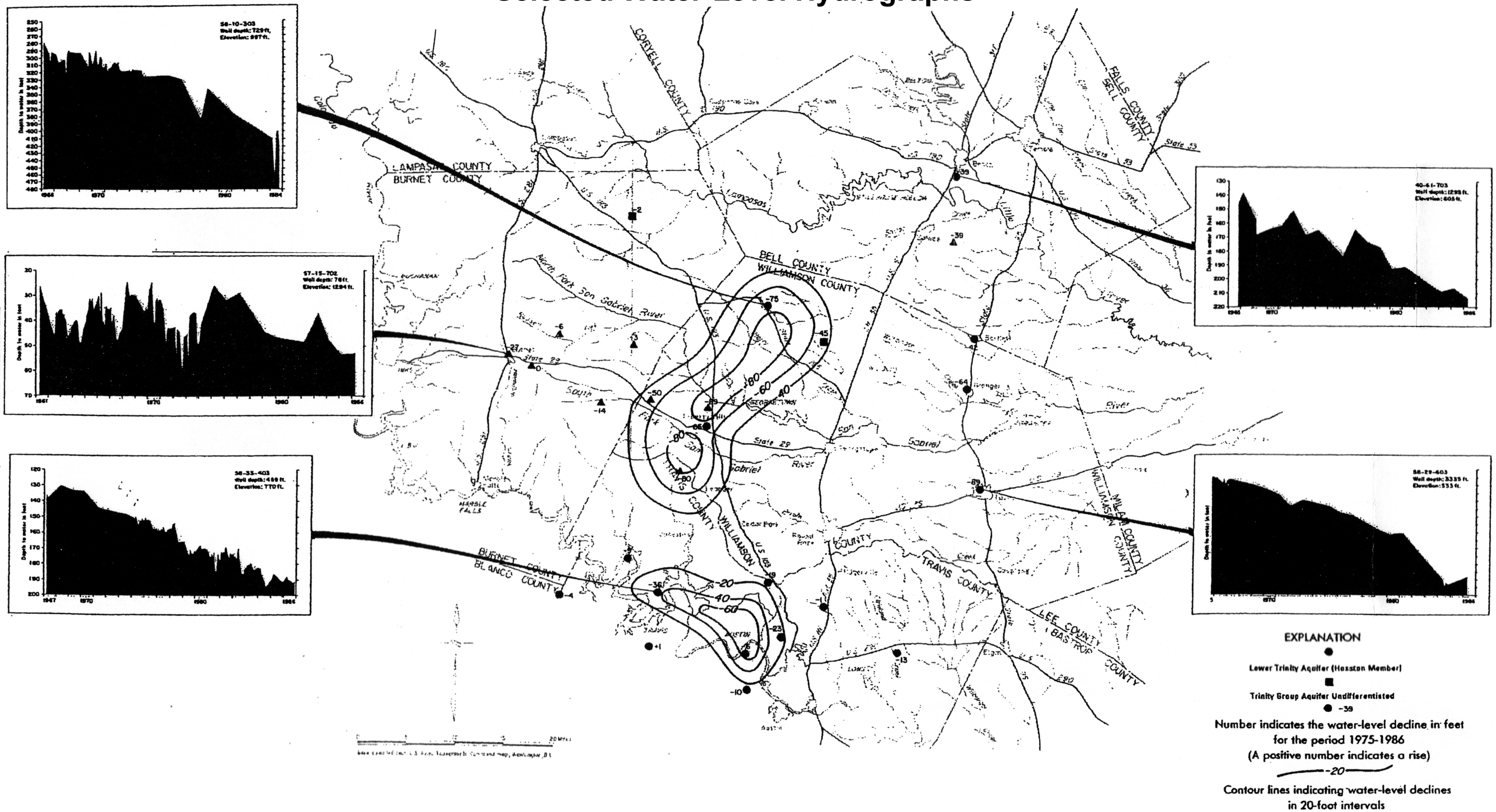



EXPLANATION

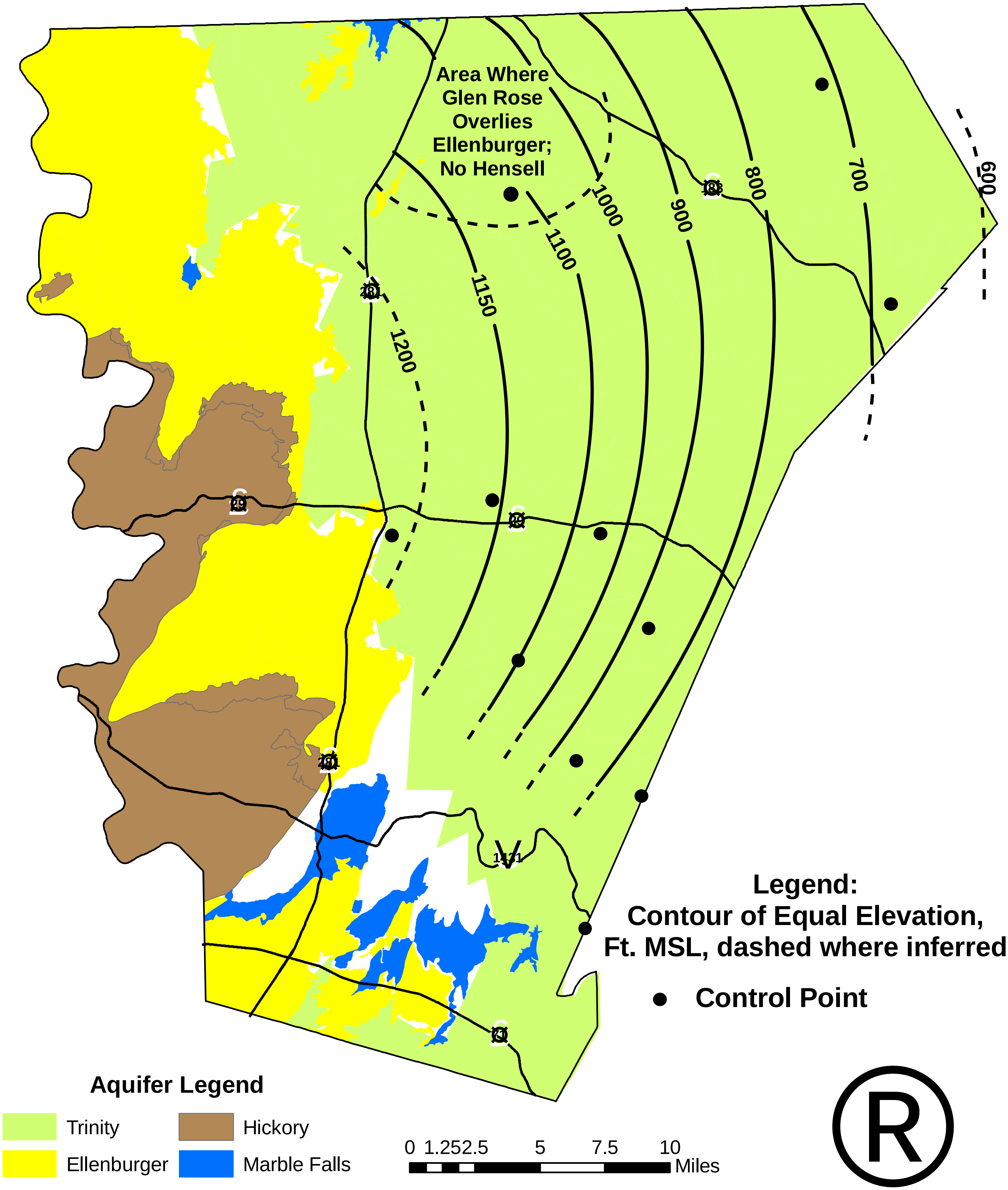
—500— WATER-LEVEL CONTOUR
Shows altitude at which water level would have stood in a tightly cased well.

311/714 WELL USED FOR CONTROL
Upper number indicates depth below land surface to water level in well.
Lower number indicates altitude of water level in well.

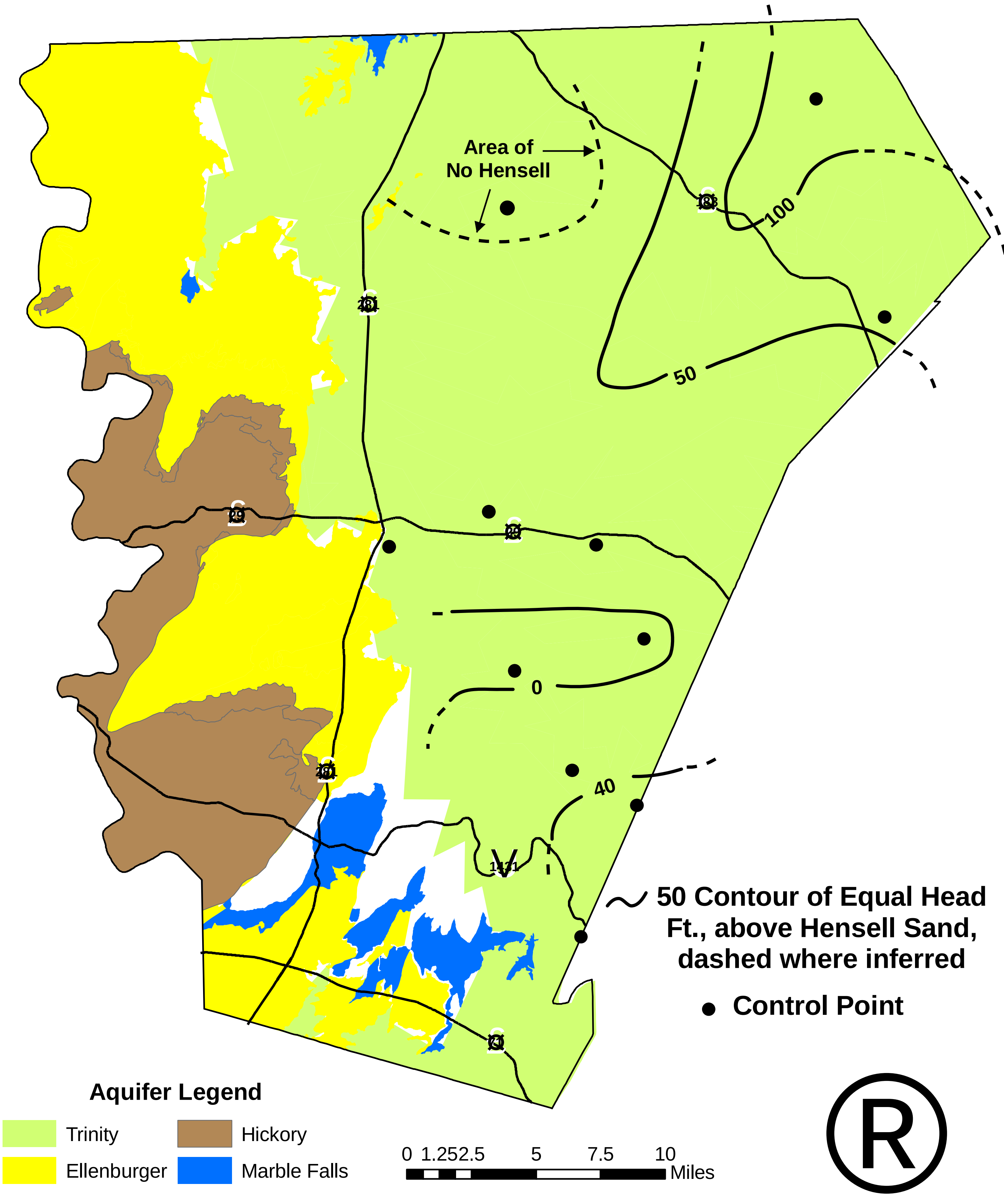
# Figure 16
# Water Level Declines in the Trinity Group Aquifer, 1975-1986, and Selected Water-Level Hydrographs



# FIGURE 17
# TRINITY AQUIFER
# POTENTIOMETRIC MAP - SUMMER 2009



## FIGURE 18
## Potentiometric Head Above Hensell Sand



LIST OF TABLES

# Table 1

| Geologic Units | | | | | |
|---|---|---|---|---|---|
| **Era** | **System** | **Group** | **Formation** | **Member or Unit** | **Hydrogeologic Units** |
| Cenozoic | Quaternary | Pleistocene to Recent floodplain (alluvium and fluviatile terrace deposits) | | | localized alluvial aquifers |
| Mesozoic | Cretaceous | Edwards Group | Segovia Formation | | Edwards Plateau Aquifer (Edwards Trinity aquifer) |
| | | | Fort Terrett Formation | Kirchburg evaporite Mbr. | |
| | | | | Dolomite Member | |
| | | | | Burrowed Member | |
| | | | | Basal Nodular Bed Member | confining bed (Edwards Trinity aquifer) |
| | | Trinity Group | Glen Rose Limestone | Upper Member | Upper and Middle Trinity Aquifer (Edwards Trinity aquifer) |
| | | | Travis Peak equivalent: Hensell Sand / Bexar | Lower Member | |
| | | | Travis Peak equivalent: Cow Creek Limestone | | |
| | | | Travis Peak equivalent: Hammett Shale | | confining bed |
| | | | Travis Peak equivalent: Sligo / Sycamore Sand / Hosston | | Lower Trinity aquifer |
| Paleozoic | Pennsylvanian | Canyon Group | undivided | | confining beds |
| | | Strawn Group | undivided | | |
| | | Bend Group | Smithwick | undivided | |
| | | | Marble Falls Limestone | | Marble Falls aquifer |
| | Mississippian and Devonian | Composed of youngest to oldest – Barnett Formation(Miss.),Chappel Limestone(Miss) Houy Formation(Dev) and the Stribling Formation (Dev) | | | Usually confining beds |
| | Ordovician | Ellenberger Group | Honeycut Formation | undivided | Ellenberger-San Saba aquifer |
| | | | Gorman Formation | undivided | |
| | | | Tanyard Formation | Staendebach Member | |
| | | | | Threadgill Member | |
| | Cambrian | Moore Hollow Group | Wilberns Formation | San Saba Member | |
| | | | | Point Peak Member | confining beds |
| | | | | Morgan Creek Limestone Mbr | |
| | | | | Welge Sandstone Member | Mid-Cambrian aquifer |
| | | | Riley Formation | Lion Mountain Sandstone Mbr | |
| | | | | Cap Mountain Limestone Mbr | confining beds |
| | | | | Hickory Sandstone Member | Hickory aquifer |
| Precambrian | | | Llanite; Oat Creek Granite; Six Mile Granite; Pegmatite and quartz veins; Town Mountain Granite; Melaryolite dikes; Red Mountain Gneiss; Coal Creek Serpertine; Mafic igneous rocks; Packsaddle Schist; Lost Creek Gneiss; Valley Springs Gneiss | | Usually confining beds |

**Geologic and hydrogeologic units in the area of interest (after Preston and others, 1996).**

# Table 2
# Central Texas GCD
# Monitoring Well Detail

| **Well No.**(3) | **Well Designation** | **Date Completed** | **Aquifer** (1) | **Total Depth(ft)**(6) | **Screened Interval(ft)** | **Completion Type**(4) | **Depth to Water(ft)**(5) | **LS Elev. (ft),MSL**(2) | **State Well No.** | **Longitude** | **Latitude** | **TDLR Track No.** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Smith 2 | 04/23/09 | GR, He | 700 | 200-240 | S | 99.5 | 834 | 5801202 | 98°7’5.26” | 30°58’51.97” | 185765 |
| 2 | Jeffcoat 1 | 05/07/09 | EB | 460 | 400-460 | S | ~100 | 1230 | 5708401 | 98°7’23.02” | 30°55’36.08” | 179536 |
| 3 | Jeffcoat 2 | 05/12/09 | EB | 640 | 420-440, 600-640 | S | 93.7 | 1220 | 5708402 | 98°7’22.2” | 30°55’34” | 179541 |
| 4 | Brown 1 | 05/19/09 | He | 425 | 310-350 | S | 249.0 | 1401 | 5715901 | 98°9’13” | 30°45’46” | 182162 |
| 5 | Brown 2 | 06/11/09 | EB | 920 | 380-920 | O | ~231.0 | 1400 | 5715902 | 98°9’12.89” | 30°45’46.78” | 186437 |
| 6 | Mattingly | 05/21/09 | He | 800 | 380-420 | S | 341.0 | 1182 | 5724503 | 98°3’20.36” | 30°41’17.24” | 181242 |
| 7 | Simmons 1 | 07/16/09 | He, Ho | 500 | 360-380, 460-480 | S | 359.2 | 1458 | 5723603 | 98°9’11.6” | 30°40’33.41” | 187850 |
| 8 | Simmons 2 | 07/30/09 | Cc | 515 | 435-515 | S | ~360 | 1462 | 5723604 | 98°9’13.99” | 30°40’33” | 195462 |
| 9 | Fischer | 07/18/09 | He, Cc | 780 | 520-540, 620-640 | S | 435.5 | 1131 | 5809303 | 97°54’25.88” | 30°51’40.89” | 187840 |
| 10 | Robinson | 07/27/09 | GR | 90 | 70-90 | S | ~77 | 1238 | 5715903 | 98°8’19.99” | 30°47’27” | 187832 |

Notes: (1) Aquifer Abbreviations: GR - Glen Rose, EB – Ellenburger, He – Hensell, Cc – Cow Creek, Ho – Hosston
(2) LS Elev.: Land Surface Elevation (ft), MSL – determined using ArcView - GCS_North_American_1983
(3) See Figure 2 for locations
(4) Completion Type – S, screen; O, open hole
(5) Depth to water – Measured during or immediately after well completion
(6) Where total depth greatly exceed bottom of screen, hole was drilled for lithologic evaluation.

Table 3

Estimates Of Recharge Rates Expressed
As Percent Of Rainfall In The Trinity
Aquifer In The Hill Country Area
From Mace, et.al., 2000

| Source | Value |
|---|---|
| Muller and Price (1979) | 1.5% |
| Ashworth (1983) | 4.0% |
| Kuniansky (1989) | 11.0% |
| Kuniansky and Holligan (1994) | 7.0% |
| Bluntzer (1992, calc.) | 6.7% |
| Bluntzer (1992), est.) | 5.0% |
| Our analysis | 6.6% |
| Our model | 4.0% |

# ATTACHMENT A

Lithologic Logs

**Well No. 1**
**SMITH 2**

| UNIT | DEPTH (ft) | DESCRIPTION |
|---|---|---|
| Alluvium | 0-30 | Sand: tan, md to crse w/trace fn gravel; silty below 30’ |
| Glen Rose Ls. | 30-205 | Limestone: gray, slightly sandy, sandy below 120’; dark brown below 195’ |
| Hensell Sd. | 205-235 | Sand: gray, md To crse w/thin beds dark gray limestone |
| Cow Creek Ls. | 235-270<br><br>270-360 | Shale: gray, soft, calcareous; brown, sandy; clayey w/thin limestone layers below 250’.<br><br>Limestone: gray, sandy, hard |
| Smithwick Shale (?) | 360-700 | Shale: dark brown to black |

Note: water 10-15 gpm at 135’

**Well No. 2**
**JEFFCOAT 1**

| UNIT | DEPTH (ft) | DESCRIPTION |
|---|---|---|
| Glen Rose Ls. | 0-180 | Limestone: tan, slightly shaley gray below 20’ |
| Ellenburger Grp. | 180-460 | Dolomite: gray to tan, hard, bit chattering, damp at 215’ |

Notes: (1) 215’ - 2 gpm
(2) 405’ - 60 gpm
(3) 457’ - 90 gpm

**Well No. 3**
**JEFFCOAT 2**

| UNIT | DEPTH (ft) | DESCRIPTION |
|---|---|---|
| Glen Rose Ls. | 0-175 | Limestone: tan, gray below 20’ sandy at 170’ |
| Ellenburger Grp. | 175-640 | Dolomite: gray to tan, hard |

Notes: (1) 200’ - 2 gpm
(2) 420’ - 25 gpm
(3) 635’ - 75+ gpm

**Well No. 4**
**BROWN 1**

| UNIT | DEPTH (ft) | DESCRIPTION |
|---|---|---|
| Fredericksburg | 0-30 | Limestone: white, soft |
| Glen Rose Ls. | 30-130 | Clay: blue, calcareous; yellowish brown below 65'; gray below 75' |
| | 130-225 | Limestone: gray, shaley, more shaley below 140' |
| | 225-240 | Clay: yellowish, calcareous sandy 237-238' |
| Hensell Sd. | 240-282 | Clay: red, sandy, calcareous |
| | 252-295 | Sand: red to dark brown, w/fn gravel (no water) |
| | 295-315 | Clay: red, sandy, calcareous; yellowish, very sandy below 305' |
| | 315-340 | Sand: gray, md. to crse |
| | 340-350 | Limestone: gray, interbedded w/red clay |
| | 350-355 | Sand: gray, crse, w/fn gravel |
| Cow Creek Ls. | 355-390 | Limestone: light gray to gray, soft, Drilling fast |
| Ellenburger Grp. | 390-425 | Dolomite: gray, hard |

Note: 315-340': 50 gpm

**Well No. 5**
**BROWN 2**

| UNIT | DEPTH (ft) | DESCRIPTION |
|---|---|---|
| Hensell Sd. | 240-295’<br><br>295-348’ | Sand:  reddish brown, clayey<br><br>Sand:  gray, md to crse |
| Cow Creek | 348-380’ | Limestone:  light gray to gray, soft |
| Ellenburger Grp. | 380-920’ | Dolomite: gray, hard |

Note:  See Brown No. 1 Well 0-240’

Notes:   Fractures  730, 920:  75 gpm

**Well No. 6**
**MATTINGLY WELL**

| UNIT | DEPTH (ft) | DESCRIPTION |
|---|---|---|
| Glen Rose Ls. | 0-315 | Limestone: yellow, soft; gray Below 20'; clayey 60-70'; sandy 260-270' ; dark gray below 280' |
| Hensell Sd. | 315-432 | Sand: gray, md to crse, calcareous, relatively dry to 340'; coarse at 405'; red at 432' |
| | 432-450 | Clay: red, sandy |
| | 450-460 | Sand: red, md to crse |
| Cow Creek Ls. | 460-515 | Limestone: gray, hard, bit chattering, very sandy 490-498'; shaley below 498' |
| | 515-545 | Clay: gray, soft |
| | 545-615 | Limetone: yellowish brown, slightly hard |
| Hosston Sd. | 645-695 | Sandstone: light gray, fn; fn to md below 665' |
| Smithwick Shale (?) | 695-800 | Shale: dark gray, soft |

Note: 340-420: 20 gpm

**Well No. 7**
**SIMMONS 1**

| UNIT | DEPTH (ft) | DESCRIPTION |
|---|---|---|
| Fredericksburg | 0-12 | Limestone: white, soft |
| Glen Rose Ls. | 12-340 | Limestone: tan to white, brown below 80'; light gray below 90'; shaley, marly below 150'; sandy 150-155' |
| Hensell Sd. | 340-380 | Sandstone: gray, fn, weakly cemented; fn to md below 355'; fn below 370' |
| Cow Creek Ls. | 380-385 | Shale: light gray, marly |
| | 385-395 | Sand: light gray, md, loose |
| | 395-440 | Clay: gray, silty, soft, shaley, interbedded w/sandstone below 430' |
| | 440-470 | Limestone: yellowish gray, sandy; clayey below 460' |
| Hosston Sd. | 470-480 | Sandstone: gray, fn, weakly cemented |
| | 480-500 | Clay: light gray, calcareous |

Note: 340-380': 15-20 gpm

**Well No. 8**
**SIMMONS 2**

| UNIT | DEPTH (ft) | DESCRIPTION |
|---|---|---|
| Cow Creek Ls. | 400-425 | Limestone: gray, clayey;<br>very sandy below 410';<br>slightly clayey 420-425' |
| | 425-520 | Sand: gray, fn to md; sand heaving into hole at 520';<br>Terminated due to heaving sand |

Note: See Simmons Well No. 1 to Depth of 400'

**Well No. 9**
**FISCHER WELL**

| UNIT | DEPTH (ft) | DESCRIPTION |
|---|---|---|
| Fredericksburg | 0-40 | Clay: yellow, silty |
| Glen Rose Ls. | 40-410 | Limestone: gray, clayey, shaley 90-240'; sandy 240-400' |
| | 410-450 | Shale: gray, soft |
| | 450-465 | Limestone: gray, soft |
| | 465-490 | Shale: gray; sandy below 475' |
| Hensell Sd. | 490-539 | Sand: dark gray, md w/occasional layer of dolomitic ls |
| Cow Creek Ls. | 539-580 | Shale: light gray |
| | 580-720 | Limestone, light gray, sandy, shaley below 600', sandy 615-620' |
| Smithwick Shale (?) | 720-780 | Shale: Red 720-750, dark gray below 750' |

Note: 525-539: 40 gpm

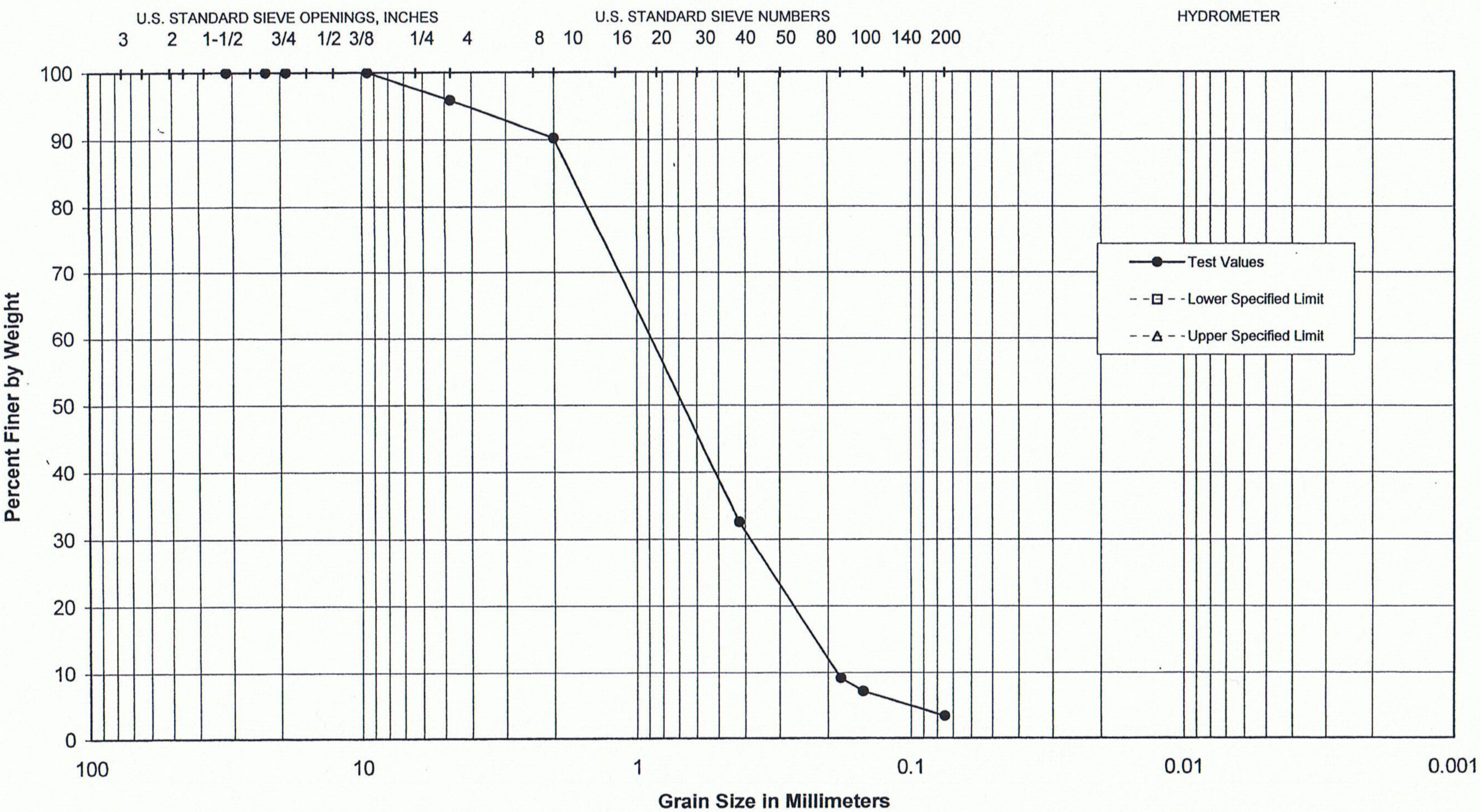
**Well No. 10**
**ROBINSON WELL**

| UNIT | DEPTH (ft) | DESCRIPTION |
|---|---|---|
| Glen Rose | 0-10 | Clay: brown, silty, sandy, |
| | 10-12 | Gravel: brown, sandy |
| | 12-50 | Shale: blue, calcareous |
| | 50-62 | Limestone: blue, shaley |
| | 62-68 | Shale: light gray to blue calcareous |
| | 68-90 | Limestone: light gray, sandy below 87’ |

# ATTACHMENT B

## Grain Size Analyses

# GRAIN SIZE CURVE




| GRAVEL | | SAND | | | SILT or CLAY |
|---|---|---|---|---|---|
| Coarse | Fine | Coarse | Medium | Fine | |

Job No.: 09-KCE-0021 Date: 5/4/2009 Method: Tex 110-E

Project: Central Texas Groundwater Conservation District

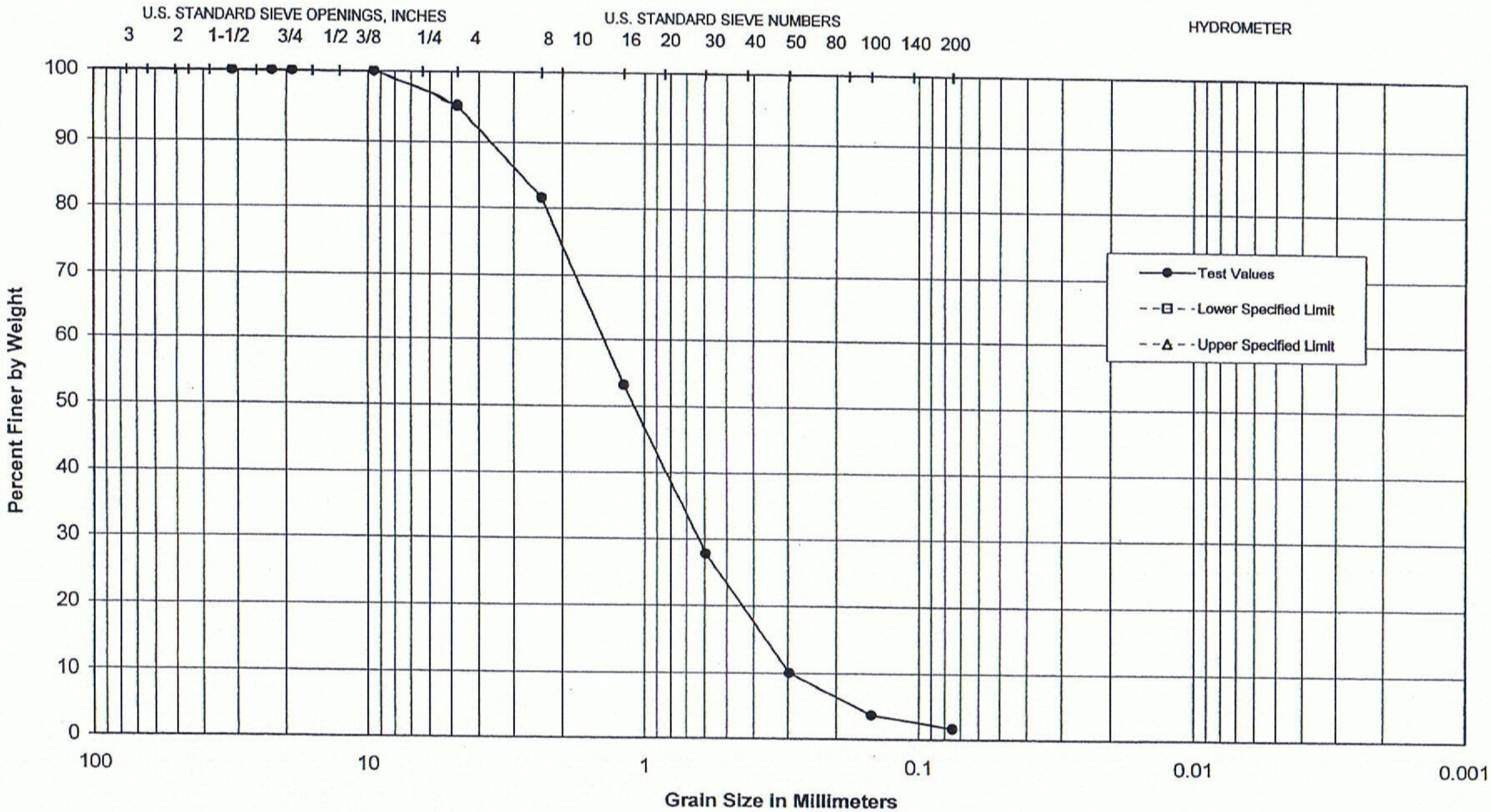
Material: Sand

I.D. No.: Sample No. 1

Location: Smith Well Site in Oakalla

Source: Smith Well Site in Oakalla

# GRAIN SIZE CURVE




| GRAVEL | | SAND | | | SILT or CLAY |
|---|---|---|---|---|---|
| Coarse | Fine | Coarse | Medium | Fine | |

Job No.: 09-KCE-0021 Date: 6/1/2009 Method: Tex 110-E I.D. No.: Sample No. 2

Project: Central Texas Groundwater Conservation District Location: Brown Well #1

Material: Coarse Sand – 315-340' Source: